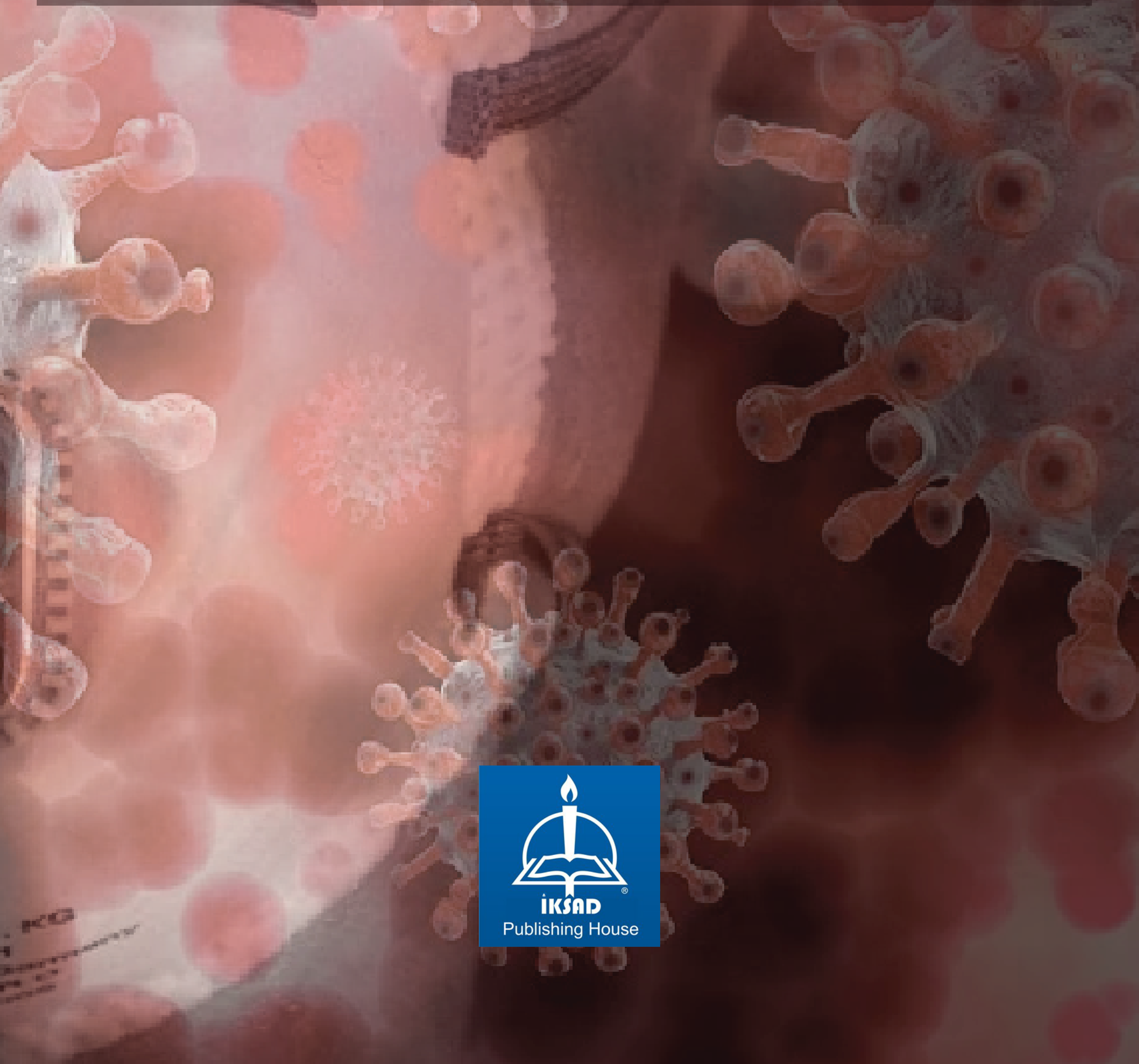
FUZZY CONTROL DESIGN IN DIAGNOSIS OF THE NEW CORONAVIRUS (COVID 19) DISEASE

Mehmet Nuri ÖDÜK



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Mehmet Nuri ÖDÜK

Institution of Economic Development and Social
Researches Publications®
(The Licence Number of Publicator: 2014/31220)
TURKEY TR: +90 342 606 06 75
USA: +1 631 685 0 853
E mail: iksadyayinevi@gmail.com
www.iksadyayinevi.com

It is responsibility of the author to abide by the publishing ethics rules.

ISBN: 978-625-8007-84-8
Cover Design: İbrahim KAYA
November / 2021
Ankara / Turkey
Size = 16 x 24 cm

PREFACE

The COVID-19 epidemic caused by the SARS-CoV-2 virus, which spread from China to the world in December 2019, quickly spread to 6 continents and hundreds of countries and went down in history as the first pandemic caused by corona viruses. Today, the Covid-19 (Corona virus) epidemic, which affects many countries around the world and causes change and transformation in many areas in Turkey, has significantly affected our lives. Covid-19, which emerged in the Far East and shook the whole world in a short time, caused disruptions and changes in different areas.

Since the isolation of the new type of coronavirus, researches on the COVID-19 disease and SARS-CoV-2 virus have begun to be conducted in many countries. It is the first diagnosis that is important in the fight against the epidemic. According to the diagnosis, the treatment processes are continued.

Following the developing artificial intelligence technologies, many concepts are also questioned and researched. Fuzzy logic, which emerges where human's ambiguous thinking and decision-making ability combines with artificial intelligence technology, is among the most researched topics. One of them is fuzzy logic called Fuzzy Logic. The concept of fuzzy logic is located at the intersection of artificial intelligence, mathematics, robotics, sociology, medicine and science.

In this study, fuzzy logic model was applied in covid 19 diagnostic studies. With the hope that the epidemic will end as soon as possible and the work will be beneficial for users.

Mehmer Nuri ÖDÜK

Sharing his professional knowledge about the book, I would like to thank my wife, Dr. Sema ÖDÜK, my daughter Saliha Sude ÖDÜK and my son Mehmet Samet ÖDÜK.

CONTENTS

INTRODUCTION

Expert systems are used in almost every branch of science (engineering, industry, chemistry, education, industry, etc.), as well as in the field of medicine, which are extremely efficient and widely used (Raw, 2016).

In the field of medicine; The reasons such as the increase in the diversity of diseases, the abundance of medical data, long evaluation periods, the interference of human errors in the diagnosis of the disease, the difficulties encountered in the diagnosis and treatment of diseases have increased the importance of the use of expert systems (Tekin, 1996; Özata and Aslan, 2004).

Fuzzy expert systems are used effectively in the field of medicine. In our time, many expert systems are designed for disease diagnosis. In this book, a web-based expert system is designed to diagnose the New Coronavirus (Covid-19) disease, which started in the world in 2019 and still continues its effect in Turkey.

Thanks to this system; It is aimed to reduce dependency on specialist personnel, to accelerate the treatment process of the disease, to ensure that the treatment process continues successfully, to increase the quality of medical education of specialists trained in the medical field, and to form the basis for the medical expert systems to be established for this disease in the coming years. Patients who will access the system over the internet will be able to easily diagnose the disease if they enter the required information. The designed system is web-based; It will provide many advantages in terms of informing the patients, minimizing the communication disorder between the patient and the doctor, and saving time, space and effort due to remote access. We see the concepts of Fuzzy Control in many areas of our lives. The first explanation about fuzzy control was made in 1965 by Prof. Dr. Lotfi A. Zadeh put it forward.

Fuzzy Control has been used in technology, defense industry, agriculture, health and artificial intelligence. At the same time, It is used in every medical field today. Fuzzy Control application areas are wide in scope. These apps affect our lives.

In treatment control automation, it is aimed to control the fuzzy appropriate values of the disease diagnosis input parameters and the output parameters of what the disease may be, with Fuzzy Logic methods. Such a flexible control highlights the importance of human health.

Human health has always been important for centuries. In 2019, 2020 and 2021, the disease of the Corona virus left its mark in the world and in Turkey. People were exposed to both physical and psychological diseases during the days they were in quarantine. Therefore, the importance of our health has increased. Progress has been made in finding diseases by obtaining information from experts.

Artificial intelligence method reduces the cost, time spent and medical error of human expertise in the field of medicine. Decision support systems and expert systems have found wide application in the medical field thanks to intelligent diagnostic programs due to their important features such as uncertainty, subjectivity and sensitivity that characterize medical diagnoses. Although it is thought that these systems will replace physicians, this is not a correct idea (Shortliffe, 1987).

These systems have been created to assist physicians in many fields. For example; finding hidden relationships between symptoms and diseases, revealing the relationships between important factors in multifactorial diseases, presenting current information to physicians, and helping physicians discover the information they will gain through experience in advance. It is an undeniable fact that clinical decision support systems facilitate the work of physicians and help them make decisions in today's world, where it is very difficult for physicians to make decisions due to the rapid obsolescence of information and the increasing amount of information (Keleş, 2007).

Clinical decision support systems be defined as computer software that provides support to physicians in their clinical decisions in the diagnosis of disease (Koç, 2012).

These systems are frequently used in areas with high data capacity such as intensive care. In addition, it assists specialists in supporting treatment recommendations, monitoring and training in clinical laboratories. The reliability and accuracy of these systems have been proven and studies to develop these systems are still ongoing (Shortliffe, 1987).

Many positive effects of these systems have been identified in terms of support for decision making, disease management, diagnosis and treatment of diseases (Raymond and Dold, 2002).

These systems have an important role in disease diagnosis considering their benefits and advantages.

In addition, it is known that only laboratory findings are not sufficient in diagnosing the disease and therefore physicians have difficulties in diagnosing the disease from time to time. For this reason, there is a need for artificial intelligence software that can perform clinical diagnostic procedures including the patient's medical history as well as laboratory tests to be taken from patients and make recommendations to doctors. Fuzzy expert system applications made in the medical field will be highly successful and will be very helpful to physicians.

1. LITERATURE RESEARCH

There are many systems used in disease diagnosis and treatment designed using the Fuzzy Expert System. In many of these studies, it is aimed to identify the factors that cause the disease, to facilitate the diagnosis and treatment of the disease, to reduce the costs and to minimize the workforce. Some of these studies are:

Allahverdi (2002b) gave extensive information about artificial intelligence, expert systems, basic structures of expert systems, expert system design methods, expert system design examples and applications, information engineering, methods of presenting information and fuzzy logic.

Elmas (2003b) included basic information about fuzzy logic, classical and fuzzy sets, inference mechanism and defuzzification methods.

Bates and Young (2003) designed a decision support system to assist physicians in the decision-making process in intensive care units. Designed using a fuzzy expert system, this system consists of 2 inputs and 1 output. The input parameters of the system were determined as blood pressure and the amount of urine per hour, and the output parameter as the flow rate in the vessels (blood pressure and urea balance).

Sarıtaş (2003a) developed a Fuzzy Expert System to be used in the medical field and designed two decision support systems to help physicians make decisions. The first of these systems is a fuzzy expert system that determines the dosage of salazopryne drug amount used in chronic intestinal disease, and the second is a fuzzy expert system application designed for the detection of prostate cancer risk. This system, which will prevent unnecessary biopsies from many patients, will guide physicians on whether to take a biopsy. In these designed systems, the data of 4641 patients were used and it was observed that the results were 96% successful when compared with the decisions of the physicians.

Sarıtaş, (2003b) designed a fuzzy expert system that determines the diagnosis of prostate cancer at exit based on certain inputs and that can be used in the education of medical students, economical, fast and reliable in terms of the consistency of the results. The inputs of the created expert system are prostate level, age and prostate-specific antigen; They determined its exit as cancer risk. The designed system aims to prevent unnecessary biopsy samples from patients and aims to determine the cancer risk of the patient according to the inputs. The most important feature of the system is that it is risk-free, economical, fast and highly reliable. The use of the system for educational purposes will also be very beneficial for students.

Koutsojannis and Hatzilygeroudis (2004) designed a fuzzy expert system applied on 70 patient data to assist physicians in the diagnosis and treatment of male impotence disease. The designed system gave very positive results. While it was observed that the system gave very good results from a physician who is not an expert in the field of urology, it was determined that it showed a success rate of 79% when compared to the results of the specialist physician.

Yücebaş (2006) designed a clinical decision support system to assist physicians in detecting the types of thyroid disease in his thesis study. The system was created using fuzzy logic and artificial intelligence. Electronic and non-electronic patient records were used to create the system in question. Yücebaş has designed the system in such a way that physicians take into account the patient's specific clinical information in their decision making. With this practice, it aimed to improve the quality of health care services, early diagnosis, prevention of errors, appropriate treatment and reduction of related costs.

Torun (2007) designed a fuzzy expert system to assist physicians in making decisions for the diagnosis and treatment of coronary heart disease according to the patient's risk status in the next 10 years. Thanks to these 6 designed systems, it is aimed to determine the heart disease risk of the patient more precisely. The system gives the risk ratio to the user and recommends using one of the normal life, diet and drug treatments. When the results of the designed system are compared with the data in the literature, it is seen that it gives very positive results and can be evaluated as an alternative study in the diagnosis of coronary heart disease.

Babalık and Güler (2007) developed an expert system that can be used in the diagnosis and treatment of throat infections in their article. The expert system they developed can be used to support physicians' decision making and to archive patient information. The developed expert system works with the user in the form of questions and answers and guides the user according to the answers. In addition, past patient records, questions asked and answers received will be stored and used in the follow-up of patients and in the training of physician candidates at different times.

Etik (2007) carried out fuzzy expert system design for operating room air conditioning control systems in his master's thesis.

Akyol et al. (2009) stated that it is not possible to use appropriate mathematical models in applications in computer and construction fields, especially due to insufficient data or the interaction of the data used in many variables, and they explained with examples that the fuzzy logic method can be used further and obtain appropriate results in the specified fields.

Ödük (2009) designed Greenhouse Automation with Fuzzy Control Method in his master's thesis.

Sarıtaş (2009) designed a fuzzy expert system to be used in determining the dosage of drugs used in chronic bowel disease symptoms such as sedimentation and prostate specific antigen. In the designed system, they aimed to determine the appropriate drug dosage in the light of the data of the studies conducted on the patients. When the drug dosages given to the patients by the doctor were compared with the drug doses given to the same patients by the system, it was seen that the system was quite successful. The system designed to assist physicians has been observed to minimize or completely remove adverse effects.

Akcan (2011) designed a fuzzy expert system to help dentists make decisions in the detection and treatment of priodontal dental disease in his master's thesis. In the 7 fuzzy expert system that will be used in the detection of priodontal dental disease, clinical and radiographic findings were considered as input values and the degree of the disease was tried to be determined as output. Within the scope of the study, disease-related risk factors, which are other values that cannot be blurred, were included in the Expert System, and the type of disease and treatment method were tried to be determined as the output value. With the designed BUS, it is envisaged to facilitate the work of dentists, to make the most accurate diagnosis and to help dentists in determining the appropriate treatment. The system aims to increase the rate of intervention to the disease by reducing the possible loss of time due to dentists. Thus, it is possible to make the patient's recovery process easier and faster.

Akyol et al. (2011) make system traffic analysis by keeping some performance values within the desired limits, as well as the wishes of the passengers using the elevators in high-rise buildings to reach their destination as soon as possible and safely. It has been shown that fuzzy logic approach should be used in controlling In order to show that the elevator made with the fuzzy logic method will be economical; Elevator management is designed with fuzzy logic method for a 50-storey building.

Büyükkaracığan et al. (2011) applied the fuzzy logic method for different mix calculations of cement, which is one of the main components in the concrete mix. The compressive strength values for C 25 concrete mixtures containing different amounts of cement, fly ash and additives were tried to be evaluated by fuzzy logic model. As a result of the study, there is a significant difference between the values predicted by the fuzzy logic method model and the experimental results.A high correlation was detected and it was concluded that the model test results were estimated with 97% accuracy.

Altan (2011), in his master's thesis, is based on the process of eliminating the difficulties encountered in the process of monitoring the values of vital functions encountered during the operation, interpreting the data obtained after the follow-up and determining the course of the operation with a fuzzy expert system. In this system, it is possible to blur the status of the data received from the patient instantly with respect to each other, to query and clarify from a certain knowledge base, and to inform the patient's condition visually and audibly. The system takes 4 vital functions that affect the operation process as input. In response to this input, he performed a fuzzy calculation of the output with a single signal that gives the patient's health status during the operation. The created fuzzy expert system provided convenience to the medical personnel in providing the treatment of the patient during the surgery, diagnosing the disease and treating the disease.

Allahverdi (2011) studied anemia, which is an important health problem in children, with symptoms such as a fast heartbeat and feeling of fatigue, which makes the skin pale because of the low flow in the blood vessels on the skin surface. In this study, they defined the system developed for determining the level of anemia for children, based on the fact that the hemoglobin and hematocrit test are frequently used to determine the level of anemia. As input parameters; Hb and hematocrit were used as output parameters and anemia level was used. Takagi-Sugeno type fuzzy neural network was used and the success rate was found to be between 90% and 95.8%. When other studies in the literature are examined, it is seen that the FCM algorithm provides 97% success. Despite a detailed study, the fact that the application was carried out only on children 8 shows that it is a very special study and cannot be generalized to all patients.

Yılmaz (2012) in his master's thesis; He designed a system to detect the level of iron deficiency anemia using the Fuzzy Expert System structure. This designed system has helped specialist physicians to make a diagnosis. In the realization process of system design; The information obtained from 100 patients was examined, and the fuzzy rule base was created by blurring the entries together with the specialist physician. Mamdani extraction mechanism and centroid defuzzification method, which are frequently used in the literature, were used. As a result of the work of the system, which was designed with the help of Delphi-2010, a visual programming language, a concrete display of the level of anemia was provided. It has been seen that the designed system will provide great convenience to physicians in making quick and correct decisions.

Patel (2012) designed a fuzzy expert system to determine the severity of asthma in their article. The designed system has 5 inputs (Peak Expiratory Flow Rate (PEFR), Daytime Symptom Frequency (DSF), Nighttime Symptom Frequency (NSF), Peak Expiratory Flow Rate Variability (PEFR Variability), Oxygen Saturation (SaO2)) and one output. When the output data were compared, it was seen that quite stable results were obtained.

Büyükkaracığan and Ödük (2013) emphasized that the determination of the instantaneous flow amount in the basin plays an important role in the planning of projects related to water and river engineering, and it is very important for the development of a hydrological forecasting model based on historical records, hydroelectric dam management and planning. For this purpose, an artificial neural network model was established to predict monthly flows of the Gediz Stream. As a result of the analysis, they concluded that the artificial neural network algorithm is suitable for monthly flows of the Gediz Stream.

Tosin and Yinka (2013) designed a fuzzy expert system to assist physicians in making decisions for the diagnosis of pneumonia in children in the article they published. They were able to reach more precise and faster results than other methods used in the diagnosis of the disease. (Walia, 2015) developed a decision support system for tuberculosis diagnosis using fuzzy expert system in their article. In the study, it was aimed to detect the presence of 9 bacteria and to support physicians in the determination of tuberculosis disease. Data from 65 patients were used. The system is designed as 9 inputs and 1 output. The success rate of the designed system was determined as 77%.

Buyukkaracigan (2015). In this study, first of all, artificial intelligence systems, which are widely used in the solution of civil engineering systems, are examined with their technical aspects and basic principles. Finally, he made a literature review for the applications of artificial intelligence techniques in the field of civil engineering and gave information about these studies and their results.

Tarakçı (2017 designed a fuzzy expert system for the diagnosis of Rheumatoid Arthritis in his master's thesis.

Büyükkaracığan (2021a) applied feedforward backpropagation method (IBGY) and generalized regression neural network (GRSA) method to precipitation-flow data obtained from Havran Dere Basin. As a result of the study, he concluded that IBGY simulation gives better results than both GRSA and classical statistical and stochastic model predictions.

Büyükkaracığan (2021b) used the flow data of Kayganlı Station in the Gediz basin and the monthly average temperature and monthly total precipitation data in the same region. Three different models were created, in which temperature and precipitation values were used separately, both temperature and precipitation data were used as inputs, and the current value was selected as output. Models were prepared using 1990-2015 data and tested with 2016, 2017 and 2018 data. As a result, it has been shown that the fuzzy logic method gives appropriate results when both temperature and precipitation data are used as inputs.

2. GENERAL INFORMATION ABOUT THE NEW CORONAVIRUS (COVID-19) DISEASE

In this section, the definition, history, epidemiology, etiology, clinical symptoms, transmission route and laboratory tests of the New Coronavirus (Covid-19) disease will be discussed in detail.

2.1 Definition of Novel Coronavirus (Covid-19) Disease

The Novel Coronavirus Disease (COVID-19) was first seen in China in December 2019. That's why it's called Covid-19. It has been seen in many patients, especially with symptoms of fever, cough and dyspnea. It is a virus identified on January 13, 2020.

The epidemic was detected in the seafood and animal market in China. Later, it spread from person to person and spread all over the world. It especially affected Europe and America. In our country, many cases have been detected with the tests conducted with our state. As a result, morbidity and mortality have increased.

The new coronavirus is a large family of viruses that can cause disease in animals and humans. A virus is a contagious disease-causing microbe. Microbes are invisible to the naked eye. In humans, several Corona viruses cause respiratory infections ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and severe Acute Respiratory Syndrome (SARS). New Coronavirus disease is caused by the SAR-CoV-2 virus.

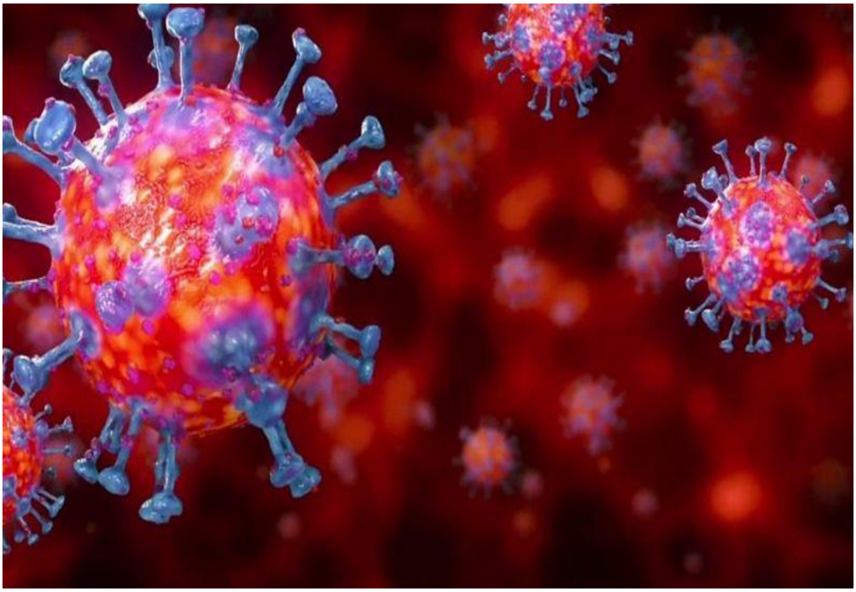
.  .

Figure 2.1 Novel Coronavirus Disease shape

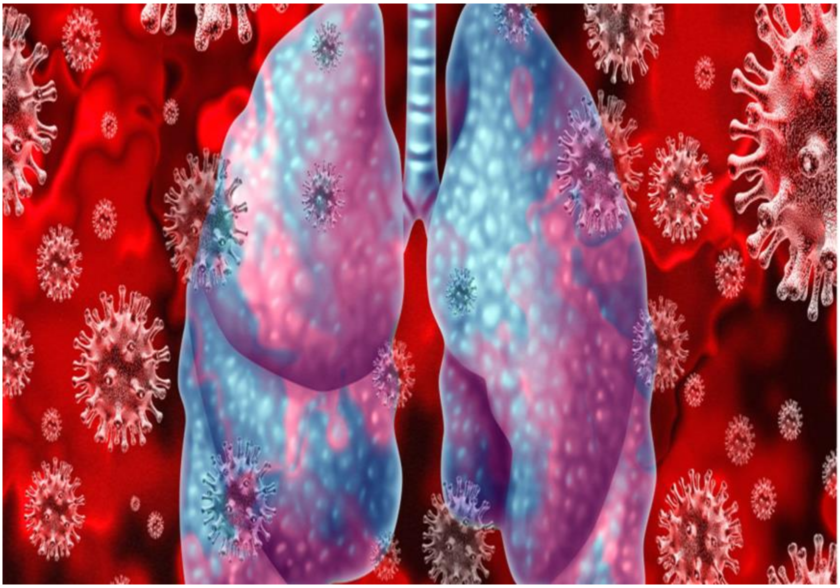


Figure 2.2 Appearance of the New Coronavirus Disease on the Lungs

2.2 History of Coronaviruses

Coronaviruses were discovered in 1960. The first viruses are infectious bronchitis virus seen in chickens and subtypes HCoV-229E, HCoV-OC43 that cause colds. It is the SARS coronavirus, discovered in 2003. HCoV NL63 in 2004, HKU1 diagnosed in 2005, MERS-CoV in 2012. In 2019, a new coranavirus emerged. Viruses cause respiratory tract infections.

2.3 Epidemiology of Coronaviruses

Epidemiology is the medical science that affects the distribution and incidence of diseases, accidents and health-related conditions in the society.

Cases of pneumonia of unknown etiology were reported on 31 December 2019 in Wuhan City, China. Fever, dyspnea, and radiological findings consistent with bilateral lung pneumonic infiltration were detected in the cases. According to the World Health Organization's COVID-19 report of the People's Republic of China, the death cases have generally been individuals with advanced age or concomitant systemic disease (hypertension, diabetes, cardiovascular disease, cancer, other immunosuppressive conditions, especially chronic lung diseases). . The first imported case is a 61-year-old Chinese woman, reported from Thailand on 13 January 2020. In the following days, as the number of countries reporting imported cases increased gradually, countries with domestic transmission began to emerge at the end of February. As of the beginning of March 2020, the rate of the epidemic slowed down in China, while there was an increase in COVID-19 cases and deaths related to this infection in Iran, the Republic of Korea GENERAL INFORMATION, EPIDEMIOLOGY AND DIAGNOSIS 9 (South Korea) and Italy. In the ongoing process, serious case increases were seen first in Europe and then in North America.

The causative agent of the pneumonia cluster detected on 31 December 2019 was identified as a new coronavirus that had not been detected in humans before on 7 January 2020. After this date, the number of patients increased rapidly, and the disease was seen in health workers. The disease has spread rapidly due to its human-to-human transmission feature. The first COVID-19 case in our country was detected on March 11, 2020. In the ongoing process, there has been an increase in the number of cases in our country as well as in the world. It is a disease that infects people of all ages. The number of cases in our country and other detailed up-to-date information can be found at the Ministry of Health of the Republic of Turkey https://covid19.saglik.gov.tr it can be accessed from the web address.

2.4. Etiology of the New Coronavirus (Covid-19)

Etiology is the science used to determine the symptoms behind diseases. It also helps to find the reasons behind the deaths. Symptom means a sign or sign. The etiology of the disease is determined by physical examination, x-ray or analysis results. From these elements, the etiology of the disease is determined. The World Health

Organization has reported cases of pneumonia of unknown etiology in China.

2.5. New Coronavirus Clinical Symptoms

As a result of the studies carried out during the pandemic process, new information is added to the natural course of COVID-19. Common signs of infection are respiratory symptoms, fever, cough and dyspnea. Symptoms such as headache, sore throat, runny nose, muscle and joint pain, extreme weakness, new loss of sense of smell and taste, diarrhea can also be seen. Although the disease can be asymptomatic, in severe cases, pneumonia, severe acute respiratory tract infection, kidney failure and even death may develop. While the fatality rate was 11% in the SARS epidemic and 35-50% in MERS-CoV, the fatality rate was reported as 3,8 % according to the WHO's COVID-19 report of the People's Republic of China. As of 02 May 2020, this rate is 2,6 % in our country.

Asymptomatic infection: In the literature, quantitative RT-PCR (nasopharyngeal swab samples) test positivity has also been reported in asymptomatic individuals in population screenings. Most of the asymptomatic cases developed some symptoms in the later stage of the infection, but there are also cases that were asymptomatic during the clinical follow-up period.

2.6. New Coronavirus (Covid-19) Transmission Way

The disease is mainly transmitted by droplets. In addition, the droplets released by sick individuals through coughing and sneezing are transmitted by contacting and contacting the mouth, nose or eye mucosa after contact with other people's hands. Since the virus can be detected in the respiratory tract secretions of asymptomatic people, these people can be contagious. In a meta-analysis study by Khalili et al, the mean incubation time was calculated as 5.84 days (99% CI 4,8 - 6,8). The median incubation period is 4,8 days. In general, the incubation period varies between 2-14 days. The contagious period of COVID-19 is not known for certain. It is thought to begin 1-2 days before the symptomatic period and end with the disappearance of symptoms.

2.6.1. Infectious

Viral shedding begins 1-2 days before the onset of symptoms and peaks during the onset of symptoms in throat swabs. Although it decreases rapidly within the first seven days, it can extend beyond the second week. Finding similar viral loads in symptomatic and asymptomatic/minimally symptomatic patients in some studies indicates that asymptomatic individuals also play a role in transmission. On the other hand, there are also studies reporting that viral load is higher in severe cases. Virus peaks at the onset of symptoms in saliva samples taken from the posterior pharynx 12 T.C. It is determined at the levels of MINISTRY OF HEALTH, GENERAL DIRECTORATE OF PUBLIC HEALTH. In mild cases, viral clearance usually occurs within the first 10 days, while in more severe cases it is prolonged; It can be detected for more than one month in nasopharyngeal swab and stool samples (usually longer periods). Although viral RNA was negative in two consecutive respiratory tract samples from time to time, it later became positive again. It is accepted that such positivity is due to methodological reasons rather than reactivation/reinfection.

Especially after the 2nd week of the disease, the virus is positive in the stool. So far, only one case has been able to produce the virus from a stool sample, and transmission in this way has not been reported. This suggests that fecal-oral transmission is unlikely so far. The virus is rarely found positive in blood and urine, and it is accepted that the virus does not pose a security problem in terms of blood banking. Apart from that, no virus was detected in milk, vaginal swab and sperm samples. The viral load is higher in the elderly. Viral load is an important marker for disease severity and prognosis. It has been shown that the viral load is 60 times higher in severe cases than in mild cases. Coronaviruses are generally viruses that are not very resistant to the external environment. There is a durability period that varies according to factors such as the humidity and fever of the environment, the amount of organic matter from which it is expelled, and the texture of the contaminated surface. It is generally accepted that it loses its activity on inanimate surfaces within a few hours. When interpreting the duration of activity on inanimate surfaces, it should not be forgotten that not only the continuation of the virus' activity, but also the duration of the contact is important in contamination.

2.6.2. Sensitive Person

The entire society is susceptible to COVID-19. Healthcare workers are the most risky occupational group in terms of exposure to the factor. Men, people over the age of 50, people with comorbidities (Hypertension, Heart Disease, Diabetes, Malignant, COPD, Kidney Disease, etc.), seasonal agricultural workers and people living in care and rehabilitation centers, schools, barracks, prison and detention houses and immigrant camps They are vulnerable groups for COVID-19. Basic reproduction number: R0): How many different individuals will be infected by an infected individual in an all-susceptible population during the period of infectivity after ingesting the agent. If R0 is greater than 1, each existing infection causes more than one new infection.

The disease spreads among humans and can cause an epidemic. In the models made, it has been reported that the average R0 for COVID-19 is between 2.76-3.25 in Italy, the average R0 is 3.28 and the median R0 is 2.79 in China. The highest R0 value was reported as 14,8 on the Diamond Princess Ship at the beginning of the pandemic. In the calculations for Turkey, the R0 value was 9,6 on the 10th day of the epidemic, while it was 1.30 on the 45th day. The disease transmission coefficient should be calculated at regular intervals during the epidemic and should be considered as one of the follow-up criteria of the epidemic. Herd Immunity Level: If a certain percentage of people in a society become immune to any infectious disease, it means the protection of the whole society against that disease. Taking R0 as 2,2, the herd immunity level was calculated as 60% for COVID-19.

2.7. Laboratory Tests

In patients who meet the definition of a possible case of COVID-19, respiratory tract samples are evaluated in terms of SARS-CoV-2 at the General Directorate of Public Health (HSGM) Microbiology Reference Laboratory and laboratories serving in designated provinces (https://covid19.saglik.gov.tr/TR-68720). /covid-19-authorized-diagnostic-labs-list. html). Considering that confections can occur even if other respiratory pathogens are detected in the patient, all patient samples that fit the COVID-19 probable case definition should also be evaluated for SARS-CoV-2.

2.7.1. Nucleic acid amplification tests (NAAT)

Routine confirmation of COVID-19 cases is based on detection of specific sequences of virus RNA by a NAAT test such as real-time reverse transcription polymerase chain reaction (rRT-PCR) and confirmation by nucleic acid sequence analysis when necessary. RNA extraction should be performed in a BSL-2 or equivalent biosafety cabinet. Fevering samples prior to RNA extraction is not recommended. Although different protocols targeting the N, E, S, RdRp genes have been published so far for molecular tests, where

SARS-CoV-2 virus is commonly seen, it is simpler such as screening with rRT-PCR for a single identifying target. It is sufficient to adopt an algorithm. One or more negative results cannot exclude the possibility of COVID-19. The following factors may cause a negative result in an infected individual:

» Poor quality sample with very little patient material

» For example, getting the infection at a very early or late stage,

» The sample is not properly processed and sent,

» Technical reasons inherent in the test, such as PCR inhibition or virus mutation

» When a negative result is obtained from a patient with a high suspicion of COVID-19, the fluctuating distribution of SARS-CoV-2 virus in symptomatic and asymptomatic cases, additional samples containing lower respiratory tract samples should be obtained and studied, if possible, especially if only upper respiratory tract samples were collected.

2.7.2. Sequencing

Sequence data is very important to understand the source of the virus and how it spreads. WHO has stated that laboratories should share the sequence data they obtain on the relevant platforms.

2.7.3. Serological tests

In general, antibody response (IgM, IgA and IgG) develops after a certain period of time in those who experience COVID-19 asymptomatic or symptomatic. Therefore, serological tests cannot be used for diagnosis in the early stages of the disease. Although the first antibody response (IgM) starts after 6-7 days, most of the patients develop antibody positivity 10 days after the onset of symptoms. Today, it is not certain whether the detected antibodies provide immunity and how long they can be detected (IgG). To determine the serological response, ELISA or rapid antibody tests that detect IgM/IgG are currently used. Reliable antibody tests can be used for different purposes:

1. In cases where NAAT tests are negative and have a strong epidemiological association with COVID-19 infection, the study of serological tests on serum samples taken in the acute and/or convalescent phase may support the diagnosis.
2. Serological tests help to investigate the ongoing epidemic, and provide a retrospective evaluation of the attack rate and severity of the epidemic.
3. UTS registered validated tests can be used for monitoring and evaluation
4. The performance of antibody tests may vary depending on the seroprevalence in the population studied. Especially in cases where seroprevalence is low, seroprevalence studies should be carefully constructed and interpreted, since false positive rates in these tests can lead to misleading results and interpretations.
5. Data and experience on the performance characteristics of currently available kits, other than those specified by their

manufacturers, are limited and it is difficult to make general recommendations regarding their use other than the above-mentioned purposes.

3. EXPERT SYSTEMS

Expert systems can be defined as computer programs that produce solutions to problems by acting as experts for a particular set of problems. Expert systems can be expressed as the transition from the data processing stage to the information processing stage (Allahverdi, 2002b).

Expert systems are knowledge-based systems and are an application area of artificial intelligence that deals with problems in a broader framework and aims to imitate human intelligence in their solution. In expert systems, algorithms and inference mechanisms operate by interacting. To make a more specific definition for the expert system, it can be defined as a computer-aided decision-making tool, which is created based on the information obtained with the help of an expert, and uses events and experiences in solving complex problems (Baykal and Beyan, 2004).

Expert systems are intelligent computer programs that do not allow the solution of problems that are as difficult and complex as a person who is an expert in their field and produce solutions like an expert. These systems are computer-based systems and have brought a new dimension to management sciences with the symbolic operations they use. A well-designed expert system can imitate them by acting like experts in problem solving stages. The reason why the system is called an expert system is because it tries to replace the experts by using the knowledge of one or more experts. The goal here is to be able to design a system like an expert or better than an expert. Such a system will not make a person an expert, but will enable an expert to do some or all of the work. Therefore, this aspect of the system has a significant impact on organizations and management (Allahverdi, 1995).

3.1. General Structure of Expert Systems

Figure 3.1 shows the general structure of an expert system. Expert systems basically consist of two basic components. These; knowledge base (database, rule base) and inference mechanism. knowledge base; It is where the knowledge necessary to understand and solve problems is used. The inference mechanism is; it can be called as the method used to extract new information from the information we have (Allahverdi, 2002b).

Besides these basic components; There is also a user interface that allows users to communicate with computers, an annotation facility that uses facts 24 to produce a result, and an information retrieval facility used to hold and upload information. Expert systems are systems that do not have algorithms and always do information-based operations. By calling information from the knowledge base, the operation is performed, the result is obtained and the explanation is made within the knowledge. The system can reach and use the information it needs, and if it is designed correctly, it can gain the ability to learn by improving itself (Allahverdi, 2002).

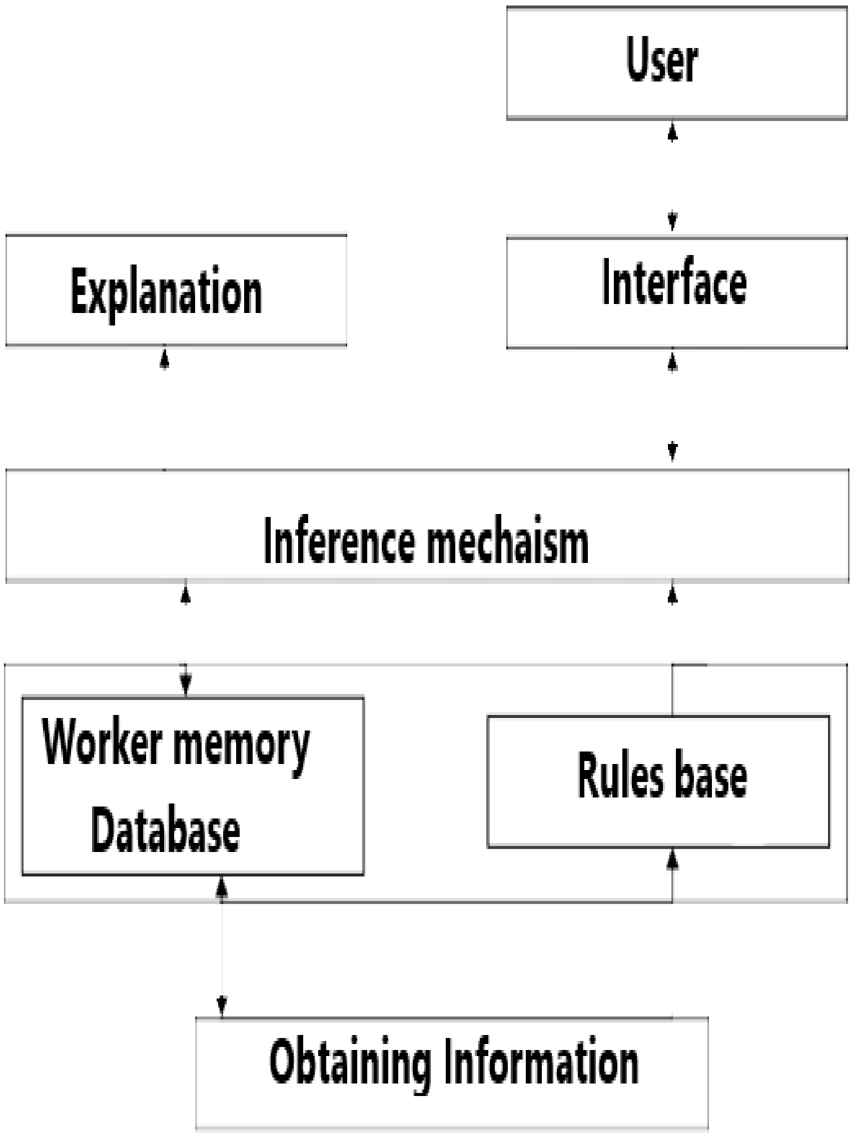


Figure 3.1. Structure of an expert system

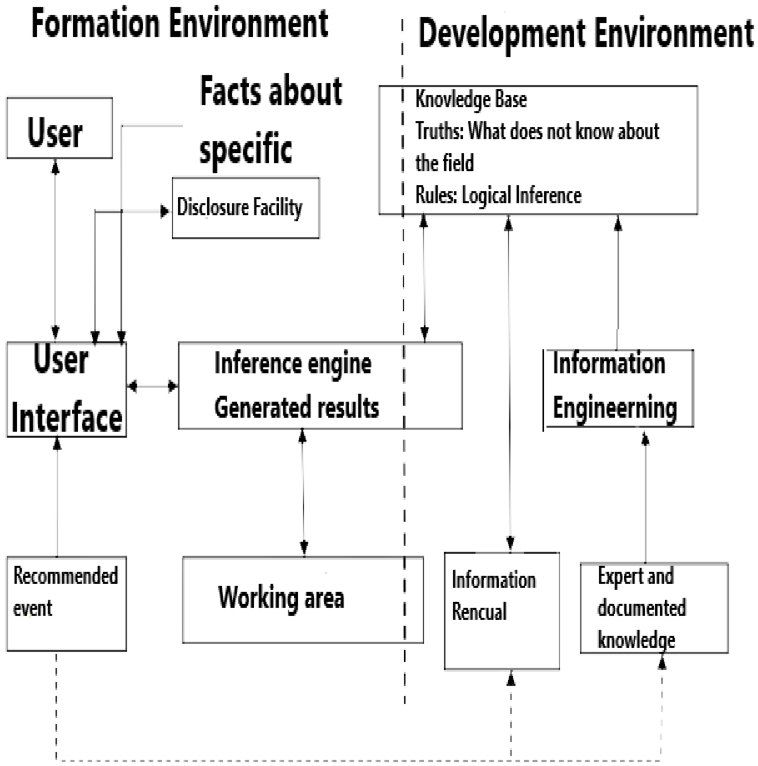


Figure 3,2. An expert system design and block representation

An example of a medical decision-making system is given in Figure 3,3. In this system, the knowledge and experience obtained from a doctor is transferred to the knowledge base. An inference function about a disease is obtained by evaluating the information in the knowledge base. The information obtained from the user interface is transferred to the inference engine and a decision is obtained for the incoming query (Deperlioğlu and Polat, 2014).

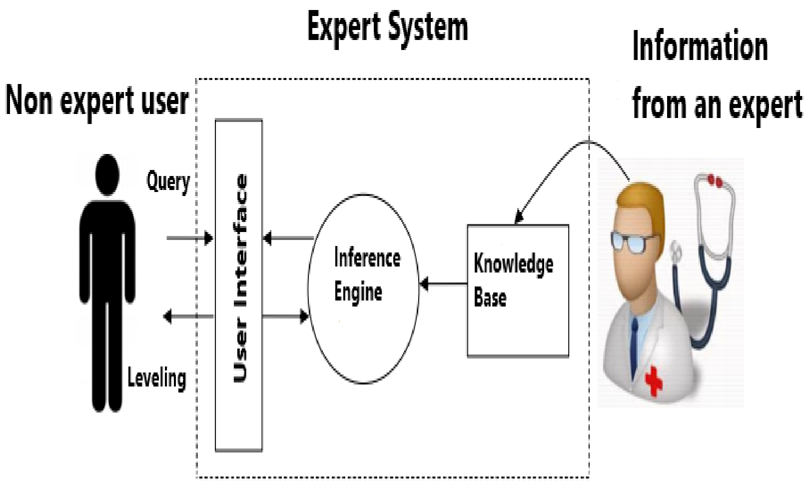


Figure 3.3. Demonstration of medical decision making system

The first thing to do in designing a fuzzy system is to obtain a collection of IF-THEN fuzzy rules. These rules are made with the help of experts. The Fuzzy Control chart is shown in Figure 2.1 below.

3.2. Application Areas and Purposes of Expert Systems

Some examples of the application areas and purposes of expert systems are shown in the table below (electric.gen.tr; Allahverdi, 2002b).

Table 3.1. Expert systems and application areas

AREA	EXPERT SYSTEM NAME	AIM
ELECTRONIC	ACE	Diagnosing phone faults
ELECTRONIC	NDS	Diagnosis of the national

		communication network
ELECTRONIC	SOPHIE	Circuit diagnostic assistance
MEDICINE	PUFF	Diagnosis of lung diseases
MEDICINE	AI/COAG	Diagnosis of blood diseases
MEDICINE	VM	Study of diseases
MEDICINE	CADUCEUS	Examination of internal diseases
MEDICINE	MYCİN	Diagnosis of bacterial infections
MEDICINE	ONCOCIN	Treatment of chemotherapy diseases
MEDICINE	ATTENDING	Anesthesia procedure instruction
MEDICINE	GUIDON	Anesthesia procedure instruction
INFORMATION TECHNOLOGİES	BDS	Diagnosis of bad parts in networks
INFORMATION TECHNOLOGİES	YES/MVS	Operating system control/monitoring
BIOLOGY	CYRSALIS	Studying the structures of proteins

BIOLOGY	DENDRAL	Molecular structure interpretation
BIOLOGY	MOLGEN	Gene duplication design
BIOLOGY	SECS	Complex organic design
THERMODYNAMICS	REACTOR	Reactor accident diagnosis and solution
THERMODYNAMICS	DELTA	Diagnosis of GE locomotives
MINING	LITHO	Data interpretation of oil wells
MINING	MUD	Diagnosis of drilling problems

3.3. Medical Expert Systems and Early Examples

Medical Expert Systems are expert systems developed in line with the advice of one or more medical experts, aiming to produce accurate results, and providing support to physicians in solving problems in medical fields. The purpose of the Medical Expert System is not to replace the physician, but to assist the physician in making a decision by giving advice and recommendations. Although there are many expert systems made in the field of medicine, Internist / Caduceus can be shown as the first Medical Expert System developed. This expert system was developed for use in the field of internal medicine in the 1970s and entered the literature as an application in which heuristic methods are used in problem solving (İncekara, 2010).

Another medical expert system is Mycin, which was designed in the 1970s and is used in the diagnosis of blood infections. Mycin pioneered many expert systems designed for commercial purposes in the following years. In addition, based on this system, systems such as Emycin and Puff for disease diagnosis and Neomaycin for use in the training of doctors were developed in the following years (Babalık and Güler, 2007).

Other than these examples, Poems (post-operative emergency medical expert system), Dxplain (diagnostic determination), Perfex (coronary cardiovascular disease diagnosis), Dr. There are many Medical Expert Systems such as Cad (internet-based diagnostic support), Oirs (medical risk management) (Özata and Aslan, 2004).

Some examples of the first expert systems used in the field of medicine are shown in the table 3.2 below (Allahverdi, 2002b; İncekara, 2010).

Table 3.2. First expert systems used in medicine

NAME	**PLACE PREPARED**	**APPLICATION AREA**
MYSIN	Stanford University	Infectious Diseases
CASNET	Rutgers University	Glaucoma

INTERNIST	Pittsburgh University	Internal diseases
ONCOCIN	Stanford University	Oncology
EXPERT	Rutgers University	Electro cliff Analysis Result
IRIS	Rutgers University	Glaucoma
GUIDON	Stanford University	Infectious Disease Learning
PUFF	Stanford University	Lung Diseases
MDX	Ohio University	Diagnosis
MECS-AL	Tokyo University	Advice
KMS	Meryland University	Diagnosis
RECONSIDER	California University	Diagnosis
RX	Stanford University	Determination of Causal Relationships
TEIRESIAS	Stanford University	Diagnosis

SETH	Poisoning Center	Treatment in Poisoning
UMDES	Soviet Union	Diagnosing Ulcer Disease
ANASTEZİ	Soviet Union	Anesthesia in Stomatology
MODIS-2	Soviet Union	Blood Pressure Diseases
LEDI-2	Soviet Union	Patient Identification

The application areas and qualifications of the medical expert systems shown in the table above are given in more detail below.

Mysin (1970): It was developed for use during the diagnosis and treatment of infectious diseases. After the operation, the patient Casnet: It is designed to be used in the diagnosis of glaucoma (eye pressure). The system, which approaches the disease in a dynamic structure, considers the possibility of the disease at every stage of life. This designed system has also been used in other eye diseases.

Internist (1970): Designed to be used in the diagnosis of internal diseases, the system diagnoses possible diseases from the patient's clinical information, laboratory test results and the history of the disease. The system was later developed and named INTERNIST II, and the information of more than 599 internal diseases was entered into this system. The system has been used to facilitate medical alternative visions, clinical research expertise and strategies.

Pip: The system is designed to diagnose kidney diseases. 36 main topics such as basic medical information, clinical data, types of diseases and physical conditions formed the structure of the system.

Expert (1980): Conducted to control and investigate the impact of medical counseling models. Experimental models in rheumatology, endochronology and ophthalmology are based on system design.

It is aimed to help doctors in the treatment process by diagnosing the contagious infectious disease.

Casnet: It is designed to be used in the diagnosis of glaucoma (eye pressure). The system, which approaches the disease in a dynamic structure, considers the possibility of the disease at every stage of life. This designed system has also been used in other eye diseases.

Internist (1970): Designed to be used in the diagnosis of internal diseases, the system diagnoses possible diseases from the patient's clinical information, laboratory test results and the history of the disease. The system was later developed and named INTERNIST II, and it was aimed to provide consultancy to specialists in terms of information about more than 599 internal diseases, such as gLedi-2. Determining the status of intensive care patients, following the course of the disease, and monitoring the changes in the patient's condition. The system has been divided into various areas within the treatment areas (cardiovascular system, kidney, liver) and a whole system has been formed by separating these areas within themselves.

Umdes: The system designed for the diagnosis and treatment of ulcer disease has been tested on 98 patients. Studies have shown that the capabilities of the system are at a high level.

Anesthesia: With the help of Expert expert system, it was developed in 1980 by writing in C language in order to determine the anesthesia method and help the physician.

Modis-2: It has been developed to diagnose hypertension and to plan the treatment process. He tried to determine the treatment method by diagnosing the disease with 30 questions he asked the patient.

Joseph (1986): Developed to teach medical school students to read EKG. It was prepared in Turbo Pascal and DOS environment.

Joseph (1997): The application, which was made in 1986, was transferred to the Windows environment in 1997 and took its place among the popular medical expert systems.

Onco-help: It is designed to be used in the diagnosis and treatment of tumors (personal tumors). It can diagnose the patient's tumor type data, histology, tumor type, location and number of the tumor, and monitor the developments and side effects in the treatment process. Pharm-2: A database was created with the knowledge of a group of specialist pharmacists and drug treatment was started. The system has been used to facilitate medical alternative visions, clinical research expertise and strategies.

Expert (1980): Conducted to control and investigate the impact of medical counseling models. Experimental models in rheumatology, endochronology and ophthalmology are based on system design. The system has been used to facilitate medical alternative visions, clinical research expertise and strategies. It is designed as a system that assists specialists in the selection of drugs for the patients to be treated.

Quawds: Designed to diagnose stroke by gait analysis. It is written in the C++ programming language.

Xdis: It is designed as a system that contains information about 300 internal diseases and their pathological symptoms, to assist physicians in the diagnosis process.

Seth: It is designed as a system to provide counseling services for treatment and care in cases of intoxication with drugs and narcotic drugs. In the database of the system, there is much necessary information and toxic substance for preliminary diagnosis. In the system created, 1153 substances that caused drug poisoning in France in 1992 were recorded in 78 categories. From 1992 to 1994, the number of poisoning incidents in the system reached 2099

3.4. Benefits of Expert Systems

The main benefits of expert systems are mentioned below (electric.gen.tr; Akcan, 2011; Direk, 2011).

Reducing costs: Compared with expert systems and humans, human studies cost more. Thus, the cost of expertise per person decreases.

Ready Information: If expert knowledge is loaded into the designed expert system, there will be no need to wait for the expert to get information and time will be saved.

Increased productivity: Expert systems work much faster than humans, so fewer people are needed and costs are lowered.

Permanent Knowledge: Experts may retire or die over time, while expert systems are permanent.

Explanation: While expert systems explain in detail the reasons for their conclusions, humans may not always do so.

Quality improvement: Expert systems provide consistent and appropriate recommendations to improve quality and aim to reduce the error rate.

Reducing operational errors: Many experts are used to advise on detecting and repairing system malfunctions. With the use of expert systems, it has been observed that malfunctions and downtimes are significantly reduced.

Flexibility: One of the advantages of the system is that the use of an expert system provides flexibility in the production and service phases.

Cheaper device usage: While people can stay connected to expensive devices during monitoring and control stages, expert systems save money by performing the same tasks with more economical devices.

Operation in hazardous environments: Expert systems can be used in order not to put human health at risk in environments that are dangerous and harmful to humans.

Reliability: Expert systems are objective and reliable. The expert system carefully considers the information and potential solutions, and reviews all the details in an objective way without getting tired and bored.

Response time: Expert systems can respond much faster than an expert, depending on hardware and software, when it is necessary to respond quickly and in real time or to scan large amounts of data.

Working with complete and imprecise information: When compared to normal computers, expert systems can produce a result based on complete and imprecise information, even if it is not as precise as a human.

Training: Expert systems with the ability to explain can be used as a teaching device to provide training.

Problem solving ability: Since expert systems handle the judgments of experts with a holistic approach, these systems have high problem solving capabilities. The decision-making styles of these systems that process information symbolically and the decision-making styles of many managers are compatible with each other.

Solving complex problems in a limited field: Expert systems can exceed human capabilities in solving complex problems.

Unsentimental answers: While people can't find solutions to problems from time to time or can make subjective decisions due to stress, resentment and emotionality, expert systems can give realistic and real-time answers to problems, away from emotionality. • Intelligent database: Expert Systems can intelligently access a database file.

3.5. Limitations of Expert Systems

In addition to the many benefits and advantages listed above, expert systems also have the limitations shown below (electric.gen.tr; Allahverdi, 2002b; Üstünkan, 2007).

- The information is not always suitable to be read and understood.
- It is difficult to reach experts on some subjects, the expert is not willing to give information for various reasons, or the experts do not have time to convey information.

- An information engineer is needed during the creation of the system. High cost due to scarcity and cost of knowledge engineer
- There are limitations due to the narrow working areas of expert systems.
- Costs and long design times of expert systems
- Misunderstandings due to the difference between the meanings attributed by the experts to the professional words they use and the known general meanings of the words.
- Managers are conservative, not open to innovations, approaching these systems with suspicion and not wanting to spend extra money.
- Experts have different perspectives on the issues.
- Difficulty in making situational assessments due to various pressures (manager, time) even for an expert who is experienced in his field, can be cited as the limitations of expert systems.

4. FUZZY CONTROL AND APPLICATIONS

Fuzzy Theory is used to implement a linguistic control strategy based on human knowledge. While designing control systems, respectively; fuzzy control rules that make up the target, knowledge base are determined and blurring and clarification are done. Fuzzy Theory was proposed in 1965. Shortly after this date, Fuzzy Control developed very quickly. The most effective application area of fuzzy sets and fuzzy logic theory is control systems.

Fuzzy systems are knowledge-based or rule-based systems. In order for a system to be controlled, the mathematical model that composes the system must be chosen well. Mathematical models of some systems are very difficult to obtain. The best way for this is to use fuzzy sets. Fuzzy sets, the concept of set used in traditional set theory, is based on the logic of two options such as "1" if an object is a member of a set or "0" if it is not. There is no "0" or "1" in traditional set theory. A problem with uncertainty is difficult to solve. This controller can act like a human. We can call this controller system Fuzzy Logic (Erkan 1999; Büyükkaracığan, 2021a). Traditional control systems are transformed into BK systems with the help of fuzzy sets. Before deciding to use Fuzzy Control in the control system, it is necessary to examine the system well. Then it is necessary to decide how to use the fuzzy system. The historical development of Fuzzy Control is given in Table 4.1 below

Table 4.1 Historical Development of Fuzzy Control.

Year	APPLICABLE	APPLICATION AREA
1972	Zadeh	Introducing Fuzzy Control
1973	Zadeh	Linguistic approach
1974	Mamdani and Assilian	Steam engine control
1976	Rutherford	Analysis of control algorithms
1977	Ostergaard	Fever exchanger and furnace control
1977	Willaeys	Optimal fuzzy control
1979	Komolov	Finite automation
1980	Tong	Evaluation of wastewater
1980	Fukami and Mizumoto	Evaluation of wastewater
1983	Hirota ve pedrycz	Probabilistic fuzzy sets
1983	Takagi ve sugeno	Derivation of Fuzzy Control
1983	Yasunubo and miyamato	Estimated Fuzzy Control
1984	Sageno and murakabi	Parking control of a car

1985	Kiszka and gupta	Stability of the fuzzy system
1985	Togai and Watanabe	Fuzzy chip
1986	Yamakawa	Fuzzy Controller hardware system
1987	Yamakawa	Application in Sendai metro
1988	Dubois and parade	Approximate reasoning

After deciding to design a fuzzy system, the first thing to do is to obtain a set of IF fuzzy rules. These rules are made with the help of experts. The Fuzzy Control chart is shown in Figure 4.1 below.

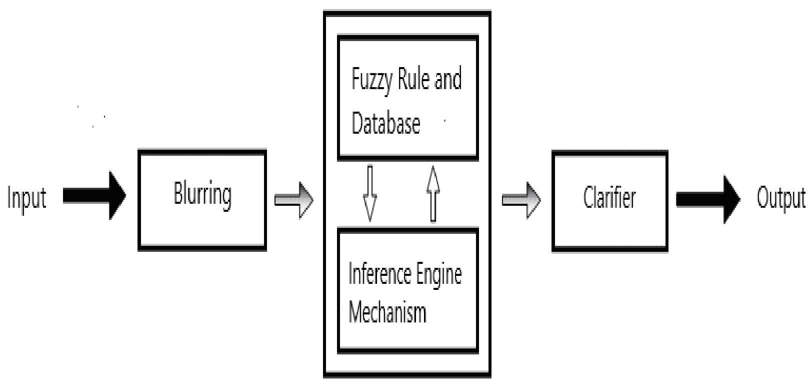


Figure 4.1 Block Diagram of Fuzzy Control.

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4.1. Blurring

Input values are converted to fuzzy values to be used in the Fuzzy Control system. The input values are converted into fuzzy values according to the membership functions they belong to, and these fuzzy values obtained correspond to the membership degrees in the membership functions they belong to (Büyükkaracığan, 2015).

Figure 4.2 shows how to convert a real value to a fuzzy value.

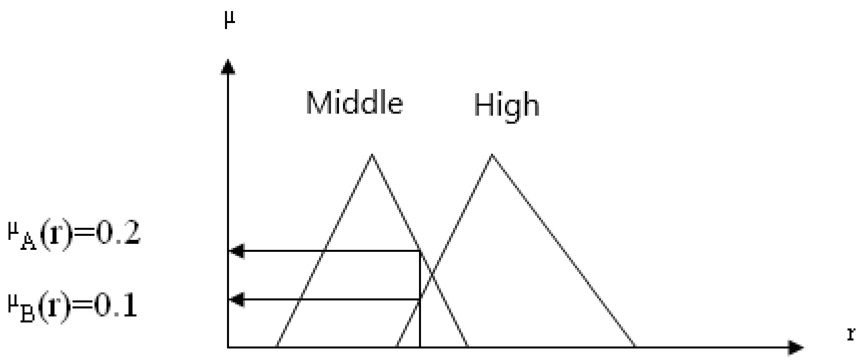

Figure 4.2 Blur Process.

4.2. Fuzzy Rule Base and Database

After deciding to design a fuzzy system, the first thing to do is to obtain the IF THEN rules table. These rules are generally created by utilizing an expert (Bay, 2006; Akyol, 2011).

It contains all the rules that can be written as a logical IF-THEN type that binds inputs to output variables in the database. In writing these rules, only all possible interval (fuzzy set) connections between input data and outputs are considered. Thus, each rule logically connects a part of the input space to the output space. All of these contexts make up the rule base. The IF – THEN concept is shown schematically in Figure 4.3 below.

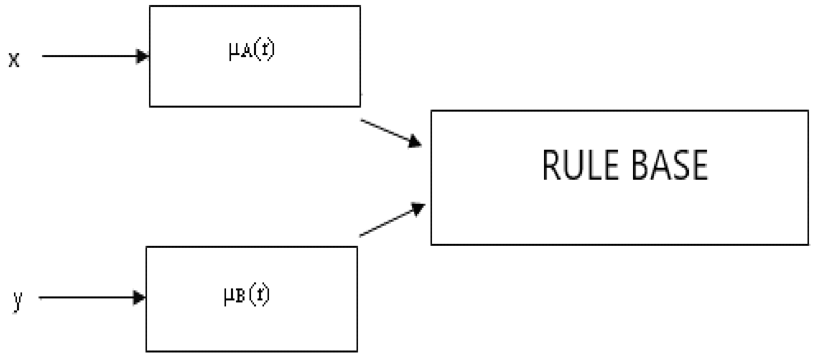

Figure 4.3 IF – THEN Concept.

4.3. Fuzzy Inference Engine Mechanism

It is a mechanism that includes a collection of operations that ensure that the system behaves with an output by gathering all the relations established between the input and output fuzzy sets in the fuzzy rule base. This engine collects the implications of each rule and determines how the whole system will output under the inputs (Büyükkaracığan, 2021b).

The decision making unit is also called the Fuzzy Engine. It is the core part of the Fuzzy Logic control. This part processes the fuzzy concepts in a way similar to the human's ability to make decisions and make inferences and determines the necessary control by making inferences.

The basis of a fuzzy controller is a rule-based system consisting of a rule analyzer, database, and rule base. Here, as in expert systems, the rules created in the rule base in the IF-THEN structure, the types and limit values of the membership functions used in the database are kept. The internal structure of a rule-based inference system used in a fuzzy controller is shown in Figure 4.4 in more detail.

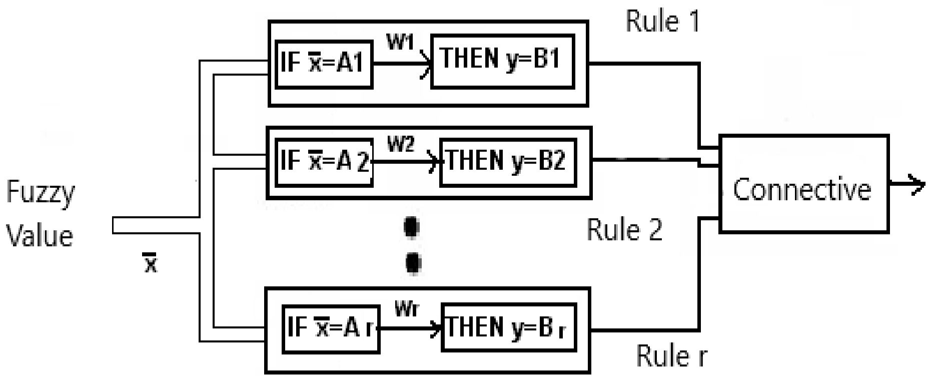

Figure 4.4 Fuzzy Rule Based Inference System Structure.

Different analysis methods can be applied in a fuzzy rule based system. The most important of them are; It is the Mamdani and Sugano model. In addition, there are different inference methods applied in the relations to be created between more than one rule in the combiner. Table 4.2 shows the most used inference methods.

Table 4.2. Inference Methods.

FUZZY INFERENCE METHOD	µA → B (x, y)
MAMDANI (MAX-MIN)	MIN (µA (x), µB (y))
MAX – PROD	(µA(x) * µB (y))

ZADEH	MAX [MIN (µA (x), µB (y))], 1-µA (x)
LUKASIEWICS	MIN (1,1- µA (x) + µB (y)
GÖDEL	1 → µA (x) <= µB (y) µB (y) → other
KLEENE-DIENES	MAX (1- µA (x), µA (y))
SHARP	1 → µA (x) <µB (x) 0 → other

4.4 Clarification

The result of the inference operation is a fuzzy set. Since fuzzy expressions or fuzzy sets do not make sense in the real world, the fuzzy information obtained at the end of the inference must be transformed into real-world information. This process is done in the clarification part. Clarification methods are below (Torun 2007; Büyükkaracığan, 2011).

4.4.1. Maximum method

In the mid-maximum method, only the rule with the largest saturation degree is sent to the output to obtain the sharp value of the output. In other words, the result fuzzy set with the highest height (with the highest membership degree) among the processed rules is processed. It corresponds to the range of values to be obtained by this method, as can be seen in Figure 4.5 where two rules are processed simultaneously. range, the result represents the large membership degree of the fuzzy set (Akyol et all., 2011).

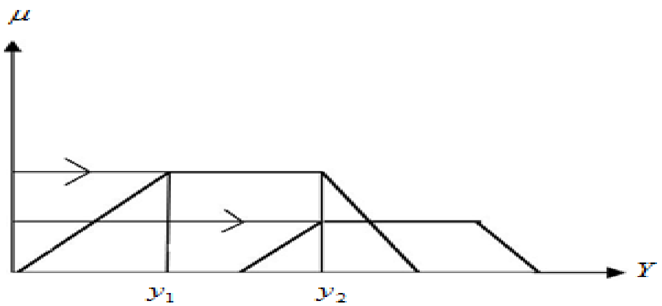

Figure 4.5. Schematic representation of the Inference Process.

$[y1\ y2]$ the result fuzzy set represents the largest membership degree in the range. There are three different uses for this method in different applications. These methods are shown below (Torun 2007)

4.4.1.1. Maximum mid-method

In this method, the limit value that determines the limits of the maximum height is averaged in the fuzzy output set with the largest height. The illustration of the method of subtracting the maximum mean is shown in Figure 4.6.

$$y' = \frac{y_1 + y_2}{2} \tag{4.1}$$

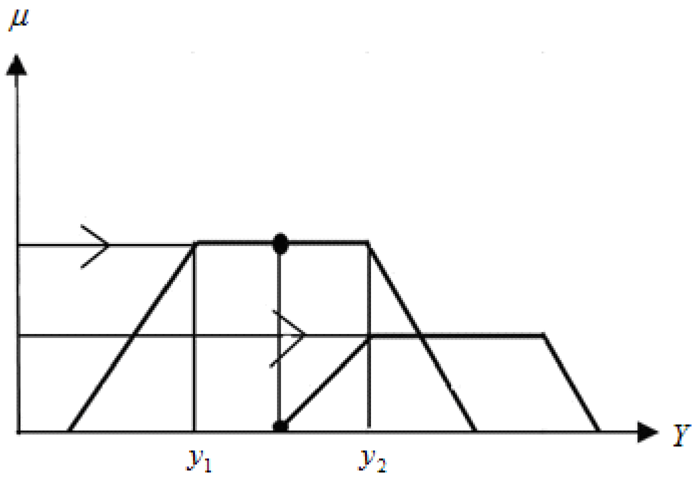

Figure 4.6. Representation of the Maximum Middle Subtraction Method.

In the literature, when "clarification according to maximum height" is mentioned, the average value is mentioned (Torun 2007).

4.4.1.2. Left edge method

In this type of application, the lower range limit value is selected as the result sharp value. The representation of the left edge point method is expressed in Figure 4,7 (Torun 2007; Akyol et.all, 2009).

$$y' = y_1 \tag{4.2}$$

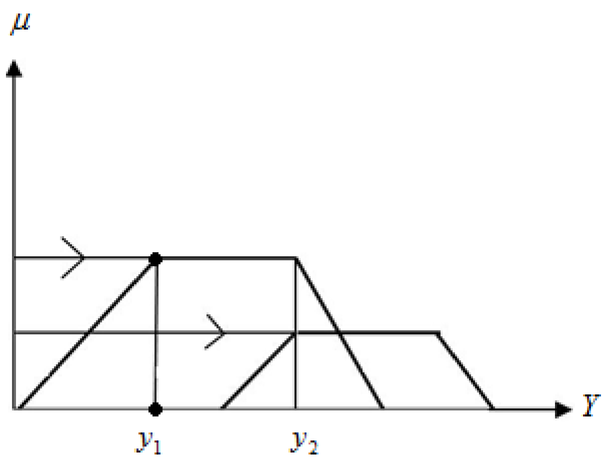

Figure 4.7. Representation of Maximum Left Edge Point Method.

4.4.1.3. Right edge method

In this type of application, the upper range limit value is selected as the result sharp value. The representation of the right margin method is shown in Figure 4.8. (Torun 2007).

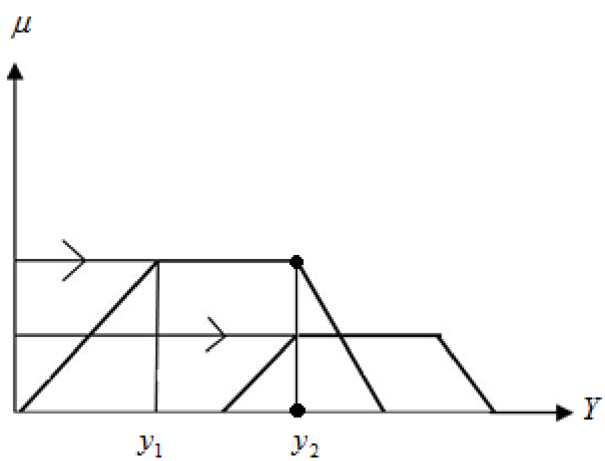

Figure 4.8. Representation of Maximum Right Side Point Method.

$$y' = y_2 \tag{4.3}$$

4.4.2. Center of gravity method

The output sharp value of the result is considered as the horizontal axis value of the center of gravity of the area formed by the sum of the fields under the compensation values of the fuzzy sets. This method is one of the most used clarification methods. Is expressed as:

$$y' = \frac{\int y * \mu(y) * dy}{\int \mu(y) * dy} \tag{4.4}$$

Technically, this calculation is performed by numerical integral at the fundamental discrete support points. The more precise the result, the longer the calculation time.

The representation of the center of gravity method is expressed in Figure 4,9. All output fuzzy sets obtained by the rules processed in the centroid method versus the maximum method are included in the calculation. Therefore, many active rules are averaged with their degree of satisfaction (Torun 2007).

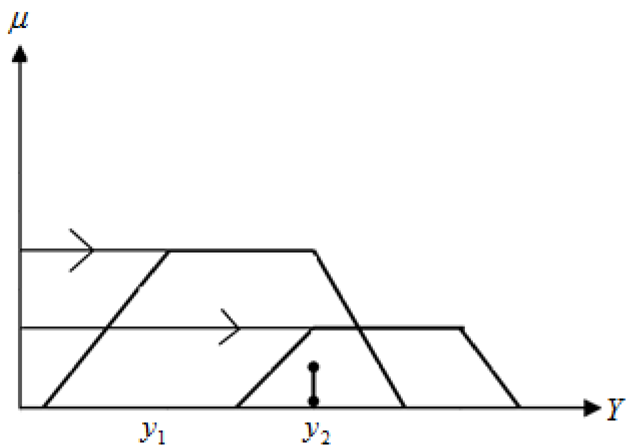

Figure 4.9 Representation of the Center of Gravity Method.

4.5. Fuzzy Control Applications

The first applications of fuzzy control were generally in industrial areas, cement industry (1980) and water treatment systems (1983). Later in the literature, it has been seen that more vigorous applications such as nuclear reactor, elevator and crane control have been used very successfully in the subway system in Sendai, Japan. This practice reached its peak in the 1990s and resulted in its use in a wide range of applications, from household appliances to stock market portfolio control, from cameras to patient monitoring expert systems. Today, special software and hardware for fuzzy control applications are readily available from the market. E.g; Omron company markets fuzzy simulation packages and special integrated circuits they call fuzzy microprocessor (Elmas 2003).

Fuzzy Control, Industrial applications as stated in Table 4,3, Audio-visual device applications as stated in Table 4,4, Household appliances applications as stated in Table 4,5, Transportation vehicles applications as stated in Table 4,6, Table 4,7 It has been used in areas such as financial applications as expressed in.

Table 4.3. Industrial Applications of Fuzzy Control (Elmas 2003).

Steel Industry	Nippon-Steel	It replaces traditional controllers.
Cement Industry	Mitsubishi-Chen	It controls the fever and oxygen ratio in the mill.
Fever Controller	Omron	It works as a hybrid with a PID controller, in case of sudden changes, it takes over the task of the PID controller.
PLC	Omron	It is used in process control in factories.
Error diagnosis	Guanghou	Finds where the error originates in a process.
Lift control	Fujitech, Toshiba, Mitsubishi	It evaluates passenger traffic, thus reducing waiting time.

Table 4.4 Audio-Visual Device Applications of Fuzzy Control (Elmas 2003).

SLR camera	Sanya-fisher, canon, minolta	It determines the best focus and lighting when there are many objects on the screen.
Video recorder	Panasonic	Eliminates the vibrations caused by handling the device by hand.

Table 4.5 Household Appliances of Fuzzy Control (Elmas 2003).

Linen	Matsushita	It senses the laundry pollution, weight and fabric type and determines the washing program accordingly.
Machine	Matsushita	It senses the condition and pollution of the ground and adjusts the engine power accordingly.
Electricity	Matsushita	Adjusts according to the amount and fever of the water used in fevering.
Broom	Mitsubishi	It detects the best working condition by sensing the ambient conditions.
Boiler	Omron	Blood pressure monitor.
Air conditioner	Sony	Adjusts the screen contrast, brightness and color.
Blood pressure monitor	Sony	Allows handwriting data and command entry.

Table 4.6 Means of Transport of Fuzzy Control (Diamond 2003).

Sendai subway system	Hitachi	It provides a comfortable journey by adjusting acceleration and deceleration, as well as adjusting the stopping position well and saving power.
Automobile powertrain	Subaru-Nissan	It senses the driving style and load and chooses the best gear ratio.
ABS brake system	Nisa	It allows the wheels to be braked without locking.

Table 4.7 Financial Applications of Fuzzy Control (Elmas 2003).

Stock trading program	Yamaichi-Securities	Manages the stock portfolio.

4.6. Expert Systems

Programs that act as an expert for a particular set of problems are called Expert Systems. The Expert System can be expressed as a transition from data processing to information processing. In data processing, the database is processed effectively depending on an algorithm, while in information processing, the knowledge base consisting of rules and facts derived from any algorithm is processed effectively. In other words, algorithms and inference mechanisms have been replaced, namely;

Traditional Programs → Algorithms + Database

Expert Systems → Inference Mechanism + Knowledge Base

The Expert System definition is made differently by various institutions and individuals, which causes a confusion of concepts. One of the most common mistakes is to confuse the Expert System with the knowledge-based systems. Knowledge-based systems solve difficult problems with the help of computerized information and reasoning. However, they differ from Expert Systems in that the problems they solve are smaller and more limited. In other words, Expert Systems contain complex information that requires real expertise. Such information is the information that individuals acquire through years of experience until they become experts. They are not found in documents such as books or magazines. Whereas, knowledge-based systems are created only with information found in publications (Allahverdi 2002).

Obtaining information from the expert and transferring it to the computer Expert system design is one of the most difficult problems. The process of designing the Expert System is often referred to as "knowledge engineering". Expert System design requires a special communication between one or more experts working under a particular problem and the Expert System designer, called the knowledge engineer. The information engineer observes the expert, takes his problem solving methods, rules, strategies and procedures, places them in the expert system or transmits them to the programmer who will do this. The two main methods of obtaining information from the expert are protocol analysis and discourse. In the first method, the expert presents his/her knowledge freely. In the second, the expert interactively presents the desired information. The most important part of an Expert System is a strong base with a structure that can increase continuously after system design. The Expert System user should be able to see the effects of new events and information and their relevance to the result.

Expert System; Artificial Neural Networks can be used with methods such as Fuzzy Logic and Genetic Algorithms. Thus, the restrictions on Expert Systems are removed.

In an Expert System used with Artificial Neural Networks, flexible learning is possible, and in an Expert System used with Fuzzy Logic, it is possible to reach correct results in case of lack of information (Allahverdi 2002).

4.7 Fuzzy Expert Systems

Fuzzy Expert System is an Expert System that uses fuzzy membership properties of functions and rules instead of Boolean logic to reason on data. Below is an example of rules in Fuzzy Expert Systems.

If X is low and Y is high, then Z is middle.

where X and Y are the names of the input variables or known data values, Z is the output variable or the name of the data whose value is to be calculated, low- membership function determined on X (fuzzy subset); high-determined membership function on Y; is the membership function determined on the middle z. The assumption part of the rule (if) defines the extent to which this rule can be applied, and the inference part (then) defines the allocation of a membership function to each of the one or more output variables. A rule can also allow more than one provision to be made. In general, the inference result in Fuzzy Expert Systems consists of three or four steps. These;
Fuzzification: Determining membership functions on input variables applied to real values to determine the degree of accuracy of each assumption;

Inference: Calculating the correct values for the assumption part of each rule and applying these values to the inference part of each rule. These results, which are in a fuzzy subset, are assigned to the output variable in each rule. In general, only min or multiplication operations are used as an inference rule. The min subtraction output membership function is obtained by intersecting the weights appropriate to the calculated accuracy of the rule assumption (fuzzy and). In product inference, the output membership function is scaled with the calculated accuracy of the rule assumption.

Composition: Combining all of the fuzzy subsets assigned to each output variable to form one fuzzy subset for each output variable. For this purpose, max or sum functions are mostly used. The max composition is obtained by taking the maxima of the fuzzy subsets assigned to the combined output fuzzy subsets inference rules variables (fuzzy or). The total composition is obtained by taking sums of fuzzy subsets assigned to the combined output fuzzy subsets inference rules variables.

Defuzzification: Fuzzy can be defined as the operation performed when the output set is desired to be converted to exact (crisp) numbers. There are many clarification methods available. The most well-known of these are the central (CENTROID) and maximum (MAXIMUM) methods.

4.8. Conventional Control System

The Traditional Control System is based on the concept of feedback. In negative feedback, the values are found by subtracting the continuously measured output values of the system from the desired actual values. It is seen that most of the applications are in the form of closed loop control.

It can be seen in control applications in the form of sequential control other than closed-loop control. In order to provide automatic control in sequential control, some movements are required at the beginning of each cycle. In elevator application, closing the door before the elevator moves is an example of sequential control.

Another type of control is on-off control. The system output is stimulated by the motion generator as on or off. Thermostat control is the most well-known application form.

Servomechanism type control is used in cases where the controlled variable completely changes to the application. This type of control is generally preferred in robot applications.
One of the advanced and most performed forms of closed-loop control is called PID (proportional integral derivative) control. Finding the PID controller output requires a more elaborate algorithm.

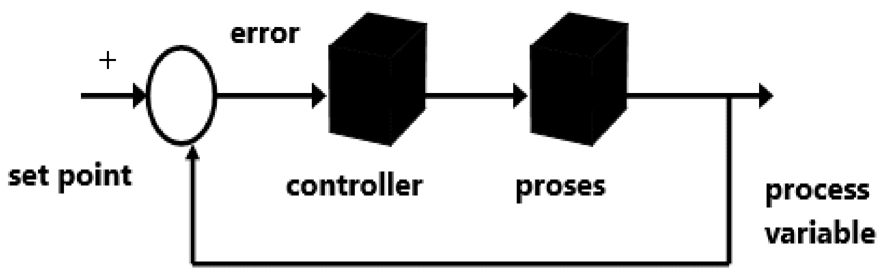

Figure 4.10 Conventional Feedback Control Loop.

To successfully perform conventional feedback control, the loop model of which is shown in Figure 4.10, it is necessary to know all of the process motion information. This is sometimes very difficult or even impossible to achieve in complex process applications. At the same time, it is often desirable to know the linear model of the process (Soy 2006).

4.9. Advantages of Fuzzy Expert Systems

The advantages of fuzzy expert systems can be listed as follows (Baykal and Beyan, 2004; Mikail, 2007; Yaralıoğlu, 2016).

- Close to human way of thinking
- It costs cheap due to its simple software.
- It brings simple solutions to the control of complex, uncertain, ill-defined, time-varying systems as in daily life.
- If the system is one that can be described by a simple mathematical model, then a conventional audit will suffice. But applying traditional logic to a complex system is both very difficult and costly. On the other hand, fuzzy expert systems can analyze the system better than traditional systems and they are also economical.
- Another advantage provided by fuzzy expert systems is that they allow direct user inputs and the user to benefit from their experiences.

4.10. Disadvantages of Fuzzy Expert Systems

The disadvantages of fuzzy logic can be counted as follows (Baykal and Beyan, 2004; Mikail, 2007; Yaralıoğlu, 2016).

- The need for experience in the creation of the rules used in practice,
- Too much time wasted due to finding membership functions by trial and error,
- It is the difficulty of performing the stability analysis.

5. MATERIALS AND METHOD

5.1. Fuzzy Expert Design

Fuzzy expert system design for the diagnosis of the new coronavirus disease, examinations were made in hospitals in Konya. Compared to normal control systems, it has been investigated how much a positive contribution the Fuzzy Expert system makes. For this, fuzzy control system, which is different from normal control systems, is designed (Figure 5,1). In this design, the input parameters are fever (ºC), cough, difficuty of respiration, diarrhea and loss of taste and smell. Output parameters are designed as coronavirus detection.

All input and output parameters are shown in Figure 5,1.

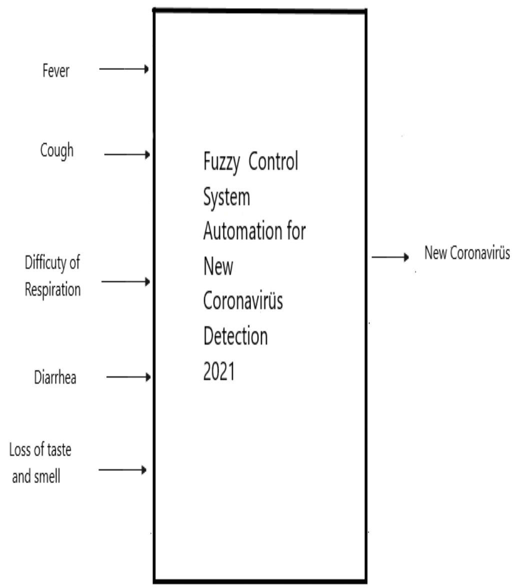

Figure 5.1. Fuzzy Expert Design 2021 Automation for Novel Coronavirus detection.

Fuzzy Control input and output values are defined as in the literature (Haque, 1994) and with five linguistic expressions according to expert opinion. These; **Very Low, Low, Middle, High, Very High.**

Seven input parameters were selected as indicated below, and the linguistic expressions determined are given in Table 5.1.

As input parameter:

1. The universal set for fever value is between [35…40] ºC.
2. The universal cluster for the cough value is between [0…100%] values.
3. The universal set for the difficuty of respiration value is between [0…100%].
4. The universal cluster for diarrhea value is between [0…100] % values.
5. The universal set for the tiredness value is between [0…100%] values.
6. The universal cluster for the taste smell of loss value is between [0…100%] values.

As output parameter:

1. The universal cluster for the novel Coronavirus is between [0…100%].

The use of Mamdani fuzzy model was preferred for all fuzzy inferences. The reason for this is that the Mamdani fuzzy model is both simple and suitable for the system structure.

The fuzzy verbal values of the system input/output variables and the properties of the variables are shown in Table 5,1 and Table 5,2 in detail.

Table 5.1. Fuzzy Variables of System 2021 Input/Output Variables.

Variable Name	**Type**	**FUZZY VERBAL VARIABLES**
Fever	Input	Very Low, Low, Middle, High, Very High
Cough	Input	Very Low, Low, Middle, High, Very High
Difficuty of Respiration	Input	Very Low, Low, Middle, High, Very High
Diarrhea	Input	Very Low, Low, Middle, High, Very High
Loss of Taste and smell	Input	Very Low, Low, Middle, High, Very High
New Coronavirus	Output	Very Low, Low, Middle, High, Very High

Table 5.2. Characteristics of System 2021 Input/Output Variables.

Variable	**Min**	**Max**	**Unit**
Fever	35	40	ºC
Cough	0	100	%
Difficuty of respiration	0	100	%
Diarrhea	0	100	%

Loss of Taste and Smell	0	100	%
New Coronavirus	0	100	%

All input and output parameters for control are blurred. Since it is seen from the literature (Sarıtaş, 2005) that the most convenient and simple method is triangular blurring, triangular blurring has been chosen here (Figure 5,3, 5,4, 5,5, 5,6, 5,7, 5,8,).

Since the membership functions of the fuzzy parameters are taken as triangular, their mathematical formulas are obtained appropriately. Here, the help of an expert was taken while determining the linguistic values.

The fever must be below 36,5ºC in order not to have a new coronavirus disease. The fever can vary between 35ºC and 40ºC. The values of the right and left sides of the blurring degrees of the input linguistic values were determined with the help of a specialist doctor. For example, “Middle” linguistic fever values will range from 36 ºC to 37 ºC, where the maximum membership degree will be 36,5 ºC, so μ is very low (36,5 ºC) = 1.

The mathematical expressions for the linguistic value of fire (X) are as follows (Figure 5.3)

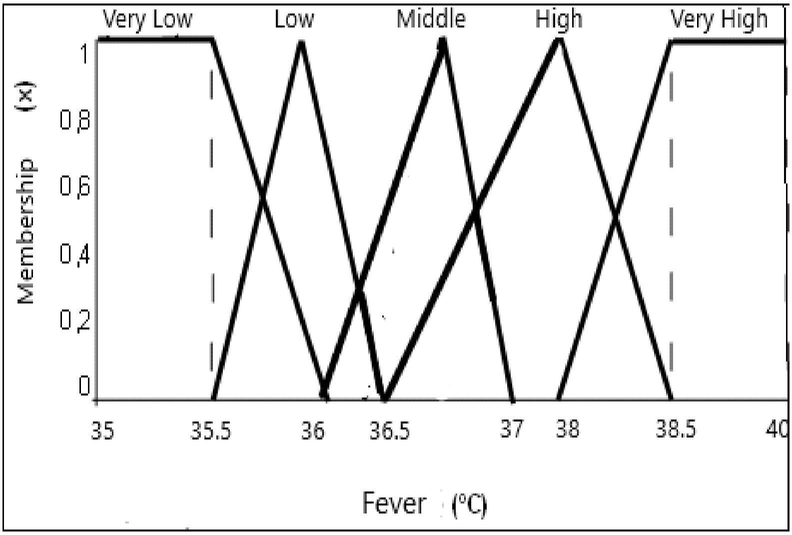

Figure 5.3. Membership Functions of Variables for Novel Coronavirus Disease Fever Value.

Below are the fever values for the new coronavirus disease.

Fuzzy expressions for fever (Fever=X, Fever value=x);

$$\mu_{\text{Very Low}}(x) = \begin{cases} 35 \leq x \leq 35.5 & ; 1 \\ 35.5 \leq x \leq 36 & ; (36 - x)/0.5 \\ x > 36 & ; 0 \end{cases}$$

$$\mu_{\text{Low}}(x) = \begin{cases} x < 35 \text{ or } x > 35.5 & ; 0 \\ 35.5 \leq x \leq 36 & ; (x - 35.5)/0.5 \\ 36 \leq x \leq 36.5 & ; (36.5 - x)/0.5 \end{cases}$$

$$\mu_{Middle}(x) = \begin{cases} x < 36 \text{ or } x > 37 & ; 0 \\ 36 \leq x \leq 36.5 & ; (x - 36)/0.5 \\ 36.5 \leq x \leq 37 & ; (37 - x)/0.5 \end{cases}$$

$$\mu_{High}(x) = \begin{cases} x < 36.5 \text{ or } x > 38.5 & ; 0 \\ 36.5 \leq x \leq 37.5 & ; (x - 36.5) \\ 37.5 \leq x \leq & ; (38.5 - x) \end{cases}$$

Fever fuzzy clusters found according to these values are given below.

$$\mu_{Very\ Low}(x) = \{ 1/35, 1/35.5, 0.2/35.9, 0/36 \}$$

$$\mu_{Low}(x) = \{ 0/35.5, 1/36, 0.4/36.3, 0/36.5 \}$$

$$\mu_{Middle}(x) = \{ 0/36, 1/36.5, 0.2/36.9, 0/37 \}$$

$$\mu_{High}(x) = \{ 0/36.5, 0.5/37, 0.2/38.3, 0/38.5 \}$$

$$\mu_{Very\ High}(x) = \{ 0/38, 0.5/38.5, 1/39, 1/40 \}$$

Cough should be below 30 percent in order not to have a new coronavirus disease.

The mathematical expressions for the linguistic value of cough (Y) are as follows (Figure 5.4).

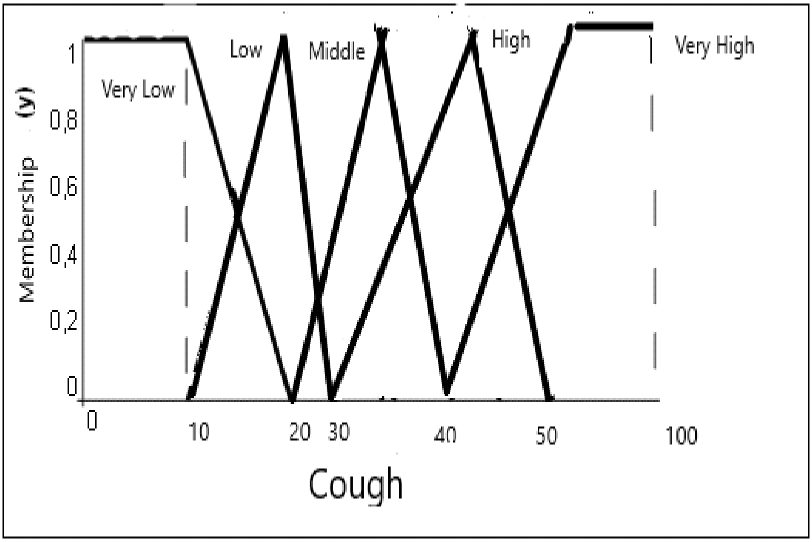

Figure 5.4 Membership Functions of Variables for Novel Coronavirus Disease Cough Value.

Blurred expressions for Cough (Cough=Y, Cough value=y);

$$\mu_{\text{Very Low}}(y) = \begin{cases} 0 \leq y \leq 10 & ;1 \\ 10 \leq y \leq 20 & ;(20 - y)/10 \\ y > 20 & ;0 \end{cases}$$

$$\mu_{Low}(y) = \begin{cases} y < 10 \text{ or } y > 30 & ; 0 \\ 10 \leq y \leq 20 & ; (y - 10)/10 \\ 20 \leq y \leq 30 & (30 - y)/10 \end{cases}$$

$$\mu_{Middle}(y) = \begin{cases} y < 20 \text{ or } y > 40 & ; 0 \\ 20 \leq y \leq 30 & ; (y - 20)/10 \\ 30 \leq y \leq 40 & (40 - y)/10 \end{cases}$$

$$\mu_{High}(y) = \begin{cases} y < 30 \text{ or } y > 50 & ; 0 \\ 30 \leq y \leq 40 & ; (y - 30)/10 \\ 40 \leq y \leq 50 & ; (50 - y)/10 \end{cases}$$

$$\mu_{Very\ High}(y) = \begin{cases} y < 40 \text{ or } y > 100 & ; 0 \\ 40 \leq y \leq 70 & ; (y - 40)/30 \\ 70 \leq y \leq 100 & ; 1 \end{cases}$$

Cough fuzzy clusters found according to these values are given below.

$$\mu_{Very\ Low}(y) = \{1/0,\ 1/10,\ 0.5/15,\ 0/20\}$$

$$\mu_{Low}(y) = \{0/10,\ 0.5/15,\ 1/20,\ 0/30\}$$

$$\mu_{Middle}(y) = \{0/20,\ 0.5/25,\ 1/30,\ 0/40\}$$

$$\mu_{High}(y) = \{0/30,\ 0.5/35,\ 1/40,\ 0/50\}$$

$$\mu_{\text{Very High}}(y) = \{\ 0/40,\ 0.33/50,\ 0.66/60,\ 1/100\ \}$$

In order not to have a new coronavirus difficuty of respiration distress must be below 30 percent.

The mathematical expressions for the linguistic value of Respiration Difficulty (Z) are as follows (Figure 5.5).

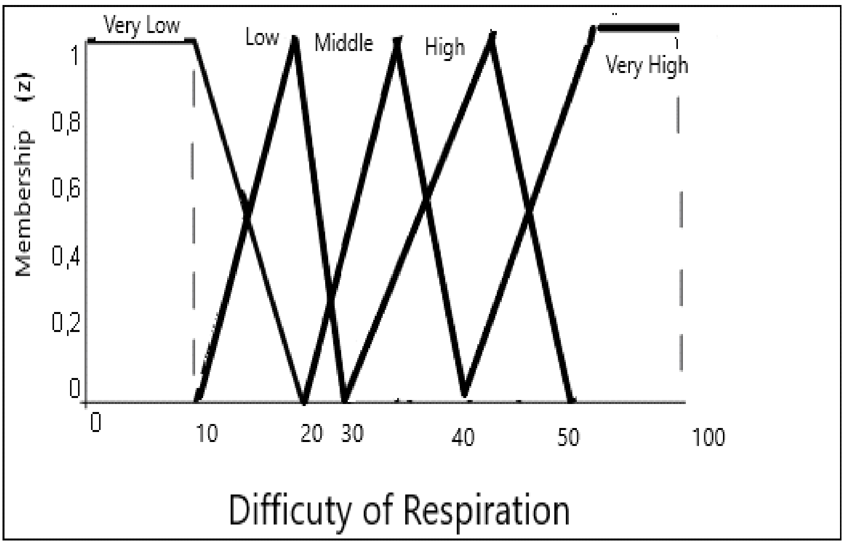

Figure 5.5 Membership Functions of Variables for Novel Coronavirus Difficulty of respiration Value.

Blurred expressions for Difficulty in Respiration (Difficulty in Respiration=Z, Difficulty of respiration value=z);

$$\mu_{\text{Very Low}}(z) = \begin{cases} 0 \le z \le 10 & ;1 \\ 10 \le z \le 20 & ;(20 - z)/10 \\ z > 20 & ;0 \end{cases}$$

$$\mu_{\text{Low}}(z) = \begin{cases} z < 10 \text{ or } z > 30 & ;0 \\ 10 \le z \le 20 & ;(z - 10)/10 \\ 20 \le z \le 30 & ;(30 - z)/10 \end{cases}$$

$$\mu_{\text{Middle}}(z) = \begin{cases} z < 20 \text{ or } z > 40 & ;0 \\ 20 \le z \le 30 & ;(z - 20)/10 \\ 30 \le z \le 40 & ;(40 - z)/10 \end{cases}$$

$$\mu_{\text{High}}(z) = \begin{cases} z < 30 \text{ or } z > 50 & ;0 \\ 30 \le z \le 40 & ;(z - 30)/10 \\ 40 \le z \le 50 & ;(50 - z)/10 \end{cases}$$

$$\mu_{\text{Very High}}(z) = \begin{cases} z < 40 \text{ or } z > 100 & ;0 \\ 40 \le z \le 70 & ;(z - 40)/30 \\ 70 \le z \le 100 & ;1 \end{cases}$$

The fuzzy sets of respiratory difficuty of respiration according to these values are given below.

$$\mu_{\text{Very Low}}(z) = \{\ 1/0,\ 1/10,\ 0.5/15,\ 0/20\ \}$$

$$\mu_{\text{Low}}(z) = \{\ 0/10,\ 0.5/15,\ 1/20,\ 0/30\ \}$$

$$\mu_{\text{Middle}}(z) = \{\ 0/20,\ 0.5/25,\ 1/30,\ 0/40\ \}$$

$$\mu_{\text{High}}(z) = \{\ 0/30,\ 0.5/35,\ 1/40,\ 0/50\ \}$$

$$\mu_{\text{Very High}}(z) = \{\ 0/40,\ 0.33/50,\ 0.66/60,\ 1/100\ \}$$

Diarrhea must be below 30 percent in order to avoid a new coronavirus disease.

The mathematical expressions for the linguistic value of diarrhea (V) are as follows (Figure 5.6).

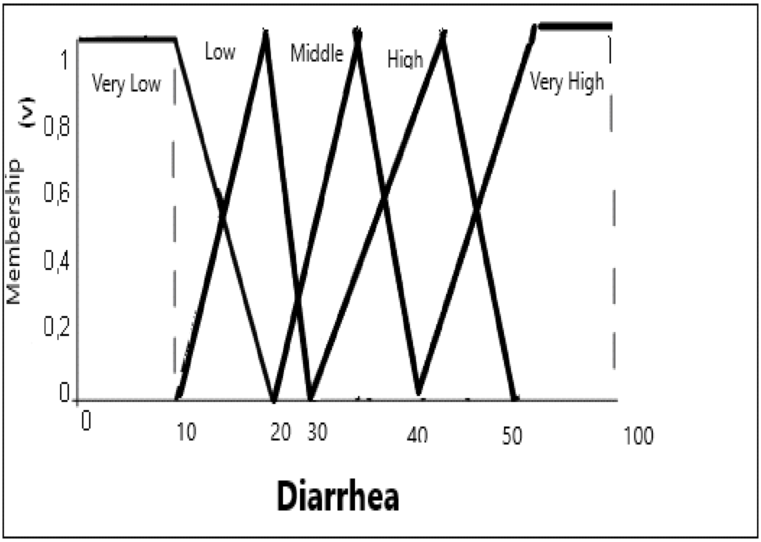

Figure 5.6 Membership Functions of Variables for Novel Coronavirus Disease Diarrhea Value.

Fuzzy expressions for diarrhea (Diarrhea =V, Diarrhea Value=v);

$$\mu_{\text{Very Low}}(v) = \begin{cases} 0 \leq v \leq 10 \;; 1 \\ 10 \leq v \leq 20 \;; (20 - v)/10 \\ v > 20 \;; 0 \end{cases}$$

$$\mu_{\text{Low}}(v) = \begin{cases} v < 10 \text{ or } v > 30 \;; 0 \\ 10 \leq v \leq 20 \;; (v - 10)/10 \\ 20 \leq v \leq 30 \; (30 - v)/10 \end{cases}$$

$$\mu_{\text{Middle}}(v) = \begin{cases} v < 20 \text{ or } v > 40 \;; 0 \\ 20 \leq v \leq 30 \;; (v - 20)/10 \\ 30 \leq v \leq 40 \; (40 - v)/10 \end{cases}$$

$$\mu_{\text{High}}(v) = \begin{cases} v < 30 \text{ or } v > 50 \;; 0 \\ 30 \leq v \leq 40 \;; (v - 30)/10 \\ 40 \leq v \leq 50 \;; (50 - v)/10 \end{cases}$$

$$\mu_{\text{Very High}}(v) = \begin{cases} v < 40 \text{ or } v > 100 \;; 0 \\ 40 \leq v \leq 70 \;; (v - 40)/30 \\ 70 \leq v \leq 100 \;; 1 \end{cases}$$

Diarrhea clusters found according to these values are given below.

$$\mu_{\text{Very Low}}(v) = \{ 0/40, 0.33/50, 0.66/60, 1/100 \}$$

$$\mu_{\text{Low}}(v) = \{ 0/10, 0.5/15, 1/20, 0/30 \}$$

$$\mu_{\text{Middle}}(v) = \{ 0/20, 0.5/25, 1/30, 0/40 \}$$

$$\mu_{\text{High}}(v) = \{ 0/30, 0.5/35, 1/40, 0/50 \}$$

$$\mu_{\text{Very High}}(v) = \{ 0/40, 0.33/50, 0.66/60, 1/100 \}$$

The loss of taste and smell must be below 30 percent in order to avoid a new coronavirus disease.

The mathematical expressions for the linguistic value of taste and smell loss (K) are as follows (Figure 5.7).

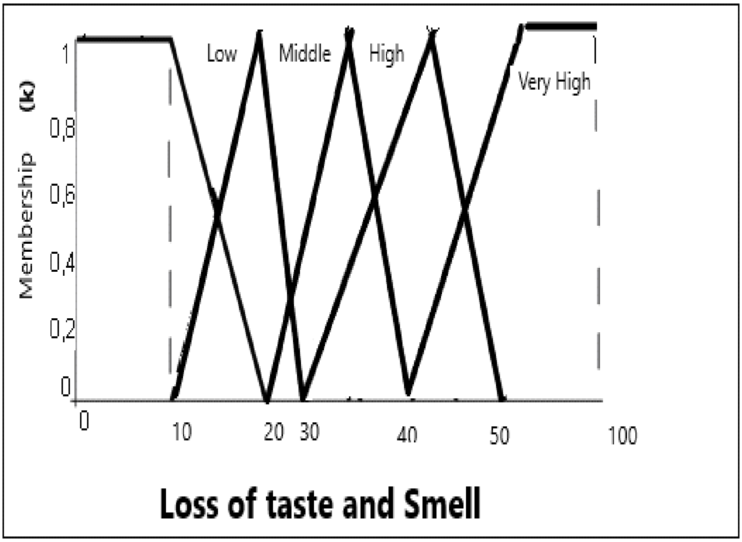

Figure 5.7. Membership Functions of Variables for Novel Coronavirus Disease Taste and Smell Loss Value.

Fuzzy expressions for odor and taste loss (Taste and odor loss = K, Taste and odor loss value = k);

$$\mu_{\text{Very Low}}(k) = \begin{cases} 0 \leq k \leq 10 & ; 1 \\ 10 \leq k \leq 20 & ; (20 - k)/10 \\ k > 20 & ; 0 \end{cases}$$

$$\mu_{\text{Low}}(k) = \begin{cases} k < 10 \text{ or } > 30 & ; 0 \\ 10 \leq k \leq 20 & ; (k - 10)/10 \\ 20 \leq k \leq 30 & ; (30 - k)/10 \end{cases}$$

$$\mu_{\text{Middle}}(k) = \begin{cases} k < 20 \text{ or } k > 40 & ; 0 \\ 20 \leq k \leq 30 & ; (k - 20)/10 \\ 30 \leq k \leq 40 & ; (40 - k)/10 \end{cases}$$

$$\mu_{High}(k) = \begin{cases} k < 30 \text{ or } k > 50 ; 0 \\ 30 \leq k \leq 40 ; (k - 30)/10 \\ 40 \leq k \leq 50 ; (50 - k)/10 \end{cases}$$

$$\mu_{Very\ High}(k) = \begin{cases} k < 40 \text{ or } k > 100 ; 0 \\ 40 \leq k \leq 70 ; (k - 40)/30 \\ 70 \leq k \leq 100 ; 1 \end{cases}$$

The fuzzy clusters of taste and smell loss found according to these values are given below.

$$\mu_{Very\ Low}(k) = \{1/0, 1/10, 0.5/15, 0/20\}$$

$$\mu_{Low}(k) = \{0/10, 0.5/15, 1/20, 0/30\}$$

$$\mu_{Middle}(k) = \{0/20, 0.5/25, 1/30, 0/40\}$$

$$\mu_{High}(k) = \{0/30, 0.5/35, 1/40, 0/50\}$$

$$\mu_{Very\ High}(k) = \{0/40, 0.33/50, 0.66/60, 1/100\}$$

The degree of turbidity of the output values was determined with the help of specialist doctors.

The mathematical expressions for the linguistic value for the novel coronavirus disease (YKV) are as follows (Figure 5.8).

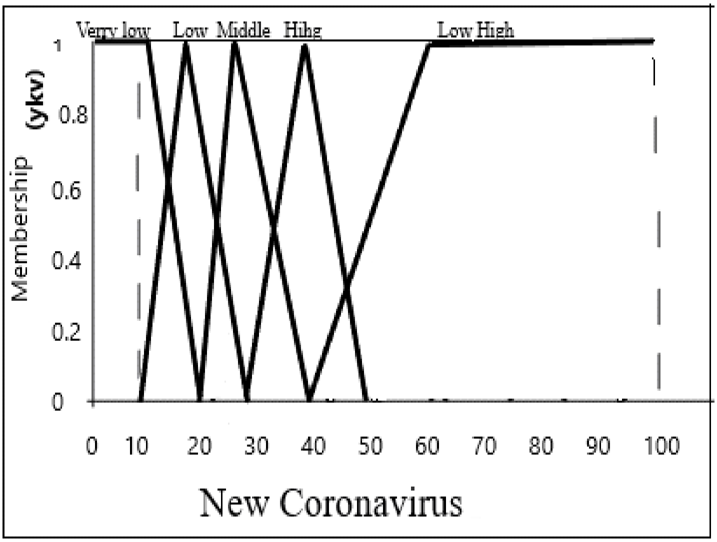

Figure 5.8 Membership Functions of Variables for Value of Novel Coronavirus Disease.

Fuzzy expressions for the Novel Coronavirus output value (New Coronavirus =YKV, New Coronavirus output value=ykv);

$$\mu_{\text{Very Low}}(ykv) = \begin{cases} 0 \le ykv \le 10 & ;1 \\ 10 \le ykv \le 20 & ;(20 - ykv)/10 \\ ykv > 20 & ;0 \end{cases}$$

$$\mu_{\text{Low}}(ykv) = \begin{cases} ykv < 10 \text{ or } ykv > 30 & ;0 \\ 10 \le ykv < 20 & ;(ykv - 10)/10 \\ 20 \le ykv \le 30 & ;(30 - ykv)/10 \end{cases}$$

$$\mu_{Middle}(ykv) = \begin{cases} ykv < 20 \text{ or } ykv > 40 : 0 \\ 20 \leq ykv \leq 30 : (ykv - 20)/10 \\ 30 \leq ykv \leq 40 : (40 - ykv)/10 \end{cases}$$

$$\mu_{High}(ykv) = \begin{cases} ykv < 30 \text{ or } ykv > 50 : 0 \\ 30 \leq ykv \leq 40 : (ykv - 30)/10 \\ 40 \leq ykv \leq 50 : (50 - ykv)/10 \end{cases}$$

$$\mu_{Very\ High}(ykv) = \begin{cases} ykv < 40 \quad ykv > 100 : 0 \\ 40 \leq ykv \leq 60 : (ykv - 40)/20 \\ 60 \leq ykv \leq 100 : 1 \end{cases}$$

The clusters of new coronavirus output values found according to these values are given below.

$$\mu_{Very\ Low}(ykv) = \{1/0, 1/10, 0.5/15, 0/20\}$$

$$\mu_{Low}(ykv) = \{0/10, 0.5/15, 1/20, 0/30\}$$

$$\mu_{Middle}(ykv) = \{0/, 0.5/25, 1/30, 0/40\}$$

$$\mu_{High}(ykv) = \{0/30, 0.5/35, 1/40, 0/50\}$$

$$\mu_{Very\ High}(ykv) = \{0/40, 0.5/50, 1/60, 1/100\}$$

The output value calculated in the new coronavirus automation 2021 system with the Fuzzy Control method is affected by the state of the input parameters. Five linguistic variables were used in the input and output parameters. It has been determined by the expert for the output values.

The fuzzy rules expressing the situations in which it affects 5 inputs and 1 output are given below.

1- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.
2- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.
3- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Middle, then the New Coronavirus output value is Low.
4- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is High, then the New Coronavirus exit value is Middle.
5- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is High.

6- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.

7- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Middle, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Low.

8- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is High, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Middle.

9- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration Very Low, Diarrhea is Very High, and Loss of Taste and Smell is Very Low, then the New Coronavirus exit value is High.

10- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.

11- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Middle, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.

12- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is High, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Low.

13- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very High, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus exit value is Middle.

14- If Fever is Very Low, Cough is Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.

15- If Fever is Very Low, Cough is Middle, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.

16- If Fever is Very Low, Cough is High, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Low.

17- If Fever is Very Low, Cough is Very High, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Low.

18- If Fever is Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Very Low.

19- If Fever is Middle, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is Low.

20- If Fever is High, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus exit value is Middle.

21- If Fever is Very High, Cough is Very Low, Difficulty of Respirationis is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Very Low, then the New Coronavirus output value is High.

22- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

23- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Middle, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

24- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is High, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Low.

25- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very High, and Loss of

Taste and Smell is Low, then the New Coronavirus output value is Middle.

26- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

26- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

27- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Middle, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

28- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is High, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

29- If Fever is Very Low, Cough is Very Low, Difficulty of Respiration is Very High, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Low.

30- If Fever is Very Low, Cough is Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

31- If Fever is Very Low, Cough is Middle, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

32- If Fever is Very Low, Cough is Middle, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

33- If Fever is Very Low, Cough is High, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

34- If Fever is Very Low, Cough is Very High, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Low.

35- If Fever is Low, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very Low.

36- If Fever is Middle, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Low.

37- If Fever is High, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Middle.

38- If Fever is Very High, Cough is Very Low, Difficulty of Respiration is Very Low, Diarrhea is Very Low, and Loss of Taste and Smell is Low, then the New Coronavirus output value is High.

Since there are 5 entries and 5 different fuzzy verbal variables in thesystem, the fuzzy rule will be 55. So there are 3125 fuzzy rules.

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3099- If Fever is Very High, Cough is Very High, , Difficulty of Respiration is Very Low, Diarrhea is Very High, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3098- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Low, Diarrhea is Very High, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3099- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Middle, Diarrhea is Very High, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3100- If Fever is Very High, Cough is Very High, Difficulty of Respiration is High, Diarrhea is Very High, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3101- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very Low, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3102- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Low, and Loss of Taste and Smellis High, then the New Coronavirus output value is Very High.

3103- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Middle, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3104- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is High, and Loss of Taste and Smell is High, then the New Coronavirus output value is Very High.

3107- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Middle, then the New Coronavirus exit value is Very High.

3108- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Low, then the New Coronavirus output value is Very High.

3109- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very Low, then the New Coronavirus exit value is Very High.

3110- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3111- If the Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Middle, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3112- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Low, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3113- If Fever is Very High, Cough is Very High, , Difficulty of Respiration is Very High, Diarrhea is Very Low, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3114- If Fever is Very High, Cough is Very High, Difficulty of Respiration is High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus exit value is Very High.

3115- If Fever is Very High, Cough is Very High, , Difficulty of Respiration is Middle, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3116- If Fever is Very High, Cough is Very High, Difficulty of Respiration is Low, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3117- If Fever is Very High, Cough is Very High, , Difficulty of Respiration is Very Low, Diarrhea is Very High, and Loss of

Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3118- If Fever is Very High, Cough is High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus exit value is Very High.

3119- If the Fever is Very High, Cough is Middle, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus exit value is Very High.

3120- If Fever is Very High, Cough is Low, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3121- If Fever is Very High, Cough is Very Low, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3122- If Fever is High, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3123- If Fever is Middle, Cough is Very High, , Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus output value is Very High.

3124- If Fever is Low, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus exit value is Very High.

3125- If Fever is Very Low, Cough is Very High, Difficulty of Respiration is Very High, Diarrhea is Very High, and Loss of Taste and Smell is Very High, then the New Coronavirus exit value is Very High.

6. INTRODUCTION OF THE NEW COROVIRUS DISEASE DIAGNOSIS FUZZY CONTROL 2021 INTERFACE

The software of the system was written in Delphi 7.0. As seen in Figure 6.1, two options are presented to the user at the start of the program. The first option is "Enter values by the user" and the second is "Enter random values". If the "Enter random values" option is selected, the program will generate its own values and calculate the output values, taking into account the limits given to the input values. When the "Enter values by the user" option is selected, the next phase of the program, the interface, is displayed as seen in Figure 6.2.

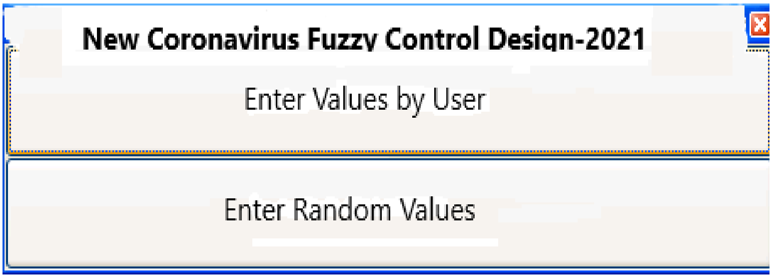

Figure 6.1 Display of the Input Option of the Program.

Figure 6.2 Home Page Image of the Automation Program.

7. CONCLUSION

The world met the new coronavirus in 2020. Especially in the early days, they could not make a definitive judgment about the symptoms of the disease by the health world. In the following times, the disease began to be diagnosed by gaining experience.

In recent years, it has started to eliminate the loss of life and money by early diagnosis of the disease by using Fuzzy Logic and Expert System in the field of health. Early detection of the new Coronavirus disease will be achieved with the help of Fuzzy Control.

During the study, we worked with specialist doctors and university hospitals in Konya. Thanks to these specialist doctors, the inputs and output values were determined.

In this study, basic information about Fuzzy Control is given, and Fuzzy Expert System inputs and outputs required for the disease are determined. Appropriate Fuzzy Expert System is designed. The widely used centroid method was used to calculate the Fuzzy Control output values.

In the study, the necessary data for the New Coronavirus disease were collected. Five linguistic values were used for the input parameters. It is provided with Delphi program for the designed control.

The accuracy of the program was made using the Matlap program. It has been seen that the results obtained in the Fuzzy Expert System are correct.

The main purpose of the study is to detect the disease before testing and to take precautions. Time and economic savings are achieved when Fuzzy Control is used. As of November 2021, 350000 tests were performed and 25000 patients were identified. The aim here is to reduce the number of tests from 300000.

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ATTACHMENTS

APPENDIX-A- “MNO_YKV_2021 New Coronavirus Disease Diagnosis Automation 2021” program with Fuzzy Control Method written with Delphi 7.0 program.

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ISBN: 978-625-8007-84-8