The Role of Fuzzy Expert System in the Medical Field: A Fuzzy Approach

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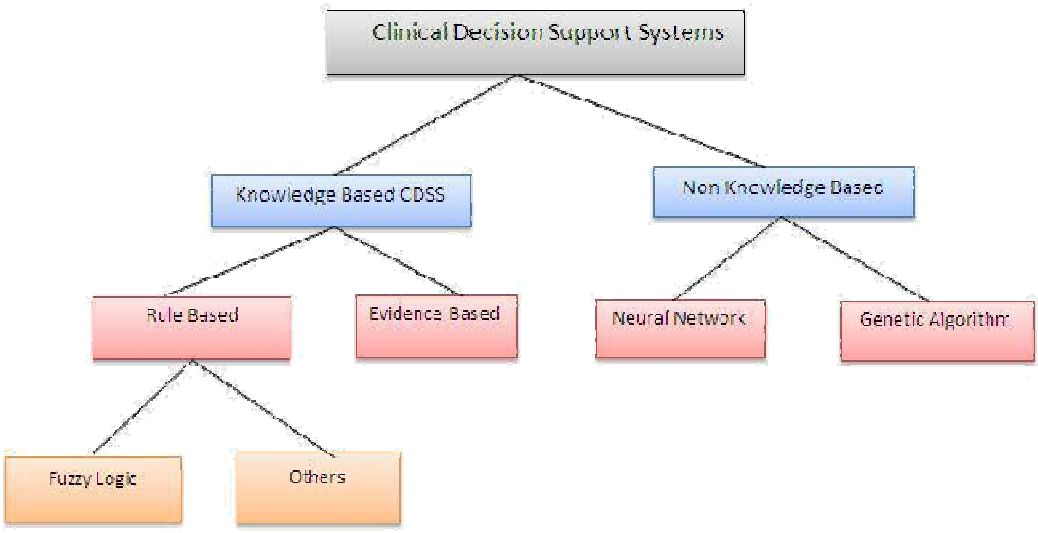
Abstract

In real world computing environment, the information is not complete, precise and certain, making very difficult to derive an actual decision. Various Clinical Decision Support Systems have been constructed by the aid of Artificial intelligence. These systems are now widely used in hospitals and clinics. They are proved to be very useful for patient as well as for medical experts in making the decisions. An essential element of the medical profession is making numerous decisions. In this process doctors rely on gained knowledge and experience. However, it seems necessary for them to have the ability to think logically, to use reasoning, to infer, to precisely and clearly express their thoughts and justify the assertions made. Fuzzy Logic explores approximation techniques from neural networks to finds the parameter of a fuzzy system. This paper which demonstrates the practical application of Information Technology (IT) in the health sector, has presented a fuzzy Expert System to help in diagnosis of thyroid disorder using a set of symptoms. The system designed is an interactive system that tells the patient his current condition as regards thyroid disorder. This paper will present the importance of logic in the medical field.
KEYWORDS: clinical decision support systems, fuzzy logic, fuzzy expert systems.

INTRODUCTION:

Before the 1970's *Mathematical Modelling (MM)* used to be a tool in hands of the scientists working mainly in Industry, Constructions, Engineering, Physics, Economics, Operations' Research, and in other positive and applied sciences. The first who described the process of MM in such a way that could be used in teaching mathematics was Pollak in ICME-3 (Karlsruhe,1976). Pollak represented the interaction between mathematics and real world with a scheme, which is known as *the circle of modelling* [1]. However life in the classroom is not like that. Recent research, ([2], [3], [4], etc), reports that students in school take *individual modelling routes* when tackling MM problems, associated with their individual learning styles. In particular, the domain of medical decision making is one driven by problems of vagueness and uncertainty. The doctor makes decisions on treatment based not simply on matching precise symptoms or measurements to diagnosis. Since computer was invented, it has been used for assisting medical professionals. In [5] authors discussed the importance of logic in the medical field and the related background such as The first research article dealing with medicine and computers appeared in late 1950s (Ledley & Lusted, 1959). Later an experimental prototype appeared in the early 60s (Warner et al., 1964). At that time limited capabilities of computer did not allow it to be a part of medical domain. In 1970s the three advisory systems: de Dombal's system for diagnosis of abdominal pain (de Dombal et al.,1972), Shortliffe's MYCIN system for antibiotics selection (Shortliffe, 1976), and HELP system for medical alerts delivery (Kuperman et al., 1991; Warner, 1979).1990s witnessed a large scale shift from administrative systems to clinical decision support systems.



The thyroid is a butterfly-shaped gland located in the front of the neck just below the Adams apple. The gland wraps around the windpipe (trachea) and has a shape that is similar to a butterfly formed by two wings (lobes) and attached by a middle part (isthmus). The gland [6] works like a tiny factory that uses iodine (mostly from the diet in foods such as seafood and salt) to produce thyroid hormones. These hormones help to regulate the body's metabolism and effects processes, such as growth and other important functions of the body [6]. The two most important hormones are thyroxine (T4) and triiodothyronine (T3), representing 99.9% and 0.1% of thyroid hormones respectively. The hormone with the most biological power is actually T3. Once released from the gland into the blood, a large amount of T4 is converted to T3 - the active hormone that affects the metabolism of cells throughout the body [6].

Thyroid disorders include such diseases and conditions as graves' disease, thyroid nodules,

Hashimoto's thyroiditis, trauma to the thyroid, thyroid cancer and birth defects. These include being born with a defective thyroid gland or without a thyroid gland [7]. Thyroid disorders can cause the thyroid gland to become overactive (hyperthyroidism) or underactive (hypothyroidism). Thyroid disorders result in a slowing of the body's chemical processes and metabolism with symptoms such as weight gain, fatigue and depression [8, 6 and 7].

Cases of the disorders are more common in women than in men. Hashimoto's thyroiditis occurs most often in females between the ages of 30 and 50 years and appears to have a genetic component because it can run in families. People over the age of fifty who have hypertension or atherosclerosis are at risk for hyperthyroidism [8, 9 and 7].

They are often misdiagnosed as depression, aging, or other causes of tiredness, fatigue, or forgetfulness. Therefore, a thyroid disorder is a possibility that must not be ruled out in diagnosis of conditions such as depression, fibromyalgia, lupus, sleep disorders, and various other conditions. Fortunately, diagnosis of thyroid problems is relatively specific by blood tests of thyroid hormone levels. Thyroid disorders are treatable, but, can be serious if untreated. Any suspicion of thyroid problems needs to be confirmed promptly by a doctor.

Students' cognition utilizes in general concepts that are inherently graded and therefore fuzzy. On the other hand, from the teacher's point of view there usually exists vagueness about the degree of success of students in each of the stages of the modelling process. All these gave us the impulsion to introduce principles of *fuzzy sets theory* in order to describe in a more effective way the process of MM in classroom. Created by Zadeh [10], fuzzy logic has been successfully developed by many researchers and has been proven to be extremely productive in many applications (see, for example, [11], [12], [13], [14], etc). The incidental thyroid nodule (ITN) is one of the most common incidental findings on imaging studies that

include the neck. An ITN is defined as a nodule not previously detected or suspected clinically, but identified by an imaging study. In [15] authors describes consensus recommendations representing this committee's review of the literature and their practice experience

Preliminary concepts and definitions

A fuzzy subset *A* of the a universal set *X* is defined by a membership function A that assigns to each element *x* of *X* a number A(x), between zero and one, which gives by degree of membership from *x* to *A*. Thus, $\mu_A : X \rightarrow [0, 1]$. It interesting to note that a classic subset *A* of *X* is a particular fuzzy set for which the membership function is the it's characteristic function of *A*, $\mu_A: X \rightarrow \{0, 1\}$. Fuzzy sets allow us to represent vague concepts expressed in natural language. The representation depends not only on the concept, but also on the context in which it is used. For example, applying the concept of high temperature in one context to weather and in another context to a nuclear reactor would necessarily be represented by very different fuzzy sets. There is many types of membership functions. We are discussing some membership functions in short –

The triangular is the simplest membership function which is formed by using straight lines. It described by the three points forming a triangle. The trapezoidal membership function has a flat top. The Gaussian distribution curve– a simple Gaussian curve and a two-sided composite of two different Gaussian curves. Another membership function, the generalized bell function g-bell is specified by three parameters. We are using triangular fuzzy function of its simplicity which shows as-

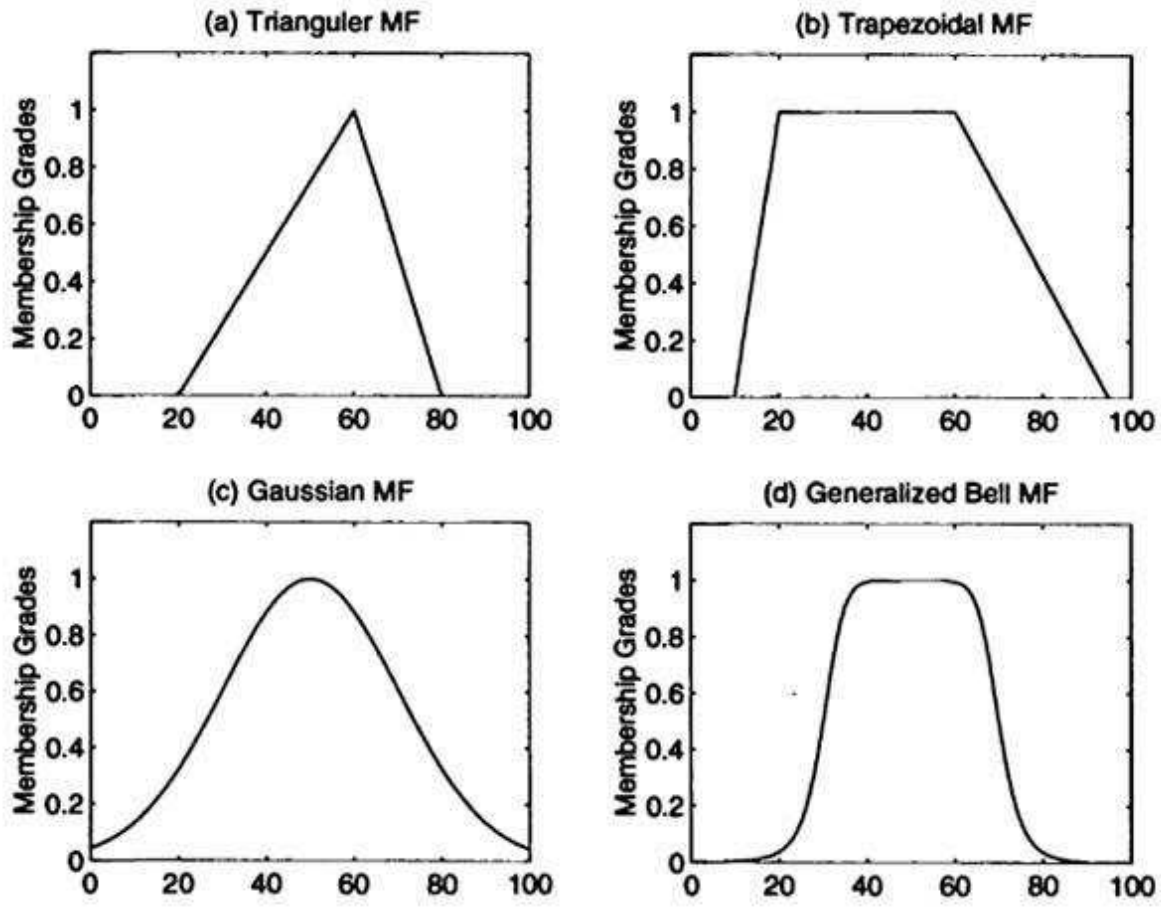


Figure 2: All types of Fuzzy Membership functions

2.1. Fuzzy rule-based systems

Basically, fuzzy rule-based systems have four components: an input processor; a collection of linguistic rules, called rule base; a fuzzy inference method and an output processor. These components process real-valued inputs to provide real-valued outputs. Fig. 1 illustrates a fuzzy rule-based system. The fuzzification is the process by which the input values of the system are translated into fuzzy sets of their respective universes. It is amapping of the dominion of the real numbers led to the fuzzy dominion. The rule base characterize the objectives and strategies used by specialists in the area, by means of a linguist rule set.

It is composed by a collection of fuzzy conditional propositions in the form if-then rules. An expert, interviewed to help formulate the fuzzy rules set, can articulate associations of linguistic inputs/outputs. The fuzzy inference machine performs approximate reasoning using the compositional rule of inference. A particular form of fuzzy inference of interest here is the Mamdani method [16]. In this case, it aggregates the rules through the logical operator OR, modelled by the maximum operator and, in each rule, the logical operators AND and THEN are modelled by the minimum operator [17]. The fuzzy rule-based system considered in this work, consists of two inputs, two outputs, and 30 fuzzy rules of the following form:

"IF the number of preys is large AND the potential of predation is very small, THEN the variation of preys increases a little AND the variation of the potential of predation increases a lot", where large, very small, increases a little, increases a lot are fuzzy sets (see Section 4).

The logic of decisions to be made, incorporated to the structure of inference of the rule base, uses fuzzy implications [16]. to simulate the wanted decisions. It generates actions–consequents – inferred from a set of input conditions –antecedents.

Finally, in defuzzification, the value of the output linguistic variable inferred by the fuzzy rule is translated to a real value. The purpose is to obtain a real number that better represents the fuzzy values of the output linguistic variable.

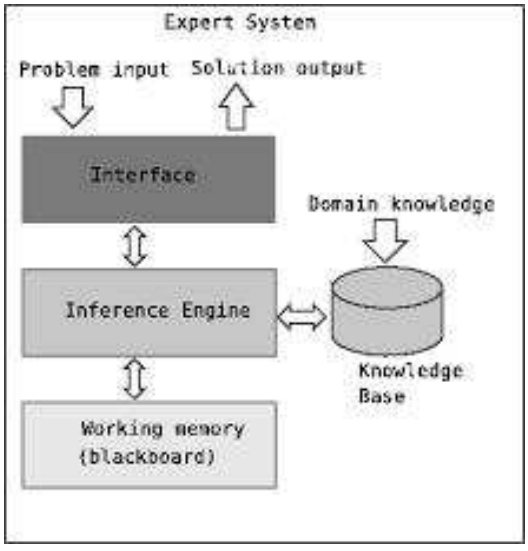


Figure 3: Model of the Fuzzy Expert system for Thyroid disorder

Methodology

The process for the medical diagnosis of Thyroid disorder starts when an individual consults a physician (doctor) and presents a set of complaints (symptoms). The physician then requests further information from the patient or from others close to him who knows about the patient's symptoms in severe cases. Data collected include patient's previous state of

health, living condition and other medical conditions. A physical examination of the patient condition is conducted and in most cases, a medical observation along with medical test(s) is carried out on the patient prior to medical treatment.

From the symptoms presented by the patient, the physician narrows down the possibilities of the illness that corresponds to the apparent symptoms and make a list of the conditions that could account for what is wrong with the patient. These are usually ranked in the order (Low, Moderate and high and so on). The physician then conducts a physical examination of the patient, studies his or her medical records and ask further questions, as he goes in an effort to rule out as many of the potential conditions as possible. When the list has been narrowed down to a single condition, it is called differential diagnosis and provides the basis for a hypothesis of what is ailing the patient. Until the physician is certain of the condition present; further medical test are performed or schedule such as medical imaging, scan, X-rays in part to conform or disprove the diagnosis or to update the patient medical history. Other Physicians, specialist and expert in the field may be consulted (sought) for further advices.

Despite all these complexities, most patient consultations are relatively brief because many diseases are obvious or the physician's experience may enable him to recognize the condition quickly. Upon the completion of the diagnosis by the physician, a treatment plan is proposed, which includes therapy and follow-up (further meeting and test to monitor the ailment and progress of the treatment if needed). Review of diagnosis may be conducted again if there is failure of the patient to respond to treatment that would normally work. The procedure of diagnosing a patient suffering from thyroid disorder is synonymous to the general approach to medical diagnosis. The physician may carry out a precise diagnosis, which requires a complete physical evaluation to determine whether the patient have thyroid disease. The examining physician accounts for possibilities of having thyroid disorder through an interview, physical examination and laboratory test. Many primary health care physicians may require tools for thyroid disorder evaluation.

To design our diagnosis system for of thyroid disorder, we designed a fuzzy membership function system which consists of a set of symptoms needed for the diagnosis (here, we are using ten basic and major symptoms):

1. Insomnia
2. Irritability
3. Nervousness
4. Unexplained weight loss
5. Heat sensitivity
6. Increased perspiration
7. Eye changes
8. Shaky hands
9. Weak length muscle
10. Brittle hair

Our fuzzy membership function is –

Where c= total number of symptoms are taken i.e. 10.

x= total number of appeared symptoms in the patients.

According to the values of defined fuzzy membership function we categories the conditions in three categories such as-

1. **Low (Not thyroid)-** if the membership value lies in [0 .143]
2. **Moderate(might be suffering from thyroid disorder)-** if the membership value lies in (1.43 0.2]
3. **Prognosis(suffering from severe thyroid disorder)-** If the membership value lies in [0.2 1]

Result and Discussion: If patients A, B, C, D, E and F want to know their status of thyroids. Their lists of symptoms are given below-

	A	B	C	D	E	F
Insomnia	Y	N	N	Y	Y	Y
Irritability	N	Y	N	Y	Y	Y
Nervousness	N	Y	Y	Y	Y	N
Unexplained Weight Loss	Y	Y	Y	Y	Y	N
Heat Sensitivity	N	N	Y	Y	Y	N
Increased Perspiration	Y	N	Y	Y	Y	N
Eye Changes	N	Y	Y	N	Y	N
Shaky Hands	N	Y	N	N	Y	N
Weaklength Muscle	N	N	N	Y	Y	N
Brittle Hair	N	Y	N	Y	N	N

Y means that symptom does appear in those patients.
N means that symptom does not appear in those patients.

Now we calculate their member ship values by the given formula in (*). The values of membership values for A, B, C, D, E, and F are 0.125, 0.2, 0.167, 0.33, 0.5 and 0.11 respectively. Hence the condition of A and F is **Low** means not effected with thyroid, condition of B and C is **Moderate** means might be suffering from thyroid disorder and condition of D and E **Prognosis** means suffering from severe thyroid disorder.

Conclusion

The need to design a system that would assist physician in medical diagnosis of Thyroid disorder cannot be over emphasized. This chapter which demonstrates the practical application of Information Technology (IT) and fuzzy mathematics in the health sector developed a fuzzy membership function to help in diagnosis of Thyroid disorder using a set of symptoms. This system which uses a set of fuzzified data set incorporated into fuzzy system is more precise than the traditional system. The system designed is an interactive system that tells the patient his current condition as regards Thyroid disease. It should however be noted that the system was not designed to give prescription of Thyroid drugs to patients and the treatment of thyroid disorder but can also be expanded to do so in subsequent research. A system of this nature that has the ability to diagnose a person suffering from Thyroid disorder should be introduced in health care delivery centres and hospitals to help ease the work of physicians.

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