ENGINEERING FROM MACHINE LEARNING TO VIRTUAL REALITY

EDITOR
Assoc. Prof. Dr. Merivan ŞAŞMAZ

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PREFACE

Engineering is a diverse field which stands on numerous pillars. In this book, the collected chapters from the experts introduce how to use Machine Learning (ML) with improvement suggestions, computational experiments with case studies, and architectural designs with famous examples. The chapters are written in plain English for the readers with different backgrounds.

Nine chapters provide detailed information with applications in various disciplines. In the first chapter, "Comparison of Machine Learning Classification Techniques in R", classification of a dataset by ML is introduced for R language. Code snippets are given in the appendix for hands on experience. ML models could be improved by additional processes such as feature selection. In the second chapter, "Classification of Brain MRI Using EfficientNet CNN Model and Feature Selection Method", performance of the trained CNN model for MRI images is improved by selecting the right features. In ML applications, selection of features increases the quality of the dataset. High quality of data is important as much as a defined ML model. Thus, in the third chapter, "On Model Complexity and Representation Power of Artificial Neural Networks", Artificial Neural Network is evaluated to obtain the simplest model without sacrificing the quality. In chapter four, "New Trends in Digital Marketing and The Effective Use of Artificial Intelligence in the Marketing Industry", application of ML is presented in the form of Artificial Intelligence. In chapter five, "Investigation of The Effect of Total Quality Management Applications on Employee Motivation by Furious Dematel Method: An Example Application", a case study is presented to understand the relation between employee motivation and quality management. In chapter six, "Effect of Bullet Geometry on Base Drag: A Ballistic Application on Design with Middle Drilled Bullet", computed experiments are given to distinguish the best design between the considered designs. Another computed experiment for waveguides is presented in chapter seven, "One of the Basic Microwave Transmission Lines: Waveguides". The last two chapters are architectural studies. The chapter eight, "Following the Traces of Sedad Hakki Eldem: A Case Study on the Contribution of Virtual Reality Based Documentary Games to Architectural Education", carries history to the virtual world as an educational material. In the chapter nine, "Basic Excavation Methods in Building-Foundation Interaction; Top-Down Method in High-Rise Buildings", different excavation

methods are detailed with their advantages and disadvantages. For the chapters, all responsibilities belong to the authors for the provided content.

We are grateful to authors for their contribution to this book, and IKSAD publishing house for their support. We intended this book to provide inspiring information with an enjoyable reading experience. We hope it serves its purpose.

Assoc. Prof. Dr. Merivan ŞAŞMAZ
December 2022

CHAPTER 1

COMPARISON OF MACHINE LEARNING CLASSIFICATION TECHNIQUES IN R[1]

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INTRODUCTION

Thanks to the developing technology, data is produced by each individual due to most of the actions we come into contact within life. Apart from the data produced by individuals, companies also obtain huge data through activities such as production, consumption and service. When this big data is used correctly, an output can be obtained in the form of reducing costs and increasing profitability for companies. In recent years, machine learning algorithms have been frequently used to interpret data correctly and to make predictions by using historical data. In this study, the results are obtained regarding the comparison of the methods related to the classification technique, which is one of the supervised machine learning algorithms, are shared.

Machine Learning is a subunit of artificial intelligence that mimics the way humans learn through the use of data and algorithms. Using statistical methods, algorithms are trained to make classifications or predictions and are used in data mining projects. Machine learning algorithms are a very useful tool for making predictions in industries with big data. In this study, the supervised machine learning classification methods “Logistic Regression, K Nearest Neighbours (K-NN), Support Vector Machines (SVM), Kernel Support Vector Machines (Kernel SVM), Naive Bayes, Decision Trees and Random Forest" methods will be examined. It is very important to determine which of these methods will make a more accurate prediction and which model is more suitable for the real-life data to be used. In this study, an application regarding the appropriate model selection is presented.

RESEARCH AND FINDINGS

In this study, the Classification Method, which is one of the supervised learning techniques in machine learning, is discussed. “Logistic Regression, K-NN, SVM, Kernel SVM, Naive Bayes, Decision Trees and Random Forest” classification techniques were examined. Logistic regression analysis aims to establish a model that can describe the relationship between categorical dependent and independent variables in a way that has the best fit by using the least number of variables (Salmon, 2003). The K-NN algorithm is a simple and easy-to-implement supervised machine learning algorithm. This algorithm assumes that similar things exist. In other words, it works with the idea that similar things are close to each other (Harrison, 2018). Initially, it calculates the distance of new observations included in a data set with certain classes to all observations (Ateş, 2019). SVM is one of the successful machine

learning algorithms developed to solve classification problems in recent years. It is frequently used because it plays a role in solving many classification problems. One of its biggest advantages is that it transforms the classification problem into a squared optimization problem and solves it. In this way, it can reach the solution faster than other algorithms by reducing the number of operations in the learning phase on the way to the solution. Thanks to this feature, it is very useful in large volume data sets (Burges, 1998). Naive Bayes classification makes classification by making probabilistic calculations according to bayes theory (Özdemir, 2021). A certain amount of trained data is entered into the system and the data entered for teaching must have a class. It is tried to determine in which class the given test data is. The more data, the easier it is to detect the real class (Çelik, 2019). Decision tree is a classification technique that is often used because the training and testing process are fast (Wu and Banzhaf; 2010). A decision tree is a structure where each link represents a rule and each leaf represents a result (October, 2021). This structure consists of roots, branches and leaves. The top node is called the root and branches to the leaves take place according to the selected criteria (Ulgen, 2017). The random forest algorithm was developed based on decision trees (Breiman, 2001). A random forest is created by randomly gathering n decision trees (Cebi, 2020).

In our study, each of these techniques is discussed and the performance results are presented comparatively on real-life data obtained from the Kaggle data platform. In the application under consideration, there are data on the decisions made by 400 individuals regarding the purchase. The purchase decision which is a dependent variable is coded as 0 and 1. Independent variables are age and estimated salary. Four different performance metrics were used for performance comparing of machine learning models. Table 1 summarizes how user performance metrics are calculated.

Table 1. Calculations of performance metrics

Metrics	Calculations
Accuracy	TP+TN/ (TP+TN+FP+FN)
Precision	TP/ (TP+FP)
Sensitivity	TP/ (TP+FN)
F1 Score	2TP/ (2TP+FP+FN)

*TN= results are predicted as negative where they are actually negative, TP=results are predicted as positive where they are actually positive, FP= results are predicted as positive where they are actually negative, FN= results are predicted as negative where they are actually positive

The accuracy metric, calculated for performance, gives an idea about the overall performance of the model. F1 Score value shows the harmonic mean of Precision and Sensitivity values.

RESULTS

In this study, which was conducted on the effect of age and salary on the purchasing decision of individuals, 75% of the 400 samples were used as the training set and the remaining 25% as the test data set. While the training dataset is 300, the test dataset is determined as 100 observations. In this direction, the machine learning algorithms are used for each model are given as an appendix, respectively.

In the model trained by logistic regression, when the estimation results are compared with the test data, there are 26 observation values in which people who have made a purchasing decision are estimated as having purchased (TP) and 57 people who have not made a purchase decision are estimated as not purchasing (TN). There are 10 people who have purchased but estimated as not purchasing (FN), and 7 people who are estimated to have purchased although they have not purchased (FP).

The second technique discussed in this study is K-NN. In the model trained for this method, when the estimation results are compared with the test data, there are 30 observation values in which the people who have made a purchasing decision are estimated as having purchased (TP), and there are 59 observation values where the people who have not made a purchasing

decision are estimated as not purchasing (TN). There are 6 people who are estimated as not purchased but purchased (FN), and 5 people who are estimated to have purchased although they have not purchased (FP).

In the model trained by SVM, when the estimation results are compared with the test data, there are 23 observation values in which the people who have made a purchasing decision are estimated as having purchased (TP), and there are 57 observation values where the people who have not made a purchase decision are estimated as not purchasing (TN). There are 13 people who are estimated as not purchased but purchased (FN), and 7 people who are estimated to have purchased although they have not purchased (FP).

The other examined technique is Kernel-SVM, and in the model trained for this method, when the estimation results and test data are compared, it is estimated that 32 people who have made a purchasing decision are estimated to have purchased (TP), and 58 people who have not made a purchase decision are estimated as not purchasing (TN). There are 4 people who have purchased but estimated not purchased (FN), and 6 people who are estimated to have purchased who have not actually purchased (FP).

In the model trained for Naive-Bayes, when the estimation results are compared with the test data, there are 29 observation values in which the people who have made a purchasing decision are estimated as purchased (TP) and 57 people who have not made a purchasing decision are estimated as not purchased (TN). There are 7 people who are estimated as not purchased but actually purchased (FN) and 7 people who are estimated to have purchased but actually not purchased (FP).

In the model that was trained for the next method, the decision tree, when the estimation results and the test data are compared, it is estimated that 30 people who have made a purchasing decision and have been actually purchased (TP), 53 people who have not made a purchase decision are estimated as not purchasing (TN). There are 6 people who are estimated as not purchased but actually purchased (FN), and 11 people who are estimated to have purchased although they have not purchased (FP).

When the application data is finally trained for the random forest model, and the prediction results are compared with the test data, it is estimated that 28 people who have made a purchase decision are estimated to have purchased (TP), and 55 people who have not made a purchase decision are estimated as not to have purchased (TN). There are 8 people who are

estimated as not purchased but actually purchased (FN), and 9 people who are estimated to have purchased although they have not purchased (FP).

Table 2. Comparison of the performance metrics of the methods

	Accuracy	Precision	Recall Sensitivity	F1 Score
Logistic regression	0,83	0,79	0,72	0,75
K-NN	0,89	**0,86**	0,83	0,85
SVM	0,80	0,77	0,64	0,70
Kernel SVM	**0,90**	0,84	**0,89**	**0,86**
Naive Bayes	0,86	0,81	0,81	0,81
Decision Tree	0,83	0,73	0,83	0,78
Random Forest	0,83	0,76	0,78	0,77

CONCLUSION

The comparative performance results obtained from the machine learning algorithms for the different models mentioned above are given in Table 2. When this table is examined, it is seen that Kernel SVM is the most suitable technique for application data. Looking at the performance metrics results of the models discussed, Kernel SVM has a higher accuracy rate than other classification models. In addition, a higher value was obtained for the Kernel SVM model in F1 score calculated by taking precision and recall into account.

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APPENDIX

APPENDIX 1

```
# Logistic Regression

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(dataset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])

test_set[-3] = scale(test_set[-3])

# Fitting Logistic Regression to the Training set

classifier = glm(formula = Purchased ~ ., family = binomial, data = training_set)

# Predicting the Test set results

prob_pred = predict(classifier, type = 'response', newdata = test_set[-3])
```

```
y_pred = ifelse(prob_pred > 0.5, 1, 0)

# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred > 0.5)
```

APPENDIX 2

```
# K-Nearest Neighbors (K-NN)

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(dataset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])

test_set[-3] = scale(test_set[-3])

# Fitting K-NN to the Training set and Predicting the Test set results

library(class)

y_pred = knn(train = training_set[, -3], test = test_set[, -3], cl = training_set[, 3], k =
5, prob = TRUE)
```

```
# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred)
```

APPENDIX 3

```
# Support Vector Machine (SVM)

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(dataset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])

test_set[-3] = scale(test_set[-3])

# Fitting SVM to the Training set

# install.packages('e1071')

library(e1071)

classifier = svm(formula = Purchased ~ ., data = training_set, type = 'C-classification',
kernel = 'linear')
```

```
# Predicting the Test set results

y_pred = predict(classifier, newdata = test_set[-3])

# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred)
```

APPENDIX 4

```
# Kernel SVM

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(dataset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])

test_set[-3] = scale(test_set[-3])

# Fitting Kernel SVM to the Training set

# install.packages('e1071')

library(e1071)
```

```
classifier = svm(formula = Purchased ~ ., = training_set, type = 'C-classification',
kernel = 'radial')

# Predicting the Test set results

y_pred = predict(classifier, newdata = test_set[-3])

# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred)
```

APPENDIX 5

```
# Naive Bayes

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(daaset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])

test_set[-3] = scale(test_set[-3])

# Fitting SVM to the Training set
```

```
# install.packages('e1071')

library(e1071)

classifier = naiveBayes(x = training_set[-3], y = training_set$Purchased)

# Predicting the Test set results

y_pred = predict(classifier, newdata = test_set[-3])

# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred)
```

APPENDIX 6

```
# Decision Tree Classification

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(dataset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])

test_set[-3] = scale(test_set[-3])
```

```
# Fitting Decision Tree Classification to the Training set

# install.packages('rpart')

library(rpart)

classifier = rpart(formula = Purchased ~ . , data = training_set)

# Predicting the Test set results

y_pred = predict(classifier, newdata = test_set[-3], type = 'class')

# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred)
```

APPENDIX 7

```
# Random Forest Classification

# Importing the dataset

dataset = read.csv('Social_Network_Ads.csv')

dataset = dataset[3:5]

# Encoding the target feature as factor

dataset$Purchased = factor(dataset$Purchased, levels = c(0, 1))

# Splitting the dataset into the Training set and Test set

# install.packages('caTools')

library(caTools)

set.seed(123)

split = sample.split(dataset$Purchased, SplitRatio = 0.75)

training_set = subset(dataset, split == TRUE)

test_set = subset(dataset, split == FALSE)

# Feature Scaling

training_set[-3] = scale(training_set[-3])
```

```
test_set[-3] = scale(test_set[-3])

# Fitting Random Forest Classification to the Training set

# install.packages('randomForest')

library(randomForest)

set.seed(123)

classifier = randomForest(x = training_set[-3], y = training_set$Purchased,ntree =
500)

# Predicting the Test set results

y_pred = predict(classifier, newdata = test_set[-3])

# Making the Confusion Matrix

cm = table(test_set[, 3], y_pred)
```

CHAPTER 2

CLASSIFICATION OF BRAIN MRI USING EFFICIENTNET CNN MODEL AND FEATURE SELECTION METHOD

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1. INTRODUCTION

The brain is one of the most vital organs because it controls the human nervous system. Because of this, disorders that might occur in the brain affect all body and cause vital problems. Tumors are among the most common disorders seen in the brain and they grow irregularly and put pressure on the brain and skull (Grisold & Grisold, 2014). Early diagnosis of tumors in the brain is one of the most important factors in the recovery of the patient. The most common method for diagnosing such instances is to examine the (magnetic resonance imaging) MRI results by specialist doctors. Especially with the developments in deep learning (DL) approaches, many methods (Budak, Çıbuk, Cömert, & Şengür, 2021; Toğaçar, Cömert, & Ergen, 2021; Uçar, Akyol, Atila, & Uçar, 2021) have been developed to support the assessment made by doctors on the MRI images.

The most frequently used approach in studies on brain tumors is to divide images into two categories normal and abnormal. Nazir et al. achieved a classification accuracy of 91.8% in their study based on feature extraction on brain MRI images (Nazir, Wahid, & Khan, 2015). Sachdeva et al. classified MRI images with 94.9% accuracy using the features they obtained with the help of the region of interest (ROI) method and genetic algorithm approach (Sachdeva, Kumar, Gupta, Khandelwal, & Ahuja, 2016). Kanmani et al., on the other hand, divided the MRI images into two classes using the threshold-based region optimization (TBRO) approach with a 96.57% accuracy rate (Kanmani & Marikkannu, 2018). In another study, MRI images were divided into two classes with 95% accuracy using the gray level co-occurrence matrix (GLCM) technique based on the probabilistic neural network (PNN) architecture (Varuna Shree & Kumar, 2018). Ari and Hanbay achieved a classification accuracy of 97.18% with the help of the DL approach suggested by using extreme learning machine (ELM) and local receptive fields (LRF) techniques for similar images (Ari & Hanbay, 2018). In 2019, Sajjad et al. achieved a 94.58% classification accuracy using a CNN method on an augmented dataset (Sajjad et al., 2019). In 2020, Toğaçar et al. achieved an accuracy of 96.05% as a result of the classification they made based on the CNN architecture named BrainMRNet they developed (Toğaçar, Ergen, & Cömert, 2020). In another study, Toğaçar et al., using the Hypercolumn technique together with AlexNet and VGG-16 CNN architectures, classified brain MRI images as binary with 96.77% accuracy rate (Toğaçar, Cömert, & Ergen, 2020). In 2021, Singh et al. achieved a 90% binary classification accuracy in their study in which they extracted features

using the VGG-16 CNN architecture (Singh, Sharma, Goel, Lamba, & Garg, 2021). In 2021, Kang et al. also achieved a binary classification accuracy of 98.83% by using pre-trained deep convolutional neural networks (CNN) and machine learning (ML) classifiers (Kang, Ullah, & Gwak, 2021).

Because it has no known risk against human health and provides high-resolution images, MRI is the first method used in the detection of brain-related disorders (Akkus, Galimzianova, Hoogi, Rubin, & Erickson, 2017). Although various image processing methods have been used for tumor areas determined by doctors with their expertise, DL methods have become important tools in the analysis of medical images in recent years. Using EfficientNet (Tan & Le, 2019) which is one of the DL techniques, it appears that medical images can be classified quite successfully and quickly (jiahao, Jiang, Huang, & Shi, 2021; Li, Qiao, Wang, & Hongxing, 2021). This study aims to develop a fast and highly successful automated diagnosis model using EfficientNet models on brain MRI images without user intervention. In this study, a new approach consisting of B0, B1, B2, B3, and B4 models from the EfficientNet group with ANOVA F-Value feature selection method and support vector machine (SVM) classifier is proposed. The major features of this study can be listed as follows: (1) A hybrid DL approach based on EfficientNet has been introduced. (2) The features extracted through EfficientNet models have been optimized with the ANOVA F-Value technique. (3) While the number of features used was reduced, high classification accuracy was achieved. (4) A highly accurate model has been demonstrated to assist doctors in MRI examinations. A brain MRI image can be labeled as "tumor" or "normal" automatically by the proposed method without any input or user intervention. The ease of use of the proposed method will allow it to be easily used by doctors and experts in medical clinics. Thus, it can help to improve diagnostic accuracy rates in real-time.

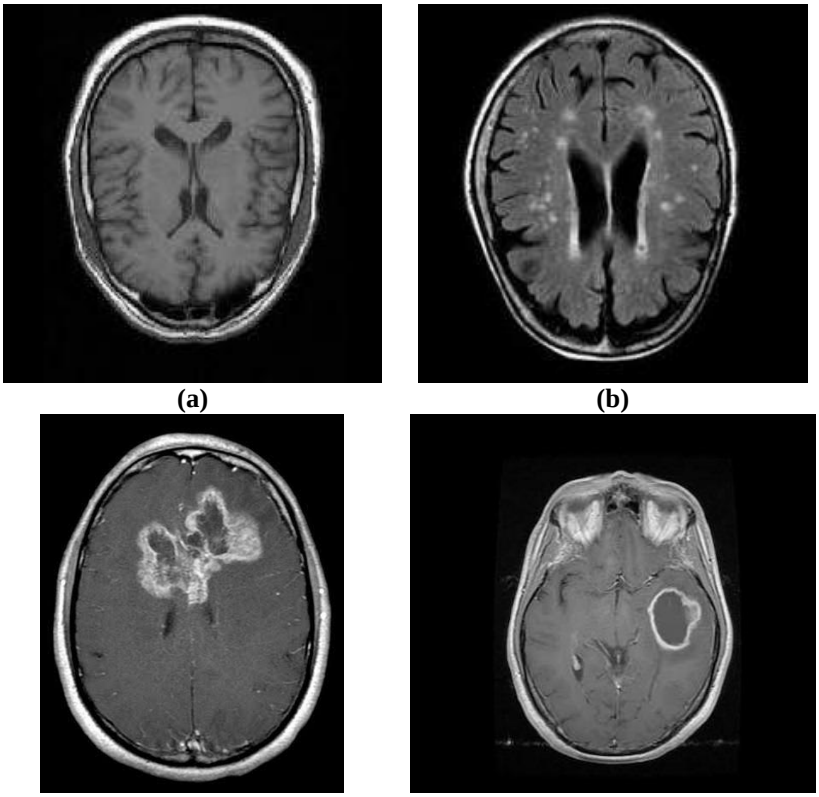
First, the data set and working method are described in the remaining part of the study. Then the proposed method is thoroughly detailed. After the experimental results and discussion sections, there is a conclusion section.

2. MATERIAL AND METHODS

This section describes in detail the dataset utilized and the proposed method for detecting brain tumors.

2.1. Dataset

The data set named Brain Tumor Detection 2020 (BTD2020) obtained from the Kaggle website was used in the study (Hamada, 2020). The data set consists of two classes of open access brain MRI images, tumor and normal. The data set contains 3000 JPEG files of different sizes and different resolutions, with 1500 tumors and 1500 normal. Examples of normal and tumor images are given in Figure 1.



(a) **(b)** **(c)** **(d)**

Figure 1: Brain MRI samples. (a) and (b) Normal, (c) and (d) Tumor

2.2. Proposed method

The focus of this study is to provide an effective and successful model for brain tumor classification. In the study, feature extraction was performed using only 5 models of the EfficientNet group, one of the deep learning architectures, in the B0-B4 range, which use fewer parameters and are faster. Later, the Z-score normalization technique was used to normalize 5000 features that were obtained by combining 1000 features from each of these

models. The most effective of these features was then chosen using the ANOVA F-Value method. Finally, classification was made by the SVM method using these selected features. Figure 2 displays the proposed method's block diagram.

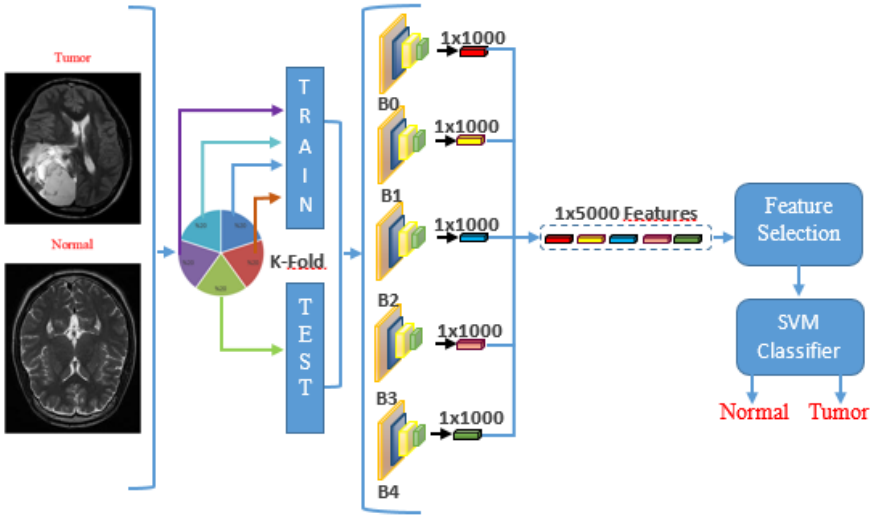


Figure 2: Illustration of proposed method

2.3. EfficientNet

The success of deep learning models, which have been trained using the ImageNet data set in the field of image classification since 2012, is increasing every year. However, most of these models created are not efficient in terms of computational costs. The EfficientNet group, which contains 8 models ranging from B0 to B7, is a technique that aims to achieve high success with low computational cost by using fewer parameters. The accuracy of 84.4% was achieved by using 66 M parameters with the B7 model on the ImageNet data set. Rectifier Linear Unit (ReLU), which is commonly used in CNN models, is replaced with a novel activation function called Swish in EfficientNet. (Tan & Le, 2019).

The EfficientNet model evenly scales depth, width, and resolution to achieve more efficient results. This method is called compound scaling. Finding an appropriate scaling factor of the width, depth, and resolution dimensions is the first stage in the compound scaling approach. To demonstrate the link between the base network and scaling sizes, the grid

search approach is used. The basic network is scaled to the desired target network with the help of the calculated coefficients (Tan & Le, 2019).

MBConv, the inverted bottleneck first introduced in MobilNETV2, has been used as the main component for EfficientNet (Sandler, Howard, Zhu, Zhmoginov, & Chen, 2018). Blocks in MBConv are made up of a layer that expands first and then compresses the channels. With this architecture, the computation is reduced by the square of the core size, which indicates the width and height of the 2D convolution window compared to traditional layers. In Figure 3, the EfficientNet B0 model is displayed.

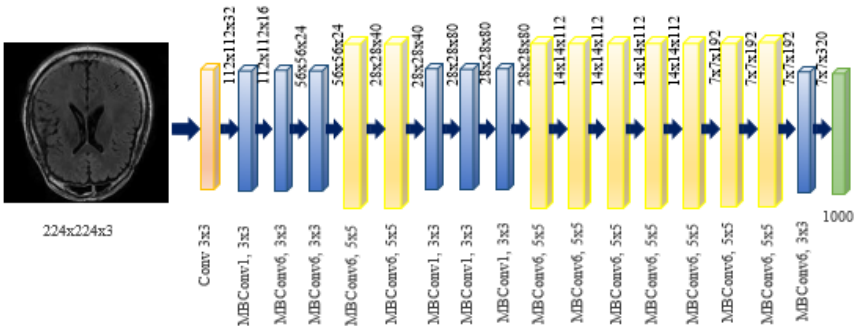


Figure 3: Schematic representation of EfficientNet

2.4. Feature selection

Feature selection techniques are widely used in the data preprocessing step to improve the success of the classification by choosing better features from the features extracted from the models (Kira & Rendell, 1992). In this study, feature selection is performed using the ANOVA F-value technique. The goal of the ANOVA F-value technique is to select the features with high variance and to use them in the analysis (scikit-learn, 2020).

2.5. Support vector machine classifier

The SVM technique developed by Vapnik in 1995 is a supervised learning method and is generally utilized for classification (Cortes & Vapnik, 1995). The main purpose of this method is to optimally separate samples from two different classes. SVM utilizes a hyperplane for the classification process. This hyperplane separates the two different classes from each other and aims to have the width of the two parallel lines at the maximum distance in the non-sample part. The data points closest to the hyperplane are support vectors.

The hyperplane having the greatest distance between the two classes is the optimum hyperplane for an SVM. (Burges, 1998). Since SVM cannot draw a linear hyper-plane in a nonlinear data set, kernel tricks called kernel numbers are used. The two most common types of kernels are polynomial and Gaussian radial basis function (RBF) kernels.

3. EXPERIMENTAL RESULTS

The performance of the suggested method was analyzed utilizing the 5-fold cross-validation approach. 80% of the MRI images were used for training and 20% for testing. 20% of the dataset was selected into five groups for the test, and the experiments were repeated for each test group as shown in Figure 4. While composing each fold, an equal number of Tumor and Normal images, 300 from each, were selected as test data. Thereby, 600 distinct images for each fold were used to examine how well the suggested method performed.

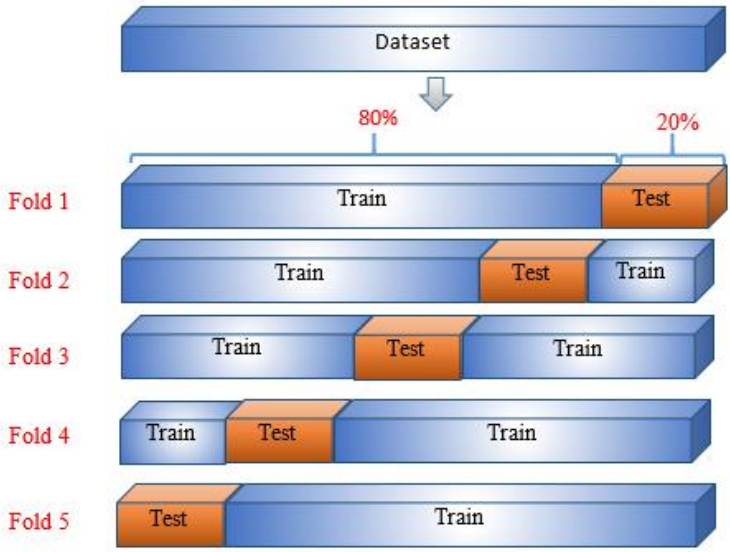


Figure 4: Schematic representation of 5-fold cross-validation technique for training and test

The experiments for this study were performed in two phases. In the first phase, feature extraction was performed with the help of 5 models in the range of EfficientNet B0-B4, and the SVM model was trained by all 5000 features by combining all features. At this stage, the accuracy rate was achieved as 98.87%.

In the second stage, the most effective features, which were selected in different numbers between 500 and 4500 by the ANOVA F-Value technique among 5000 features, were used in the training of the SVM model. Thus, it is aimed to achieve maximum accuracy with the smallest possible features by selecting the most effective features. The most successful result was obtained by using 2500 features as 98.93%. Average Sensitivity, Specificity, and Precision values for the same features were obtained as 98.93%, 98.93%, and 98.94%, respectively. Table 1 displays the results of all the experiments carried out in the study.

Table 1: Classification results of the experiments performed using different Feature Counts

# Feature Count	Average Sensitivity	Average Specificity	Average Precision	Average Accuracy
5000	98.87	98.87	98.87	98.87
500	97.53	97.53	97.55	97.53
1000	98.30	98.30	98.30	98.30
1500	98.60	98.60	98.60	98.60
2000	98.83	98.83	98.83	98.83
2500	**98.93**	**98.93**	**98.94**	**98.93**
3000	98.80	98.80	98.80	98.80
3500	98.80	98.80	98.80	98.80
4000	98.90	98.90	98.90	98.90
4500	98.77	98.77	98.77	98.77

The classification performance of each fold was examined separately in the cross-fold tests performed with 2500 features that gave the most successful results. Confusion matrices (CM) of overlapped and each fold are shown in Figure 5. Overlapped CM was created by collecting CMs obtained from all folds. Accordingly, the proposed method correctly detected 1484 of 1500 tumor images and 1484 of 1500 normal images using 2500 features.

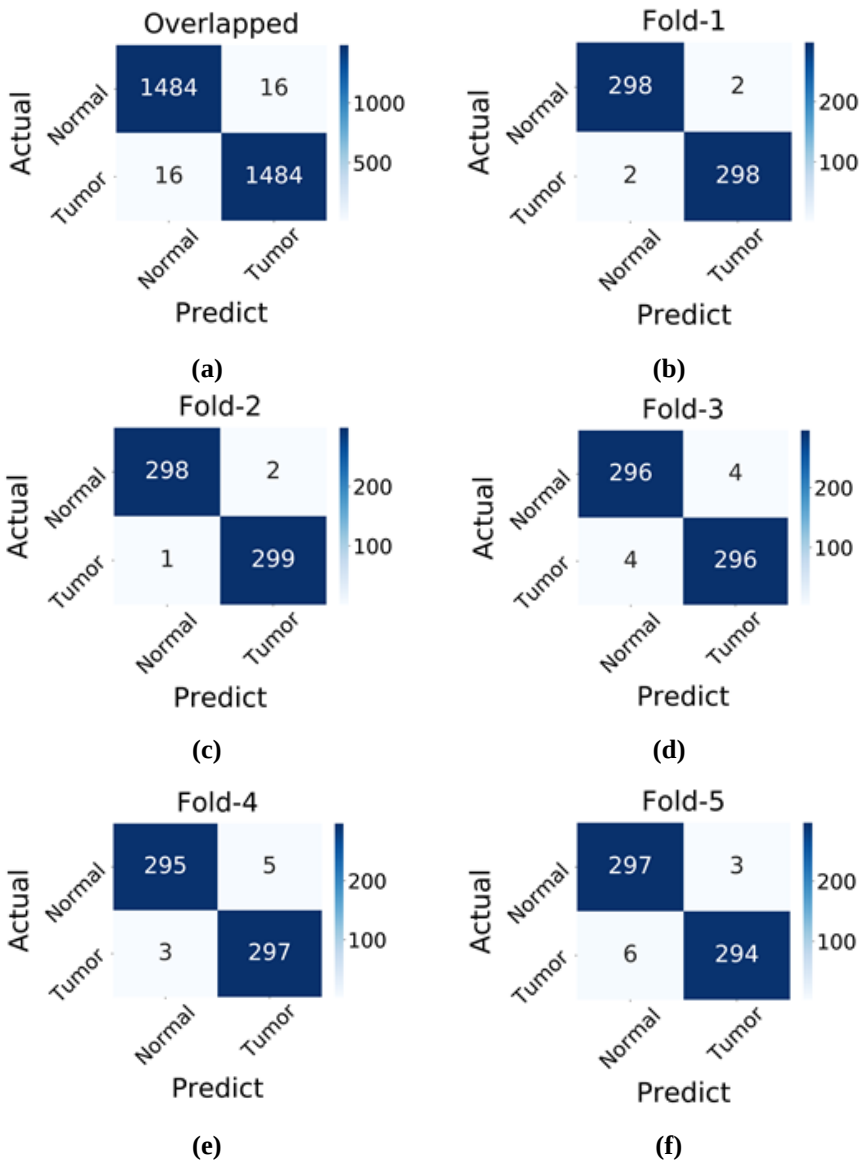


Figure 5: Confusion matrix results (a) Overlapped, (b) Fold-1, (c) Fold-2, (d) Fold-3, (e) Fold-4, and (f) Fold-5.

Table 2 contains the Precision, Specificity, Sensitivity, and Accuracy values obtained separately for all folds with 2500 features. It is seen that Fold2 had the best outcomes, with a value of 99.50% for all evaluation metrics. It can be observed that Fold5 received the lowest accuracy score of 98.50%. According to the results in Table 2, it can be noticed that the

suggested method can define the images as normal or abnormal with an accuracy of 98.93%, and the Precision, Specificity, and Sensitivity values are 98.94%, 98.93%, and 98.93%, respectively.

Table 2: Precision, specificity, sensitivity, and accuracy values of the proposed method for each fold (with 2500 features).

Folds	Performance Metrics (%)			
	Precision	**Specificity**	**Sensitivity**	**Accuracy**
Fold-1	99.33	99.33	99.33	99.33
Fold-2	99.50	99.50	99.50	99.50
Fold-3	98.67	98.67	98.67	98.67
Fold-4	98.67	98.67	98.67	98.67
Fold-5	98.50	98.50	98.50	98.50
Average	98.94	98.93	98.93	98.93

Figure 6 displays the effect of the proposed method on classification performance. The Area Under Curve (AUC) value for the proposed method was calculated as 0.99.

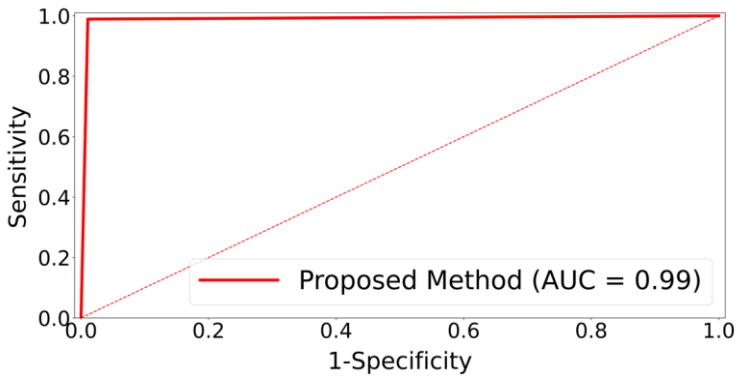


Figure 6: The ROC curve of the proposed method (with 2500 Features)

4. DISCUSSION

Early and precise detection of brain tumors, the frequency of which is rising daily is one of the most crucial elements in reducing the risk of death. Important steps have been taken to support doctors with information technologies, especially with the development of MRI techniques. Today, systems based on artificial intelligence can provide important assistance to doctors in diagnosis and decision-making processes. Table 3 contains examples of artificial intelligence and deep learning-based binary

classification studies developed for the automatic and precise diagnosis of brain tumors by MRI.

As can be understood from the data in Table 3, the proposed approach has demonstrated very superior performance. The number of images used in experiments is also higher than in many studies. In addition, unlike most of the other studies, the tests were carried out with the cross-validation technique and the reliability of the results was increased. Nazir et al. used their feed-forward ANN-based approach to classify 70 images of 25 normal and 45 tumors. With the approach that they used color moments for feature extraction, they achieved a classification accuracy of 91.8% (Nazir et al., 2015). Fayaz et al. converted gray-level images to RGB format and calculated statistical values (mean, variance and skewness) for each color channel. Utilizing these features that were extracted from 100 images, they achieved an accuracy of 92.5% as a result of the binary classification (Fayaz, Shah, Wahid, & Shah, 2016). Tajik et al. made feature extraction with GLCM and discrete wavelet transform (DWT) by utilizing the genetic algorithm and then performed the classification process with the k-nearest neighbors (KNN) and SVM techniques. In their studies where 60 images were used, they achieved a binary classification accuracy of 96.67% (Tajik, Rehman, Khan, & Khan, 2016). Varuna Shree and Kumar also achieved a 95% accuracy rate on a dataset consisting of 650 images with the approach they developed for binary classification using GLCM and DWT (Varuna Shree & Kumar, 2018).

More recently, it is seen that deep learning-based approaches have been used. Ari and Hanbay classified samples from 16 patients with 97.18% accuracy in their studies based on deep learning in which they used ELM and LRF techniques (Ari & Hanbay, 2018). In 2020, Toğaçar et al. achieved a 96.05% binary classification accuracy on the brain MRI dataset consisting of 253 images with the BrainMRNet technique they developed based on the CNN architecture (Toğaçar, Ergen, et al., 2020). In 2020, Toğaçar et al., using the Hypercolumn technique together with AlexNet and VGG-16 CNN architectures, classified the same brain MRI dataset with 96.77% accuracy (Toğaçar, Cömert, et al., 2020). In 2021, Singh et al. achieved a 90% binary classification accuracy on 50 augmented images in their study using the VGG-16 CNN architecture (Singh et al., 2021). In 2021, Kang et al. (Kang et al., 2021) achieved a binary classification accuracy of 98.83% on the BTD2020 dataset consisting of 3000 images (Hamada, 2020), including 2400 learning and 600 tests, using pre-trained deep CNNs and ML classifiers.

The proposed method using the EfficientNET group deep learning models classified the BTD2020 dataset (Hamada, 2020) with an average accuracy of 98.93%. The result obtained with the proposed method was noted as the highest accuracy rate obtained by using cross-validation among the dual brain tumor MRI classification methods that have been published. In addition, the experiments were carried out on one of the largest datasets in the literature. Both of these features show that the performance of the suggested method is highly valuable.

Table 3: Comparisons of the brain tumor MRI binary classification methods.

Year / Study	Techniques	Number of Images	Validation Tech.	Accuracy %
Nazir et al., 2015	Color Features with FF ANN	75	%80 Test %20 Train	91.80
Fayaz et al., 2016	Color Features with KNN	100	%70 Test %30 Train	92.50
Tajik et. al., 2016	Genetic Algorithm with KNN and SVM	60	10 Fold Cross val.	96.67
Varuna and Kumar, 2018	PNN and DWT	650	-	95.00
Ari & Hanbay, 2018	ELM and LRF	-	-	97.18
Toğaçar, Ergen, et al., 2020	BrainMRNet	253	%70 Test %30 Train	96.05
Toğaçar, Cömert, et al., 2020	AlexNet,VGG-16, and Hypercolumn	253	%70 Test %30 Train	96.77
Singh et al., 2021	VGG-16	50	-	90.00
Kang et al., 2021	DenseNet-121, ResNeXt-101, MnasNet, and Fully Connected layer (FC) classifier	3000	%80 Test %20 Train	98.83
2021 (Proposed)	EfficientNet B0-B4, ANOVA F-Value, and SVM	3000	5 Fold Cross Validation	98.93

CONCLUSION

This paper proposes a new method that may be used to classify brain MRI data into binary categories using deep learning techniques. The proposed method model consists of 3 main stages. Pre-trained EfficientNet B0-B4 models were utilized for feature extraction in the first stage. In the second stage, the most effective ones of features extracted by ANOVA F-Value were tried to be determined. In the last stage, the obtained features were used for the training of SVM. As a result, while there were fewer features, the classification accuracy was increased. With the proposed method, 98.93% accuracy, 98.94% Precision, 98.93% Specificity, and 98.93% Sensitivity values were obtained by using 2500 features. Consequently, a new model with high accuracy and precision that can be utilized for the evaluation of brain tumor MRI images has been proposed. The suggested method is available at https://github.com/mrtucar/EfficientNET_BrainMRI_Classification) will be able to help doctors' evaluations and decisions, and also reduce the rate of misdiagnosis.

In the proposed method, only the brain MRI image is utilized as input, and thanks to the nature of deep learning, it can be determined that the image is normal or tumorous without user intervention or any other additional information. Thereby, all processes such as feature extraction for classification and which of these features will be used are performed automatically. The findings also showed that the use of DL models with techniques such as ANOVA F-Value and SVM can increase the success of the classification. It has also been observed that fewer features can increase the success of brain MRI classification. In future studies, it is aimed to determine different tumor types by multi-classification with larger datasets. In addition, with the proposed method, binary and multi-classification studies on different medical images are also planned.

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CHAPTER 3

ON MODEL COMPLEXITY AND REPRESENTATION POWER OF ARTIFICIAL NEURAL NETWORKS

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INTRODUCTION

With the advent and improvement of digital computers, many aspects of engineering have changed. One of the most affected areas of engineering from enormous advancement of computational power is artificial intelligence (AI). Artificial neural networks (ANN) lie at the heart of modern AI and solve more and more problems of human life every day. In the third decade of twenty-first century, deep neural networks (DNN) (Goodfellow et.al., 2016) – a special type of ANN – seem to dominate many areas of scientific research and begin to solve many scientific and engineering problems. Automatic speech recognition (ASR) (Yu and Deng, 2016), (Wang et.al., 2019), (Malik et.al., 2021), (Ali et.al., 2022); object recognition (OR) (Liu et.al., 2020), (Zhao et.al., 2019), (Guo et.al., 2016), (Voulodimos et.al., 2018); human behavior understanding (HBU) (Karthickkumar and Kumar, 2020), (Pham et.al., 2022), (Wang et.al., 2020), (Herath et.al., 2017) and natural language understanding (NLU) (Otter et.al., 2020), (Sharma and Kaushik, 2017), (Lauriola et.al., 2022), (Liu et.al., 2017) are some problem domains that DNN based solutions have already taken the lead by far.

ANN are computational algorithms, structures of which are inspired from biological neural networks (Bishop, 1995). A typical example of ANN is given in Figure 1 below.

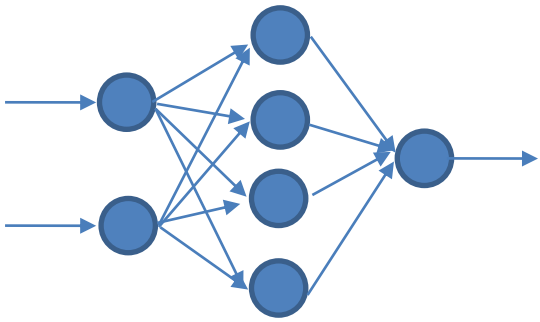

Figure 1: A typical example of ANN

1. NEURAL NETWORKS AS CLASSIFIERS

One broad type of problems that ANN are used and very successful are classification problems (Hart et.al., 2000). In classification, each data point is assigned to one of several classes. Classification is a supervised-learning problem where the network is trained using a subset of dataset called

training set and tested on another subset namely test set. Each data point has a corresponding class label. In training phase each sample from the training set is shown to the network with its corresponding label. The weights of the network are adopted optimally using an optimization algorithm so that the output of the network matches with the true label of the sample as closely as possible. After training phase, the network is tested using each and every sample in the test set by comparing the network output to the true label of the sample.

Mathematically, the input-output relation of ANN can be described with the following formula in equation (1):

$$y_k = \hat{g} \tag{1}$$

Here, k is the output index of the network. For m different classes, there are m number of outputs. For two classes, one output node is enough. For two classes, the data is assigned to class 1 when output is greater than or equal to zero and to class 2 when the output is less than zero. For more than two classes, the data is assigned to the class where the output is maximum. g and ĝ are activation functions which can be selected among several options. h is the number of hidden layer neurons, n is the dimension of input vector. w's are first and second layer adaptive weights.

In this study sigmoid activation function is used for the hidden layer and linear activation function is used for the output layer, formulas of which are given in equation (2) and equation (3), respectively.

$$g(a) = \frac{1}{1-e^{-a}} \tag{2}$$

$$\hat{g}(a) = a \tag{3}$$

The formula in equation (1) is called feedforward operation of the network. It calculates the output of the network given the input and weights. It is mainly used in test phase of the classification problem where each input is assigned to a class. In training phase one of several different learning algorithms can be chosen. Stochastic Gradient Descent (SGD) algorithm is chosen in this study because of its ease of implementation and high success rate in various applications.

Note that in classification problems what ANN or any classifier does is just drawing borders on the input space. Each part of the input space is

assigned to a specific class and between class regions are the class boundaries determined by the parameters of the classifier. One important property of any classifier is the representation power the classifier provides for the solution of the problem. This is also known as model complexity of the classifier and is critical for the success of the solution to the problem.

2. MODEL COMPLEXITY AND REPRESENTATION POWER

In this study the relationship between model complexity and representation power is investigated. Model complexity is controlled with the number of neurons of the network. Representation power is given in terms of border complexity. Simplest border is linear border and can be represented by a single layer network. As the complexity of the border increases, the complexity of the model represented by the number of the neurons in the network must increase in order to give hundred percent performance. This is shown in this study.

In order to represent the data and borders adequately, data centers consisting of single points are used as shown in Figure 2 below. Two classes are represented with blue and red colors, respectively. Squares are data centers of corresponding class. Note that for two data centers the border is linear. For three data centers that are not aligned on a straight line a linear border can still be found. The simplest configuration that can not be separated with a single linear line consists of three data centers aligned on a straight line as shown in Figure 2.

Classes that can be separated by linear lines can be classified with single layer networks with hundred percent success. For configurations that cannot be separated by simple linear lines, neural networks of at least two adaptive weight layers are needed. This is the case for the configuration shown in Figure 2. There is no single layer network that can separated the configuration in Figure 2 with hundred percent success.

In this study, Python programming language is used for both computation and data visualization. Keras library is used for classifier design and implementation. Dense layers are used for neural network layers. Matplotlib library is used for plotting the results. Only number of neurons determines the complexity of borders and so the representation power. Experiments are conducted using two hidden layers with three adaptive weight layers, but it is seen that representation power does not change with the number of layers.

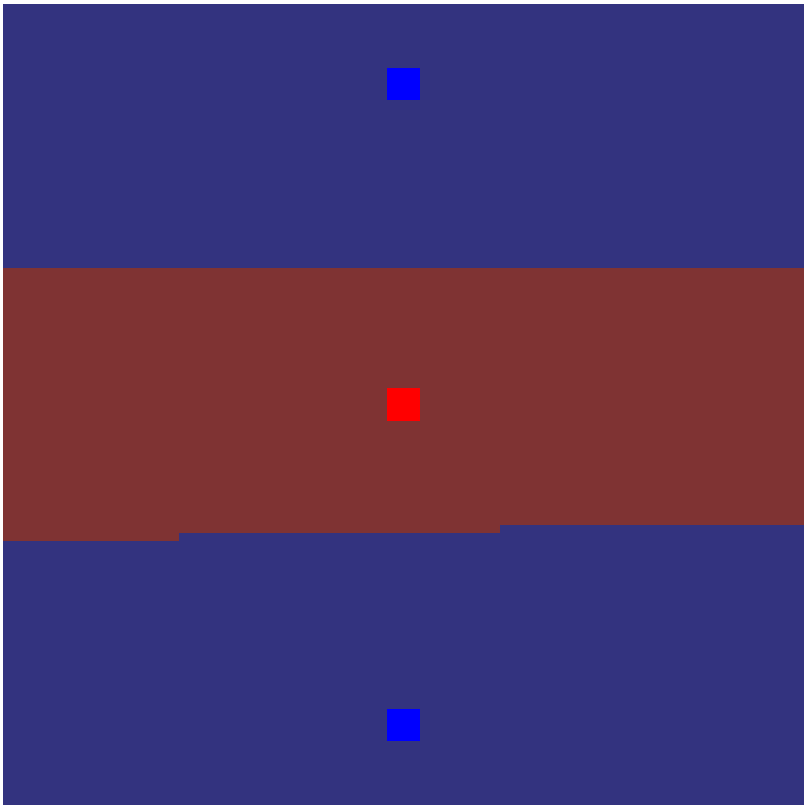

Figure 2: Data centers and class regions

In Figure 2, there are three data centers shown by colored squares. Two are blue corresponding to class 1 and one is red corresponding to class 2. Class 2 data center is in the middle of class 1 data centers and three data centers are aligned on a straight line. In this configuration, a single straight-line border cannot be found that separates two classes into two regions. In other words, a single layer neural network cannot classify this configuration correctly. A neural network with two layers of adaptive weights can divide space into regions separated with non-linear borders.

The simplest non-linear boundary configuration is with three data centers as shown in Figure 2 above. It is seen that in this configuration the minimum number of neurons needed to separate the space adequately is four. The parameters of the simulation are as follows:

Number of data points = 3, number of hidden layers = 1, number of hidden units = 4, number of initializations of weights = 1000, number of epochs for training = 1000.

For 3 hidden units, the network cannot divide the space into adequate regions, and at least 4 hidden units are needed to achieve hundred percent success rate. In the following experiments, number of data points is increased, and the number of hidden layer neurons needed to divide space adequately is investigated.

When the number of data centers is increased to four, it is seen that four hidden neurons are still enough to adequately divide the space with hundred percent success.

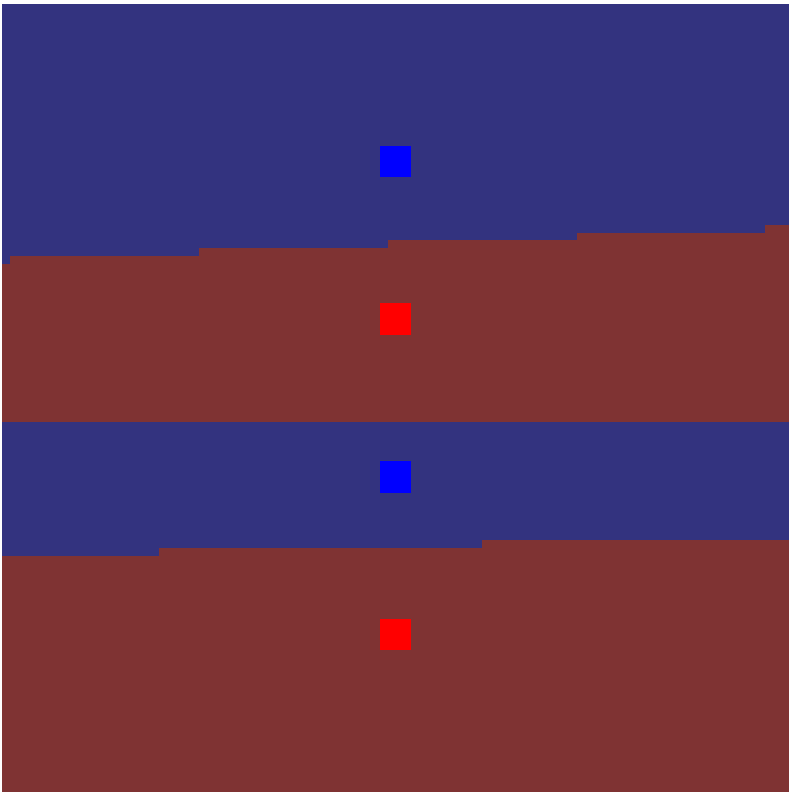

Figure 3: Number of data centers = 4, number of hidden units = 4

So, three hidden neurons cannot divide configuration of three data centers, but four hidden neurons can divide configuration of both three data centers and four data centers.

Experiments are continued to be conducted by increasing configuration complexity. Number of data centers is increased to five and it is seen that the network with four hidden neurons can still deal with this complexity as shown in Figure 4 below.

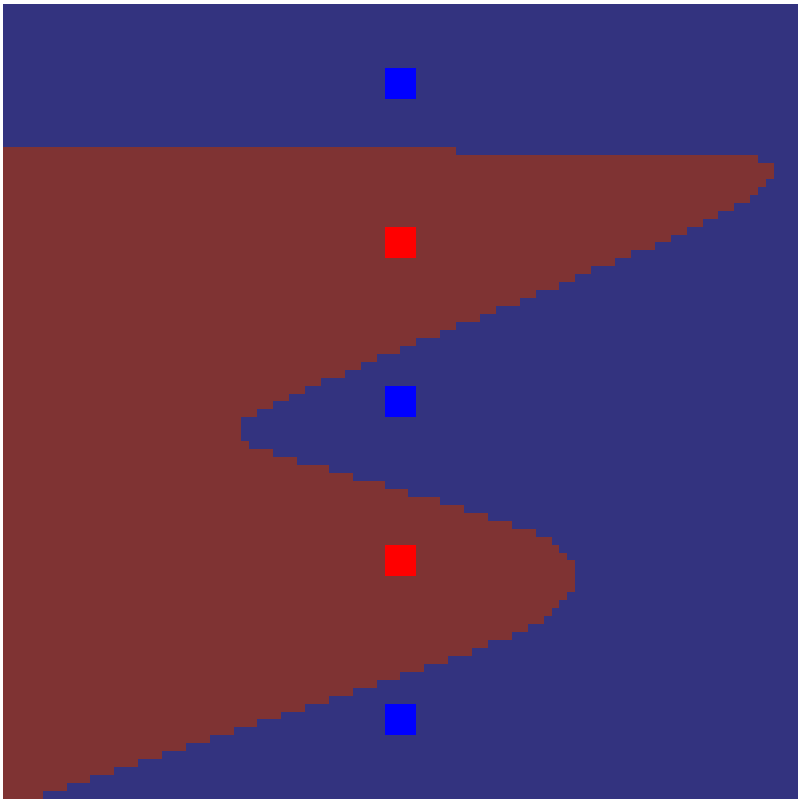

Figure 4: Number of data centers = 5, number of hidden units = 4

When the number of data centers is increased to six, it is seen that four hidden neurons cannot deal with this level of complexity. Number of neurons is increased to five and experiments are conducted with 1000 number of initializations for 1000 epochs each. For six data centers, five hidden neurons were unable to divide the space adequately to two classes with hundred percent success. So, the model complexity is increased again to six hidden neurons and this time the network was successful to divide the space to two classes perfectly as shown in Figure 5 below.

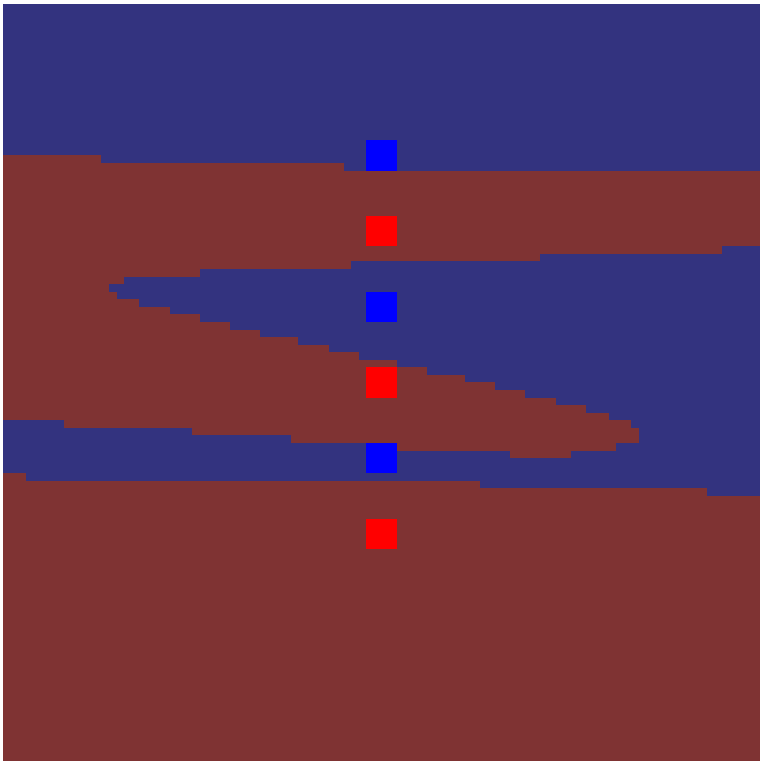

Figure 5: Number of data centers = 6, number of hidden units = 6

The structure of the network for six hidden units that can classify six different data centers correctly is shown in Figure 6 below.

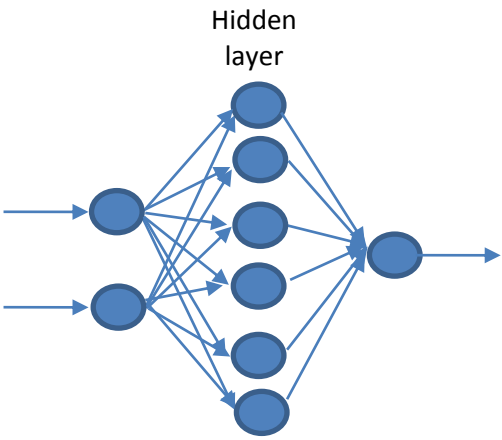

Figure 6: Two inputs, six hidden neurons, one output network

When the number of data centers is increased to seven, the problem gets even harder. The configuration of data centers distributed on the input space is shown in Figure 7.

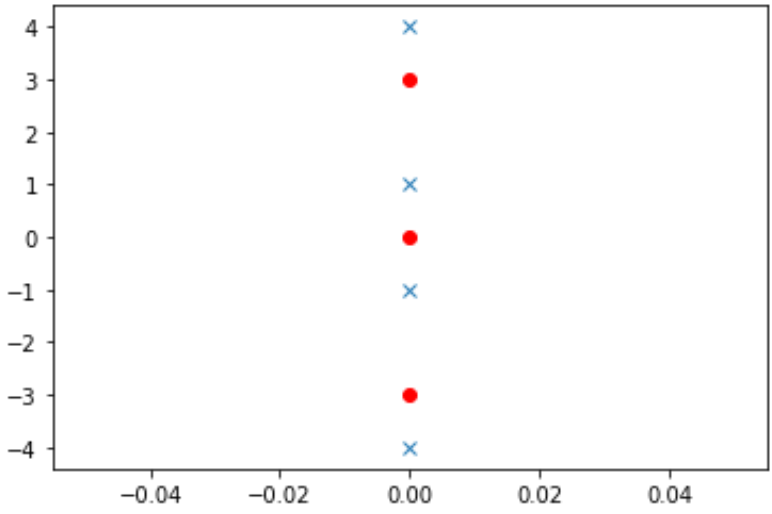

Figure 7: Number of data centers = 7. The problem is even harder.

For seven datacenters, the minimum number of hidden neurons required to classify the configuration correctly increases instantly to ten as shown in Figure 8. Note that for seven datacenters, no solution is found with seven, eight and nine hidden neurons. With ten hidden neurons, the solution seems to be satisfying with hundred percent success.

Note that increasing number of layers does not change the representation power of the network. For example, a network with five neurons in the first hidden layer and four in the second still cannot classify the dataset in Figure 6 since total number of neurons is still nine. All combinations of first and second hidden layer neuron numbers adding to nine are tried and no solution is found. So, this shows that the representation power is only related to the number of neurons but not number of layers.

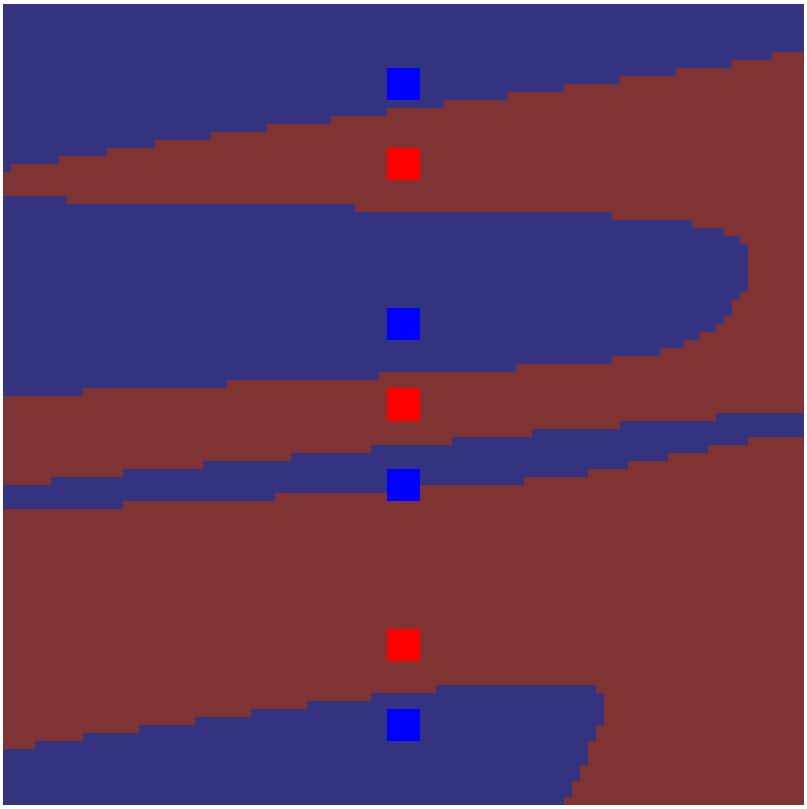

Figure 8: Number of data centers = 7, number of hidden units = 10.

CONCLUSION

As a concluding remark it can be said that complexity of dataset grows faster than the number of data centers and the required number of neurons to correctly classify the configuration increases faster. Also, representation power of the network depends on the number of neurons but not on the number of layers.

APPENDIX: Important Parts of Code for Experiments

In this section the some parts of Python code implemented to run the experiments are given. Note that by changing some parameters, like adding new data centers or adding more hidden neurons, different experiments can be conducted.

Python programming language is used to generate the synthetic data, perform the experiments and visualize the results.

In order to construct the network, generate synthetic data and visualize the results several built-in functions are imported and used as shown in code snippet below.

```
#keras packages

import keras

from keras.models import Sequential

from keras.layers import Dense

from tensorflow.keras import initializers

import tensorflow as tf

import numpy as np

import math

import matplotlib.pyplot as plt

import random

import matplotlib

import cv2

import imutils
```

Synthetic data is generated using numpy arrays as shown below.

```
x1 = [0, 4]

x2 = [0, 1]

x3 = [0, -1]

x4 = [0, -4]

x5 = [0, 3]

x6 = [0, 0]

x7 = [0, -3]

syntheticData1 = np.zeros((2, 4)) syntheticData2 = np.zeros((2, 3))

syntheticData1[:,0] = x1

syntheticData1[:,1] = x2

syntheticData1[:,2] = x3

syntheticData1[:,3] = x4

syntheticData2[:,0] = x5
```

```
syntheticData2[:,1] = x6

syntheticData2[:,2] = x7

training_inputs = np.concatenate((syntheticData1.T, syntheticData2.T), axis=0)

labels = np.concatenate((np.ones(4), -1*np.ones(3)), axis=0)
```

The neural network is constructed from built-in libraries as shown below.

```
#initializing neural network model

classifier_e25 = Sequential()

classifier_e25.add(Dense(firstHiddenLayerUnits, input_dim = training_inputs.shape[1], kernel_initializer=initializers.RandomNormal(stddev=1e0), bias_initializer=initializers.Zeros(), activation='sigmoid'))

if secondHiddenLayerUnits > 0:

    classifier_e25.add(Dense(secondHiddenLayerUnits, kernel_initializer=initializers.RandomNormal(stddev=1e0), bias_initializer=initializers.Zeros(), activation='sigmoid'))

#add output layer

classifier_e25.add(Dense(1, kernel_initializer=initializers.RandomNormal(stddev=1e0), bias_initializer=initializers.Zeros(), activation='linear'))

#compile the neural network

optimizer = tf.keras.optimizers.SGD(learning_rate=1e0)
```

The experiments are conducted iteratively for several initializations (1000) with several epochs (1000) each.

```
for tempInitIndex in range(0, numberOfInitializations):

    classifier_e25.compile(optimizer=optimizer, loss='MeanAbsoluteError', metrics=['accuracy'])

    classifier_e25_fit = classifier_e25.fit(training_inputs, labels, epochs=numberOfEpochs, verbose=0)

    tempOutputs = classifier_e25.predict(training_inputs)

    allTrue = 1

    for tempInputIndex in range(0, numberOfTrainingSamples):

        tempLabel = labels[tempInputIndex]

        tempOutput = tempOutputs[tempInputIndex]
```

```
        if tempLabel*tempOutput < 0:
            allTrue = 0
            break
    if allTrue == 1:
        print("SOLUTION FOUND!")
        print(tempOutputs)
        weights = classifier_e25.get_weights()
        tempFileName = "weightsFor" + str(numberOfTrainingSamples) + "inputs" + str(firstHiddenLayerUnits) + "firstLayer" + str(secondHiddenLayerUnits) + "secondLayer.npy"
        with open(tempFileName, 'wb') as f:
            np.save(f, weights)
        break
if allTrue == 0:
    print("NO SOLUTION!")
```

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CHAPTER 4

NEW TRENDS IN DIGITAL MARKETING AND THE EFFECTIVE USE OF ARTIFICIAL INTELLIGENCE IN THE MARKETING INDUSTRY

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INTRODUCTION

Marketing is a dynamic, ever-changing industry. Shortages of raw materials and energy, inflation, economic recessions, high unemployment, dying industries and enterprises, terrorism and war, and rapid technology improvement in particular industries have transformed marketing. The internet has prompted marketing executives to make more market-driven judgments. They require accurate, up-to-date information on consumers, items, the market, and the environment (Bala & Verma, 2018).

Digital marketing is the utilization of digital technologies to build channels of communication with prospective clients. This helps organizations achieve their objectives by serving client requirements more effectively. Internet marketing, or e-marketing, is frequently considered identical to digital marketing. This is erroneous. As a medium, the Internet is merely one of many ways to contact a client. Also included are home appliances and audio/video equipment. "Digital marketing" should be viewed as including Internet marketing. Digital marketing is not only situated on the Internet but also in the devices, electronics, user software, etc. that are used to transmit data. Consequently, digital marketing integrates digital and network technologies, allowing a person to connect not just via a mobile network but also via television. The firms' extensive reach allows them to function on a variety of technological platforms (Sawicki, 2016).

The use of digital technology is becoming increasingly commonplace in the routine activities of a significant percentage of the world's population. They have a significant bearing on people's lives since the use of digital technology has had an effect on virtually every facet of human existence. Because of this, we can witness the influence that technology is having not just on the company itself but also on all aspects of day-to-day life, such as the way people use their spare time, the kinds of skills they seek to acquire, and so on. Companies have, over the course of time, started to take advantage of the benefits that the present digital era has to offer, particularly when it comes to the promotion of their brand. Their company procedures and their relationships with their clients are built on the utilization of digital technology, which enables them to quickly become acquainted with their clients and communicate with them. On the other side, customers have the opportunity to learn more about the firm and the activities they engage in, as well as compare their personal experiences and opinions on particular goods and services. We can advertise, display, and sell our goods or services, as well as connect with our (possible) clients more effectively thanks to the various

channels and sectors that are available to us through digital marketing (Blazheska et al., 2020).

Artificial intelligence (AI) has been categorized as a subfield of computer science by computer scientists for most of its history. A common understanding of what is meant by the term "artificial intelligence" is that it refers to "the capacity of computers to duplicate human intelligent behaviors and skills, such as decision-making, learning, reasoning, perception, interaction, speech recognition, and analysis." This is generally accepted as the definition of what is meant by the term "artificial intelligence." (Abi et al., 2021).

AI is being given substantial prominence in the product launches of big technical corporations such as Apple, Google, and Amazon, and these firms are also acquiring AI-based startup companies. Apple, Google, and Amazon are examples of these types of enterprises. The recent uptick in interest in artificial intelligence is provoking a broad variety of sentiments, including optimism over the ways in which the capabilities would enhance human labor and anxiety regarding the ways in which they will eliminate employment (Agrawal et al., 2017).

The subfield of computer science that we today refer to as artificial intelligence had its beginnings in the middle of the 1950s when it was initially created. Since then, it has led to the creation of a wide range of complicated tools, many of which use human intelligence to solve problems (Pham & Pham, 1999).

The use of artificial intelligence (AI) is quickly breaking new ground in the realms of commerce, corporate operations, and political policy. The intelligence of machines and robotics combined with the skills of deep learning have generated profoundly disruptive and enabling effects in several spheres of civilization, including business, government, and society at large. They are also having an effect on the bigger trends in environmental sustainability around the globe. As the revolution in AI continues to revolutionize our society, it may herald a future filled with utopia, in which humans and machines coexist, or it may foretell a world filled with dystopia, where there is war, poverty, and misery (Goralski, & Tan, 2020).

1. LITERATURE REVIEW

Vishnoi et al. (2018) wanted to document marketing process insights that may be gleaned from the artificial intelligence (AI) ecosystem and embedded technology. Stone et al. (2020) wanted to look at the research on AI in strategic situations and show where more research is needed to use AI to make decisions about marketing.

Hassan (2021) looked at the relationship between artificial intelligence and digital marketing and found the most important ways AI is used in digital marketing. He did this by focusing on systems that help with market forecasting, process automation, making decisions, and making tasks that humans usually do better.

Huang & Rust (2021) developed a three-stage framework for strategic marketing planning using AI. AI can automate repetitive marketing tasks and operations, evaluate data to draw conclusions, and comprehend human relationships and emotions. Saheb & Amini (2021) studied AI analytics' influence on digital marketing and the function of open large data and AI analytics abilities.

Thilagavathy and Kumar (2021) focused on the increasing trend of the connection between digital marketing and artificial intelligence (AI). Wisetsri (2021) did a full evaluation of AI in marketing by looking at everything published between 1982 and 2020. He did this by using bibliometric, conceptual, and intellectual network analysis.

Chintalapati & Pandey (2022) investigated the application of AI in marketing as a new direction of research for the field. Their study put marketing into five main functional themes and nineteen smaller sub-functional themes.

2. ARTIFICIAL INTELLIGENCE IN DIGITAL MARKETING

AI-enabled digital marketing is transforming how firms produce campaign content, generate leads, cut customer acquisition costs, manage customer experiences, and convert their social media consumer base. Companies use AI for digital marketing (van Esch & Stewart Black, 2021).

Customer insights are crucial fuel for digital marketing, and thanks to AI, gathering and evaluating them has gotten much easier. With the help of data collection, analysis, and interpretation, AI is employed in digital marketing so that decisions may be made automatically. AI's cutting-edge technology can facilitate the observation-based collection of consumer data and the analysis of socioeconomic trends, both of which are susceptible to change. Therefore, AI in digital marketing employs modern tools and technology to evaluate user data and aid marketers in gaining a deeper knowledge of their target consumers. This enables digital marketers to give tailored information and goods that are appropriate to certain customer groups. In this way, AI technologies are applied in digital marketing to get insight into consumer behavior through interactions with customers. After that, these technologies will give each customer customized messages based on the queries they posed and the specifics of the information they requested. AI is also utilized to reduce human engagement in tactical tasks and communications, both of which may be facilitated with the employment of modest AI technologies. AI is used in this way because it helps save both time and money (Khatri, 2021).

In this day and age of digital marketing, the relevance of the various components has been demonstrated by the role that artificial intelligence plays. With a growing number of new companies (startups) and online retailers investing in AI to improve their operations and deliver a positive experience for their consumers, AI is being used by multinational corporations like Apple and Amazon to control the usage of voice technologies in digital marketing. Consumers will be able to improve their purchase selections by utilizing the Alexa or Siri platform, which is designed to assist in changing the "buying behavior" of customers. Beginning with the year before, there was a significant shift toward entering the digital era, which makes use of information and technology in the present day. It needs to be updated with the latest AI developments because both the industry and the market change quickly (Tiautrakul & Jindakul, 2019).

Figure 1 lists the most coveted digital marketing competencies. In fact, 42 percent of the digital marketing professionals polled named data analysis as one of the top three most coveted abilities they would be hiring for in 2020–2021. This makes data analysis the skill set that has the greatest consensus among respondents. Following data analysis and in accordance with the demand for more technical skills required for successful digital marketing, nearly four out of ten (39%) respondents said that marketing automation and software knowledge are among their top three most sought-after skill sets. 37% of digital marketers are also interested in hiring workers with UX design abilities, an area where prior research has identified a major skill need. Others identify graphic design (33%) and video production and editing (32%), respectively, as potential top-three desirable abilities (Marketingcharts, 2021).

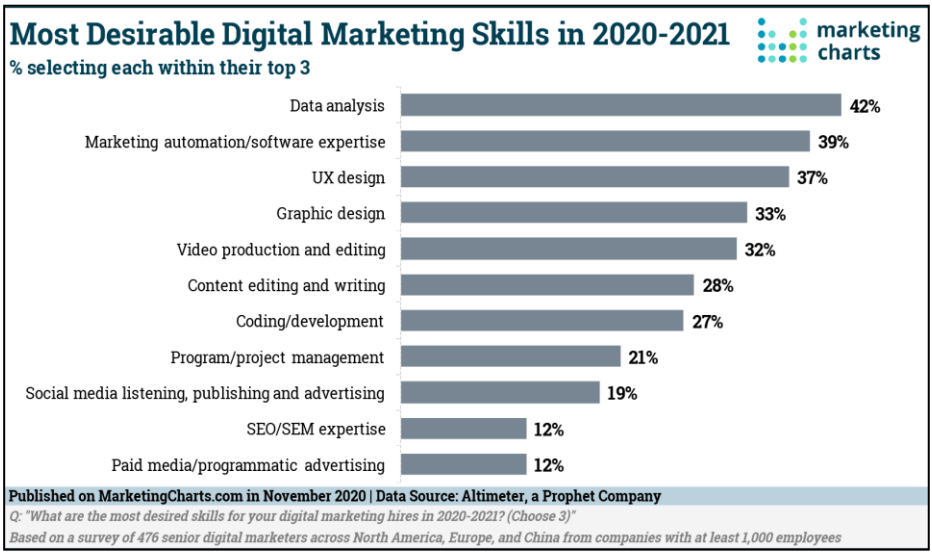

Figure 1. Most Desirable Digital Marketing Skills

Source: Marketingcharts, (2021), https://www.marketingcharts.com/business-of-marketing/staffing-115467

3. SUCCESSFUL CHARACTERISTICS OF A DIGITAL MARKETING

After gaining an awareness of what digital marketing is all about, the next step is to gain knowledge regarding the top six qualities of effective digital marketing campaigns, which are as follows (Kaur, 2017):

Reputable Online Source: Today, before entering the internet business, you need to have a quality website. It does not only help your business reach new customers in different parts of the world, but it also acts as a digital destination for your viewers, who can get to it 24 hours a day, seven days a week.

Strong presence on social media platforms: Businesses are now able to reach out to their customers and have direct conversations with them thanks to social media sites such as Facebook, Twitter, LinkedIn, and Instagram. Not only does a brand's presence on these platforms help to create trust and enhance customer service, but it also gives insights into what your consumers are doing.

SEO (search engine optimization): Nowadays, search engine optimization is an essential component of digital marketing. The popularity of a company as measured by its ranking on various search engines is directly correlated to the number of people who visit the company's website. There is a widespread notion that SEO efforts will lead to instant results. It is essential to have a solid understanding that SEO is a process that never ends and takes some time to provide results. Businesses have a responsibility to guarantee that on-page and off-page SEO activities are carried out, and this responsibility should be carried out by committed staff.

Email marketing: The inboxes of your audience members should not be inundated with emails as part of your email marketing strategy. To guarantee the highest possible profits, careful planning and execution are required. Sending customers personalized emails not only shows that a company cares about its customers, but it also makes it more likely that the customers will respond quickly. Offers and communication should be tailored to different user groups based on where in the business relationship cycle the user group in question now resides.

Engaging Content: It is expected that improved engagement rates would result from the utilization of content across several internet channels. It is critical for companies to ensure that they publish timely and relevant information across all of their channels at the appropriate intervals. Blogging

is a fantastic tool for engaging with audiences and going beyond only selling items as a means of communication.

Mobile-Friendly: Everything that an organization does digitally in the modern day should be compatible with mobile devices. The vast majority of people who use the internet do so on their mobile devices, and this fact should be reflected in all aspects of the decisions that are made about online marketing.

The experts who work in digital marketing have the task of devising tactics with the intention of capturing consumers' limited attention via the utilization of stories that are relatable to their target demographic. Consumers should be encouraged to acquire a product that is relevant and beneficial at the proper time. In today's day and age, there are a great number of advantages to using digital marketing. Because of its role in direct marketing, it has access to all online marketplaces, which allows it to grow both its audience and the market niche it serves. It brings down the costs that are involved with advertising and transactions. Paperwork, administration, communication, and distribution may all be reduced, and time can be saved via the use of digital technology in an organization. It makes it easier for customers to learn about the prices, qualities, and availability of products. With the rise of digital marketing, which keeps track of what consumers say and feel online, it is now possible to accurately measure the success of a marketing campaign (Kulova & Mihaylov, 2018).

4. DIGITAL MARKETING TRENDS

4.1. Artificial Intelligence

The use of AI in marketing has several uses, including but not limited to sales forecasting, customizing website experiences, speech recognition, content production, and chatbots. A chatbot, for instance, is frequently cited as an example of one of the most cutting-edge and potentially useful uses of AI. The use of the virtual assistant as a tool in the internet marketing of contemporary firms is becoming increasingly widespread. Companies may learn what inquiries are asked of them and how to respond to them in an acceptable manner through the use of AI. Because of this, a person interacting with the website of a company is able to have a discussion that is as close as it can get to one with a real person. The higher the amount of engagement that a bot has with its users, the more it is able to learn and the more accurate its replies become (Elhajjar et al., 2021). Due to the method by which marketing professionals increasingly interact with influencers and social media platforms, there is insufficient time to create relevant lists and tailor messages to each influencer. An influencer's amount of influence may be evaluated by evaluating their comments, past postings, how rivals treat influencers when launching product campaigns, and how AI can classify influencers as having more feedback, outcomes, and impact. One of the AI approaches, machine learning, assists another AI technique in gathering adequate data associated with user behavior and establishing a database based on the interests of consumers; the strategy also yields correct findings. Many times, advertisers will create advertisements that have nothing to do with their particular line of work. In addition, because AI collects, analyzes, and forecasts user data and behavior, marketers may now customize advertisements according to the preferences of their customers. Depending on their choices, consumers will receive advertisements that are more likely to pique their interest. Mastery of a marketing career involves a substantial expenditure of both time and effort. In this business, the scheduling of meetings, the writing of press releases, the analysis of data, and the monitoring of crucial client statistics all consume a considerable amount of time. It is unavoidable for people to make mistakes when confronted with a problem of this size. Recent technological advances suggest that AI could be used to help with these repetitive tasks by making it easier for machine learning algorithms to gather and multiply data (Saini, 2022).

4.2. Wearable Technology

Because of advancements in technology, such as better voice recognition, marketers will also be able to concentrate on producing content that is more helpful to consumers. Because voice search is gaining popularity, marketers will need to alter their marketing tactics to suit speech-based searches as the trend continues to spread. The use of technology is listed as the third most difficult obstacle. However, in order to become a digital marketing manager, you will also need to include technology in your skill set. To put the cherry on top of everything, you need to locate someone who is capable and understands the situation. Many people do not yet have access to wearable technology; thus, even if there is a lot of new wearable technology being developed (such as the Apple Watch or Google Glass), it will not attain its full capacity for some more years. The Internet of Things will rely heavily on the incorporation of technologies such as these. In addition to targeting users based on the activities they do on the Internet, marketers will be able to profit from user attitudes, behaviors, habits, and trends. This is in addition to targeting users based on the actions they take on the Internet. However, in order to keep up with its quick development and remain in touch with the shifting requirements of consumers, marketers will need to keep pace with it (Nedumaran, 2016).

4.3. Augmented Reality (AR) and Virtual Reality (VR)

AR and VR enable digital marketing platforms to create more engaging experiences. Several AR and VR apps present information on digital marketing websites, but they lack models for casual marketing because such apps are not finished and the models consider less structured marketing experience. AR and VR have various uses in gaming. Electronic games, broadcasting, and immersive cinema are examples. Manufacturing, cosmetics, healthcare, planning-to-business, and transformative marketing have all received attention (Ekmeil et al., 2021).

4.4. Chatbots

The capabilities of digital technology have now surpassed those that were earlier thought to be fundamental to the human condition. It is important to point out that while they are bringing us on an exciting journey into the unknown, they display a broad variety of talents, such as image identification, decision-making, communication, changing the context of a statement to a specific setting, and so on. The usage of chatbots, which the research identifies as a marker of digital transformation, is gaining popularity in the

marketing operations of organizations and brands, the findings of the survey indicate. Even though the first chatbot was developed in 1950, businesses have only recently started using them to interact with current and potential customers (Kaczorowska-Spychalska, 2019; State of Chatbots Report, 2018).

4.5. Big Data

The increase in the quantity and variety of high-frequency digital data is what's meant to be referred to when using the phrase "big data." Large volumes of data may be collected from a variety of sources within an organization, including but not limited to: postings and comments on social networks; digital photographs and videos; electronic catalogs; reports on cash and consumer transactions; GPS signals from mobile phones; and so on. The "big data" revolutionizes how people work and live, affecting everything from business dealings to grocery shopping and going to the movies. Each piece of information is broken down and examined so that we may better understand how consumers think and how they make purchasing decisions. In order to make the most of this chance, one must let go of outdated, antiquated notions and those that lack of imagination. We are lucky to live in a time when technological advances have made it easy to predict future consumer trends and study in more depth how people make decisions about what to buy (Dimitrieska et al., 2018).

4.6. Machine Learning (ML)

The term “AI” refers to a set of methodologies that, when applied to computers, enable the latter to carry out cognitive tasks that traditionally have required humans. Among these are learning, deductive thinking, and interaction with the machine's immediate environment. AI makes it possible to create a more personalized brand experience, which makes it easier to keep customers interested and loyal. Language-based AI is used by marketers as sales tools, payment processors, and engagement managers to enhance the customer experience (Haleem et al., 2022).

CONCLUSION

In an environment that is always becoming more complex, marketers need to stay up-to-date with the latest developments in digital marketing in order to meet the expectations of their target clients. It is important to improve one's marketing skills so that one can make the necessary plans, such as going after digital markets with unique, creative, and forward-thinking ideas.

It will be to the benefit of businesses to manage their brands and goods using digital technology, which will lead to the success of such enterprises. There has been a significant increase in the digitalization of documents as the coronavirus (Covid-19) pandemic process has advanced. Organizations must prioritize AI, machine learning and deep learning. Because digitalization has made a variety of resources and communication channels available to businesses, many companies have been able to effectively apply digital processes and communicate with their customers in novel and more effective ways. AI technologies will bring about significant breakthroughs in digital marketplaces, which means that businesses that invest in these technologies will enjoy high-profit margins as a direct result of their investments. As a result of the deployment of AI, a number of companies are increasing their market shares, which is a positive outcome for everybody involved. A greater number of people incorporating intelligent products into their day-to-day routines will lead to an increase in the level of competition between various companies. This is due to the fact that intelligent products assisted by AI make the lives of consumers significantly simpler and more convenient all around. With the start of the digital age, competition has become more intense, which could be bad for marketers, especially if technologies that use AI and robotics are used.

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CHAPTER 5

INVESTIGATION OF THE EFFECT OF TOTAL QUALITY MANAGEMENT APPLICATIONS ON EMPLOYEE MOTIVATION BY FURIOUS DEMATEL METHOD: AN EXAMPLE APPLICATION

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INTRODUCTION

Quality, one of the issues many businesses do not want to compromise, has turned from being a marketing tool to one of the purposes of companies today. It is an essential investment for companies to transform quality into a management approach rather than a widespread, well-known, and ordinary understanding of quality. In other words, the feeling of quality as a duty consciousness of every employee, from the smallest to the largest, ensures integrity and satisfaction by exceeding customer satisfaction.

Today, with the increasing rate of change, the expectation of continuous change of the society, the increase in the quality of life, the rapid changes in technology, the ever-increasing competition in the world, and the globalization, the quality understanding of the companies is also changing and developing. The understanding of quality, which started with mastery, master-apprentice relationship, has now reached the understanding of Total Quality Management. The aim of Total Quality Management is to fulfill customer requests and to aim for continuous improvement of all processes by keeping employees motivated every day.

In this study, in consultation with the quality chief and quality engineers in an aluminum factory operating in Sakarya, a few of the Total Quality Management principles were selected, and research was conducted on the effect of these principles on employee motivation. First, this effect was examined in theory with the Fuzzy DEMATEL method, and it was decided which criterion would be prioritized for motivation. In the second part of the study, a questionnaire consisting of 20 questions was applied to 107 blue-collar employees of the selected enterprise, and the practical equivalent of the criteria determined in theory was examined.

1. TOTAL QUALITY MANAGEMENT

Total Quality Management, briefly TQM, is a management philosophy that considers every activity a process. It is to fulfill the customer requests under the desired conditions, at the desired time, at once, and every time. In other words, it is the mobilization of the entire organization to do its best to make quality continuous and efficient.

TQM is a management system. The basis of this management system is that every activity in the whole process serves quality. The transformation of quality, which is one of the parameters in the superiority or failure of a product or service, into an understanding will ensure that businesses are long-term. In this context, in the understanding of TQM, service, process, customer

and continuous improvement consist of four main characters (Uryan, 2022). TQM is concerned with the management of not only certain departments but also entire enterprises with strategic knowledge.

1.1 Historical Development of Total Quality Management

TQM was first described as a new form of management by Henry Ford in his book My Life and Work in 1926. However, this form of government, which was not well understood and in demand at that time, started to be implemented by the Japanese since the 1950s. Japanese managers have succeeded in spreading quality to all their departments and have adopted this as well as a Japanese philosophy. Japanese products, which are notorious for their poor quality by adopting the TQM method, have had a say in the world market within 5 years. Seeing the success of the Japanese administrators, the USA and European states decided to implement this management approach after the 1980s.

After 1989, a scoring system was developed with the "Malcolm Baldrige National Quality Award," which means an excellent reputation for companies. With this system, companies' understanding of quality was embodied. Companies that wanted to win the award included TQM principles in their management processes.

1.2. Basic Principles of TQM

The criteria used in this study were selected among all TQM principles, as described below.

1.2.1. Customer Focus

This principle puts the customer at the center of the firm ve the principle is based on the understanding that "the customer determines the quality." Businesses and organizations; should understand the needs of current and potential customers. It should produce solutions for these needs, make customer needs and expectations a part of the organization, and direct them. Afterward, he should monitor the customer reactions and decide how to approach his customers according to the results.

Employees in a business are customers; even everyone who works is actually a customer of each other (Rossiter, 1998). Because their satisfaction is also crucial to the company. The internal customers satisfy the consumers who buy goods or services from the business, the external customers. In summary, the satisfaction of internal and external customers is correlated.

1.2.2. Process management

The process is the whole of the operations in which businesses transform their existing resources into output in the most efficient way and turn them into value-added products. All businesses have many short or long processes, easy or arduous. A phenomenon encountered every day should also be managed. In other words, the desired results can be achieved quickly if the appropriate resources and activities are handled as a process.

In this context, first, processes must be defined and measured. Then the process should be designed in its best form. At this stage, attention should be paid to process steps, workflows, control measurements, training needs, methods, material information, and other resources. Designing and operating the process in a particular order always gives better results. It is easier to understand where there is a malfunction, time wasted and the source of the error encountered.

1.2.3. Continuous Improvement (Kaizen)

Continuous improvement is based on the philosophy that each new day is better than the previous one. It is a concept that came out of Japan, governed by philosophies. Looking at the origin of the word, Kai: Change Zen: means better in Japanese. In this principle, potential development areas of the enterprise are determined. Periodic checks are made using excellence criteria in these areas of development. The efficiency and effectiveness of all processes are continuously improved. According to the Kaizen process, all of the employees of the business should review their work and think 'how can I achieve better every day'.

Businesses that use this principle as their target develop by adding new features to themselves every day. In this way, Kaizen becomes an essential factor in increasing quality and productivity, which is the enterprise's primary purpose, in the enterprise's growth, and in gaining a place in the market.

1.2.4. Leadership

According to the leadership principle, a good leader should be knowledgeable in mentoring and guiding employees by example. The leader is the person who determines the purpose and direction of the organization and will provide the necessary environment for the employees to achieve the business goals. A person with leadership qualities; should know how to manage teamwork and respect the employees and create an environment where employees can talk freely, focus on people, suppliers, and customers

who will benefit the business in the organization, and aim to serve them. It should take a determined stance in solving the problems experienced in the business. It should be someone who represents the business and the quality of the business in all respects. Therefore, the business should adopt its mission and vision.

1.2.5. Employee Participation

Employees are the foundation of a business. Employees who use their abilities for the benefit of the enterprise can adapt to the objectives and directions of the enterprise. However, it is of great importance that the enterprise allocates its employees. An employee should be the problem owner and accept responsibility for solving problems. For the business to achieve its goals, it must be creative and innovative. They must seize opportunities to create value for the customer and be excited and proud to be part of the organization.

There is a human factor on which the understanding of total quality management is based. Practices such as providing training to employees, giving importance to teamwork, and embracing their work takes place in environments where employees freely express their ideas.

1.3. Motivation

Another element that needs to be considered in TQM is motivation. Motivation covers people's wants and needs. Employees need the motivation to do their jobs in the desired way and efficiently. Motivation involves directing, influencing, and activating businesses and employees to meet their needs (Keser, 2006). Individuals with increased motivation increase their loyalty to their work, and thus their performance increases (Önen & Kanayran, 2015). In other words, the motivation and satisfaction of employees play an essential role in the implementation of TQM.

"Motivation is what drives people and determines the directions of their actions, their thoughts, hopes, beliefs, in short, desire; their needs and fears." (Fındıkçı, 2000). According to robin Motivation is "The employee's willingness to exert a high level of effort to achieve organizational goals, depending on the satisfaction of an individual need" (Robbins, 1996). According to Lussier, it is "the internal process that directs the person to the behavior to meet his needs" (Lussier, 1996).

As can be understood from these definitions, motivation can be defined as the desire of a person to do a job if you meet his needs. In other words, if businesses are concerned about ensuring the motivation of their

employees and give importance to their needs, they can see the benefits and contributions of their employees to their companies.

1.4. Fuzzy DEMATEL Method

The DEMATEL method was developed to analyze the relationship and interaction between problems in groups that are difficult to understand (Tzeng et al., 2007). The DEMATEL method determines which criteria, considered the causes of a problem that has become complex and difficult to understand, are affected and which are influencing. Thus, it simplifies the problem and provides the opportunity to analyze it. The primary purpose of the method is to obtain meaningful data by visualizing mixed cause-effect relationships. However, deciding the degree of interaction between the criteria in the selected cause-effect relationships is challenging. The reason for this is the difficulties experienced by experts in expressing the interaction between criteria quantitatively. To facilitate these difficulties, Lin and Wu blurred the DEMATEL method (Lin & Wu, 2008).

The fuzzy DEMATEL steps are as follows: To measure the relationships between the criteria $\{C_1, C_2\ldots, C_n\}$, a pairwise comparison matrix is created by the selected expert using linguistic expressions. If it is assumed that the decision-makers consist of p experts, p decision matrices are obtained. The fuzzy direct relationship matrix is denoted as $\tilde{Z}$.

$$\tilde{x} = \frac{\tilde{z}_{ij}{}^{k}}{r^{(k)}} = \left(\frac{l_{ij}{}^{k}}{r^{(k)}}, \frac{m_{ij}{}^{k}}{r^{(k)}}, \frac{u_{ij}{}^{k}}{r^{(k)}}\right) \quad (1)$$

$$r^{k} = \max_{1<i<n}\left(\sum_{j=1}^{n} u_{ij}^{k}\right) \quad (2)$$

The normalized relationship matrix is created using equations 1 and 2. In the equations, "l" is the first of the fuzzy triangular numbers, "m" is the second of the fuzzy triangular numbers, and "u" is the third of the fuzzy triangular numbers. Using equation (2), all the "u" s are collected in a column, and a value is found for each. The largest of these values is selected, and "r" is found. Then the whole matrix is divided by "r," and a normalized direct relation matrix is obtained. Normalized direct relation matrix is denoted by

$$"\tilde{X}." \begin{bmatrix} \tilde{X}_{11} & \cdots & \tilde{X}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{X}_{n1} & \cdots & \tilde{X}_{nn} \end{bmatrix}$$

After obtaining the normalized direct relationship matrix, the total relationship matrix will be created using equation (3).

$$\tilde{T} = \sum_{i=1}^{\infty} \tilde{X}^i = \tilde{X}(I - \tilde{X})^{-1} \quad (3)$$

After the $\tilde{T}$ matrix is obtained, $\tilde{D}_i + \tilde{R}_i$ and $\tilde{D}_i - \tilde{R}_i$ values are calculated, with the sum of the column elements $\tilde{D}_i$ and the sum of the row elements $\tilde{R}_i$.

$$\breve{D}_i = \sum_{i=1}^{n} \tilde{T}_{ij} \qquad (i = 1,2, \dots , n) \quad (4a)$$

$$\breve{R}_i = \sum_{i=1}^{n} \tilde{T}_{ij} \qquad (i = 1,2, \dots , n) \quad (4b)$$

$\tilde{D}_i$ and $\tilde{R}_i$ values found are used for each criterion, and $\tilde{D}_i$+$\tilde{R}_i$ and $\tilde{D}_i$-$\tilde{R}_i$ values are found for each criterion. These values show the relationship between each criterion and other criteria.

Some criteria have positive values for the $\tilde{D} - \tilde{R}_i$ value. These criteria have a higher impact and priority over other criteria. Such criteria are called influencing criteria. Some criteria for the $\tilde{D} - \tilde{R}_i$ value also have a negative value. On the other hand, these criteria have a lower impact and priority than others and are defined as the affected criteria. $\tilde{D}$ + $\tilde{R}_i$ values indicate the level of relationship between criteria. Criteria with a high $\tilde{D}$ + $\tilde{R}_i$ value are more related to other criteria. It is understood that criteria with low $\tilde{D}$ + $\tilde{R}_i$ values are less related to other criteria.

Since the obtained $\tilde{D}$ + $\tilde{R}_i$ and $\tilde{D}$ - $\tilde{R}_i$ values still contain fuzzy triangular numbers, they contain three numbers. Clarification is performed by reducing them to a single value.

Equation (5a, 5b) is used for this. Here, the representation of the formula changes, and the abbreviation "def" above the parenthesis is an abbreviation of "defuzzifying," which means clarification. (l, m, u) represents fuzzy triangular numbers, respectively. The first fuzzy number is l; the second is m, and the third is u.

$$\breve{D}_i^{def} + \breve{R}_i^{def} = \frac{1}{4}(l + 2m + u) \quad (5a)$$

$$\breve{D}_i^{def} - \breve{R}_i^{def} = \frac{1}{4}(l + 2m + u) \quad (5b)$$

After the clarification process, the cause-effect relationship is examined by drawing a diagram on the graph.

After the clarification process, the last step of the solution, obtaining the weights, is obtained using equations (6) and equation (7). Here, the criterion with the highest weight will be the criterion chosen for the solution.

$$w_i = ((D_i^{def} + R_i^{def})^2 + D_i^{def} - R_i^{def})^2)^{1/2} \quad (6)$$

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (7)$$

The literature study, including the Fuzzy DEMATEL method to be used in this study and Total Quality Management, which is the subject of the study, is given in Table 1 below.

Table 1. Literature Review

Year	Author	Application	Contents	Method
2022	Sivuk, D. Temiz, T.	The relationship between TQM Practices and job satisfaction of hospital employees	TQM practices and job satisfaction were compared over the perceptions of hospital employees.	Survey and Structural Equation Model
2022	Çelik, P. Gök Kısa, C.	Evaluation of critical factors affecting project success	In the sample application, the importance levels were determined and listed.	Fuzzy DEMATEL
2021	Özdağoğlu, A. Keleş, M.K.Işıldak,B.	Ranking of Airports	The services and performances of 52 airports were examined and listed.	Fuzzy DEMATEL and MABAC
2021	Aburahmah, R.	The role of leadership in the implementation of TQM	By examining an industrial group of companies, the relationship between TQM elements and the performance of organizations is examined.	Hypothesis Tests
2021	Hosseini, S. Paydar, M	Rescue solutions for ecotourism centers during the Covid-19 pandemic	Some practical and useful extraordinary action plans have been developed for ecotourism centers.	Fuzzy DEMATEL and Fuzzy VIKOR
2020	Ömürgönülşen, M. Çekiç, B. Ar, İ.M.	Evaluation of the factors to be considered in the Industry 4.0 harmonization process	Industry 4.0 compliance of logistics companies has been examined. The degree of importance of the factors has been determined	Fuzzy DEMATEL
2020	Çukurova, M.	Quality in translation in national translation companies	Quality standards and TQM criteria in oral and written translation studies were examined.	Netnography and Interview Technique
2020	Çakılcı, C.	Conceptual framework model for improving cold chain management in the supply chain	Performance criteria affecting cold chain management were defined and the causality relationship between these criteria was examined.	Fuzzy DEMATEL

Table 1 (continued). Literature Review

Year	Author	Application	Contents	Method
2020	Petcharit, A. Sornsaruht, P. Pimdee, P.	TQM analysis in Thai auto parts industry	A research tool with a 5-level scale was developed for 455 auto parts managers across Thailand.	Survey and Data Analysis
2019	Nagase, K. Ha Nguyen, T.	The effect of TQM on customer satisfaction	The effect of TQM on perceived service quality and patient satisfaction was investigated by a healthcare institution.	Survey, SPSS and AMOS
2019	Zhang, X. Jiafu, S.	The approach to predicting participants in crowdsourcing	Selected from a pool of participants for a specific resource usage task, the participant goes through a 4-step methodology.	Fuzzy DEMATEL and TOPSIS
2019	Dahlgaard, J. Reyes L. Chen, K.K: Dahlgaard Parkı,S.M.	Examination of management control within the scope of TQM	Management control and the evolution of organizational learning are studied.	Literature research
2019	Gallo, P. Balogova, B. Tomcikova, L. Nemec, J	The impact of the TQM tool in small and medium enterprises	The economic, mathematical, and statistical main advantages of using TQM as an innovative management tool have been systematized.	Hypothesis Tests

Year	Author	Aplication	Contents	Method
2018	Albayrak, Ö. Erkayman, B.	Smart wristband selection for athletes	It has been decided which brand and feature of the wristband is the most efficient for the athletes.	Fuzzy DEMATEL and EDAS
2018	Neven A. Rateb J. S. Ali T. Alireza M. Mahmood H. A.	TQM practices and organizational performance in construction chemicals companies	It has been understood that managers provide an understanding of the dynamic role of TQM practices, which have a direct impact on the performance of firms.	Survey
2017	Wu, SM. Liu, HC. Wang, LE.	Hesitant fuzzy integrated MCDM approach for quality function distribution: a case study in electric vehicle	House of quality practice was used in the manufacture and distribution of electric vehicles and in quality control.	Fuzzy DEMATEL and Fuzzy VIKOR
2017	Özkan Özen, Y.D. Koçak, A.	Enterprise resource planning software selection and evaluation	The selection criteria for the selection of ERP in the application software of 2 software companies were examined. A guiding strategic roadmap was created in the installation of the ERP software.	Fuzzy AHP and Fuzzy DEMATEL

1.5. Application Example

Today, with the increasing rate of change due to the advancement and developments in technology, the expectation of continuous change of the society, the increase in the quality of life, the ever-increasing competition and globalization in the world, the quality understanding of the enterprises is constantly changing and developing.

Quality, which is one of the issues that many businesses do not want to compromise, has turned into one of the purposes of companies today, out of being a marketing tool. It is an important investment for companies to transform quality into a management approach rather than a widespread, well-known and ordinary understanding of quality. In other words, the feeling of quality as a duty consciousness of every employee, from the smallest to the largest, ensures integrity and satisfaction by exceeding customer satisfaction.

1.6.1. Description of The Problem

Even if the physical resources of an enterprise are to the desired extent, humans will still transform them into added value. Therefore, human-based approaches are gaining more importance today.

It should be one of the most important objectives of the business not to leave its customers to its competitors for its rise, continuity, and branding. For this reason, it should know the people it serves well and closely know their wishes and needs.

At this point, the enterprise must first ensure the satisfaction of its employees for the satisfaction of the customer, who is affected by the product it produces and is the buyer of the final output of the goods or services. In other words, the inner satisfaction must be reflected outside.

However, businesses always need help keeping their employees' satisfaction and motivation alive. It cannot always respond to every request of every employee. This situation reduces the efficiency and productivity of employees and businesses daily.

In the sample application, a solution will be sought for the problem that the enterprises cannot provide the satisfaction and motivation of their employees at the desired level.

1.6.2. Steps to Follow for Solving the Problem

First of all, the TQM method was researched and examined, help was received from a qualified experts in the enterprise, and it was determined which criteria to work on in light of the literature review. Again, the criteria

were evaluated by the same experts. The criteria were weighted with the fuzzy DEMATEL method.

In order to examine the interaction between TQM Principles and Motivation, the hypothesis of each criterion was formed by literature review. Questionnaire questions for the sample in which the application will be made were prepared with the quality engineer in the enterprise, and a survey study was conducted. The results of the survey study were explained with the SPSS program.

Finally, the results obtained by the Fuzzy DEMATEL method and the results of the survey application were compared, and their compatibility was compared and analyzed in theory and practice. The steps are summarized in Table 2.

Table 2. Solution Stages

Solution Stages	Process steps	Solution Tool, Method, Technique, Program etc.
1	Determination of Criteria	Expert Opinion, Literature Review
2	Evaluation of the Criteria	Expert Opinion
3	Weighting of Criteria	Fuzzy DEMATEL, Ms Excel
4	Generating Hypotheses	Literature Review
5	Preparation of Survey Questions	Likert Scale, Survey Application
6	Evaluation of Survey Responses	SPSS, MS Excel
7	Results of the Problem and Analysis	Correlation and Regression Analysis, SPSS

1.6.2.1. Determination of Criteria

The criteria were determined by researching and examining the Total Quality Management approach and by taking the study in the literature (Şimşek, 2001) as a reference and the opinions of the qualified expert. A total of 5 criteria were used in the study. Moreover, employee motivation is the affected criterion, which is affected by five criteria here. In order to have an idea about the criteria, in Table 3 below, the criteria and what they express are given concisely and understandably.

Table 3. Criteria and Meanings

	Criteria	Explanation
K1	Customer Focus	It puts the customer at the center of the business. It adopts the understanding that the "customer determines the quality".
K2	Process management	The situation of producing value-added products and services with the follow-up of the processes determined in the enterprises.
K3	Continuous Improvement (Kaizen)	The situation of producing value-added products and services with the follow-up of the processes determined in the enterprises.
K4	Leadership	It is essential in quality management that a leader with leadership qualities and competencies guides his employees.
K5	Employee Participation	It contributes to the motivation of the employees to take a one-to-one role in the processes, to express their ideas and to know that their ideas will be taken into account, and to take an active role in teamwork.

1.6.2.2. Evaluation of the Criteria

The relationship between the five determining criteria can be evaluated linguistically. However, linguistic variables are complicated to quantify. Here, the criteria were evaluated linguistically with the quality expert. Then, the fuzzy scale proposed by Li was used.

Linguistic terms are expressed using fuzzy numbers. (Li, 1999) The linguistic scales that describe the relationship between the criteria and the corresponding fuzzy scale are in Table 4 below. The formulaic equivalents of fuzzy numbers given side by side are (l, m, u).

Table 4. Fuzzy Linguistic Scale

Linguistic Scales	Fuzzy Number Equivalents
Very little effective	(0,00;0,00;0,25)
Less effective	(0,00;0,25;0,50)
Normal effective	(0,25;0,50;0,75)
Effective	(0,50;0,75;1,00)
Too effective	(0,75;1,00;1,00)

1.6.2.3. Weighting of Criteria

Fuzzy DEMATEL method is used in this section. The steps are as follows.

1. Determining the Relationship between the Criteria: First, expert opinions were taken, and a binary linguistic relationship comparison matrix was created that examines the relationship between the criteria. It is as in Table 5.

Table 5. Binary Linguistic Comparison Matrix

Kriterler	K1	K2	K3	K4	K5
K1	0	Slightly effective	Normally effective	Slightly effective	Slightly effective
K2	Too effective	0	Too more effective	Fazla etkili	Less effective
K3	Normally effective	Too more effective		Normally effective	Slightly effective
K4	Slightly effective	less effective	Normally effective	0	Too more effective
K5	less effective	Slightly effective	Too effective	Too more effective	0

2. Forming the Direct Relationship Matrix: The matrix is created by arranging the fuzzy triangular numbers corresponding to the linguistic scales in Table 5. It is shown in Table 6.

Table 6. Direct Relationship Matrix

Criterias	K1	K2	K3	K4	K5
K1	0,00 0,00 0,00	0,00 0,07 0,14	0,07 0,14 0,21	0,00 0,00 0,07	0,00 0,00 0,07
K2	0,14 0,21 0,28	0,00 0,00 0,00	0,21 0,28 0,28	0,14 0,21 0,28	0,00 0,07 0,14
K3	0,07 0,14 0,21	0,21 0,28 0,28	0,00 0,00 0,00	0,07 0,14 0,21	0,00 0,00 0,07
K4	0,00 0,00 0,07	0,00 0,07 0,14	0,07 0,14 0,21	0,00 0,00 0,00	0,21 0,28 0,28
K5	0,00 0,07 0,14	0,00 0,00 0,07	0,14 0,21 0,28	0,21 0,28 0,28	0,00 0,00 0,00

3. Generating the Normalized Direct Relationship Matrix: After creating the direct relationship matrix, the direct relationship matrix normalized with the equation (1) and equation (2) described above is created. It is as in Table 7.

Table 7. Normalized Direct Relationship Matrix

Criterias	K1	K2	K3	K4	K5
K1	0,00 0,00 0,00	0,00 0,25 0,50	0,25 0,50 0,75	0,00 0,00 0,25	0,00 0,00 0,25
K2	0,50 0,75 1,00	0,00 0,00 0,00	0,75 1,00 1,00	0,50 0,75 1,00	0,00 0,25 0,50
K3	0,25 0,50 0,75	0,75 1,00 1,00	0,00 0,00 0,00	0,25 0,50 0,75	0,00 0,00 0,25
K4	0,00 0,00 0,25	0,00 0,25 0,50	0,25 0,50 0,75	0,00 0,00 0,00	0,75 1,00 1,00
K5	0,00 0,25 0,50	0,00 0,00 0,25	0,50 0,75 1,00	0,75 1,00 1,00	0,00 0,00 0,00

4. Creating the Total Relationship Matrix: Using equation (3), the total relationship matrix is obtained. The total relationship matrix is given in Table 8.

Table 8. Total Relationship Matrix

Criterias	K1	K2	K3	K4	K5
K1	0,007 0,05 0,007	0,01 0,13 0,01	0,07 0,20 0,07	0,007 0,06 0,007	0,001 0,02 0,001
K2	0,16 0,32 0,16	0,05 0,17 0,05	0,24 0,46 0,24	0,17 0,36 0,17	0,03 0,18 0,03
K3	0,10 0,25 0,10	0,22 0,37 0,22	0,06 0,20 0,06	0,11 0,27 0,11	0,02 0,10 0,02
K4	0,01 0,10 0,01	0,02 0,17 0,02	0,11 0,29 0,11	0,05 0,17 0,05	0,22 0,34 0,22
K5	0,01 0,15 0,17	0,03 0,13 0,03	0,17 0,34 0,17	0,23 0,39 0,23	0,04 0,11 0,04

5: Evaluation of the Cause-Effect Relationship: After the T matrix is obtained, D+R and D-R values are calculated using equation (4) to give the sum of the column elements and the sum of the row elements to give the R value. Calculated values are given in Table 9.

Table 9. D+R and D-R Values

Criterias	D+R	D-R
K1	0,38 1,33 0,54	0,19 0,41 0,35
K2	0,98 2,46 0,98	-0,32 -0,52 -0,32
K3	1,16 2,68 1,16	0,14 0,30 0,14
K4	0,97 2,32 0,97	0,15 0,18 0,15
K5	0,79 1,87 0,95	-0,16 -0,37 -0,32

6. Clarification Process: The clarification process is applied using Equation (5) and is shown in Table 10.

Table 10. Clarification Process

Ctiteria	D+R	D-R
K1	3,58	1,36
K2	6,88	-1,68
K3	7,68	0,88
K4	6,58	0,66
K5	5,48	-1,22

7. Drawing Cause-Effect Relationship Diagram: The cause-Effect Relationship Diagram is drawn using D+R and D-R values obtained after the clarification process. It is as given in Figure 1.

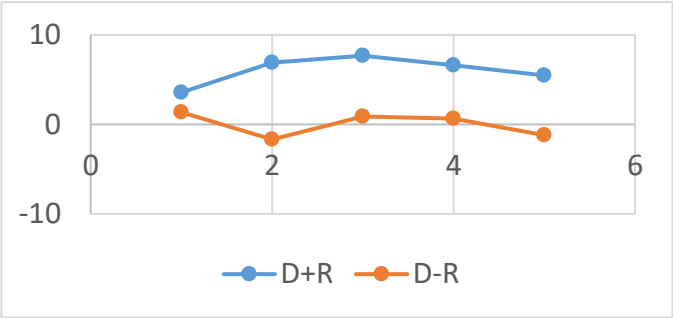

Figure 1. Cause-effect Diagram

According to Figure 1, the 3rd criterion with a high D+R value, Continuous Improvement, is more related to other criteria.1. customer orientation, which is the criterion, is less related to other criteria when D-R values are examined, 1.,3. and 4. criteria, namely customer focus, continuous improvement, and leadership. They have a more substantial influence on others. Customer focus is the most influential criterion. The second and fifth criteria, that is, process management and employee participation, are the criteria that are affected. It affects others less (Albayrak, Erkayman, 2018).

8. Obtaining the Weights: Finally, each selected criterion's weight value was calculated using the D+R, and D-R values obtained and equation (6) and (7). The results are shown in Table 11.

Table 11. Criterion Weights

Criterias	D+R	D-R	w	W	Criterion Priorities
K1	3,58	1,36	3,829621	0,12406	5
K2	6,88	-1,68	7,082147	0,229424	2
K3	7,68	0,88	7,730252	0,25042	1
K4	6,58	0,66	6,613017	0,214227	3
K5	5,48	-1,22	5,614161	0,181869	4
		Toplam	30,8692		

1.6.2.4. Generating Hypotheses

A questionnaire of 20 questions was prepared for 107 blue-collar employees to find the practical equivalent of the criteria that we examined theoretically and came to a conclusion in the study. Before the questionnaire application, assumptions, namely hypotheses, were created for each criterion to ensure the study itself. In this section, a literature review was used. In light of the survey results, hypothesis tests were applied, and the accuracies of the hypotheses are measured. The hypotheses are given below:

H1: Customer Focus increases employee motivation.
H2: Process Management increases employee motivation.
H3: Continuous Improvement (Kaizen) increases employee motivation.
H4: Leadership increases employee motivation.
H5: Employee Involvement increases employee motivation.

1.6.2.5. Preparation of Survey Questions

A questionnaire consisting of twenty questions, four for each criterion applied to one hundred and seven blue-collar employees in an aluminum factory operating in Sakarya, was used. While preparing the questionnaire, the opinion of the quality engineer in the enterprise was taken. The questionnaire used a five-point Likert scale and was designed and implemented through Google Forms.

1.6.2.6. Valuation of Survey Responses

When the average of the answers to the survey questions is taken and analyzed, according to the employees, the most important criterion that increases their motivation is the process management applied by the factory. However, the averages are close to each other. With an average of 12.71, the 1st selected criterion is followed by customer focus, continuous improvement (kaizen), leadership, and employee participation, with 12.24, 12.11, 11.98, and 11.94, respectively.

The applied questionnaires were recorded on Excel and the normality test was applied first so that other hypothesis tests could be applied to the questionnaire results. The answers to the questions belonging to the same criteria were gathered together and averaged. Thus, the probability of satisfying the normality assumption of the data set is increased. In other words, the probability of the data set approaching normality has increased.

According to SPSS results given in table 12 and table 13 below; In the test applied at 95% confidence interval, skewness and kurtosis values, which are the most important points in which we examine normality, are examined. In the literature, 2 acceptances have been found for the ranges of these values. The most widely accepted and used one is between -1.5 and +1.5 according to (Tabachnick and Fidell, 2013). According to George and Mallery (2010), the skewness and kurtosis values between -2 and +2 values show the normality of the data set. It has been observed that the study complies with both sources. That is, the data set used is usually distributed. Thus, the feasibility of other statistical analyzes was confirmed.

Table 12. Normality Test Results 1

Cases						
	Valid		**Missing**		**Total**	
	N	Perfect	N	Perfect	N	Perfect
Customer avg. answer	107	58,8%	75	41,2%	182	100,0%
Process avg. answer	107	58,8%	75	41,2%	182	100,0%
Improvement avg. answer	107	58,8%	75	41,2%	182	100,0%
Leadership avg. answer	107	58,8%	75	41,2%	182	100,0%
Employees avg. answer	107	58,8%	75	41,2%	182	100,0%

Table 13. Normality Test Results 2

		Descriptives	Statistic	Std.Error
Customer avg. answer	Mean		3,0607	,07407
	95%Confidence interval for Mean	Lower Bound	2,9139	
		Upper Bound	3,2076	
	5% Trimmed mean		3,0623	
	Median		3,0000	
	Variance		,587	
	Std. Deviation		,76621	
	Minimum		1,00	
	Maximum		5,00	
	Range		4,00	
	Interquartile Range		1,00	
	Skewness		,042	,234
	Kurtosis		,052	,463
Process avg. answer	Mean		3,1799	,07157
	95%Confidence interval for Mean	Lower Bound	3,0380	
		Upper Bound	3,3218	
	5% Trimmed mean		3,1669	
	Median		3,2500	
	Variance		,548	
	Std. Deviation		,74034	
	Minimum		1,75	
	Maximum		5,00	
	Range		3,25	
	Interquartile Range		1,25	
	Skewness		,204	,234
	Kurtosis		-,347	,463
Improvement avg. answer	Mean		3,0280	,07184
	95%Confidence interval for Mean	Lower Bound	2,8856	
		Upper Bound	3,1705	
	5% Trimmed mean		3,0312	
	Median		3,0000	
	Variance		,552	
	Std. Deviation		,74315	
	Minimum		1,25	
	Maximum		5,00	
	Range		3,75	
	Interquartile Range		1,00	
	Skewness		,005	,234
	Kurtosis		-,152	,453

Table 13 (continied). Normality Test Results 2

		Descriptives	Statistic	Std.Error
Leadership **avg. answer**	Mean		2,9953	,07034
	95%Confidence interval for Mean	Lower Bound	2,8559	
		Upper Bound	3,1348	
	5% Trimmed mean		2,9870	
	Median		3,0000	
	Variance		,529	
	Std. Deviation		,72764	
	Minimum		1,50	
	Maximum		4,75	
	Range		3,25	
	Interquartile Range		1,25	
	Skewness		,122	,234
	Kurtosis		-,812	,463
Employees **avg. answer**	Mean		2,9860	,06753
	95%Confidence interval for Mean	Lower Bound	2,8521	
		Upper Bound	3,1199	
	5% Trimmed mean		3,0035	
	Median		3,0000	
	Variance		,488	
	Std. Deviation		,69858	
	Minimum		1,25	
	Maximum		4,25	
	Range		3,00	
	Interquartile Range		1,00	
	Skewness		-,298	204
	Kurtosis		-,623	463

1.7.Statistical Analysis

Correlation analysis; it is a statistical method that provides information about the relationship between variables, the direction and severity of this relationship. In this section, the relationship between TQM principles and motivation, and the direction and severity of the relationship will be examined.

1.7.1. Correlation Analysis

In the study, correlation analysis was performed to observe the relationship between the criteria before examining the cause-effect relationship between TQM principles and motivation with regression analysis. There is no concept of dependent or independent variables in correlation analysis; all variables are considered the same. The relationships of the variables are examined, but their effects on each other cannot be observed, so the correlation is not causality (Bakırcı, 2016). The Pearson analysis method was used because the data set was normally distributed. The results are given in Table 14.

Table 14. Correlation analysis results

Correlations						
		Customer avg. ans.	Process avg. ans.	Improvement avg. ans.	Leadership avg. ans.	Employees avg. ans.
Customer avg. ans.	Pearson correlation	1	,008	-,129	-,034	-,186
	Sig(2-talled)		,938	,184	,725	,056
	N	107	107	107	107	107
Process avg. ans.	Pearson correlation	,008,	1	-,086	,086	,070
	Sig(2-talled)	938		,364	,361	,474
	N	107	107	107	107	107
Improvement avg. answer	Pearson correlation	-,129	-,089	1	-,078	-,044
	Sig(2-talled)	,184	,364		,423	,656
	N	107	107	107	107	107
Leadership avg. answer	Pearson correlation	-,034	,089	-,078	1	-,009
	Sig(2-talled)	,725	,361	,423		,923
	N	107	107	107	107	107
Employees avg. answer	Pearson correlation	-,186	,070	-,044	-,009	1
	Sig(2-talled)	,056	,474	,656	,923	
	N	107	107	107	107	107

When the results are examined, it is observed that there is a positive relationship between customer focus and process management, leadership and process management, and employee participation and process management.

Generally, if r>0.70, it is accepted that there is a strong relationship between the variables; if it is between r=0.40 and 0.70, it is moderate; if it is between r=0.20 and 0.40, it is weak, and if r<0.20 it will be neglected. (Öztürk, E.E., 2020).

Strengths: Customer-process management, leadership, leadership-employee involvement.

Moderate: process management-employee involvement; continuous improvement-leadership, continuous improvement-employee participation

Weak: process management-continuous improvement, process management-leadership;

Negligible: customer-continuous improvement, customer-employee involvement, continuous improvement-customer.

1.7.2. Regression Analysis

Regression analysis is a statistical method that helps analyze the relationship between two or more variables of interest. In order to measure the accuracy of the hypotheses determined in the study, the relationship between TQM principles accepted as independent variable and motivation determined as dependent variable was examined. In order to measure the accuracy of the hypotheses we determined in the 4th step of the solution, the relationship between the independent variable TQM principles and the dependent variable motivation was examined. As a result, the regression is significant.

In the analysis results, VIF (Variance Inflation Factor), i.e., variance increase factor value is 2.5 and below (Allison, 1999), (Pan, & Jackson, 2008), 4 and below (Hair, 2010) or 10 and below (Hair et al., 1995) literature studies have been discussed. VIF values were found to be suitable for both studies. If the VIF value were more significant than these suggested numbers, we would face the multicollinearity problem.

For R value = 90, it shows how well the created model fits the observed values. The R^2 value is 45. Explanatory variables explain 45% of the dependent variable (Table 15).

As a result of the analysis, it is a meaningful regression model. F(5, 101) = 2.003 (Table 16).

When the hypothesis test results were examined, the Sigma values in Figure 7 were found as H2(,005), H3(,009), H4(,005), and H5(,001). Since P<0.01, these hypotheses are accepted.

Process Management, Continuous Improvement (Kaizen), Leadership, and Employee Participation criteria affect motivation positively.

Table 15. Regression analysis results 1

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,300[a]	,90	,45	,78876
a.predictors: (Contant), employees avr.ans., Customer avr.ans.,, Process avr.ans.,, improvement avr.ans.,, Leadership avr.ans.,				

Table 16. Regression analysis results 2

ANOVA[a]						
Model		Sum of Square	df	Mean square	F	Sig.
1	Regression	6,229	5	1,246	2,003	,085[b]
	Residual	62,836	101	,622		
	Total	69,065	106			

a.depended Variable: motivation
b.Predictors. (Contant), , employees avr.ans., Customer avr.ans.,, Process avr.ans.,, improvement avr.ans.,, Leadership avr.ans.,

Table 17. Regression analysis results

Model		Understandardized B	Coefficient std. Error	Standardized coeffident Beta	1	Sig.	95.0%Confidence Interval for B Lower Bound	Upper bound	Zero order	Partial	Part	Collinearity Staristics Tolerance	VIF
1	Contant	1,082	,790		1,359	,174	,0486	2,649					
	Customer avg. answer	,273	,103	,259	2,654	,102	,069	,477	,257	,255	,252	,944	1,059
	Process avg. answer	,063	,104	,058	,605	,005	-,144	,271	,068	,060	,057	,981	1,020
	Improvement avg. answer	,096	,105	,088	,913	,009	-,304	,112	-,125	-,090	-,087	,966	1,035
	Leadership avg. answer	,075	,106	,067	,704	,005	,285	,136	-,065	-,070	-,067	,984	1,016
	Employees avg. answer	,101	,112	,087	,901	,001	-,121	,324	,048	,089	,085	,956	1,046

a: depended variable: motivation

1.8. Economic Evaluation of the Study

When the study is examined from an economic point of view, it can be said that the possibility of doing value-added work will increase with the time, budget, etc. that the enterprise will allocate to Total Quality Management. Because all companies are systems and it is the creativity and motivation of the employees that keeps the system alive. In an environment where the motivation of the employees increases, the value they attach to the company also increases and they work more efficiently where they involve themselves and are a part of. Therefore, this efficiency is reflected in the satisfaction of the customers. A satisfied customer will remain loyal to the company.

Quality is one of the most important investments that the company will make for itself. Many brands even emphasize quality standards. Adopting the understanding of quality by all company employees ensures that the company uses its resources efficiently and adopts a management philosophy.

When quality becomes a goal for a company, the company acquires a mission and vision. A business without a mission cannot guide and guide its employees. Suppose the mission binds all business units and its employees' motivation. In that case, that business becomes a business where people who come together without serving a specific purpose work to save the day without team spirit, only by considering their interests. Moreover, that

business cannot institutionalize, grow, become a brand and find a place in the market.

Since the stance of the enterprises will be reflected directly in their employees, the employees of a company that does not have a goal and a high aim will not have a goal, and their motivation will decrease over time. It cannot be said that the future of such a business will be very bright. Therefore, businesses should have a management philosophy to bring their units and employees together under a standard roof. One of the most appropriate philosophies is Total Quality Management.

CONCLUSION

Businesses need a management philosophy to efficiently carry out all the processes they contain. This management approach must always include quality. If a business wants to survive, not compromising quality should be one of its primary goals.

In addition, as the importance given by the enterprises to the motivation of their employee's increases, the change in their quality also increases. A business that pleases its internal customers and employees also pleases its external customers.

In this context, the effect of Total Quality Management and its principles, which is today's current understanding of quality, on employee motivation has been examined in this study. Among the many criteria accepted in the literature, five criteria were selected. With the Fuzzy DEMATEL method, the most important criterion that positively affects employee motivation has been determined as Continuous Improvement (Kaizen).

However, as a result of the survey conducted in the selected enterprise within the scope of this study, the most crucial criterion affecting the employees' motivation was Process Management.

As a result, we can say that; The survey and hypothesis tests show that; The selected business cares about the motivation of its employees and carries out TQM studies that will positively affect their motivation. However, it will benefit the enterprise to increase the studies, training, and incentives for Continuous Improvement (Kaizen).

While the Process Management, Continuous Improvement, Leadership, and Employee Participation criteria positively affect the employees' motivation for this enterprise, it must be said that the Customer

Orientation principle applied by the enterprise has a different level of contribution to its employees.

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CHAPTER 6

EFFECT OF BULLET GEOMETRY ON BASE DRAG: A BALLISTIC APPLICATION ON DESIGN WITH MIDDLE DRILLED BULLET

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INTRODUCTION

Due to the geometry of bullet, turbulence effect and drag force in the area discharged by bullet are 50% or more of aerodynamic resistance. There is a certain pressure difference in the front and rear parts of bullet. High pressure occurs in front of bullet and low pressure occurs in the back. As a result of this situation, a turbulence and vacuum effect occurs in region where bullet is discharged and tries to stop bullet. It is assumed that designed perforated geometry can reduce this effect by transmitting a portion of pressure in the front of bullet to the rear of bullet.

1. DESIGN OF BULLET NOSE GEOMETRY

Determination of nose geometry of rockets, planes, missiles and bullets is very important in terms of achieving flight performance. Flight of these objects can be hypersonic, supersonic, transonic or subsonic. Ability of these objects to fly with minimum air resistance is one of the most important issues in aerodynamics.

In the definition of nose geometry, total length of nose is L, radius of base of nose is R, the x-y is axisymmetric axis set, coordinate of any point on the nose arc on the axis of symmetry is and, y is radius of this point.

Since the bullet nose geometries are axially symmetrical, the equations to define nose geometry are two dimensional. Equations describe perfect nose geometry. In fact, due to manufacturing problems, noses of flying objects are dulled by rounding or made cut.

1.1. Nose Shapes

Bullet nose shapes can be designed quite differently. However, the commonly used types such as round profile tip, conical profile tip and ogival profile tip bullets are widely preferred. Round-nosed bullets are elongated with a nose measuring half the bullet diameter (half the bullet diameter). Pointed type bullets have a sharp and long tip. Conical bullets are generally cone-shaped. The main nose types are examined in detail below.

1.1.1. Conical Nose

One of the commonly used nose shapes is a simple conical nose. This shape is generally selected for ease of production and also for drag characteristics (Chin, 1961).

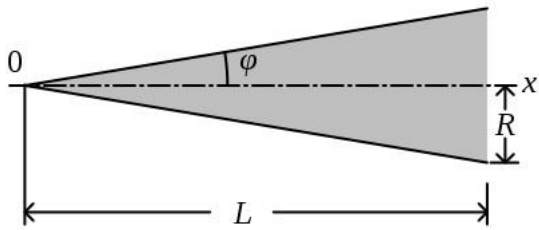

Figure 1. Conical nose

1.1.2. Spherical Cut Cone Nose

In practice, conical noses are spherically dulled for ease of manufacture. Cone edge must be tangent to sphere surface to prevent shock waves from forming at the junction of sphere piece and cone (Carlucci & Jacobson, 2014).

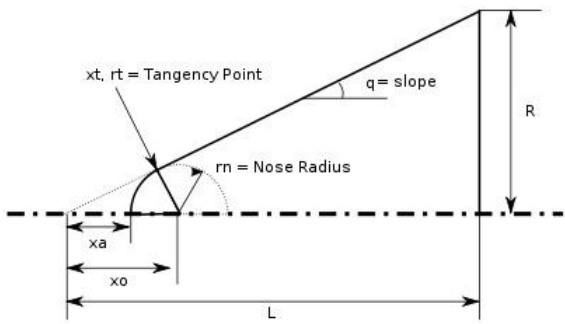

Figure 2. Spherical cut cone nose

1.1.3. Biconical Nose

It is obtained by adding a truncated cone of length L_2 with a cone bottom radius greater than the first cone to a conical nose of length L_1 (Chin, 1961).

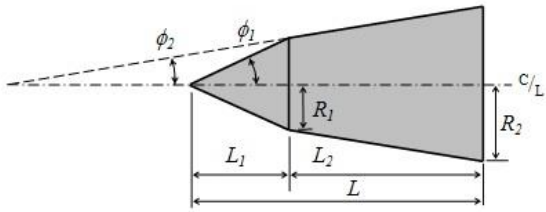

Figure 3. Biconical Nose

1.1.4. Elliptical Nose

This type of nose profile consists of half ellipse. Long axis of ellipse coincides with nose axis. These types of noses are used in subsonic flights. If L = R spherical nose is obtained. These type of nose structures are used in some tank repellent missiles and subsonic model rockets and pistol bullets (Chin, 1961).

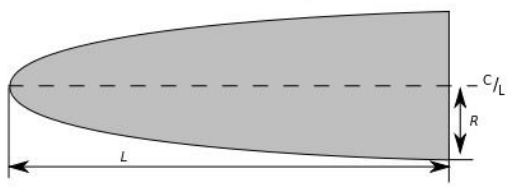

Figure 4: Elliptical Nose

1.1.5. Parabolic Nose

These types of noses are not blunt and are called parabolic noses. This type of parabolic nose series is obtained by rotating two-dimensional parabola 360 degrees around bullet axis (Chin, 1961).

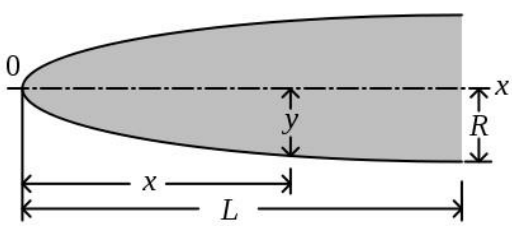

Figure 5: Parabolic Nose

1.1.6. Ogive (Tangent Ogive) Nose

After a simple cone, the most common nose cone shape in model rocketry is tangent ogive shape. The profile of this shape consists of a circle cut. Rocket body is tangential to concave of nose cone. This shape is largely in demand because of the ease of construction of profile shape (Chin, 1961) (Carlucci & Jacobson, 2014).

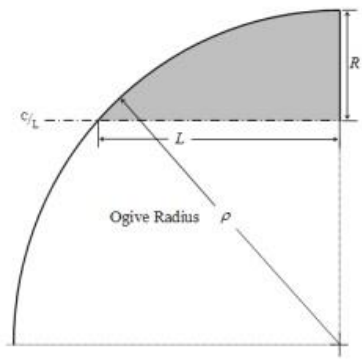

Figure 6: Ogive (Tangent Ogive) Nose

1.1.7. Secant Ogive Nose

Although profile of this shape also consists of a circle cut, base of shape is not above radius of circle defined by radius ogive. Rocket body does not tangent to concave of nose cone. Ogive radius is a factor to be chosen to define shape of nose rather than R and L (as in tangent ogive). If radius of selected secant ogive is greater than radius of tangent ogive, which is same as R and L, resulting secant ogive will appear as ogive whose bottom is cut. If selected tangent is smaller than ogive, then resulting secant ogive will have a protrusion greater than base diameter. Classic example of this figure is the nose cone of the MGR - 1 Honest John missile. In addition, selected ogive radius should be greater than twice length of nose cone (Carlucci & Jacobson, 2014) (Chin, 1961).

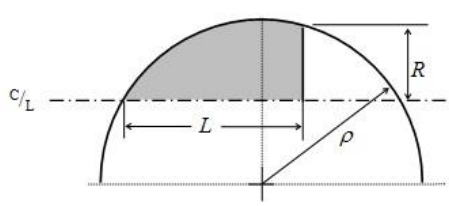

Figure 7: Secant ogive nose

1.1.8. Spherical Cut Tangent Nose

Tangent ogive nose is usually cut from a part of sphere (Chin, 1961).

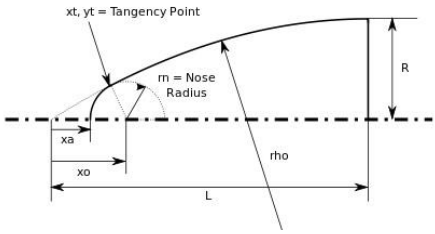

Figure 8: Spherical cut tangent ogive nose

1.2. Nose Drag Characteristics

In subsonic flights of aircraft, rockets and bullets below Mach 0.8 value, nose pressure drag values are basically zero or close to zero for all nose shapes. Drag force is mainly caused by friction drag. Friction drag generally depends on size of wet area of object, surface roughness and whether surface is discontinuous or not. For example, for rockets and bullets that will make subsonic flights, blunt (elliptical), elliptical short nose geometries are the most suitable shapes (Akçay 1983, 2018).

In transonic region, pressure resistance is quite high due to shock waves that are generated. In supersonic region, drag force is partially reduced due to reduced angles of shock waves with the surface. In these two flight zones, the most important factors affecting pressure drag are nose geometry, nose fineness ratio and discontinuity in body geometry. In the transonic zone of $0.8 \leq M \leq 1.2$ flight range, aerodynamic calculations are difficult. In drag force calculations to be made in this region, empirical values obtained from experiments are generally used. For objects to fly in the transonic region, optimal nose geometries are those obtained by exponential series obtained for Von Karman Ogive or n = 1/2. Warplane noses are generally designed taking into account transonic flight zone. For example, F-16 nose geometry is very close to shape of Von Karman Ogive. Conical nose is most suitable for flying objects at hypersonic and high supersonic speeds (Akçay 1983, 2018) (Cummings, Yang, & Oh, 1995).

Effect of fineness ratio on drag force; the ratio of size of nose spring to diameter of bottom of nose is called as fineness ratio. For wings and fins, this description is occasionally referred as aspect ratio. Fineness ratio is generally used within ratio of entire length of object to the object diameter. Length-diameter ratio is used as nose spring caliber. In supersonic and

hypersonic flights, fineness rate has a great effect on pressure drag. It is not beneficial if fineness ratio is greater than 5/1. This is because when rate of fineness increases, wet area of object also increases. Increase in wet area causes drag force due to friction to increase. Therefore, it is necessary to optimize by considering decrease in shock drag and increase in friction drag in determination of fineness ratio of object (Akçay 1983, 2018) (Cummings, Yang, & Oh, 1995).

2. DRAG FORCE

Drag force of axially symmetrical delicate objects consists of following three main parts.

- Nose pressure drag
- Friction drag
- Floor drag

Total drag force depends on geometric structure of object, Mach number and Reynolds number. If nose of object is not blunt, nose pressure drag may be neglected in subsonic flows, bottom of object can be tapered, and bottom drag may be omitted (Aküzüm & Aygün, 2016).

In case of large objects, fineness ratio consists of frictional force with greatest coefficient of drag. There is no ready-made statement for calculating drag force of axially symmetrical delicate bodies. For this reason, pressure, friction and floor drag must be calculated separately (Mccoy, 2012).

2.1. Nose Pressure Drag

Pressure drag of objects whose noses are not excessively blunt is approximately zero in subsonic flow. Pressure drag at supersonic velocities is calculated by Von Karman - Tsien method or second order shock expansion theory. Pressure drag of objects with delicate nose geometry ($Ln / D \geq 3$) at transonic velocities are calculated by Wu and Aoyoma method. If nose structure of body becomes blunt or nose is cut, pressure drag is obtained by modified Newtonian theory. The modified Newtonian Theory gives very good results even at low supersonic speeds under above geometric conditions. Pressure drag varies with Reynolds number. Boundary layer around body changes geometry of body and hence it changes pressure distribution around the body (Mccoy, 2012).

2.2. Friction Drag

Friction drag generally makes up the largest portion of total drag. Therefore, it must be determined correctly. There are different methods of calculating coefficient of friction.

Schlichting states that friction drag is strictly dependent on Mach number, Reynolds number, surface temperature and surface roughness as it relates to boundary layer theory. In general, coefficient of friction calculated for plate is used in axially symmetrical delicate bodies. This assumption does not apply fully to nose of bodies. For example, coefficient of friction in nose portion of bullet type body having a nasal fineness ratio dn = 2.5 is 15 percent higher than friction force coefficient of plates (Mccoy, 2012).

Coefficient of surface friction force depends on whether flow is laminar or turbulent. Coefficient of friction is higher in turbulent state than in laminar state. Whether flow around body is laminar or turbulent depends on surface roughness, heat transfer and Reynolds number.

Blasius states coefficient of friction in laminar flow as following:

$$C_F = \frac{0.664}{Re^{1/2}} \qquad (5.10^5 \leq Re \leq 5.10^6$$

It was stated that the following connection is valid between Schlichting coefficient of friction and Reynolds number in turbulent flow.

$$C_F = \frac{0.455}{(\log_{10} Re)^{2.58}} \qquad (Re \leq 10^9$$

In general, axial symmetrical delicate objects such as bullets and rockets are flow laminar in nose and turbulent in other parts (Akçay 1983, 2018) (Mccoy, 2012).

Von Driest has developed a method for calculating friction force coefficient of plane plate based on Mach number, Reynolds number, surface temperature and Prandtl number in turbulent flow.

2.3. Bottom Drag

Bottom drag makes up 50 percent or more of total drag in axially symmetrical delicate bodies. Delery and Sirieix studied base flow in detail (Carriere, Sirieix, & Delery, 1975).

In bottom flow, there is interference event of boundary layer separated from surface of object by general flow. Region behind bottom where flow circulates is called “dead flow zone” and pressure is indicated by

"Pt". Dead flow zone is surrounded by boundary layer over body and outer potential flow in boundary intermediate layer. Boundary layer thickness increases as a result of mixing of boundary layer separated from bottom with dead flow zone and external flow. Boundary layer is directed back to point of adhesion on axis and goes back axially (Nietubicz & Struek, 1988).

Bottom drag depends on whether bottom flow is laminar or turbulent, number of Mach, number of Reynolds, shape of object and the bottom, angle of attack, heating or cooling of object. Since no sufficient method has been developed for calculation of bottom drag force, values of bottom drag force are based on experimental results.

If angle of attack is zero, dead-flow zone is axially symmetrical and drag force is constant at subsonic velocities due to bottom pressure. Atlı measured bottom drag force as $C_{D_t} = 0.153$ in his experiments with baseline flow for low subsonic velocities. At subsonic and high subsonic speeds, it is around $C_{DB} = 0.12$. At supersonic and transonic speeds, shock waves expanding depending on bottom angle occur. Shock waves directly affect bottom pressure. Intensity of shock waves is function of Mach number. Therefore, bottom drag force varies with Mach number. Dead flow zone has a major effect on bottom pressure. In this region, a mixture occurs between outer stream and boundary layer (Atli, 1988).

Mixture event is strongly dependent on thickness of boundary layer preceding separation point and velocity and density profiles of boundary layer at separation point. Therefore, shape of bottom becomes important. Bottom drag coefficient is minimum at a certain value of base angle and increases at values below or above it. This is especially important for bullet design (Wanchai, Chue, Nguyen, Pey, & Yu, 2015).

3. DRILLED BULLET GEOMETRY

Drilled bullet geometry was obtained by drilling a hole of 3.55 mm diameter along bullet axis from bottom of standard 7.62x51 mm ammunition. Aim of this geometry is to reduce bottom drag force, which is the most effective of drag forces acting on axially symmetrical delicate objects.

3.1. Computer Supported Analysis

In ANSYS program, flow of 600 random particles of air around them at a speed of 800 m / s was simulated with 200 step iteration for 7.62x51 mm bullet and generated geometry. Bullet is positioned in - z direction in analysis environment.

4. RESULTS AND DISCUSSION

As a result of the analysis, it was found that bottom drag force decreased. However, as surface area in contact with air increases in the new geometry, friction drag force is increased. In addition, formation of extra sharp corners in nose can create shock waves at supersonic velocities, which is undesirable. As a result of the analysis, velocity of the bullet decreased. Therefore, instead of applying such a change to any standard bullet, it would be a more accurate design approach to reach the most appropriate form by designing a more specific and scratch projectile.

This type of geometry is more suitable to be applied to cannon or tank bullet of larger diameter and to go farther than small caliber bullets, but ability of bullet to penetrate due to its nose structure lowers bullet from its class of armor piercing bullets. Such a geometry, however, does not constitute an obstacle to plugged artillery shells, which can be flared in the air, and such geometry would be more suitable for use in artillery shells.

When it is thought more about use of geometry, it can be used for electromagnetic ball systems currently being developed by many countries. Bullets in these weapon systems can reach very high speeds such as 6000 km / h and are subject to a lot of bottom drag. In addition, a new torpedo design can be created by placing propellers and fins in the area of hole in torpedoes.

The analyzes conducted in this study were at a very basic level and were prepared to create a general idea. The subject needs to be further investigated and explored.

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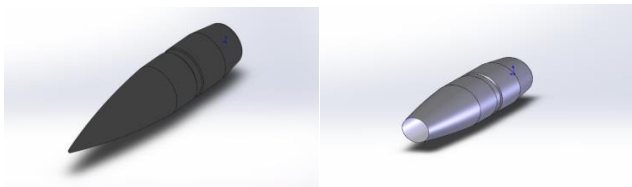

Figure 9: The bullet design used (7.62x51 mm (left)) and the generated geometry (right)

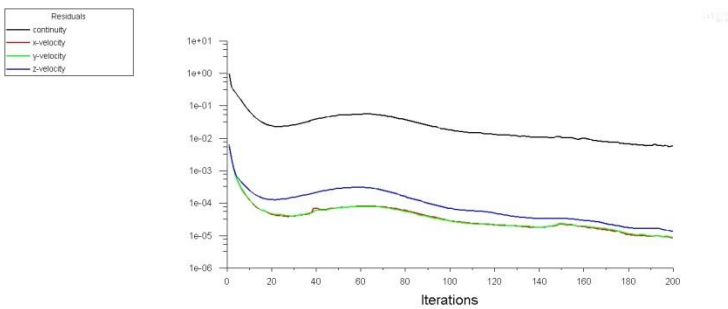

Figure 10: For air particles flying around 7.62x51 mm bullet

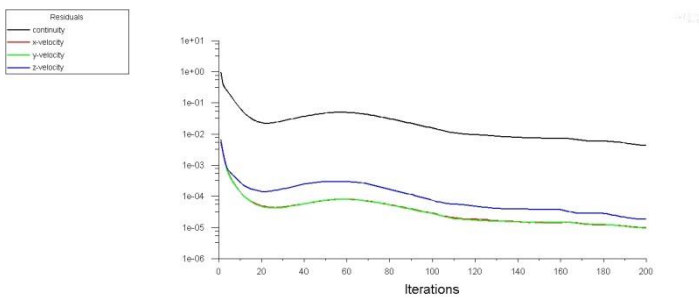

Figure 11: For air particles flying around generated geometry

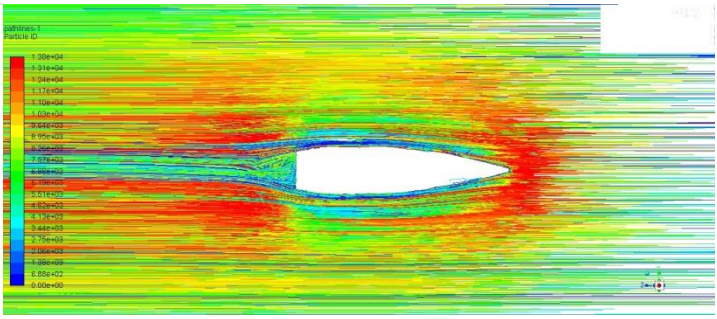

Figure 12: Flow vectors of particles around 7.62x51 mm

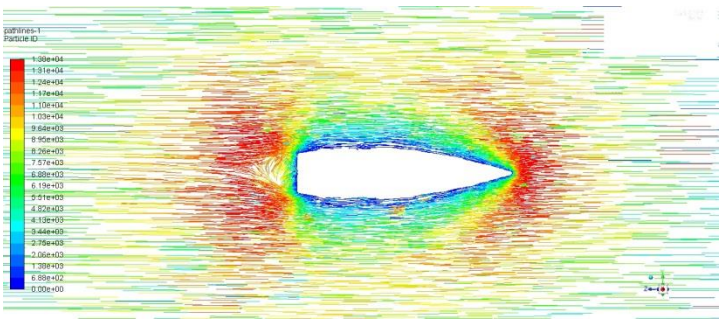

Figure 13: Flow lines of particles around 7.62x51 mm [0 -1 second]

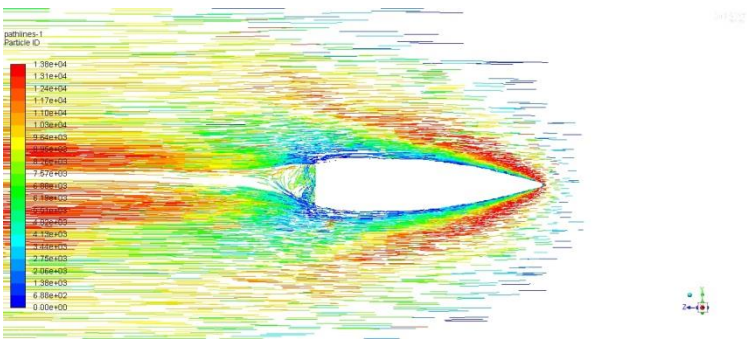

Figure 14: Flow lines of particles around 7.62x51 mm [after 1 second]

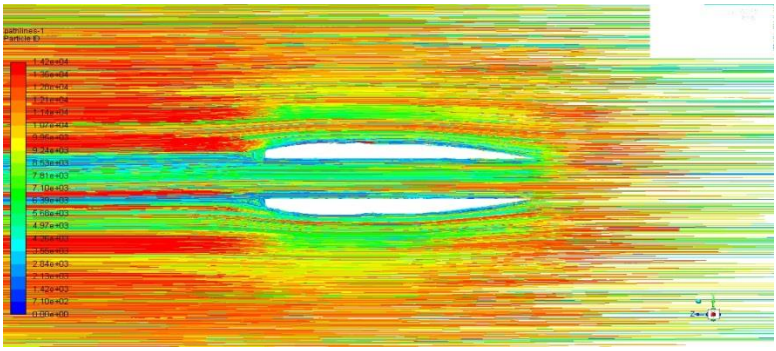

Figure 15: Flow vectors of particles around designed geometry

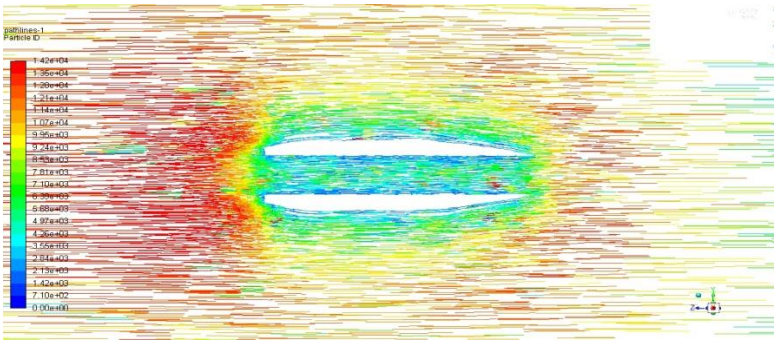

Figure 16: Flow lines of particles around designed geometry [0-1 second]

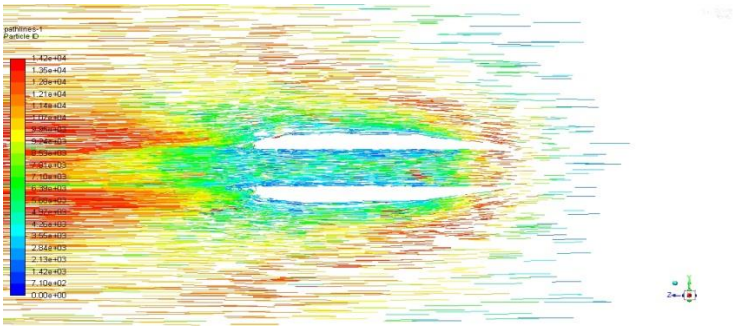

Figure 17: Flow lines of particles around designed geometry [after 1 second]

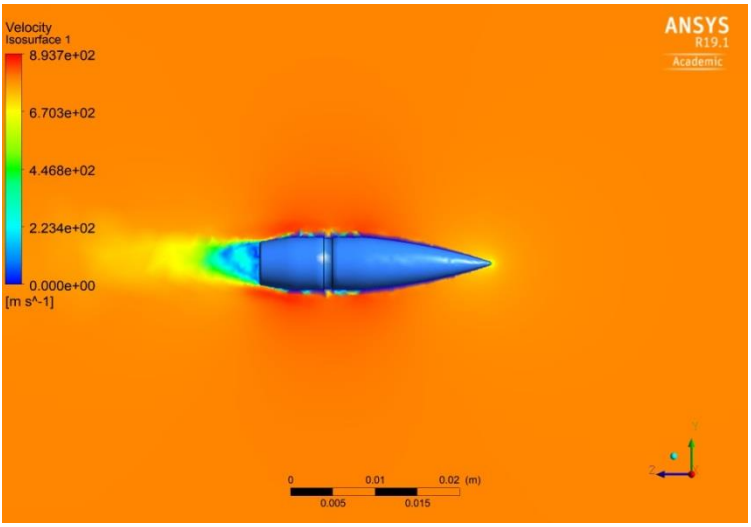

Figure 18: Velocity Distribution around 7.62x51 mm

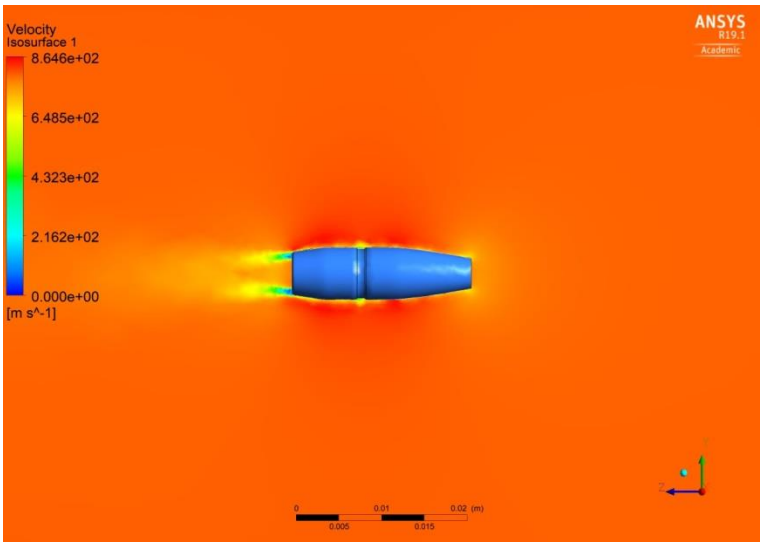

Figure 19: Velocity distribution around designed geometry

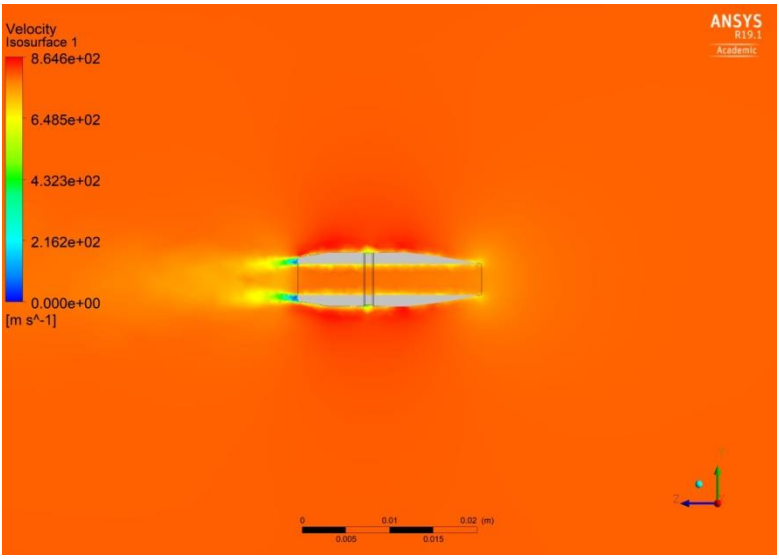

Figure 20: Velocity distribution around designed geometry (sectional view)

CONCLUSION

Flow analyzes of bullets with hole in the middle and 7,62*51 mm classical design were carried out successfully. As a result of the analysis, it was determined that the drag force from the bottom decreased in the hole-in-the-middle bullet design. However, as the surface area in contact with the air increases in the new geometry, the drag force increases. In addition, the formation of extra sharp corners in the nose can be observed as a result of the analysis that unwanted shock waves occur at supersonic speeds. The decrease in the velocity of the bullet appears as a negative situation. As a result, it will be possible to use the bullet designed in this way effectively according to the classical design under special conditions. Thus, the new design geometry is more suitable for application to larger diameter cannon or tank shells. On the other hand, the penetrating ability of the bullet due to the nose structure makes the bullet fall out of the armor-piercing bullets class.

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CHAPTER 7

ONE OF THE BASIC MICROWAVE TRANSMISSION LINES: WAVEGUIDES

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INTRODUCTION

The use of conventional electrical cables is sufficient to transmit low frequency (e.g. 50 Hz) AC signals such as grid voltage. However, at high-frequency signals that change direction more than a million times per second, energy radiates out of the cable, and power is lost. In addition, high-frequency currents are reflected from the connection points and return to the source. Thus, it becomes difficult for the power to reach the end-point (Ulaby et al., 2014). For these reasons, transmission lines (TLs) such as microstrip lines, coaxial cables, fiber optic cables and waveguides are needed to transmit high-frequency electromagnetic signals with minimum reflections and losses over a wideband of frequencies. The structures of these TLs are given in Figure 1 (Andriambeloson, 2011, Testguy, 2018, Costa et.al., 2017, Ansari et al.,2021).

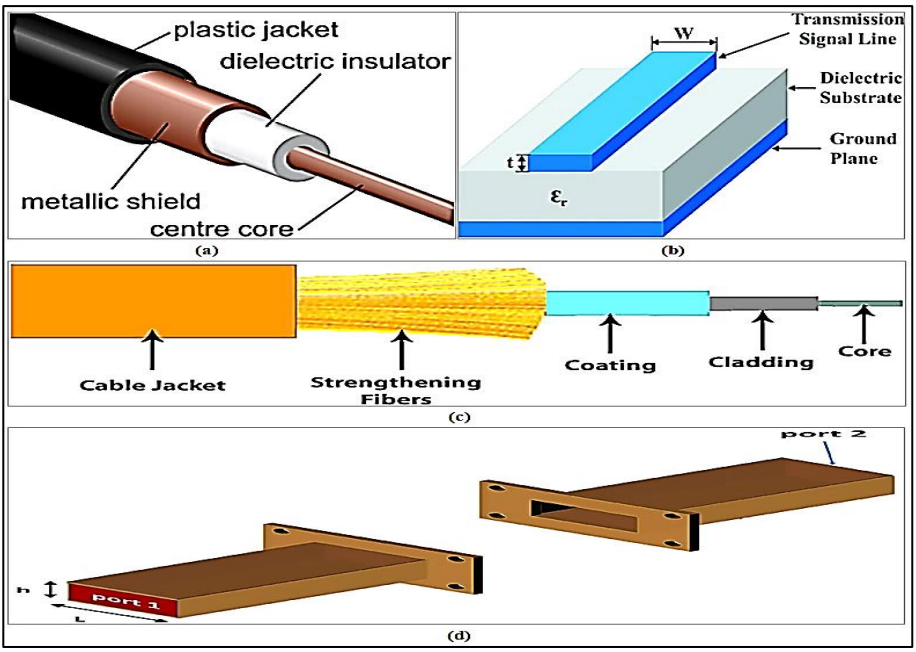

Figure 1. The structures of basic TLs:
a) Coaxial cable, b) Microstrip line, c) Fiber optic cable, d) Waveguide (Andriambeloson, 2011, Testguy, 2018, Costa et.al., 2017 and Ansari et al., 2021)

In this chapter, an overview of the waveguides is made and their status and importance in microwave engineering are mentioned. Accordingly, firstly the waveguides will be introduced, and their advantages and disadvantages will be explained. Then, their types will be shown and energy propagations in the waveguides will be mentioned. Furthermore, some

important terms such as impedance, velocity and wavelength in the waveguides will be given in details. Finally, the study will be concluded and those who read this chapter will have a general knowledge of the waveguide and its theory.

1. WHAT IS WAVEGUIDE?

Waves ranging from 0.3 to 300 GHz (corresponding to the wavelengths ranging from one meter to one millimeter) in the electromagnetic spectrum region are considered 'microwaves' (Sorrentino & Bianchi, 2010 and Jones et. al., 2013). Waveguides are efficient structures in which electromagnetic waves, especially microwaves, are transferred and directed. Their inner surfaces are not mirrored but are electrical conductors. They are constructed of very conductive materials such as copper, partially silver or gold-plated brass, metal-plated ceramics etc.

Waveguides are usually hollow. Thus, they can transmit waves by trapping them in conductive pipes. Some of the important features of waveguides are being able to direct the signal exactly where it is needed, control large amounts of power, and act as a high pass filter (Antenna-Theory, 2011).

Since they can handle high transmission peaks with relatively low levels of signal loss throughout microwave frequencies, they offer a better alternative connection than strip-line and coaxial technology between transmitters and receivers in microwave transmission systems (Thomasnet, 2022). They are used in many applications in microwave regions such as transferring energy in radar systems, connecting feed points in dish antennas, transferring power from the magnetron to the cooking chamber in microwave ovens, etc.

1.1. Advantages and Disadvantages of Waveguides

There are many advantages of using waveguides at microwave frequencies. Some of these are summarized below.

- Since they have a shielded structure, there is no loss during radiation.
- Thanks to the spacing between their conductors, they can carry much more power compared to other transmission lines.
- Weak signals transmitted within waveguides are shielded against external noise.

- They have lower dielectric losses compared to two-wire and coaxial transmission lines.
- Copper losses are at minimum levels due to their large surface area.

- Besides their advantages, they also have various negative features. Some of these are given below.
- Their large size limits their use at low frequencies.
- Since their inner surfaces must be plated with gold or silver to reduce the skin effect, their costs are high.
- They are difficult to mount, as there are hollow pipes in the structures.
- It is necessary to use special couplers at their connection points for working safely and efficiently.

1.2. Types of Waveguides

There are different types of waveguides according to their features and geometric shapes. The most common of these are rectangular, cylindrical, and double ridge. Rectangular waveguides are generally preferred in radar systems and radio communications and are used in important parts such as directional couplers, taper sections, etc. Circular waveguides are easier to implement than rectangular ones since they have only one dimension (radius). They are often preferred in radio frequency equipment where rotation is required.

Double-ridged waveguides are another type of equipment used in the microwave systems due to their low cut-off frequency, low impedance, wide frequency band, and ability to adapt to coaxial cable.

Signals only above the cut-off frequency are carried by the waveguides. Below this certain frequency, the signals are attenuated. The cut-off frequency formulas of the rectangular, circular, and double-ridge waveguides can be seen in detail in **(**Mehrdadian et. al., 2014, Siaka et. al., 2017, EverythingRF, 2022).

The views and images of the mentioned waveguide types are shown in Figure 2 (Dolph-Microwave, 2022(a), 2022(b), EverythingRF, 2022).

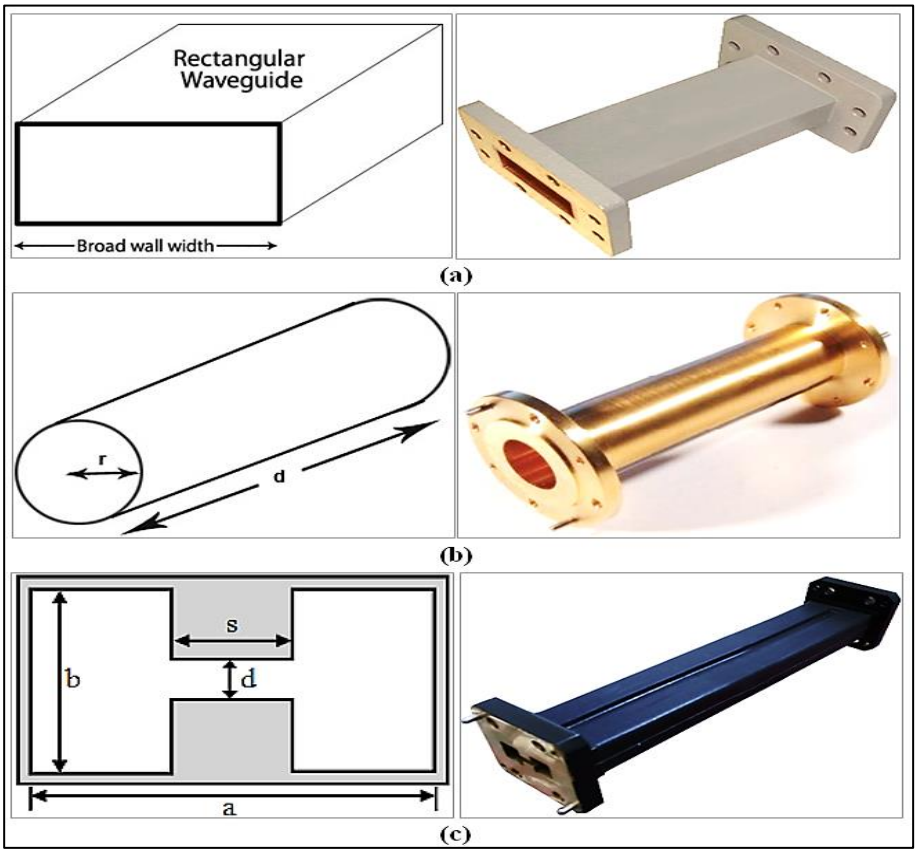

Figure 2. Types of Waveguides: a) Rectangular, b) Cylindrical, c) Double-ridge **(**Mehrdadian et. al., 2014, Siaka et. al., 2017, EverythingRF, 2022)

2. PROPAGATION MODES IN WAVEGUIDES

An electric field (E) can be defined as the electric force per unit charge. It is caused from electric charges and time-varying currents. A magnetic field (H) is described as an influence around a magnet, moving electric charge, or electric field, in which magnetic forces can be observed (Purcell & Morin, 2013, Feynman et. al., 1963). Electromagnetic fields (EMF) are created by the combination of E and H. In other words, they are appearances of EMF.

In electromagnetic waves, the E and H fields are perpendicular to each other. If the H is in the direction of propagation, it is called Transverse Electric (TE-mode). If the E is in the direction of propagation, it is called Transverse Magnetic (TM-mode). In addition, if there is no E or H field in the direction of propagation, it is named transverse electromagnetic (TEM mode).

Waveguides often support TE or TM waves (Pozar, 2012). To describe the shape of the TE or TM waves, a subscript is used to express the electric field change. The first and second indices indicate the number of half-wave changes of the electric field on the wide and narrow sides, respectively. The first 12 TE modes in a rectangular waveguide and the first six modes in a circular waveguide are given in Figure 3 (Jensen, 2012).

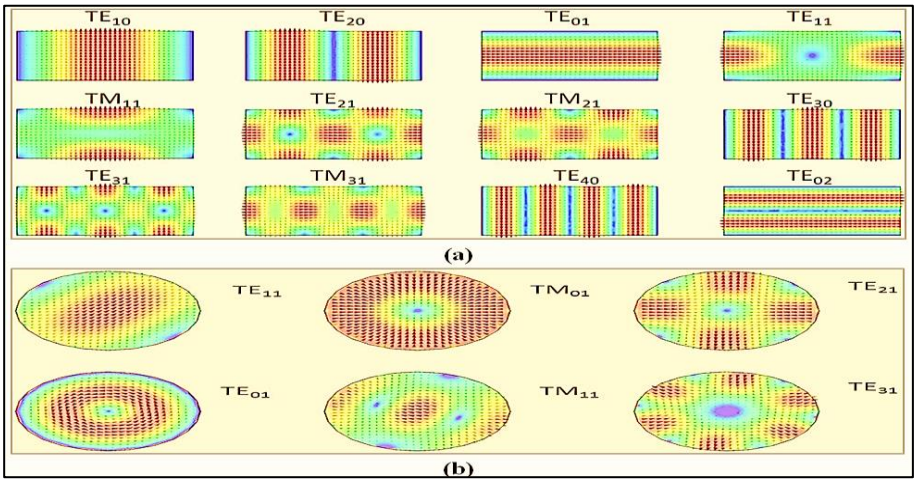

Figure 3. The propagation modes in waveguides (Jensen, 2012)

3. VELOCITY AND IMPEDANCE IN WAVEGUIDES

The propagation speed of the wave that follows the change limits of the modulated wave is called the 'Group Velocity (*Vg*)'. It means if there is modulation in microwave propagation, the group rate is involved. On the other hand, the change of the carrier wave is with the 'Phase Velocity (*Vp*)'. Hence, these two types of velocity are important terms for waveguides (Pozar, 2012). Since the best power transfer occurs when the waveguide impedance matches the source and load, the characteristic impedance is another important subject (Edminister, 1993). In this section, the concepts of group velocity, phase velocity and impedance are briefly explained.

3.1. Group and Phase Velocity

'*Vg*' can be described as the rate at which the wave propagates along the waveguide. It can also be expressed as the straight-line velocity of propagation of the wave down the center line. However, '*Vp*' can be described as the propagation velocity of the point on the waveguide wall where the wave hits (Carry, 1989). *Vg* and *Vp* are calculated by Equations (1) and (2), respectively (Ellingson, 2020).

$$V_g = \frac{1}{\sqrt{\mu\varepsilon}} \sqrt{1 - \left(\frac{f_{mn}}{f}\right)^2} \quad (1), \qquad V_p = \frac{1}{\sqrt{\mu\varepsilon}} \frac{1}{\sqrt{1 - \left(\frac{f_{mn}}{f}\right)^2}} \quad (2)$$

where *m* and *n* are the propagation mode indices, f_{mn} is the cut-off frequency, f is equal to $w/2\pi$ where *w* is the angular velocity. In addition, ε and μ are the permittivity and permeability, respectively. It is known that the space velocity (*Vc*) of the propagation in free space (the speed of light) is equal to 3 x 10^8 m/s. According to the Equations (1) and (2), *Vg* is always less than *Vc*. This is due to the fact that the path travelled by the wave while bouncing back and forth is longer than the straight path. But surprisingly, *Vp* is faster than both the *Vg* and *Vc*.

3.2. Characteristic Impedance

The waveguide's characteristic impedance varies for different waveguides types. In other words, it has not a unique value. It can be calculated as a coefficient ratio of narrow and wide wall dimensions and wave impedance in the rectangular waveguide. However, it is found by a coefficient and its wave impedance in the circular waveguide. In the ridge waveguide, it is the ratio of the square of gap voltage to the transmitted power.

CONCLUSIONS

There are several TLs used to transmit high-frequency electromagnetic signals with minimum reflections and losses. In this study, waveguides which are one of the basic and important microwave TLs were introduced. For this purpose, first of all, an overview of the general features of the waveguides was made. Then, the advantages, disadvantages and types of the waveguides were mentioned. After that, propagation modes in waveguides (TE-mode and TM-mode) were examined, some modes in the rectangular and circular waveguides were shown. Furthermore, velocity and impedance terms which are the important issues for waveguides were described. In summary, the state and importance of the waveguides in microwave engineering can be understood in this chapter.

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CHAPTER 8

FOLLOWING THE TRACES OF SEDAD HAKKI ELDEM: A CASE STUDY ON THE CONTRIBUTION OF VIRTUAL REALITY BASED DOCUMENTARY GAMES TO ARCHITECTURAL EDUCATION

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INTRODUCTION[7]

Digitalization and communication technologies are the distinguishing features of the 21st century. Their reflections are visible on every aspect of life from work to education, from commercial activities to socialization. Especially after the widespread use of the internet and mobile devices, digital technologies have become an integral part of our everyday lives. One aspect of those digital technologies is digital gaming, which is recently addressing not only children, but every age group through various genres. In a global context, digital games are both products and producers of collisions between domains such as work and leisure, fact and fiction, and education and entertainment (de Castell & Jenson, 2007). Some of the genres of digital games are considered only time-consuming and fun activities, as some others can be didactic because of their contents and methods. One of these didactic genres is called *documentary games* that bring real-life and gaming experience together.

The concept of "documentary games" is an emerging phenomenon that attempts to align the gaming experience with a non-fictional background through historical accuracy. The modelling of real-world systems and interactions in games is not a new method, but the specificity and authenticity of the models is the part that separates documentary games from other genres of gaming (Fullerton, 2008). Even though the very definition of documentary is controversial in terms of objectivity and accuracy, documentary games might be considered as a contribution to *the artful reshaping of the historical world* (Raessens, 2006). Accordingly, they provide significant benefits to the gamer's experience with a realistic and historically accurate environment. An important support for the documentary games is the use of virtual reality technologies, as they ensure an immersive realistic experience for the user. Virtual reality allows users to forget the existence of the physical environment and believe that they are in the virtual world through the property called *transparent immediacy* (Lee et al., 2017). Thus, the effect of the gaming experience on the user becomes more permanent and persuasive.

Interactive computer activities intended for education have been developing in the last decades (Magelssen, 2008). Regarding their experiential structure and the aim to stimulate feelings and emotions, documentary games

[7] This chapter is extended version of the conference paper titled "Virtual Reality Based Documentary Games' Contribution To Architectural Education: A Case Study" which was presented in International Social Sciences Congress in the Age of Digital Transformation, 11-12 November 2022, Istanbul.

in virtual reality environments potentially contribute to learning processes as well. Therefore, they can be utilized in education, especially in disciplines that encourage learning by doing methods. One of the disciplines that cherishes education through experience is architecture. Major parts of the education curriculum in architecture are based on learning by doing activities. Additionally, the connection between architecture and digital technologies is very strong (Ceylan, 2020). Hence, a documentary game in virtual reality environments can be considered as a suitable method to support architectural education.

This chapter presents a study that attempts to use a documentary game in virtual reality environment as a contribution to architectural education. The study is conducted in the scope of a scientific research project supported by Bahçeşehir University in Turkey and is being executed by a multidisciplinary team consisting of architects, interior designers, educators, digital game designers, and developers. In the scope of this research, the background of the initial steps and preliminary outcomes of the production process are highlighted, in order to form a basis for future studies focusing on the further phases of the project. The main aim of the study is to investigate the relationship between documentary games in virtual reality environments and architectural education. Researchers claim that digital games have a highly positive influence on educational activities (Wernbacher et al., 2020). The level of positive influence may increase proportional to the gaming experience being an immersive one. Therefore, the use of virtual reality technologies in the game may have a significant contribution to the educational outcomes through its full scale and virtual life experience that addresses multiple senses. The study also aims to examine the experience of common users in this documentary game. Even though the documentary game targets mainly architecture students, it will be open for other users as well. The opinions and impressions of common users over an architectural game in virtual reality and their level of awareness on the physical environment presented in the game is for the authors an interesting potential outcome of the study.

The genre of documentary games is relatively new in the gaming industry. Although there are already games focused on certain historical events such as the World War II, the French Revolution, or some ancient wars, their focus is not directly on the physical environment. Therefore, their contribution to user experience in the physical space is limited. Additionally, virtual reality as an emerging technology is only recently developing to create

more realistic and accurate virtual environments. There are recently only few examples that offer an immersive VR experience in a realistic and historically accurate built environment. This study puts the built environment in its focal point and tries to present it accurately and realistically, with the documents derived from historical sources such as original blueprints and photographs. The VR experience as the outcome of the study might be a significant contribution to architectural education and a novel approach for developing documentary games in VR environments with educational purposes that directly highlight the physical environment itself.

1. HISTORICAL FOUNDATIONS

Within the framework of the research project and to form the foundation of the documentary game, the modernization movements and the changing understanding of architecture in Turkey at the beginning of the 20th century were studied. This period is an important and experimental process in terms of the transition from traditional architectural understanding to modern architecture in Turkey. Moreover, the buildings of this period are among the significant elements of the architectural heritage with their unique styles and characters.

Undoubtedly, one of the most striking architects of this period is Sedad Hakkı Eldem. He lived between 1908-1988 and worked as an architect during the development period of the new Turkey and is considered one of the most influential architects of his time. Rather than using the contemporary language and forms of the West directly, Sedad Hakkı Eldem created his architectural production style by giving references to traditional Turkish architecture in his designs. Thus, he has pioneered the search for national expression in modernism (Bozdoğan, 2012). According to this, the research project focused on the architect Sedad Hakkı Eldem and his buildings.

1.1. Architectural Heritage Preservation

Buildings that make up the architectural heritage of a city are the most concrete reflections of the lifestyles, socio-cultural characteristics, and even economies of past societies. Architectural heritage is the building and building groups that are the common property of humanity and should be transferred to the future with their original qualities that have survived to the present day, of different scales and qualifications, and that should be preserved with all their values and in accordance with integrated conservation principles (ICOMOS, 2013). In this context, it is essential to protect these structures and ensure their sustainability in every sense, in terms of preserving cultural identity and

transferring it to future generations. Although the issue of architectural heritage protection seems to be on the agenda of many cities, significant losses are experienced in the urbanization processes. The destruction of historic city centers, old housing stock, and monuments continues in most developing countries, either with active clean-up and regeneration policies or passive policies of doing nothing to stop the gradual degradation and decline of such areas (Steinberg, 1996). On the other hand, structures located in more touristic areas are relatively lucky to survive.

Istanbul is a city with a multi-layered urban structure that has hosted many civilizations throughout history. Consequently, it has a rich urban texture consisting of buildings from different periods. In this context, it has an important architectural heritage. Buildings from the beginning of the 20th century are also among the crucial parts of this heritage. This period is a process of change and transformation in terms of expressing the transition from traditional Ottoman culture and life to Western and modern life. Within the framework of the new republic's modernist attitude, these structures, which draw attention with their unique features, also point to a radical change in the architectural texture of the city.

Although the architecture of early republican period has an important place in the architectural history of Turkey, it does not draw enough attention from both the professional architectural environment and architectural education. Today, it can be seen that some structures of this period are preserved, some of them have undergone various structural interventions, and some of them are destroyed. Generally, protection is shaped by the value of antiquity. This is a handicap for relatively recent buildings of architectural heritage. Furthermore, aesthetic qualities are problematic for near-term structures that require expertise to be defined (Polat, 2018). Regarding the potential of the architectural products of the Republican Era to be "cultural heritage," there are substantial deficiencies in theory development, criteria formation, determination of legal status, etc. (Kayın, 2007). A similar situation exists for the works of Sedad Hakkı Eldem, whose different structures have been discussed within the framework of this study. In addition to these, it is noteworthy that the resources, inventory, and documentation of this period’s structures are quite inadequate. In this context, the research of Sedad Hakkı Eldem buildings within the project's scope is essential for the recognition and documentation of cultural heritage. In addition, presenting this work with the idea of an experiential game will create an awareness of this period for many users, especially architects and architecture students.

1.2. Selected Buildings

Within the scope of the study, three different projects of Sedad Hakkı Eldem were selected: Ceylan Apartment (1932-1933), Taşlık Coffee House (1947-1948), and Atatürk Library (1973-1975). The selected buildings belong to three different periods of the architect's career. In addition, the selected buildings have different functions. Thus, it was also aimed to present a spatial variety to the users during the game. Today, Ceylan Apartment consists of residences and offices. Due to the change in function, the original design of the building could not be adequately preserved, and various additions and changes were made to its facade and interior. The second building, Taşlık Coffee House, was completely destroyed. This is also one of the main reasons for choosing this structure. Lastly, the Atatürk Library maintains its library function by relatively preserving its general architectural character.

Ceylan Apartment | Taşlık Coffee House | Atatürk Library

Figure 1: Building Photos

Ceylan Apartment is one of the most important residential buildings of the Early Republican Period. The Early Republic refers to a period in which the understanding of housing was redefined. This was a period of transformation in which the traditional culture of living was replaced by “modern housing” discourses and “apartment” buildings as new forms of housing production (Şahin & Şener, 2021). In this context, Ceylan Apartment is a foremost “modern” sample of its period with its structural system, plan scheme, and facade features. This building, which was constructed in 1932-1933, is also considered the first important, large, and carefully detailed structure of Sedad Hakkı (Tanju, 1996). The building is located on the Cumhuriyet Street in Taksim, next to Gezi Park. Since it is located on a triangular corner plot, it has a wide panorama.

The second building, Taşlık Coffee House, is considered as one of the architect's most important works. The building was built between 1947-1948

in Maçka, in the area where a luxury hotel is located today. It was built with the reinforced concrete technique, and its facades were covered with wood. It has a plan type with a central sofa. This type of plan is a widely used layout in old Turkish housing. The plan of the coffee house is similar to Amcazade Köprülü Hüseyin Paşa Mansion, one of the oldest examples of Ottoman civil architecture. This building, which was restored by the hotel and used with different functions, is not standing today.

The third building of the study is the Atatürk Library. The building was constructed in Taksim between 1973-1975. It was planned as a cultural complex but later constructed only as a library. The building consists of smaller hexagonal modules positioned around a large hexagon that forms the center. This building can be described as the late period work of the Sedad Hakkı Eldem. It has more comprehensive documentation compared to the Early Republican Period buildings of the architect. It is possible to reach many plans, sketches, and images of the building. The building still serves as a library.

2. PRODUCTION PROCESS

The general process of the study can be summarized as follows: Conducting research on the life and architectural career of Sedad Hakkı Eldem and revealing relevant documents, conducting research on the buildings to be used in the study (Ceylan Apartment, Taşlık Coffeehouse, Atatürk Library), accessing the technical drawings of these buildings, transferring the technical data of the selected buildings obtained from printed sources to the digital environment (AutoCAD), completing the missing parts via photos or other documents, converting 2D drawings to 3D models (Sketchup), transferring the prepared model to the 3Ds Max program and adding the remaining details here, and finally exporting the final model to Unreal Engine and making the model interactive.

The technical drawings found from the sources were often non-scale drawings from printed publications. While some of these sources had measurements, some had units that could be used as a reference. These studies were drawn in the AutoCAD environment, in the most appropriate proportion to the actual size. In this context, although the technical drawings made in AutoCAD are not 100% correct, it can be said that, in general, they are created in proportion to the accurate dimensions of the buildings. For all three buildings, only the plan drawings were transferred to AutoCAD. Details such as the height seen in the sections were articulated during three-dimensional

production in Sketchup. Additionally, to each structural element was assigned a different layer, so that they could be handled separately during the 3d modelling process.

After the technical drawings of the structures were completed, they were transferred to Sketchup. Then, each production unit was grouped separately and started to become three-dimensional. For example, the columns were raised by grouping them separately. In addition, if there were relevant details in the sources found, units were started to be increased in line with the specified measurements. If not, it has been tried to adhere to the heights by proportioning the photographs found. In this way, a rough model was created. Details such as doors, windows, flooring were added later.

As the next step, the model completed in Sketchup has been imported into 3Ds Max. The images, videos, and plans found were rechecked, and details were added that could not be added in SketchUp. Then, the model was divided into parts to be topologically correct. These parts were exported to the Unreal Engine which is game engine separately. A plug-in of Unreal Engine called data smith using 3Ds Max was used at this stage. Drawings that were two-dimensional in AutoCAD and three-dimensional in Sketchup have become interactive with the help of Unreal Engine.

The works for the three structures were examined separately under the following sub-headings.

2.1. Ceylan Apartment

Ceylan Apartment was one of the first projects of Sedad Hakkı Eldem. Therefore, it was problematic to reach data, especially in digital media. The plans and sections of Ceylan Apartment were accessed from the Arkitekt Journal database (Eldem, 1933) of the Chamber of Architects. In cases where the drawings were not sufficiently readable, photographs found on the internet were used. In addition, one of the inhabitants of the building, was contacted, so it became possible to access the interior details of the building. During this visit, many photos were taken from the common areas of the building and the interior of the apartment. A short informal interview was held with the inhabitants. This visit was very useful in transferring some points to the model that were not clear in the technical drawings and in the photographs. Regarding the 3d modelling of the building, an approach of mass to details was developed. To understand the building in general and establish proportional relations between different elements, a quick

conceptual model was formed. Thanks to this model, it was possible to easily see which details of the structure were missing in three dimensions.

The building consists of 7 floors in total. Since the floors from the 1st to the 5th floor are the same, a single model was made and then copied. The core of the building continues each floor, so that the modelling process started from there. Details such as windows, doors, stairs, and other interior elements were added in the following phases of modelling. After the conceptual model, the process of the detailed model started. Columns and walls were raised according to the heights in the technical drawings, and then window and door details were added. At the last stage of the Sketchup model, details such as balcony, balcony railing, parquet were added. For the remaining details, the 3Ds Max program was used. Then, the model was transferred into the Unreal Engine and interactive objects were added.

Figure 2: Ceylan Apartment, photo-model comparison

2.2. Taşlık Coffee House

Taşlık Coffee House is a building that does not exist today, unlike the other two. In this respect, it was not possible to go and visit the place; as only the printed sources could be examined. Especially the drawings and visuals obtained from the Arkitekt database of the Chamber of Architects played an important role in transferring the building to the computer environment (Eldem, 1950). The fact that the images of the interior are very few made it necessary to model some parts of the building regarding proportional relationships. For example, since it is known that the sitting height was taken

as approximately 45 cm, the other heights were calculated by proportioning to this measurement and applied to the model.

The fact that Taşlık Coffee House has a more right-angled plan compared to the other two structures has provided convenience, especially when drawing in AutoCAD. Since the roof has a unique form and structure, it is modelled and emphasized with details separately. After the general state of the building was fully revealed, details such as roof elements, walls, windows, interior were dealt with. The details appearing on the interior ceiling, together with the fountain in the middle occurred in the final phase of the building model. After the necessary elements were modelled in Sketchup, the rest of the details were added in 3Ds Max. Then, the model was transferred into the Unreal Engine and made interactive with touchable and holdable objects.

Figure 3: Taşlık Coffee House, photo-model comparison

2.3. Atatürk Library

Atatürk Library is the building that has preserved its original features and elements more than the other two. For the building, like the others, firstly, the internet resources were searched for documentation. Compared to the other two, it was easier to reach reliable data because it is a more recent work. Almost all the existing drawings were legible. As a result, it has been relatively easy to transfer these hand drawings to digital media. However, in particular points of the drawing, it was clear that the library was not the same as its original state. Therefore, the building was visited and examined to clarify those points. During the visit, the deficiencies and differences encountered in the drawings were noted. Afterward, these parts were revised on AutoCAD. Based on the final technical drawings, 3d modelling process on Sketchup started.

Atatürk Library is being used as the main hub in the VR experience. The collected images and objects are exhibited here, and visual elements such

as videos and photographs are displayed in the conference hall of the library. These elements have been added in Unreal Engine, for making the model interactive. Additionally, environmental details such as trees and buildings have also been added to the game experience.

Figure 4: Atatürk Library, photo-model comparison

3. OUTCOMES OF THE VR EXPERIENCE

The overall experience of visiting the three buildings in virtual reality environment holds remarkable outcomes for the rest of the research. Firstly, the quality and features of the virtual models are crucial for a desirable gaming experience. The detail level needs to be high enough to maintain a realistic immersive experience, but the fluency of the process is also important. Too many details which mean too many polygons and vertices may cause performance problems in the processors. Thus, the rendering quality of the virtual environment needs to be in a balance between visual quality and fluency.

Secondly, compatibility between various software is a very effective issue in the production phase. In this study, various 3d modelling software and gaming engine were used, and eventually, the workflow was focused on AutoCAD for technical drawings, Sketchup and 3ds Max for modelling, and Unreal for the gaming engine. The compatibility between the programs ensured the continuity of the workflow. However, there have been several points where the work had to be redone due to format transformations.

Lastly, interactivity is crucial for a gaming experience in the virtual reality environment. The first initial tests of the experience without interactive elements were like a usual VR experience in an architectural model and were not triggering much curiosity. But after the interactive elements were added, the experience became much more exciting and immersive. The quaintness

level of the experience increases proportionally with the number of interactive elements it includes.

CONCLUSION

As the conclusion of this phase of the research, it may be stated that the contribution of digital games to education is proven by researchers from various fields of work. This study approaches this phenomenon from the perspective of architectural education by trying to contribute to the training of young architects through a gaming experience in immersive virtual reality environments. Moreover, it is also effective in terms of creating awareness among the society for the protection of cultural heritage.

Moreover, the documentation of existing architectural work from pre-digitalized periods is crucial. The buildings in the scope of this study are elements of cultural heritage, and their transfer to upcoming generations needs to be ensured through the digitalization of the archives. Even if their physical existence is at stake, digital archiving methods help for the preservation of their original situation and conditions.

As the study is still under the production phase, the authors will gain more reliable and scientific data from beta tests and end-user experiences. This study is a pilot project for a thorough research planned for the future. After all the production, post-production, and experiment phases of the study are finalized, their methods will be utilized for the execution of further similar projects that focus on different periods, different architects, styles, and buildings. When the database of the library becomes richer and wider with more projects, it will be more effective and beneficial for architectural education, as well as the preservation of the cultural heritage.

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CHAPTER 9

BASIC EXCAVATION METHODS IN BUILDING-FOUNDATION INTERACTION; TOP-DOWN METHOD IN HIGH-RISE BUILDINGS

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INTRODUCTION

High-rise buildings are central to contemporary architecture (Ali and Moon, 2018). Due to the increasing need for housing and buildings with the increasing population day by day, horizontal structuring is being replaced by vertical structuring (Lotfabadi, 2014). Vertical structuring has led to the emergence of high-rise buildings. This buildings have become increasingly common over time. In terms of engineering and architecture, it is at an important point in the building stock by making progress in the context of technic and design. The fact that high-rise buildings are in the category of mega-structures requires that these structures be addressed in terms of economic, environmental and socio-cultural aspects. In economic terms, the use of innovative technologies also imposes a burden on costs. Making effective solutions at the least cost also strengthens the strategic dimension of building planning.

It is important to use construction site management effectively from the foundation to the tower. In the construction process, economic planning according to transportation and construction techniques should be considered from the design stage. The condition of the buildings in the immediate vicinity should be reviewed by looking at the state of the built environment and a high-rise building design should be made in accordance with the existing structures and protect the integrity of the city. Facade, plan and detail analyzes should be carried out by making plans according to the climate factor. In high-rise buildings that require complex construction systems, the energy planning of the building should also be done in advance. Energy saving analyses should be applied with the efficient use of renewable energy sources (Takva et al., 2022a). From a socio-cultural viewpoint, the potential of the region should be brought to the fore by considering the economic levels, living standards, lifestyles and cultural understandings of the people in the region where the design will be applied. It can be seen that versatile parameters should be considered in the design of high-rise buildings. These parameters should be analyzed in detail from the design of the building to the implementation process.

Looking at the history of high-rise buildings, functional efficiency is at the forefront in the first high-rise buildings. The use of environmentally friendly practices and renewable energy sources has remained in the background (Lotfabadi, 2014). Today, energy and material use are the primary design parameters (Fracastoro and Serraino, 2011). Until the late 1600s, there were no high rise buildings, except for a few six or seven-story

Roman apartment buildings and gothic cathedrals in Europe. Buildings ranging from five to seven stories were built in Paris in the 17th century. High-rise buildings began to be built in the 1860s. In 1885, a ten-story building was implemented by William Le Baron Jenney in Chicago. 5 years later, Sullivan's Wainwright Building took its place in the building stock (Gifford, 2007). From the 1920s to the 1930s, the high-rise building typology was seen as an architectural force. The United States is one of the countries where high-rise buildings emerge. The Tribune Tower, which was built in Chicago with a height of 141 meters in 1925, the Chrysler Building in New York with a height of 319 meters in 1930 and the Empire State Building with a height of 381 meters in 1932 are important high-rise buildings (Guedes and Cantuária, 2017). The Empire State Building is one of the last representatives of the art-nouveau movement and is shown as the 'golden age of the skyscrapers' (Gonçalves, 2010). After these structures, the high-rise building market expanded and spread, and today, high-rise buildings are encountered in various parts of the world.

In high-rise buildings where complex construction systems are used, the advantages are also high, although the construction difficulties are high. The often repetitive type of floor plan involves material savings and standardization. With the occurrence of standardization, low-cost systems can be developed. Modular high-rise systems also provide cost-effective use (Takva et al., 2022b). High-rise geometry is also economically decisive. Complicated and complex geometric shapes affect the planning process of design and implementation (Takva and İlerisoy, 2021). Mega columns and cores, outriggers and rigid frame systems form complex structural systems (Kamgar and Rahgozar, 2017; Günel and Ilgin, 2014). Diagrid structures also provide geometric freedom in creating flexible designs for high-rise buildings (Mohsenian et al., 2020; Moon, 2008). The advancement of scientific processes and technological innovations in engineering offer new construction methodologies (Szolomicki and Golasz-Szolomicka, 2019). Long-lasting and multi-functional building classes are created with the use of sustainable materials (Ilerisoy and Takva, 2017; Oldfield et al., 2009). The use of reinforced concrete, steel and composite building materials is common in high-rise buildings (Pan et al., 2021; Liew et al., 2019; Lu et al., 2013). High-rise buildings take up less space in terms of land use compared with horizontally positioned structures. A better use of daylight and thermal mass is provided. Because of multi-functional design, versatile experiences are offered for users (Lotfabadi, 2014). Towers, skyscrapers, or high-rise

buildings represent the advancement and modernization of urban construction by making a more efficient use of dense urban land (Zahiri et al., 2016). Choosing the location of high-rise buildings in cities has strategic importance. High-rise buildings applied in any region provide mobility by attracting the business potential to that region and creating new business opportunities (Tamošaitienė et al., 2013). For this reason, focal points in cities are developing toward regions with high-rise buildings. It emerges because of the dominance of high-rise buildings in city planning and that they are an indicator of power.

Today, with the developing technology, knowledge and experience, excavations with a depths exceeding 30 meters can be made on the foundations of high-rise buildings. Before deep excavations are carried out, the groundwater condition of the ground and the soil structure should be determined because of certain tests. Failure to perform adequate tests may cause collapses during infrastructure works during or after excavation. In addition to these, excessive deformations that may occur on the excavation facades during and after excavation can damage the surrounding environment and infrastructure such as neighboring buildings, roads and pavements. To prevent these situations that may cause damage to the structure, appropriate excavation methods should be selected and appropriate shoring systems should be preferred (Arıkoler, 2011). The main excavation methods are open-cut, cut and cover and top-down technique (Figure 1). In this study, excavation methods were explained and sample structures were analyzed by examining the top-down technique in high-rise buildings. The ground building elements applied in the context of the top-down method were investigated by referring to the architectural and structural features of 8 examples of high-rise buildings. It is aimed to create a reference for future studies by making evaluations about these high-rise buildings.

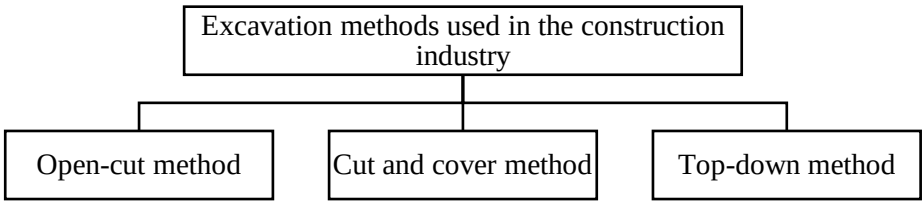

Figure 1: Major excavation methods (by the authors)

1. BUILDING FOUNDATION EXCAVATION METHODS

Excavations cover economic, safety and technical issues. Excavation operations consist of leveling, digging, compaction and filling operations (Kim et al., 2020). Heavy vehicles such as excavators, dozers, graders and dump trucks are involved in these operations (Park et al., 2022). Deep excavation projects in the construction industry also pose a risk factors and require expertise (Valipour et al., 2017; Zhou and Zhang, 2011). With an increase in building heights in high-rise buildings, the number of researches on deep excavations is also increasing. The physical condition of the area where the high-rise will be built is effective in determining the excavation methods in the structure-ground interaction. Elements such as the empty or built environment around the building, the liquefaction status of the land, its strength, feasibility, frost level and foundation depth also affect the construction technique. The design of high-rise buildings often requires deep ground excavation, depending on the proximity of the surrounding structures. Therefore, it has the potential to damage surrounding structures (Sekhavatian and Choobbasti, 2019). While excavating, it is necessary to be sensitive to the work machines and to consider the effects of vibration. At this point, engineering calculations and structural analysis must be made (Jiang et al., 2020). After detailed soil investigations, temporary support systems (pillar levels, anchor design and dimensions) and excavation slope support system (in case of rock, inclination angle, etc.) should be installed (Sindhwani et al., 2022). High-rise structures usually rise on piled raft foundations. Pile raft foundations are used to transfer the structural load from the top of the structure to the ground. Structures can be constructed at soft to medium soft soil levels, with piles determined based on calculations. It is important to consider the dynamic effect of a pile element as well as its static effect (Bazaz et al., 2021; Liyanapathirana and Nishanthan, 2016). The increasing population density, the number of building floors, the need for parking and technical services have brought about an increase in the number of basement floors. Therefore, the number of deep excavations is also increasing (Hong et al., 2013). These excavations are carried out on a wide scale, from metro stations to high-rise buildings (Kung, 2009). Three different excavation methods were investigated to understand the deep excavation techniques.

1.1. Open-cut Method

The open-cut technique, which is one of the excavation techniques to reach the required depth, is one of the traditional excavation systems. It is

widely used in the laying of underground pipelines and metro station constructions, as well as in the building construction processes (Tsung et al., 2016). It is the most common method of deep excavation. Exploring the existing equipment, digging and shoring, depending on the terrain, completing with dewatering and backfilling are the stages of this system (Onsarigo and Adamtey, 2020). Figure 2 illustrates these stages simply. The sides of the excavation maximize the angle of inclination, providing protection and stability against subsidence of the side excavation areas. During the excavation process to the required depth and soil level, the basement is built from the bottom up. After the basement works are completed, the excavated areas between the basement and the side slopes are filled. In the open-cut technique, afforestation or spraying concrete to protect the sloped sections prevents soil erosion, especially on rainy days. In some cases, lateral supports such as sheet piles are used to reduce soil movement and differential settlement (Chew, 2017).

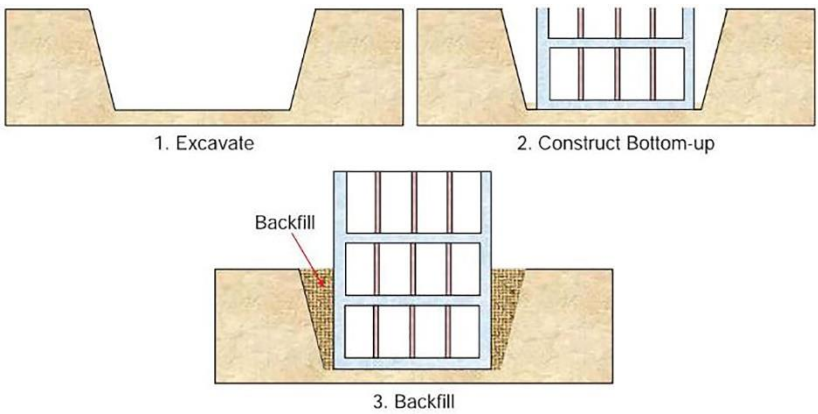

Figure 2: Stages of the construction process in the open-cut technique (Chew, 2017)

Although it is a simple and fast method, it has downsides due to noise, dust and the possibility of damaging the floors of the surrounding buildings (Tsung et al., 2016). In built-up urban areas, this technique is often not a practical solution as space constraints and adjacent ground movement. Since the soil has a direct effect on the slope in the open-cut technique, it is necessary to analyze the geological situation of the area in detail. The main limitation of this technique is that the area is exposed to weather conditions. During a disaster such as a flood, it is necessary to provide a temporary

drainage system and drain the water (Chew, 2017). A limitation of the method is the discharge of excavation material outside the construction site and the backfilling problem. During the execution of these processes, especially in urban areas and densely populated areas, it creates a negative impact on traffic, the environment, local businesses and residents (Onsarigo and Adamtey, 2020). Compared with trenchless pipe replacement, it has emitted approximately 80% more carbon dioxide emissions on average, which has a negative impact (Ariaratnam and Sihabuddin, 2009).

1.2. Cut and Cover Method

The cut and cover technique is generally used in the built environments where the land area is limited. It is frequently encountered in the construction of subway structures. There are also areas of use in high-rise buildings (Tan and Wei, 2012). During excavation, the edge areas were lowered vertically. However, this poses a major challenge to ground stability, especially for deep basements. Additional support is required to support the excavation as the retaining wall excavation progresses down to the deep basement level. The next basements were then built in the traditional way. In the buildings rising from the basement to the ground level, the temporary pillars are removed from the bottom to the top, respectively (Chew, 2017). Figure 3 summarizes the steps of this method. The selection of the soil support system should be chosen by considering the ground movements, the groundwater and condition of the building foundations around the area to be excavated (Kaul, 2010). During construction, permanent floor slabs also serve as the support provided by the struts, significantly reducing the need for additional support and extensive formwork. This provides time and cost savings (Behnia et al., 2021).

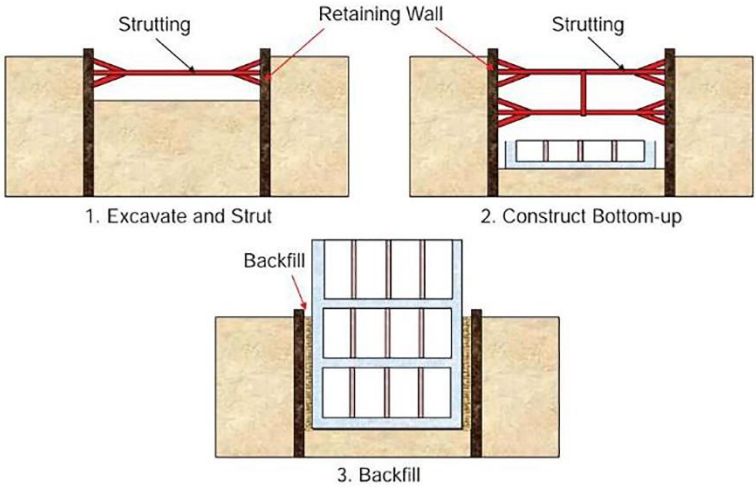

Figure 3: Construction phase in the cut and cover technique (Chew, 2017)

Basement constructions with diaphragm walls around a cramped area can be made within this method. Impermeable diaphragm walls prevent water from flowing into the excavation area after any precipitation and provide resistance to adverse weather conditions. The diaphragm wall is supported by side supports and heavy planks (Behnia et al., 2021). A working stage is being built to provide access inside and outside the site, to provide a platform for operating mechanical plants. Excavations can reach the basement level mainly by arm excavator. The excavated soil is transported outside the construction site by trucks. As the excavation progresses to a deeper level, smaller excavators are assigned to the basements for excavation. The excavation edges are reinforced using opposing lateral supports with various loads. With the further excavation progress, intermediate vertical posts and bracings are used in the depths. The stresses in the poles are controlled to ensure proper load transfer. After excavation, the basement slabs are built from bottom-up and the pillars are removed as the construction and ground gain strength. Where an open area is needed for access or it is not economical to support the shape of the area with horizontal battens, different mechanisms are applied (Chew, 2017).

1.3. Top-down Method

Open-cut and cut and cover techniques adopt the traditional principle of bottom-up construction, where excavation is done at the bottom first. The

basements and upper floors are built upward. Contrary to these techniques, in the top-down technique, the top-down construction principle is applied. As the excavation progresses, it forms the permanent structural elements of the basement floor are downwards. Unlike bottom-up construction methods, this technique does not leave a dug open pit that could result in soil movement and water retention. This method is a suitable solution for deep basements where soil and water movements need to be minimized, time constraints and construction site space are limited (Chew, 2017). In this system, floor slabs are generally used as a lateral support along with the retaining wall and steel profiled piles during excavation (Arıkoler, 2011). During the construction of the top-down technique, permanent perimeter walls (plate pile, diaphragm wall, secant pile, adjacent bored pile) can also be applied. More concrete should be poured at the floor level at the furthest level from the ground level (Chew, 2017). Figure 4 shows the stages of the excavation method. It offers the advantage by eliminating the requirements for temporary pillar supports used in the traditional construction method (Hong et al., 2010). Most of the system loads are covered by floor slabs and rigid concrete layers (Tan and Li, 2011).

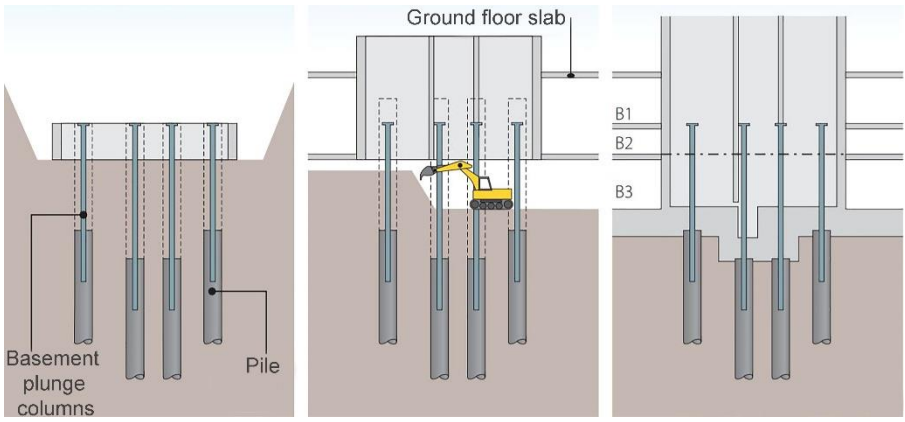

Figure 4: Construction phase in the top-down technique (Takva et al., 2022c)

It is known that the top-down construction method was first used in Japan. In the 1950s, it developed with the diaphragm wall combination (Tang and Zhao, 2016). This method saves time in constructions that require deep excavation, while the excavation of the basement floors, and the flooring production continues, while the production of the upper floors continues. It is

an advantageous method as it supports the ground perimeter wall at the upper level without the need to support it with a pillar system. It also has many positive aspects on deformation and displacement control (Wang et al., 2010). It enables rapid production in areas with urban density and sensitive areas with historical buildings. It reduces the dust level and the carbon production. The fact that all work is carried out at the construction site creates an advantage by preventing the increase in traffic density in the surrounding area (Takva et al., 2022c). Generally, the top-down strategy is suitable for most ground conditions and can be applied even in the weakest ground conditions and soil conditions. It can be used in subway stations, underground car parks and high-rise buildings with deep basement excavations since deformations are limited and form a rigid construction system (Arıkoler, 2011).

Looking at the construction process, primarily surrounding retaining walls are created. Holes for piles are dug in the planned places in the ground. Next, the installation of piles and profiles is carried out. This process also involved the placement of load-bearing columns. The placement of the profiles with the stud method can be done either at this stage or before the concrete pouring. After the placement stage, the first stage of excavation is started. The slab concrete of the first basement floor is poured, and the beam productions are completed. Installations are laid by switching to the floor infrastructure production. In the second stage of the excavation, the intermediate basement floors are excavated and the floor concrete is poured. This process is repeated until the desired optimum depth is reached. The construction of the superstructure also continued simultaneously in this process. The foundation is being manufactured and the basement floors are under construction. To protect the from groundwater, the water level is drawn to the lower parts and dewatering is carried out. The process ends with the completion of the drainage systems.

2. EXAMINATION OF THE TOP-DOWN METHOD ON EXAMPLES OF HIGH-RISE BUILDINGS

The top-down method has become one of the most stable excavation methods in buildings where the foundation depth increases. This method, which shortens the construction period, offers ideal solutions for complex construction systems. It gives positive results in terms of cost by saving on the elements that provide anchorage and foundation support. In this system, bored piles with a high load-bearing capacity are used. The vertical positioning and alignment of the piles are critical points. Most high-rise structures are

supported on bored pile foundations. A rigid system is obtained by increasing the core construction on these piles (Parker and Wood, 2013). In this section, examples using the top-down method, which form the foundations of 8 high-rise buildings, are examined. Structures and their properties are given in Table 1.

2.1. Forum Office Tower

The Forum Office Tower, implemented on Orchard Road in Singapore, is a 17-floor office building with a shopping mall podium on its side. The building has a geometry close to a rectangular plan. Diaphragm walls with T-shaped support elements were used on the basis of the structure, which was built in 1986. It has been calculated that loads of up to 1,600 tons can be carried by placing the bored piles. The piles are placed at a maximum distance of 10 meters. Due to the high water level, continuous diaphragm walls applied at a deeper level were preferred, unlike the general diaphragm walls, to transfer the loads of the columns to the load-bearing system. The structure, in which the top-down method is applied, continues its function today (Ramaswamy and Pertusier, 1986).

2.2. Central Plaza Tower

The Central Plaza Tower is 374 meters high and is located in Hong Kong. The total weight of the building, which has a triangular plan, is seven hundred and thirty thousand tons. Its widest side is approximately 74 meters, while the other side is approximately 64 meters long. It is located in the center of Hong Kong's business districts. The building, which is positioned on rough terrain, is very close to the seaside. There are also many high-rise buildings around the building (Li et al., 2005). Central Plaza, the tallest structure in Hong Kong from 1995 to 2003, was built as an office function to serve many people. This was implemented by local and regional companies using low-cost solutions. When the structure was completed, it was in the highest reinforced concrete structure class in the world. Caisson foundation application has been made (Cartier, 1999). It is one of the high-rise buildings where the top-down method has been successfully applied.

2.3. The Centre

The Centre is an office building located in Hong Kong. Construction started in 1993 and was completed in 1998. There are three basement floors, two of which are car parks and one floor is a store. The main structure is 292 meters high, reaching a height of 350 meters with the addition of roof and tower structural elements. The floors are usually repeated each other and

consist of 2183 square meters, but on the 70th floor, the plan of the building is getting smaller. The plan form of the building was obtained from combinations of triangular and rectangular geometric shapes. The tower is constructed of reinforced concrete and structural steel frame. The building, in which a piled raft foundation is used, is placed on 4 circular piles 24 meters high and 26 meters wide. Due to the narrow construction area and subway tunnels in central Hong Kong, the top-down method was used to construct the three basement floors. The typical floor plan is supported by 12 steel columns planned around the central core. The steel structure on the outer boundary of the building meets the wind loads (Forbes, 1997).

2.4. Shanghai World Financial Center

The Shanghai World Financial Center is a megastructure comprising composite, steel and concrete building materials. Located in China, the structure is 492 meters high. Any two floors are not identical to each other, but reinforced concrete walls and a steel frame repeat the structure. In addition to the museum and restaurant functions, there are offices on the mezzanine and mixed use. Designs for this structure began in 1993. By 1995, its structural design was completed. However, the suspended project took its current form with an alternative design in 1999. To reduce the weight of the structure, the thickness of the concrete shear walls in the service core was narrowed. A diagonal framed outrigger truss system is used in the structure. With this system, an extra reduction of the building load has been achieved. These conceptual changes are created an efficient and economic structural system. Structural steel and reinforced concrete are used in the load-bearing structure system of the building (Robertson and See, 2007).

2.5. The Troika

The Troika is located in downtown Kuala Lumpur. This project consists of three tower structures. Curtain walls were used extensively in the towers in the combined structure. At the ground level, there are four floors of commercial space that include offices, shops, cafes and courtyards. At the 24th floor level, a sky lobby called sky bridges has been built between the towers and has a view. The project includes apartments, offices, shops and restaurants. From the structural perspective, bored cast concrete piles with a diameter of 2 meters and a length of 49 meters form the tower foundation. Top-down construction method was used for 4-floor foundation work. In the main tower, the structural framework consists of large-span slabs supported by shear walls. Steel joints were anchored between the floor and curtain walls.

During the construction phase, precast formwork permanent panels were used. There are cantilevers close to 6 meters in the building. Areas where openings close to 18 meters are passed were built (Parker and Wood, 2013).

2.6. Heron Tower

The Heron Tower is located north of London city centre. The building, whose main function is the office, also has restaurants and sky bar functions. Unlike the first high-rise generation in the city, it is a building where innovative technologies are applied, adopting environmental requirements in the urban context with its monolithic form and transparent structure. The building area, located in a busy traffic artery with narrow sidewalks, has been revitalized with landscape elements and cafes and transformed into a new public space. London's view was evaluated by positioning the restaurant function on the roof level. With innovative technologies such as photovoltaic panels, the carbon emissions produced by the building have been reduced. The durability and robustness of the tower are provided by stainless steel material with transparent glasses. There are steel diagonal structural elements on the facade. Top-down method, one of the advanced construction techniques, was used to increase the bearing capacity of the foundation. This saves costs and construction time (Parker and Wood, 2013).

2.7. Abeno Harukas

The Abeno Harukas is 300 meters high and is located in Abeno, Japan. It is located in Osaka, at the junction of three main railroad transport arteries. Includes office, museum, hotel, observatory and shop functions. The building was completed in 2013 and opened for use in 2014 (Mizutani et al., 2015). The foundation of the building is a piled raft foundation consisting of piles and having a depth of 30.5 meters above ground level. Cast-in-place concrete piles are buried at a depth of 70 meters. The building has a rectangular plan. It has a complex building system. Seismic controls were performed and measures were taken against earthquakes and wind. Reinforced concrete and steel columns are used in the building. In the building structure, truss systems also play a supporting role. Rigidity is provided using outrigger systems. In the long term, the structural system was checked with durability calculations considering the horizontal forces created by wind and earthquake effects. The raft foundation is 1 meter high (Hirakawa et al., 2016).

2.8. Shanghai Tower

The Shanghai Tower is the highest building in Shanghai and China when its construction is completed. It is 632 meters high. The podium foundation construction was made with the top-down method. Advantages are provided by this method. More use of the construction area, minimizing the effect of noise and dust, saving on basic support elements and being environmentally friendly are some of these advantages. The ground where the building is located consists of soft earth material. The high-rise building had five floors of podiums and five floors of basements. The excavation depth of the tower is approximately 31 meters, while the podium is approximately 27 meters. In the construction of the basement floors on the basis of the podium, it was first descended to minus 3.8 meters, secondly to minus 9.7 meters, thirdly to minus 15.7 meters, fourthly to minus 19.7 meters, and fifthly to minus 23.4. The foundation construction was completed at minus 27.2 meters. The diaphragm walls used in the excavation, in addition to the retaining wall function, form the permanent foundation outer walls in the final version of the foundation construction. It also acts as a support mechanism against the requirements of waterproofing and structural loading tests (Jia et al., 2012).

Table 1: Features of the top-down method applied in high-rise buildings and foundation excavations (by the authors)

High-rise building	**Building image**	**Year of completion**	**Number of floors**	**Location**	**Building elements used in foundation excavation**
Singapore Forum Office Tower		1986	17	Orchard road, Singapore	T-shaped barrettes, diaphragm walls, bored piles
Central Plaza		1992	78	Wan Chai, Hong Kong	3 levels with perimeter diaphragm walls, piles

The Centre		1998	73	99 Queen's Road Central, Hong Kong	Four large circular 24-meter deep and 26-meter diameter piles, diaphragm walls
Shanghai World Financial Center		2008	101	Shanghai, China	Concrete-filled steel pipe friction piles, diaphragm walls
The Troika		2011	Tower A: 38, Tower B: 44, Tower C: 50	Kuala Lumpur, Malaysia	Bored cast concrete piles with a diameter of 2 meters and a length of 49 meters, diaphragm walls
Heron Tower		2011	46	London, United Kingdom	12 meters long piles, diaphragm walls
Abeno Harukas		2014	60	Osaka, Japan	Cast-in-place concrete piles, a Takenaka Soilcement Wall (TSW) using H-shaped steel
Shanghai Tower		2015	128	Shanghai, China	Multipurpose diaphragm wall, vertical props (hollow sectioned steel pipe columns (filled with high-strength concrete building material))

CONCLUSION

Building a solid foundation means a long-lasting structure. The service life of structures with insufficient foundation strength is shorter than a structures with sufficient foundation strength. The reactions of the structures sitting on a durable ground against different loads are also within stable limits. In a rigid and stable structure system, the effect of live and dead loads on the structure is transferred to the ground and then to the foundation. Therefore, the load transfer mechanism of structures without a solid foundation is weakened. The basic calculations of multi-storey buildings are directly proportional to their load-bearing capacities. While non-complex foundation types are sufficient depending on parameters such as soil liquefaction and soil structure in low-rise buildings, factors such as the use of complex mechanisms and the weight of the structure necessitate different ground solutions. As the complexity of the building increases, the soil and foundation properties should be considered together with the complex construction systems. There are different excavation methods for the application of different foundation types. The main excavation methods are open-cut, cut and cover and top-down technique.

While the research techniques can be applied in many buildings, the top-down technique comes to the forefront in terms of ease of use due to reasons such as fast construction process in high-rise buildings and lack of space. In this study, 8 building samples in which the top-down method is applied in high-rise buildings were examined. When the examined samples are evaluated, the building elements used in the top-down method also vary because of the location and terrain characteristics of each building. Diaphragm walls, which are effective in the formation of the basements of the buildings and take part in the dewatering process as well as being a support element, are common in every high-rise example examined. The pile size varies from project to project. The reason for this, it depends on factors such as the weight of the high-rise structure, the structural system, the terrain conditions and the number of basement floors. The width and height of the piles are also considered on the scale of these parameters. There are also similarities and differences in terms of material. While the use of steel piles is high in some high-rise buildings, it has been found that steel and concrete or composite systems are used in some of them. At this point where engineering calculations come into play, providing effective and optimum solutions is decisive in the life of the building. Considering the top-down method, which is one the innovative technologies, on the basis of high-rise buildings, it has

been concluded that the designs can be constructed by establishing different teams specialized in this field, and the concept of planning and time is important. By giving a different perspective to architects and engineers in this study, an evaluation has been made on the concept of foundation excavation, which is a technical issue in high-rise buildings.

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