African Journal of Biotechnology Vol. 11(4), pp. 979-991, 12 January, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.2499
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Comparison with Sugeno Model and Measurement Of Cancer Risk Analysis By New Fuzzy Logic Approach

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Accepted 14 November, 2011

Every year thousands of human mortality from cancer is due to limitation of medical sources and unable to use the existing sources effectively. Patient losses can be reduced by using the numerical (quantitative) techniques in the system of medical and health. Cancer is the leading life-threatening disease for people in today's world. Although cancer formation is different for each type of cancer, it is determined in studies and research conducted that stress also triggers cancer types. Early precaution is very important for the people who have not been sick yet that have high mortality rate and expensive treatment such as cancer. With this type of study, the possibility of getting disease may decrease and people can take measures for the disease. In this study, for the three cancer types selected as pilot by introducing a new type of fuzzy logic model, the opportunity of revealing of risks for catching these cancer types of people and the opportunity of providing preliminary diagnosis to the person to remove this risk are presented. After the calculation of risk outcome, the effect of stress on cancer is discussed and calculated. Due to this type of study, people will have the chance to take measures against catching cancer and the rate of catching cancer can be decreased. Due to this study, the presentation of strong software is aimed, so that related techniques are used in the health field and sample studies are conducted. Furthermore, the performance status of the new technique was revealed by calculating performance measurements of the outcomes of the models developed by the new type of fuzzy logic technique for three cancer types selected as pilot within the study and Takagi-Sugeno type of fuzzy logic model.

Key words: Fuzzy logic, artificial ıntelligence, cancer, risk analysis, preliminary diagnosis, soft computing, new fuzzy logic technique.

INTRODUCTION

The past few years have witnessed a rapid growth in the number and variety of applications of fuzzy logic (FL). FL techniques have been used in image-understanding applications such as detection of edges, feature extraction, classification, and clustering. Fuzzy logic poses the ability to mimic the human mind to effectively employ modes of reasoning that are approximate rather than exact. In traditional hard computing, decisions or actions are based on precision, certainty, and vigor. Precision and certainty carry a cost. In soft computing, tolerance and impression are explored in decision making. The exploration of the tolerance for imprecision and uncertainty underlies the remarkable human ability to understand distorted speech, decipher sloppy handwriting, comprehend nuances of natural language, summarize text, and recognize and classify images. With FL, we can specify

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mapping rules in terms of words rather than numbers. Computing with the words explores imprecision and tolerance. Another basic concept in FL is the fuzzy if–then rule. Although rule-based systems have a long history of use in artificial intelligence, what is missing in such systems is machinery for dealing with fuzzy consequents or fuzzy antecedents. In most applications, an FL solution is a translation of a human solution. Thirdly, FL can model nonlinear functions of arbitrary complexity to a desired degree of accuracy. FL is a convenient way to map an input space to an output space. FL is one of the tools used to model a multiinput, multioutput system. FL approach gives to machines the ability of processing special data of humans and of working by benefiting from their experiences and fore-sights. While bringing in this ability, it uses symbolical expressions instead of numerical expressions. The transfer of these symbolical expressions to the machines is based on a mathematical foundation. This mathematical foundation is the FL Sets Theory and FL based on Zadeh (1965). The foundation of FL controller is based on this kind of verbal expressions and on the logical relationships among these. During the application of the FL controller, the mathematical modeling of the system is not essential. The transfer of verbal expressions to the computer is based on a mathematical foundation. This mathematical foundation is named as fuzzy sets theory and FL. FL expresses multi-level procedures in (0,1) range, not like the two levels of (0,1) as known in classical logic. FL has the ability to conduct procedures according to information that is not fully known or is not completely entered (Elmas, 2007).

Most of the Takagi–Sugeno fuzzy systems found in the literature (Joh et al., 1998; Li et al., 2003; Takagi and Sugeno, 1985; Tanaka and Sugeno, 1992; Wang et al., 1996; Wang et al., 2003; Wang et al., 1995; Ying, 1998) have only used linear functions of input variables as rule consequent (i.e., linear rule consequent) and can be called as Takagi– Sugeno Fuzzy Models with Fixed Coefficient (TSFMFC). It simply means that the coefficients of state variables in the consequents of each rule are fixed constants. This paper presents an extended Takagi–Sugeno fuzzy model named as Takagi–Sugeno fuzzy model with variable coefficient and it is proved that it can approximate a class of nonlinear systems, non-linear dynamic systems, and nonlinear control systems.

As a result of restricted medical resources, ineffective usage of existing resources, every year hundred thousands of people in the world lose their lives due to specific diseases. Usage of numerical systems in medicine and health systems may reduce the loss of patients (Alvarez, 2000). Mathematical models may be used almost everywhere a decision making problem exists.

Cancer is a genetic disease, formed as a result of growth and proliferation of cells in an uncontrolled or abnormal manner due to cells' exiting from program by DNA damage and is the leading life threatening disease for human in today's world. Although cancer formation is different for each type of cancer, it is determined in studies and research conducted that stress also triggers cancer types. Stress is a bodily constraint, coming from physical and social environment, not causing the disease directly, but causing bodily and psychological diseases due to its reduction of resistance of human body. It is suggested that especially psychological stresses pressurize the immune system by reducing T lymphocytes. On the other hand, this reduction in the response of the immune system increases the frequency of infectious diseases and cancer. Stress leads to settlement of cancerogenic cells and to their spread in the entire body by disrupting the immune system of the body. Animal studies have shown such a relationship between stress and cancer (Bilge et al., 2008).

Fuzzy logic plays an important role in the field of medicine and has been investigated in many medical applications (Abbod et al., 2001). Some of the applications of fuzzy logic in medicine are as follows (Torres and Nieto., 2006):

1) To determine breast cancer, lung cancer, or prostate cancer,
2) To assist the diagnosis of central nervous system tumors,
3) To separate benign lesions from malign ones,
4) To display quantitative estimates of drug usage,
5) To characterize subspecies of stroke and concomitant ischemic stroke,
6) To improve decision making in radiation therapy,
7) To control hypertension during anesthesia,
8) To determine rehabilitation techniques for flexor-tendon,
9) To determine appropriate lithium dosage,
10) To calculate the volume and cavity of brain tissues in magnetic resonance images and to analyze functional magnetic resonance images.

Early precaution is very important for the people who have not been sick yet that have high mortality rate and expensive treatment such as cancer. With this type of study, the possibility of getting disease may decrease and people can take measures for the disease. To the extent that the cancer is diagnosed earlier, its treatment is successful at that level. If medicine can use techniques such as fuzzy logic from artificial intelligence methods in their own fields, in the future, many diseases such as cancer may reach a treatable level or may be prevented due to early diagnosis. Thus, expensive treatments or surgeries may not even be required. Today, most of people catching cancer apply hospitals at advanced stages of the disease and thus, are diagnosed late. As a result of this, treatments are useless most of the time and patient dies in a short period of time. Future oriented diagnosis of cancer disease in healthy people is one of the most important issues that should be emphasized (Abbod et al., 2001).

The purpose of the study is to determine the risks of catching these types of cancers in the future for healthy people and to diagnose preliminarily by specifying pilot cancer types to work on. Based on this, firstly, similar studies conducted by using artificial intelligence and fuzzy logic model in medicine and in subject of cancer are reviewed, implications are made, incomplete issues are determined, afterwards, the cancer types to be worked on are determined and even furthermore, the factors forming this cancer type will be investigated. After implications are made, these factors are used on the model formed by the composition of a new type of fuzzy logic model. In this respect, breast cancer, lung cancer, and colon cancer are selected pilot cancer types. The reason for selection of these cancer types is the frequency of patient numbers and the appropriateness for this kind of study for the indicated cancer types. The risks of catching breast, lung, and colon cancers for people by using a new type of fuzzy logic model within the study are revealed and the opportunity to offer suggestions to the person to remove this risk is provided.

In the study, data held is reviewed with the purpose of solving the problem and fuzzy logic model as a new approach and risk analysis method and sample are presented. The reason of selection of fuzzy logic model is the effective drawing of conclusion of systems, where fuzzy decision is used, depending on uncertain linguistic information as the human logic can do. In this study, the purpose is to investigate the usability of the Fuzzy Logic model in health field in the light of data held; to assess the performance difference of the new Fuzzy Logic method formed with respect to other methods, and to evaluate and share the results obtained.

In our research, different than studies conducted in literature, not only the difference of performance outcomes of prepared application, producing statistical data, and determination of risk factors affecting breast, lung, and colon cancers, the development of an application to work in every computer system loaded with .NET framework that can be used by doctor or potential patient for people suspected to have or may have breast, lung, and colon cancer is aimed. Besides this, another objective is to be able to introduce a fuzzy logic method that can produce more successful results. Moreover, it is aimed that introductions of fuzzy logic models determined for breast, lung, and colon cancers from cancer types selected as pilot are composed from findings known without any testing and taking expert opinion. As a result of this, without any analysis or expert, a person can calculate the risk status for any of the 3 cancer types conveniently with the help of software in any computer loaded with .NET framework. Except all these, the effect of stress, as subject having a triggering role in every kind of disease at our age, on cancer types is also tried to be construed within the software, different than other studies. In the study, firstly, performance report is extracted by using Takagi-Sugeno method from fuzzy logic models, afterwards, new fuzzy logic method is introduced and performance differences by the renewed system are brought up. It is observed that fuzzy logic method used produced more successful results in proportion to the amount of its data held.

FUZZY LOGIC

Fuzzy logic aims to model human thinking and reasoning and to apply the model to problems according to needs. It tries to equip computers with the ability to process special data of humans and to work by making use of their experiences and insights. When human logic solves problems, it creates verbal rules such as "if <event realized> is this, the <result> is that". Fuzzy logic tries to adapt these verbal rules and the ability to make decisions of humans to machines/computers. It uses verbal variables and terms together with verbal rules (Ishibuchi et al., 1995).

Verbal rules and terms used in human decision-making process are fuzzy rather than precise. Adapting human logic system to computers/machines will increase problem-solving ability of computers/machines. Verbal terms and variables are expressed mathematically as membership degrees and membership functions. Fuzzy decision-making mechanisms use symbolic verbal phrases instead of numeric values. Transferring these symbolic verbal phrases to computers are based on mathematics. This mathematical basis is fuzzy logic.

Systems that use fuzzy logic are alternatives to the difficulty of mathematical modeling of complex non-linear problems and fuzzy logic meets mathematical modeling requirement of a system.

Systems that use fuzzy logic can produce effective results based on indefinite verbal knowledge like humans. In fuzzy logic, information is verbal phrases such as big, small, very, few etc. instead of numeric values. If a system's behavior can be expressed by rules or requires very complex non-linear processes, fuzzy logic approach can be applied in this system.

Fuzzy cluster concept is an extension of a classical cluster. In classical cluster, an element is either within a cluster (1) or is not within a cluster (0) (Figure1). In fuzzy clusters, an element has any membership value between 0 and 1 (Elbi, 1991). In classical clusters, "1" represents being a member while "0" represents not being a member. In fuzzy clusters, "1" represents full membership (full membership degree), degrees between "0" and "1" represent degrees of membership and "0" represents full non-membership (full non-membership) (Klir et al., 1995).

While variables in mathematics usually take numerical

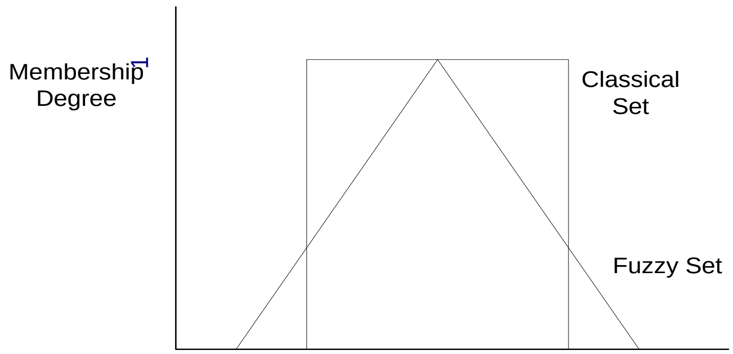

Figure 1. Indication of a classical and fuzzy cluster on coordinate system.

values, in fuzzy logic applications, the non-numeric linguistic variables are often used to facilitate the expression of rules and facts.

A linguistic variable such as age may have a value such as young or its antonym old. However, the great utility of linguistic variables is that they can be modified via linguistic hedges applied to primary terms. The linguistic hedges can be associated with certain functions. For example, L. A. Zadeh proposed to take the square of the membership function. This model, however, does not work properly (Ishibuchi et al., 1997).

Usage of fuzzy logic in medicine and similar studies & Why use fuzzy logic?

Most of concepts used in medicine are fuzzy. Fuzzy logic method is convenient for medical applications due to the uncertain nature of medical concepts and of the relationships among these concepts. Uncertain medicals cases may be defined by fuzzy sets. Fuzzy logic suggests methods of solution production that have the ability of approximate drawing of conclusion (Nguyen et al., 2001). Due to the complexity of the practice in medicine, the traditional quantitative analysis approaches are not appropriate. Information insufficiency and uncertainty in medicine conflicting with this information most of the time are general realities. The sources of uncertainty can be classified as follows (Torres et al., 2006):

- Presence of information deficiency about the patient.
- Most of the time, patient's medical history is provided by patient himself/herself and/or by his/her family. To a large extent, this information is generally subjective and uncertain.
- Health examination. Most of the time, physician obtains objective data, however, in some cases, the border between normal and pathological cases is not clear-cut.
- Test results related to the laboratory and other diagnosis may also be subject to some errors and even to patient's misconduct prior to examination.
- There might be symptoms that are faked, exaggerated, and displayed less than they are. Patient may neglect to talk about some of the symptoms.

When studies are analyzed in detail, it is observed that artificial intelligence techniques for health sciences are applied to a large extent for diagnosis and identification. The same case also applies for cancer diseases. For methods used in studies reviewed, introductions and clinical findings are emphasized; findings that cannot be known without analysis and taking expert opinion are emphasized in the model as introduction. Besides this, ready-made tools that are held for artificial intelligence by application software such as FuzzyTech or Matlab have been used in studies reviewed. Moreover, a new fuzzy logic model has not been developed within the studies, Mamdani type Fuzzy Logic Model previously used or techniques such as Multi-layer artificial nerve web have been used in the solution of the problem.

In this research, the reason for using fuzzy logic is with intuitional, arriving at the conclusion without any complexness in depth. Because of fuzzy logic's flexible structure and working on indefinite data without any expert assistance, fuzzy logic is ideal for the system of the cancer risk analysis.

This study makes risk analysis for taking mesasures unlike diagnose. Because of that, the reasons for choosing fuzzy logic in contrast to other systems are other systems' lack of flexible structure, operation for accurate data and production of accurate results.

Here is a list of general observations about fuzzy logic:

1) Fuzzy logic is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are very simple. Fuzzy logic is a more intuitive approach without the far-reaching complexity.
2) Fuzzy logic is flexible. With any given system, it is

easy to layer on more functionality without starting again from scratch.

3) Fuzzy logic is tolerant of imprecise data. Everything is imprecise if you look closely enough, but more than that, most things are imprecise even on careful inspection. Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end.

4) Fuzzy logic can model nonlinear functions of arbitrary complexity.

5) Fuzzy logic can be built on top of the experience of experts. In direct contrast to neural networks, which take training data and generate opaque, impenetrable models, fuzzy logic lets you rely on the experience of people who already understand your system.

6) Fuzzy logic is based on natural language. The basis for fuzzy logic is the basis for human communication. This observation underpins many of the other statements about fuzzy logic. Because fuzzy logic is built on the structures of qualitative description used in everyday language, fuzzy logic is easy to use.

MATERIALS AND METHODS

Proposed fuzzy logic method and application

Proposed method: New type of fuzzy logic model

Firstly, Takagi-Sugeno type fuzzy logic models are developed for cancer types specified as pilot within the study and have been used within the application software. Performance measurements of Takagi-Sugeno type fuzzy logic model have been made for 3 cancer types by using various model cases. Since the result produced by the model will be very important for the industry such as health where even the smallest detail has great importance, the requirement to introduce a fuzzy logic model that may have higher performance has arisen. In this respect, a new type of fuzzy logic model approach is introduced by making modifications on the Mamdani type fuzzy logic model and by introducing new methods.

Generally in practice, making the change ranges appearing in classical set form fuzzy is required for fuzzy set, logic, and system procedures (Tsai et al., 2011; Guadarrama et al., 2004). For this, it is considered that all the elements that may be present in a range have various values between 0 and 1, instead of having membership degree equal to 1. In this case, it is accepted that some elements include uncertainty. In case of arising of these uncertainties from non-numerical cases, fuzziness is mentioned. Convenience of fuzzy sets depends on the skill of being able to form membership degree functions appropriate for different concepts. Most frequently used functions are triangle and trapezoid for ease. The display of elements pertaining to any fuzzy set by triangle membership function and trapezoid membership function on new type fuzzy logic approach are displayed in Figure 2 and Figure 3. When triangle membership function is used, fuzzification is done according to variable's value. First of all, variable's maximum probable value is held and this value's trigonometric functions and Euclid relation are formulated for doing the fuzzification. For the trapezoid membership function, trapezoid splits into triangle shapes and the same formulations are applied. Triangle membership function's fuzzifaction formulation is shown in equation (1) and trapezoid membership function's fuzzifaction formulation is shown in equation (2). In fuzzification formulations, for the symbolized values, "ϑ" fuzzy value reveals, "max'" while the entry states maximum fuzzy set's maximum value and "x-y-z-t" states membership function's threshold value.

$$
\begin{aligned}
&if\ \ x > \vartheta \ \ \| \ \ z < \vartheta \ \Rightarrow 0 \\
&if\ \ x \le \vartheta \le y \Rightarrow \frac{\max'\ \vartheta[\sin(\vartheta) - \sin(x)]}{[\sin(y) - \sin(x)]} \\
&if\ \ y \le \vartheta \le z \Rightarrow \frac{\max'\ \vartheta[\sin(z) - \sin(\vartheta)]}{[\sin(z) - \sin(y)]}
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
&if\ \ x > \vartheta \ \ \| \ \ t < \vartheta \Rightarrow 0 \\
&if\ \ x \le \vartheta \le y \Rightarrow \frac{\max'\ \vartheta[\sin(\vartheta) - \sin(x)]}{[\sin(y) - \sin(x)]} \\
&if\ \ y \le \vartheta \le z \Rightarrow 1 \\
&if\ \ z \le \vartheta \le t \Rightarrow \frac{\max'\ \vartheta[\sin(t) - \sin(\vartheta)]}{[\sin(t) - \sin(z)]}
\end{aligned}
\tag{2}
$$

Besides functions being in the form of triangle or trapezoid used frequently or being in other appropriate forms, sub sets are required to be in a form that is overlapping with each other.

In fuzzy logic, rules are formulated by conditional cases in the form of 'if ... then, ... let it be'. All input variables are converted to verbal variable values, step of producing fuzzy result is applied based on rules for current status and values of verbal variables are calculated at exit. On the other hand, a fuzzy rule should have verbal input and output terms in the form of 'if ... then, ... let it be' (for example, if X value is A, then let Y value be B). 'if ...' section is named status; '... let it be' section is named result or decision section. In the example of 'if X value is A, then let Y value be B', A and B are verbal words and they indicate to which status X and Y values pertain to in fuzzy sets X and Y. As rules are processed in order, result found is processed to exits indicated by following equations and rules for new type fuzzy logic approach within the rules related with entry values made fuzzy themselves (Yager, 1996).

Rule processing unit formulation is shown in equations (3). In the equation of the rule processing unit k_1, k_2, k_3; symbolizes the results to achieve tresult, k_{result}; results of Rule Processing Unit, ϑ_n; the input values to calculate fuzzy value and n; output set number that generates results.

$$
\begin{aligned}
k_1 &= \frac{\vartheta_1 + \vartheta_2 + ... + \vartheta_n}{\eta} \\
k_2 &= (\vartheta_1 - k_1)^2 + (\vartheta_2 - k_1)^2 + ... + (\vartheta_n - k_1)^2 \\
k_3 &= \frac{k_2}{n} \\
k_{result} &= \sqrt{k_3}
\end{aligned}
\tag{3}
$$

If more than one value exists in any of the output values for related

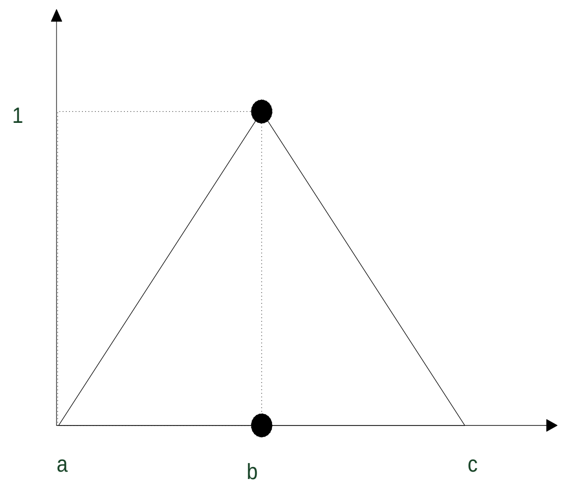

Figure 2. Triangle membership type membership degree calculation.

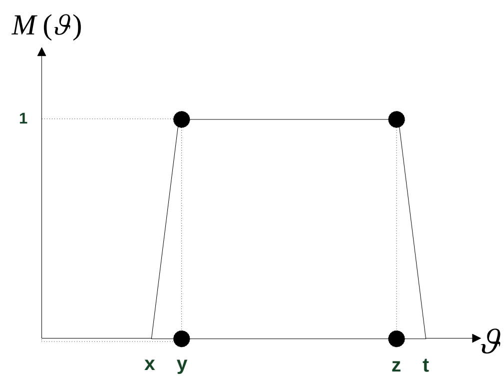

Figure 3. Trapezoid membership type and membership degree calculation.

rules, the greatest value within these values is selected.

In practical applications, especially in engineering plans, projects, and designs, definite numerical values are required for sizing. The implications of the fuzzy variable, set, logic, and systems in artificial intelligence studies, that might be fuzzy, should be converted to definite numbers. All of the procedures made for conversion of fuzzy information into definite results are named defuzzification procedures (Belohlavek et al., 2006; Steimann, 1997).

The defuzzification process will be made by applying the following equation in the new type fuzzy logic approach by using peak values of related output set produced as result and output values calculated within the rules. Defuzzification equation is shown in equation (4).

$$\chi_{avg} = \frac{n}{\frac{1}{h_1}+\frac{1}{h_2}+...+\frac{1}{h_n}} \qquad (4)$$

$$Final\ \ Output = \frac{(p_1\times\chi_{avg})+(p_2\times\chi_{avg})+..+(p_n\times\chi_{avg})}{h_1+h_2+..+h_n}$$

where χ_{avg}; symbolizes the harmonic averages for defuzzification, n; output set number that generates results, h_n; the highest value of sets, p_n; the point where the relevant set gets to the peak point, and “Final Output” the outcome of defuzzification process.

Takagi-Sugeno type fuzzy inference

Introduced in 1985, it is similar to the Mamdani method in many respects. The first two parts of the fuzzy inference process,fuzzifying the inputs and applying the fuzzy operator, are exactly the same. The main difference between Mamdani and Sugeno is that the Sugeno output membership functions are either linear or constant (Takagi and Sugeno, 1985).

A typical rule in a Sugeno fuzzy model has the form:

If Input1=x and Input2=y, then Output is z=ax+by+c

The output level zi of each rule is weighted by the firing strength wi of the rule. For example, for an AND rule with Input1=x and Input2=y,

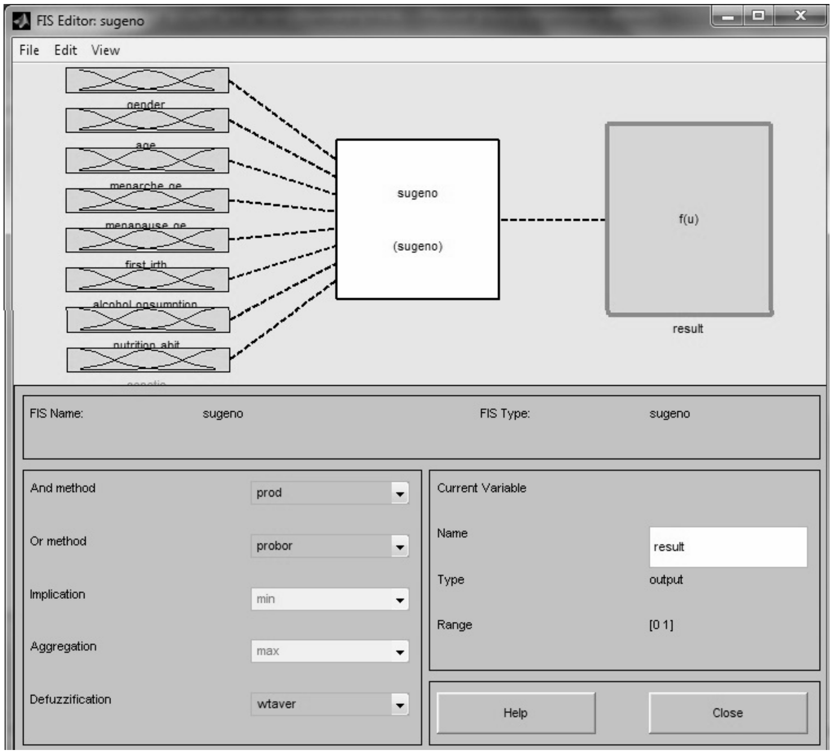

Figure 4. Takagi-Sugeno type fuzzy logic model for breast cancer.

the firing strength is; wi = AndMethod (F1(x), F2(y)) where F1,2(.) are the membership functions for Inputs 1 and 2. The final output of the system is the weighted average of all rule outputs, computed as in equation (5).

$$Final \quad Output = \frac{\sum_{i=1}^{N} W_i Z_i}{\sum_{i=1}^{N} W_i} \qquad (5)$$

where W_i; symbolizes the weighted average for inputs, N; the number of rules, Z_i; the rule outputs of sets, and "Final Output" the result of process.

It can be used linear techniques for non-linear systems. Takagi-Sugeno is suitable for mathematical analysis.

Comparison of Sugeno and proposed methods

Sugeno Model is a more compact and computationally efficient representation than a proposed model, the Sugeno model lends itself to the use of adaptive techniques for constructing fuzzy models. These adaptive techniques can be used to customize the membership functions so that the fuzzy system best models the data.

Advantages of the Sugeno Method
1) It is computationally efficient.
2) It works well with linear techniques.
3) It works well with optimization and adaptive techniques.
4) It is well suited to mathematical analysis.

Advantages of the Proposed Method
1) It is intuitive (Suitable for medical applications).
2) It has widespread acceptance.
3) It is well suited to human input.

Cancer risk analysis application

After catching diseases such as cancer, for diseases with very difficult treatments and recoveries, taking precautions before the initiation of the disease, learning about risk status, or preliminary diagnosis for the disease are important issues. In consideration of this case, a software, that will measure the susceptibility for that cancer type and risk status for specific cancer types at healthy people or at people not diagnosed with the disease, is developed by selecting fuzzy logic model from artificial intelligence techniques in this study. In this respect, breast, lung, and colon cancers are selected as pilot cancer types. The reason for selection of indicated cancer types is the appropriateness of the factors leading to these diseases for this type of study and their substantially high incidences in the world.

Firstly, fuzzy logic models previously used are reviewed, and before all else, solutions have been produced for cancer types related to Takagi-Sugeno type fuzzy logic model (Figure 4).

After expert opinions about this subject of risk factors for breast cancer, lung cancer, and colon cancer diseases are obtained and literature studies are determined, fuzzy logic models are developed for fuzzy logic cancer types. In breast cancer model, gender, age, genetic status, menarche age, menopause age, first birth age, alcohol

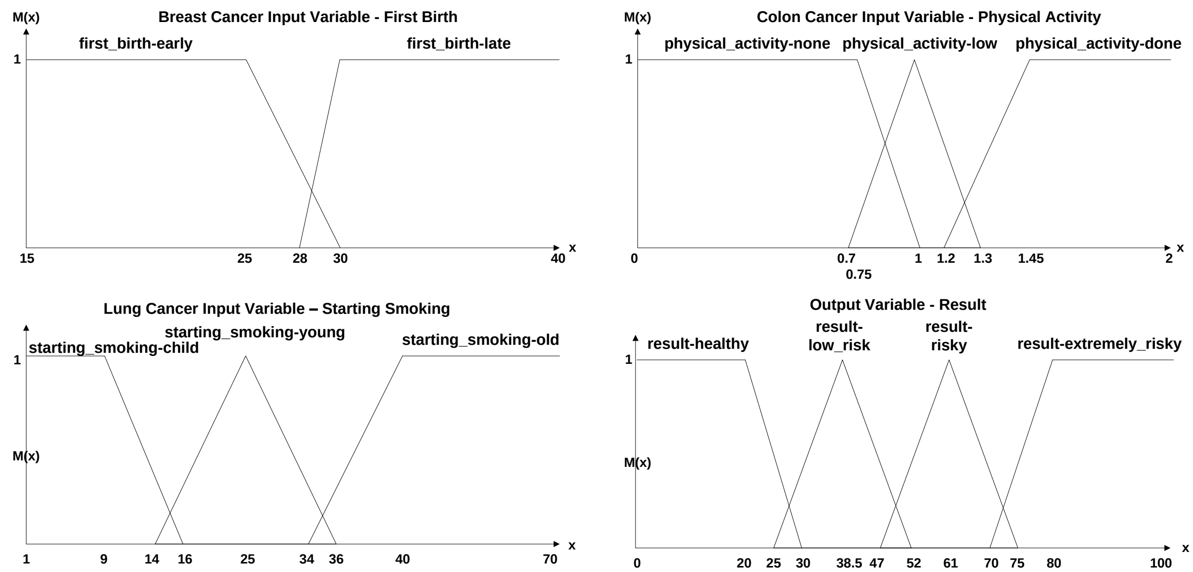

Figure 5. Examples of membership degrees.

consumption, and nutrition habit are determined as factors for cancer risk (Seker et al., 2003; Ravi et al., 2003). In lung cancer model, gender, age, skin status, smoking, age of starting smoking, passive smoking environment, occupational status, living environment, genetic status, economic status, and nutrition habit are determined as factors for cancer risk (Van Zandwijk, 2001). Lastly, in colon cancer model, age, genetic status, cancer history, inflammation status in the intestines, physical activity status, weight status, smoking, alcohol consumption, and nutrition habit are determined as factors for cancer risk ((Brand et al., 2006; Bao et al., 2011; Nguyen et al., 2001;).

Pursuant to all, membership degrees of all factors in 3 models are determined. As an output result of data received from these factors, risk status of the person for this cancer type had been analyzed within the model (excessively risky, risky, slightly risky, and healthy) (Figure 5).

After performance measurements of the models are made for breast, lung, and colon cancer diseases, modifications are made on Mamdani type fuzzy logic model and a new type of method is introduced. New fuzzy logic method formed has been used for breast, lung, and colon cancer diseases, and performance measurements have been made. Newly formed fuzzy logic method produced better results compared to Takagi-Sugeno type fuzzy logic method for 3 cancer models. Software structure has been composed by combining advantages of the programming techniques, oriented to the object, through the C# programming language, at Visual Studio .Net 2010 platform. Within the software, 5 different visually based software programs are actualized. The first of these forms is the section where the cancer type is selected to calculate risk analysis. According to the selection made, 2nd, 3rd, or 4th forms will be opened. Second application software calculates risk status of the person for breast cancer by new type fuzzy logic method; third application software calculates risk status of the person for lung cancer by new type fuzzy logic method; fourth application software calculates risk status of the person for colon cancer by new type fuzzy logic method. Fifth form calculates the risk status, that will be formed by the triggering of the cancer types by stress factor based on risk result calculated for breast, lung, or colon cancers, by new type fuzzy logic method. After determination of membership functions and membership degrees for fuzzy logic model formed for breast cancer, lung cancer, and colon cancer, rules of fuzzy logic model have been determined in the light of data held and expert opinion. 115 rules for breast cancer, 180 rules for lung cancer, and 152 rules formed for colon cancer are applied, data held are tested, and the best result for fuzzy logic model has been reached. In Table 1, some sample rules are presented for three cancer types. After completion of design of fuzzy logic models, membership degrees, and setting rules, cancer analysis software is developed by new type fuzzy logic approach.

After completion of all entries on the software by the user, by applying equation (1) or equation (2) to every entry value receiving a value within the software, fuzziness of the values entered are actualized. After completion of entry of all fields related to the person on the software and pressing of “calculate the risk outcome” button, membership degrees for all entries are calculated one by one with new fuzzy logic method formed and all of the rules formed for the model are controlled in order. In cases included by related rules, calculation oriented to related output is made by new fuzzy logic method formed. As a result of rules, risk status of the person as pertaining to Healthy, Slightly Risky, Risky, or Excessively Risky groups and calculation of these membership degrees are assigned by calculating with equation (3).

After application of all rules, in order to calculate the outcome of the risk status of the person, by conversion of values produced as a result of rules into formulas of different probabilities separately, purification value of the values within Healthy, Slightly Risky, Risky, and Excessively Risky groups is calculated by applying equation (4). Person’s risk status is calculated according to the output resulting value; to which group is the person pertaining to, at which value, is found (Figure 6). It is observed that the result is better than Takagi-Sugeno method, which is reached by testing our system, by data of patients and healthy people held for the related cancer type in the fuzzy logic model software that is formed by new method and is conducting risk analysis for breast cancer, lung cancer, and colon cancer. Firstly, in 87 of 120 data held for Takagi-Sugeno type fuzzy logic model for performance of breast cancer analysis of the system, accurate results are obtained, performance measurement is ensured at 72.5 % rate. In 97 of 120 data held for new type fuzzy logic model provided by new method formed, accurate results are obtained, performance measurement is ensured at 81 % rate. In 93 of 140 data

Table 1. Sample rules.

Sample rule
Age=(young or middle aged) and genetic=none and cancer caught=none and ınflmamation=none and nutrition habit= healthy and physical activity=(done or low) and weight=(small or low) and smoking=none and alcohol consumption=sometimes → healthy (colon cancer).
Age=(young or middle aged) and genetic=none and cancer caught=none and ınflmamation=none and nutrition habit= healthy and physical activity=(done or low) and weight=(small or low) and smoking=normal and alcohol consumption=sometimes → low risk (colon cancer).
Age=(young or middle aged) and genetic=none and cancer caught=none and ınflmamation=none and nutrition habit= healthy and physical activity=(done or low) and weight=(small or low) and smoking=extreme and alcohol consumption=(none or sometimes) → risky (colon cancer).
Gender=male and age=old and genetic=far and alcohol consumption=none → low risk (breast cancer)
Gender=female and age=middle aged and genetic=1st degree and menarche age=age early and alcohol consumption=lots of → extremely risky (breast cancer).
Gender=female and age=old and folk=white and smoking=none and passive smoking environment=none and vacation=desk job and residential environment=none and genetic=none → low risk → (lung cancer).
Gender=male and age=(young or middle aged) and folk=white and smoking=none and passive smoking environment=none and vacation=risk area and residential environment=none and genetic=none and economic status=(poor or fair) → risky → (lung cancer).

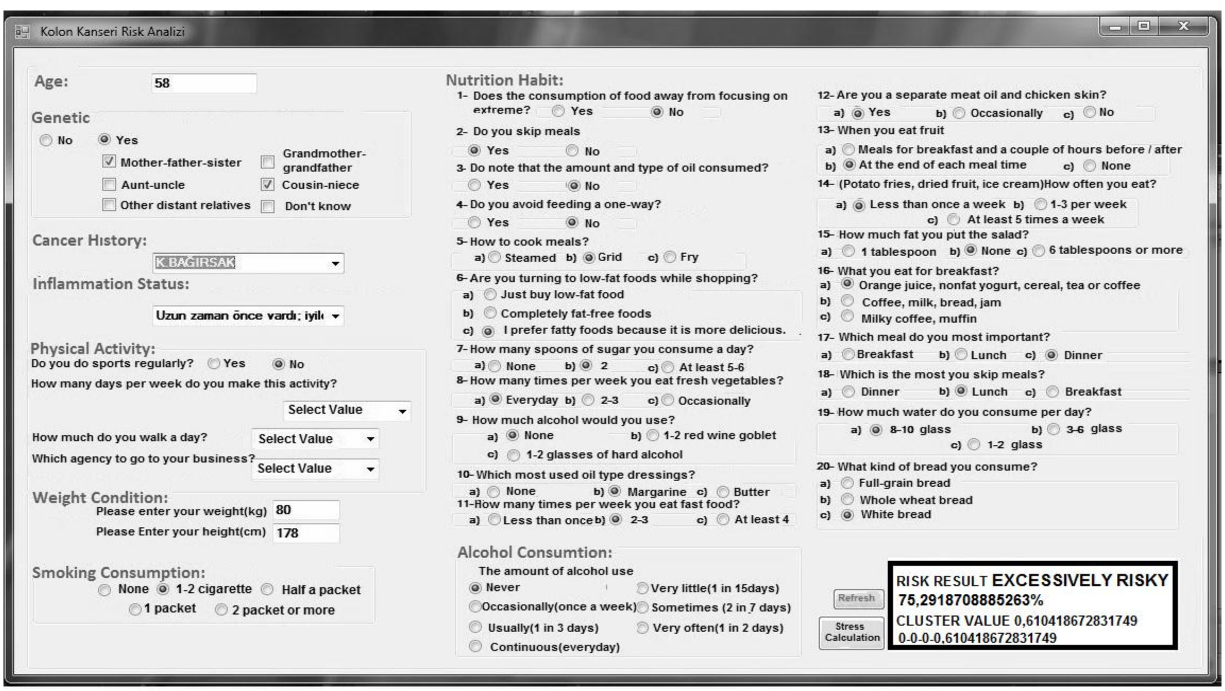

Figure 6. Risk analysis software for the lung cancer with using fuzzy logic model – Sample outcome analysis.

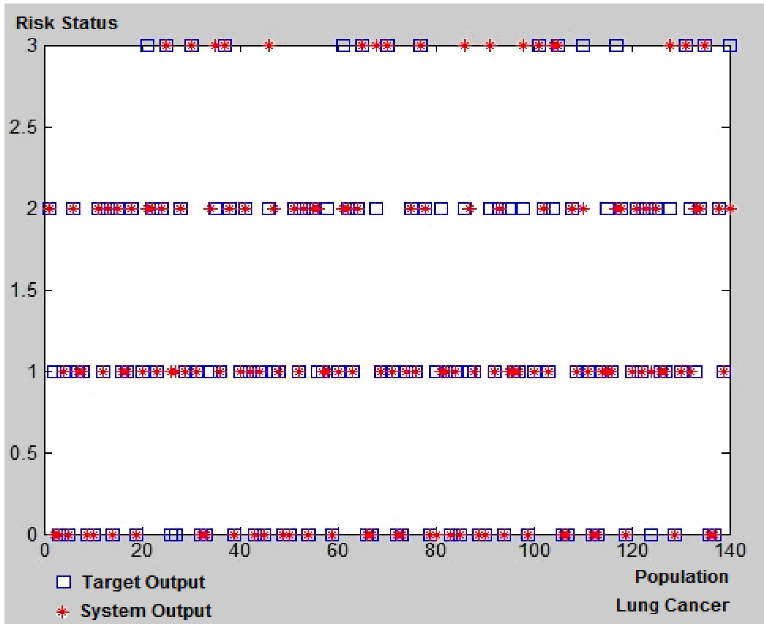

Figure 7. Fuzzy logic model for lung cancer software –performance charts.

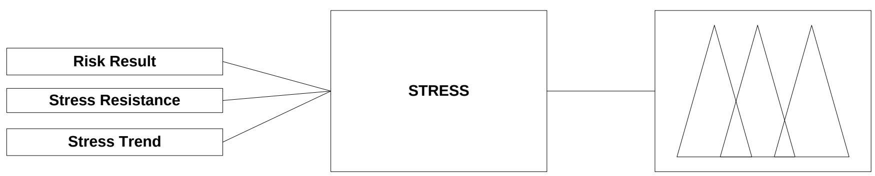

Figure 8. Stress-cancer fuzzy logic model.

held firstly in Takagi-Sugeno type fuzzy logic model for performance of lung cancer analysis of the system, accurate results are obtained, performance measurement is ensured at 66.4 % rate. In 112 of 140 data held for new type fuzzy logic model provided by new method formed, accurate results are obtained, performance measurement is ensured at 80 % rate (Figure 7). In 80 of 110 data held for Takagi-Sugeno type fuzzy logic model for performance of colon cancer analysis of the system, accurate results are obtained, performance measurement is ensured at 72.7 % rate. In 91 of 110 data held for new type fuzzy logic model provided by new method formed, accurate results are obtained, performance measurement is ensured at 83 % rate. According to risk outcome calculated from any of the breast cancer, lung cancer, and colon cancer models, in order to calculate the effect of stress on cancer disease, stress model was composed by using fuzzy logic model. After expert opinions about the effects of stress on breast cancer, lung cancer, and colon cancer were obtained and status was determined by literature studies, the design of fuzzy logic model was started and fuzzy logic model was developed for the effect of stress on cancer. In stress-cancer model, risk outcome calculated by the model for cancer types, stress resistance test result, and inclination towards stress was determined as factor for cancer risk. Pursuant to these, membership degrees of three different factors was determined. As an output result of data received from these three factors, risk status of the person for this cancer type was analyzed within the model (excessively risky, risky, slightly risky, and healthy) (Figure 8). Stress resistance test of 22 questions to measure the stres resistance of the person; stress inclination test of 26 questions to measure the inclination of the person towards stress was prepared by expert psychologists. Due to fuzzy logic model formed by new method for breast cancer, lung cancer, and colon cancers, risk outcome calculated within the software was determined as final entry value for stress fuzzy logic model. The purpose hereby is to be able to compare risk outcome determined by the model with the triggering status together with the stress effect. After membership functions and membership degrees were determined for fuzzy logic model formed for the effect of stress on cancer, the rules of fuzzy logic model was determined in the light of data held and expert opinion. The best result was reached for fuzzy logic model by the application of 64 rules formed and by testing data held.

After answering of all of person stress resistance scale and stress inclination scale questions on the software and pressing of “calculate the stress effect” button, membership degrees for stress resistance and stress inclination entries were calculated by the new fuzzy logic method formed and all of the rules formed for the model were controlled in order. In cases included by related rules, calculation oriented to related output was made by new fuzzy logic method formed. As a result of rules, risk status of the person as pertaining to healthy, slightly risky, risky, or excessively risky groups and calculation of these membership degrees were assigned by calculation. After application of all rules, in order to calculate the outcome of the risk status of the person, by conversion of values produced as a result of rules into formulas of 14 different probabilities separately, purification value of the values within healthy, slightly risky, risky, and excessively risky group was calculated by applying formula (4). Person's risk status was calculated according to the output resulting value; to which group is the person pertaining to, and at which value was it found (healthy, slightly risky, risky, excessively risky).

It was observed that the result was better than Takagi-Sugeno method, which was reached by testing our system by data of patients and healthy people held for the related cancer type in the fuzzy logic model software that was formed by the new method and was conducted risk analysis for the effect of stress on breast cancer, lung cancer, and colon cancer diseases.

RESULTS AND DISCUSSION

When scientific studies conducted were reviewed, it was observed that artificial intelligence techniques for health sciences are applied for diagnosis and identification to a large extent. The same case also applies for cancer diseases. After catching diseases such as cancer, for diseases with very difficult treatments and recoveries, taking precautions before the initiation of the disease, learning about risk status, or preliminary diagnosis for the disease are important issues. In consideration of this case, a software, that will measure the susceptibility for that cancer type and risk status for specific cancer types in healthy people or in people not diagnosed with the disease, was developed by selecting fuzzy logic model from artificial intelligence techniques in this study. In the research conducted, it was understood that cancer disease types are linked to each other. After determination of cancer disease types (breast, lung and colon) selected as pilot in thesis study, the fuzzy logic model from artificial intelligence methods, which is widely used among disciplines and has a mathematical infrastructure, was selected, and even, risks of a healthyperson for catching these cancer types in the future were revealed.

In this study, different from studies conducted in literature, not only the difference of performance outcomes of prepared application, production of statistical data, and determination of risk factors affecting breast, lung, and colon cancers, an application that will work in every computer system loaded with NET framework that can be used by doctor or potential patient for people suspected to have or may have breast, lung, and colon cancer was developed. Besides this, a new method that can produce more successful results within the study was introduced. Moreover, all introductions of fuzzy logic models determined for breast, lung, and colon cancers from cancer types selected as pilot were composed from findings that can be known without any testing and taking expert opinion. As a result of this, without any analysis or expert, a person can calculate the risk status for any of the three cancer types conveniently with the help of the software in any computer. Except all these, the effect of stress, as subject having a triggering role in every kind of disease at our age, on cancer types was construed within the software different from other studies.

In the study, performance report was extracted by using Takagi-Sugeno method from fuzzy logic models, afterwards, new fuzzy logic method was introduced and performance differences by the renewed system was brought up. The reason for selection of breast cancer, lung cancer, and colon cancer as pilot cancer types within the study is the frequency of patient numbers for the indicated cancer types and their appropriateness for this type of study. The risks of catching breast, lung, and colon cancers for people by using a new type of fuzzy logic model within the study was revealed and the opportunity to offer suggestions to the person to remove this risk was provided. In the study, data held was reviewed with the purpose of solving the problem and fuzzy logic model as a new approach and risk analysis method and sample is presented. The reason of selection of fuzzy logic model is the effective drawing of conclu-sion of systems, where fuzzy decision is used, depending on uncertain linguistic information as the human logic can do. Firstly, fuzzy logic models previously used have been reviewed, and before all else, solutions have been produced for cancer types related to Takagi-Sugeno type fuzzy logic model. After performance measurements of the models were made for breast, lung, and colon cancer diseases, modifications were made on mamdani type fuzzy logic model and a new type of method was introduced. New fuzzy logic method formed was used for breast, lung, and colon cancer diseases, and performance measurements was made. Newly formed fuzzy logic method produced better results compared to Takagi-Sugeno type fuzzy logic method for the three cancer models.

The model used in our work is a high degree Takagi-Sugeno fuzzy modeling has been a very complex structure. The system was been difficult to train because of a lot of sub-cluster and input. Besides this reasons Takagi-Sugeno modeling were not suitable for human intuition. Due to all these reasons, Sugeno model is insufficient and ineffective in this work.

The new obtained method was discovered by modifying the Mamdani method which is one the techniques of fuzzy logic. Whilst only process was made with Euclid relation in Mamdani method, differently, trigonometric functions were used additionally during defuzzification process in the new method ; besides many other different methods were applied such as calculation of harmonic average in rule processing unit and defuzzification. Thus it is observed that the obtained results were more successful for the system in process.

It was observed that the best result is reached by testing our system by data of patients and healthy people held for the related cancer type in the fuzzy logic model software that is formed by new method and is conducting risk analysis for some cancer types such as breast cancer, lung cancer and colon cancer. The system's

	Gender	Age	Menarche Age	Menopause Age	First Birth	Alcohol Consumption	Nutrition Habit	Genetic	Result of the Model	Real Result
1	Female	33	14	None	27	Once a week	Lean	None	Low Risk	Healthy
2	Female	42	15	None	32	Twice a week	Oily	Niece	Risky	Patient
3	Male	52	None	None	None	Fortnightly	Oily	Aunt	Risky	Healthy
4	Female	25	None	None	None	A three-day	Lean	Other	Low Risk	Healthy
5	Male	37	None	None	None	Every other day	Oily	Mother	Risky	Patient

Performance Breast Cancer	97/120	81%
Data	63 Patient	57 healthy

	Gender	Age	Color of Skin	Smoking	Starting Smoking	Passive Smoking	Vacation	Residential Environment	Genetic	Economic Status	Nutrition Habit	Result of the Model	Real Result
1	Male	53	Brunette	Half a packet	25	Only home	Clean worker	City Center	None	2100	Bad	Risky	Patient
2	Male	36	Dark fair-skinned	None	None	Only friends	Desk job	City Building Estate	None	2500	Good	Low Risk	Healthy
3	Female	34	Fair	1-2 piece	30	Only friends	Desk job	City Building Estate	None	3000	Bad	Risky	Healthy
4	Male	29	Brunette	Half a packet	20	Work-Friends	Desk job	Garden House	None	1400	Good	Risky	Patient
5	Male	41	On fair-skinned	1 packet	16	All	Clean worker	City Center	Don't know	1000	Good	Extremely Risky	Patient

Performance Lung Cancer	112/140	80%
Data	86 Patient	54 Healthy

	Age	Genetic	Cancer Caught	Inflamnation	Physical Activity	Weight-Height	Smoking	Alocohol Consumption	Nutrition Habit	Result of the Model	Real Result
1	28	None	None	None	Yes	75-180	None	None	Good	Low Risk	Healthy
2	45	Cousin	None	None	Lowly	75-190	1-2 piece	Once a week	Bad	Risky	Patient
3	38	Uncle	Uterine	Had long time ago-healed	Yes	86-180	Half a packet	A three-day	Bad	Extremely Risky	Patient
4	53	None	Colon	Had a short time ago-healed	Yes	95-190	1-2 piece	Twice a week	Bad	Extremely Risky	Patient
5	44	Don't know	None	Had long time ago-healed	Yes	80-182	None	Fortnightly	Good	Low Risk	Patient

Performance Colon Cancer	91/110	83%
Data	69 patient	41 Healthy

	Type of Cancer	Risk Result	Stress Resistance	Stress Trend	Result of the Model	Real Result
1	Breast	Low Risk	Quite Resistant	Very Tendecy	Risky	Patient
2	Breast	Low Risk	Quite Resistant	Resistance	Low Risk	Patient
3	Breast	Risky	Flimsy	Inclined	Extremely Risky	Patient
4	Lung	Low Risk	Inclined	Light Inclined	Risky	Patient
5	Lung	Low Risk	Quite Resistant	Inclined	Risky	Healthy
6	Lung	Risky	Quite Resistant	Inclined	Extremely Risky	Patient
7	Colon	Risky	Flimsy	Inclined	Risky	Patient
8	Colon	Low Risk	Inclined	Light Inclined	Risky	Patient
9	Colon	Healthy	Flimsy	Resistance	Low Risk	Patient

Performance Breast Cancer&Stress	22/30	76%
Performance Lung Cancer&Stress	23/30	77%
Performance Colon Cancer&Stress	24/30	80%

Data Breast Cancer	19 Patient	11 Healthy
Data Lung Cancer	16 Patient	14 Healthy
Data Colon Cancer	18 Patient	12 Healthy

Figure 9. Sample cancer-stress data and model performance.

performance in breast cancer was calculated at 81 % rate. Firstly, in 87 of 120 data held for Takagi-Sugeno type fuzzy logic model, accurate results were obtained, performance measurement has been ensured at 72.5 % rate. In 97 of 120 data held for new type fuzzy logic model provided by new method formed, accurate results was obtained, performance measurement was ensured at 81 % rate. Accordingly, when the calculations about lung cancer was done, the system's performance in this subject was 80 % rate. 93 of 140 data held in Takagi-Sugeno type fuzzy logic model, scientific consequences was maintained and performance measurement was ensured at 66.4 % rate. Then, 112 of 140 data held for new type fuzzy logic model supplied by new method formed, scientific consequences was maintained and performance measurement was ensured at 80% rate. At the last step of the performance measurement, the system's performance in colon cancer was calculated at 83 % rate. This time, 80 of 110 data held for Takagi-Sugeno type fuzzy logic model, accurate data was aquired and performance measurement was ensured at 72.7 % rate. Finally, 91 of 110 data held for new type fuzzy logic model provided by new method formed, accurate results were obtained and performance measurement was ensured at 83 % rate (Table 2).

After completion of the fuzzy logic model software that is conducting risk analysis of people for breast, lung, and colon cancers selected as pilot, the effect of stress status on cancer was investigated and fuzzy logic model was developed for the triggering status of three cancer types. When test was conducted on fuzzy logic model software formed by new method to 30 people each from healthy people or people with cancer disease, within three cancer types separately, performance measurements at rates of 76 % (22/30) for breast cancer, 77 % (23/30) for lung cancer, and 80 % (24/30) for colon cancer was ensured (Table 2). Dataset were taken from Şişli Etfal Hospital Oncology Services. Each sample data were shown in Figure 9 that compares the results of 120 datasets for breast cancer, 140 datasets for lung cancer and 110 datasets for colon cancer which were used in cancer risk analysis and the real results. Similarly, Sample 9 data are

Table 2. Performance measurement for the Mamdani method and the new type fuzzy logic method on cancer types.

Type of cancer/effect of stress	Performance of mamdani method (%)	Performance of new type fuzzy logic method (%)
Breast cancer	79	81
Lung cancer	78	80
Colon cancer	81	83
Effect of stress on breast cancer	73	76
Effect of stress on lung cancer	73	77
Effect of stress on colon cancer	75	80

shown in Figure 9. A compares was done on the results of 30 datasets for breast cancer, 30 datasets for lung cancer and 30 datasets for colon cancer, after the the effects of stress on breast, lung and colon cancer and the real results were calculated. In order to measure the compatibility and the performance of the study, risk analysis was experimented in the system by using data of patients and healthy people. However, 100% accuracy in the system could not be detected since the risk status of a person with low risk rate may change in the future with different living conditions and factors.

In future, image processing techniques can be added in this study. Thus the system's performance increase and the success of diagnostic can be ensured.

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