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Evolutionary Effect of Fuzzy Logic in the Healthcare Domain

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ABSTRACT

Fuzzy logic plays an essential role in human life. It has been used in various fields such as facial pattern recognition, air conditioners, washing machines, vacuum cleaners etc. The main objective of this paper is to reveal the development of fuzzy logic-based system to improve the quality and reliability of medical diagnosis. Also deals with monitoring and modeling of the visual Prolog Programming were used to create the proposed medical diagnostic system. This article examines the evolution of fuzzy logic's application in the domain of healthcare.

KEYWORDS: *Logic, Fuzzy controllers, Fuzzifier, Membership function, Health Care, Fuzzy inference system (FIS), Fuzzy expert systems (FES).*

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INTRODUCTION

In the health era, fuzzy logic plays an important role in our day to day life. Fuzzy set theory is increasingly applied in modern technologies, especially for design that can be utilized in everyday human life. Fuzzy set theory was first discovered by great Professor (Zadeh, 1965) of the University of California at Berkeley and it has been implemented in different practical applications for controlling an automatic steam engine by (Mamdani, 1974). Fuzzy thinking or concepts are those that do not match the facts or information present. Fuzzy logic is a methodology that resembles human reasoning. A single disease can manifest itself in a variety of ways relative to patient, and one symptom may be associated with multiple diseases depending on its severity.

According to the World Health Organization (WHO): "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or Multiple diseases existing in a patient, on the other hand, may interact and interfere with the normal classification of any of the diseases. One of the issues with traditional medical diagnostic methods is their inaccuracy and imprecision, which has resulted in the loss of number of lives of innocent people. Medical diagnostic processes are now carried out using computer-related technologies such as algorithms, models and technologies to assure accuracy and precision, which has considerably reduced the number of patients who die every day in different hospital across the globe.

In the fields of medicine and bioinformatics, uncertainty is common. There are several "fuzzy areas": there may be little (or incorrect) information on the patient, family medical history may be incomplete; lab results may be incorrect and so on. Humans are also dealing with an increase in the number of mental

problems, with no clear classification system in place. Depending on the regional and demographic features, a single disease such as COVID-19, might impact various patients with varying degrees of severity. Fuzzy logic looks to be an effective technique to cope with many of the flaws discovered in medical information.

Fuzzy Logic in Medical Domain

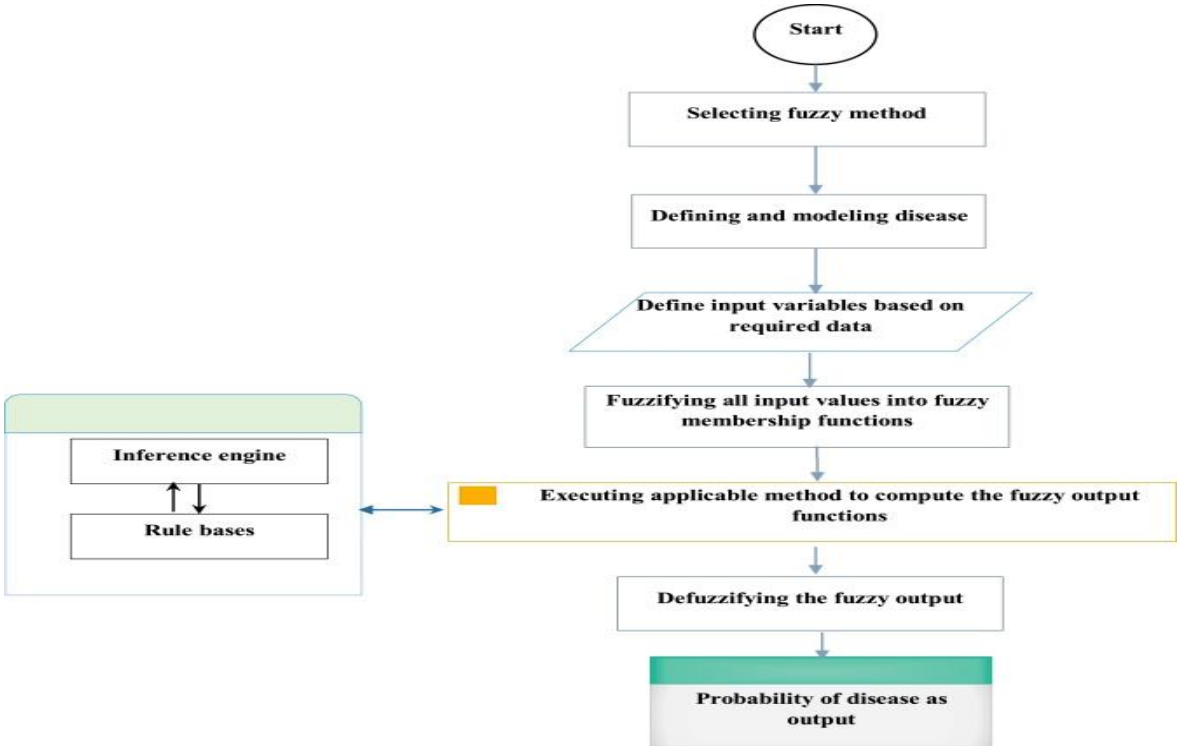

Figure 1: Process of Fuzzy Logic in Medical Domain

Application of Fuzzy Logic

There are numerous applications of fuzzy logic in daily life. It has been used to solve real-life world problem when human may face many uncertain situations.

We use fuzzy logic:

- To decide the response to treatment with major depressive disorder.
- To investigate cancer and detect its various stages.
- To improve decision-process in radiotherapy.
- To investigate diabetic neuropathy and to identify diabetic retinopathy in its early stages.
- To investigate level of blood pressure.
- To use magnetic resonance imaging (MRI) to determine the volume of brain tissue and to assess functional MRI data.
- To manage hypertension during anesthesia.
- To regulate flexor-tendon repair techniques.
- To detect cancer or prostate cancer.
- Determine neurons in the brain of a human.
- To show volumetric drug usage

Fuzzy Systems in Medicine

In medical domain, the role of medicineplays a crucial role. In spite of technological advances, AI also employed in fuzzy logic, which play a vital role in medicine such mathematical model enables for not only a quick action but also an efficient diagnosis. A fuzzy classifier has developed to distinguish blood pressure levels by (Guzman et al., 2019). The study's key results

reveal that the finest designs for performing said categorization are a type-1 fuzzy inference system or an interval type-2 fuzzy inference system (Guzmán, Miramontes, Melin et al., 2019). In order to give a risk assessment for hypertension, fuzzy logic was also used. In 2018, a model combining neural networks and fuzzy logic was created for this goal because they controlled the classification uncertainty; fuzzy systems were an integral part of this research. This hybrid model produced good results and exceeded expectations in its duty. Fuzzy systems have also been found to be useful in the diagnosis of Parkinson's disease in studies. (Abiyev and Abizade, 2016 & Biswas, 1997) suggested a technique for monitoring Parkinson's disease that combines fuzzy systems and neural networks. Kaur, Trehan, Kaur et al. (2017) proposed fuzzy neural system (FNS) enables for accurate classification of healthy people,as demonstrated by simulations of the system using data from the UCI machine learning repository. Another experiment proclaimed by (Abiyev, Abizade, 2016) to use fuzzy inference systems (FIS) or fuzzy expert systems (FES) to test the system for classifying medical data sets.

Orthopedics

Although Orthopedics is analogous to surgery in that, common orthopedic problem has no clear fuzzy remedy. There were two stories which looked to use improper logic, but both were about medical records and orthopedic patient waiting lists. However, fuzzy and non-fuzzy rule-bases were compared in the detection of orthopedic complaints in electrically stimulated walking of paraplegic people utilizing fuzzy identification approaches, starting with initial condition detection by (Geman, 2013).

Cardiology and Vascular Surgery

(Sau & Chizeck, 1994) has been experimented on cardiovascular study and fuzzy concepts were the focus of the earliest works on fuzzy logic and cardiology. We employ fuzzy set theory to assess cardiac functions, analyses cerebrovascular illness, and analyze ECGs. Several researchers in cardiovascular health referred to the concept of fuzzy sets in the mid-1990s. One application was the implementation of fuzzy control of a whole artificial heart.

Endocrinology

Endocrinology is a major aspect of internal medicine, which is a large medical branch. In 1978, a Version of an inference engine that deals with ambiguity was employed in the treatment of diabetic patients. For diabetic medicine, an expert system (PROTIS) was designed to predict fuzzy rules (Stadelmann et al., 1975) proposed a decision support system for the treatment of diabetic out-patients utilising fuzzy categorization .Based on a quantitative analysis of the dynamical reactions of glucose tolerance tests, fuzzy inference was applied to construct a diagnosis system for diabetic patients. For diabetics, a knowledge-based system based on fuzzy rules and hierarchical neural networks was recently developed.

Surgery

In surgery, advanced diagnostic tools have shown to be quite beneficial. Advanced image segmentation, pathophysiology thinking, and enhanced control mechanisms and simulating systems in anesthesia are examples of such instruments. Many implementations of fuzzy inference system to control medication flow for maintaining anesthetic levels, muscular relaxation, and patient monitoring and alarm have been documented in anesthesia. A distinct section will be dedicated to the subject; it’s been employed in virtual reality (VR) training. In an indirect way, fuzzy logic is used. Statistical competency evaluation would be component if VR surgical simulators are to play a significant role in the future... Because the “vague” is characterized by “too long”, “too short” or “too close”, “too far”, It's feasible that fuzzy logic concepts may be utilized to assess skill in a virtual reality surgical simulator. In another sector, surgery, fuzzy logic is utilized to modify an untrained segmentation algorithm to build an area of the patient by (Buisson et al., 1987).

Education

There are several ways to use fuzzy logic in teaching. Fuzzy mathematics was used to instruct students in a healthcare context and it has circulated by (Raposio, et al., 1999). A fuzzy medicine evaluation of nursing administrators' self-taught competency was also described.

Virtual Reality is a cutting-edge technology that can educate surgeon's new operations and assess their competency level before they operate on a patient, which has inspected by (Wang and Sun, 1996).

Oncology

The worldwide researchers (McLeish, et.al, 1989) have concentrated on classification job (for distinguishing cancer from normal tissue) and the advice tasks for therapy have been the focus of fuzzy logic in oncology. Advanced image processing was used heavily in therapy. Ovarian cancer has been subjected to magnetic resonance imaging analysis. The majority of the time, picture clustering technique is employed to determine brain tumor segmentation. Finally, utilising 3-D ultrasonic echographic pictures, Breast tumours were diagnosed using a fuzzy reasoning system. Fuzzy logic is a promising diagnostic method for improving tumor markers.

Gerontology

The application of fuzzy logic for clustering has been a common theme in gerontology applications. This is an illustration of how fuzzy logic can be used to forecast cell ageing. Furthermore, a fuzzy relational structure (Ellison & Massaro) were used to create the databases for developing a veterinary expert system.

Psychology

The fuzzy logical model of perception (FLMP) paradigm has been expanded to include perception and identified by (Manshi & Poonia). The FLMP outperforms an additive model by combining the results of two feature studies. The Concept Hierarchy Memory Model (CHMM), a neural network-based cognitive architecture for conceptual knowledge representation and common-sense reasoning with fuzzy interactions between concepts, was given the weights and linkages connecting the ideas. CHMM uses conventional reasoning to solve problems.

Blood Pressure

For each person, the latest models use "fuzzy logic" to decide how much the cuff should be inflated to achieve a pressure of around 20mm Hg over the systolic pressure.

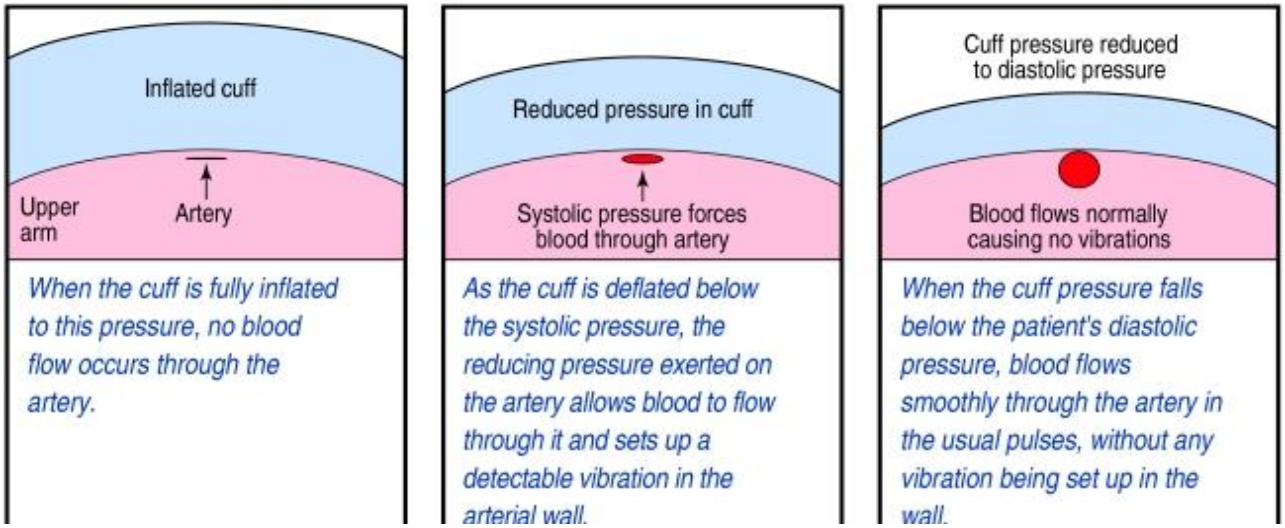

Figure 2: Level of blood pressure

Fuzzy logic is used to accept the BP values as an input. Finally, using a fuzzy method, the values can be compared. The output of the implementation is depicted in this diagram. We intend to use data mining algorithms to extract fuzzy inference rules in the future, and a machine learning component may be included.

RESULTS AND DISCUSSION

The outcome from fuzzy logic system promises to give better health facility not only patient but also common people in the world who have been strive for prime healthcare. We can calculate the COVID-19 cases by using fuzzy approximation method.

According to a recent study, it will take nearly four weeks for the corona virus pandemic to collapse the healthcare system once it starts. The COVID-19 problem is defined by a mathematical model based on four parameters, which are

(i) The number of additional infectious cases predicted per infected case (Xo);

(ii) Incubation period (m) this means the time it takes for an infection to manifest itself as a symptom.

(iii) V= duration of disease

(iv) N= the period of time between the beginning of a symptom and recovery or death.

Assume that one infectious case produces Xo additional infectious cases after one incubation time (m). The total number of cases is currently 1+Xo. After two experimental periods, Xo2 cases are made by the prior Xo instances (2 m).1+Xo+Xo^2 is the total number of cases. Considering that the number of cases anticipated by $day_{t.m}$ equals $C_{t.m}$ the total number of cases can be represented as

$C = \sum C_{t.m}$

Where C= Total cases that have been forecast.

$C_{t.m=}$ The number of incident cases predicted on $day_{t.m}$

Predicted number of COVID-19 cases using Xo= 4 and m = 7 days.

Table 1: Total no of cases

Time of incubation(m)	$Day_{t.m}$	Predicted incident cases ($C_{t.m}$)	Total cases that have been forecast. (C)
0	0	1(=X_o^0)	1
1	7	4(=X_0^1)	5 (=1+4)
2	14	16(=X_0^2)	21(=1+4+16)
3	21	64 (=X_0^3)	85 (=1+4+16+64)

CONCLUSION

Fuzzy logic is a powerful tool for implementing essential principles including control, communication, adaptation, and structure. Fuzzy set theory and the theories that follow it provide a highly relevant and widely applicable foundation for constructing knowledge-based systems in medicine. We employed fuzzy logic to recognize medical articles in the MEDLINE database. We utilized terms like fuzzy logic and membership grade as keywords. Clinical trials indicate the adequacy of the patient data and fuzzy knowledge description, as well as the chosen fuzzy inference processes, in terms of critical medical applicability and result accuracy. Furthermore, the use of a Fuzzy logic-based medical diagnostic system will lessen doctors' workload during consultations and alleviate other issues related with hospital visits. More advanced medical diagnosis systems can be built to aid in areas such as patient registration, drug prescription, and the storage of patient information and data in the medical sector.

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