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A Fuzzy Based System for Determining the Severity Level of Osteomyelitis

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Abstract— ***Medical diagnosis is the art of determining a person's pathological status from an available set of findings. Medical diagnosis involves a complex decision process that involves a lot of uncertainty especially when the disease has multiple symptoms. Fuzzy logic is a computational paradigm that provides a mathematical tool for dealing with the uncertainty and the imprecision typical of human reasoning. Osteomyelitis is an infection of the bone, a rare but serious condition. People with osteomyelitis often feel severe pain in the infected bone and affects their mobility which a serious issue. This research work employs the use of Fuzzy Logic Control (FLC) methodology to design a system for the determination of severity level of osteomyelitis to avoid further deterioration of the problem. Fuzzy models have the capability of recognizing, representing, manipulating, interpreting, and utilizing data and information that are vague and lack certainty in which medical field is not an exemption. In this research, a four input (pain, swelling, fever and age) and one output (severity level) Multiple Input Single Output (MISO) rules fuzzy controller was designed and implemented, and will provide a valid fuzzy inference system that will determine the severity level of osteomyelitis based on identified factors (input variables). This research work tries to eliminate the error-prone conclusion in decision making by modeling and developing several input cases, rules and the implementation and simulation of the model through Fuzzy Logic Control toolbox in MATLAB 7.6.0.***

Keywords— ***Fuzzy logic, Fuzzy logic controller (FLC), Fuzzy inference system, Membership function, Fuzzy control rules***

I. INTRODUCTION

Health is wealth. Indeed, for as long as history has been recorded, humans have been searching for ways to improve their physical and mental health. Health scientists continue to research, experiment, study and work long and hard to discover new ways of bringing health and happiness to mankind. Therefore, the natural world is being harnessed as never before to take advantage of what nature and technology provides for our well being. Our mobility is an important daily requirement so much so that any disruption to it severely degrades our perceived quality of life [1]. (Lai *et al.*, 2009). Osteomyelitis is a disease that threatens the mobility of those affected.

Osteomyelitis (sometimes abbreviated to OM, and derived from Greek words *osteon*, meaning bone, *myelo-* meaning marrow, and *-itis* meaning inflammation) is infection and inflammation of the bone or bone marrow [2].(Kumar *et al.*, 2007). Osteomyelitis is an infection of the bone, a rare but serious condition. Osteomyelitis (pronounced: os-tee-oh-my-uh-lie-tus) is a bone infection often caused by bacteria called *Staphylococcus* aureus (pronounced: sta-fuh-low-kah-kus are-ee-us), a type of staph bacteria; but it can also be caused by fungi or other germs. Depending on how the bone becomes infected and the age of the person, other types of bacteria can cause it too. In kids and teens, osteomyelitis usually affects the long bones of the arms and legs. In adults, the feet, spine bones (*vertebrae*) and hips (pelvis) are most commonly affected [3].(Joel, 2010). Bacteria can infect bones in a number of ways. Bacteria can travel into the bone through the bloodstream from other infected areas in the body. This is called hematogenous (pronounced: heh-meh-tah-gen-us, *hema* refers to the blood) osteomyelitis, and is the most common way that people get bone infections [3]. (Joel, 2010).

Osteomyelitis affects different people in different ways depending on which part of the body is affected as it affects different parts of the body in adults and children. Pain is the main problem for some people, while others find their main problem as difficulty in walking [4]. (David *et al*., 2012).

Acute osteomyelitis develops rapidly over a period of 7 to 10 days. The symptoms for acute and chronic osteomyelitis are very similar and include: bone pain, fever, general discomfort, uneasiness, or ill-feeling (malaise), local swelling, redness, and warmth. Other symptoms that may occur with this disease are: chills, excessive sweating, low back pain, swelling of the ankles, feet, and legs. Osteomyelitis in the vertebrae makes itself known through severe back pain, especially at night [5]. (John, 2012).

In children, osteomyelitis is usually acute (acute osteomyelitis occurs with a rapid onset, that is, comes on quickly); they develop pain or tenderness over the affected bone, and they may have difficulty or inability to use the affected limb or to bear weight or walk due to severe pain. They may also have fever, chills, and redness at the site of infection. Acute osteomyelitis comes on quickly, is easier to treat, and overall turns out better than chronic osteomyelitis. In children, osteomyelitis usually shows up in arm or leg bones [6]. (Kimball, 2012). The disease (Osteomyelitis) exerts a high cost in terms of pain and decreased function in adults. It is a major cause of pain and physical disability associated with significant social and economical burden most especially in adults. Osteomyelitis (OM) is a major public health issue causing chronic disability and reduction in quality of life in children and adults.

With improvement in science and technology, intelligent computing has been used in assisting and enhancing qualitative services, thereby reducing the mortality rate and also alleviating the economic burden placed on the society through lost working time as well as social and medical costs due to one ailment or the other of which osteomyelitis is not an exception.

Fuzzy logic (a paradigm of artificial intelligence), provides a mathematical tool for dealing with the uncertainty and imprecision typical of human reasoning that has been used in assisting the medical personnel in making decision [7]. (Radha and Rajagopalan, 2007). Fuzzy logic can also be described as a tool of artificial intelligence based on the observation that people make decisions based on imprecise and non-numerical information [8]. (Oguzhan *et al*., 2001). Practically, an expert physician tends usually to specify his experience in rather fuzzy (unclear) terms, which is more natural to him than trying to cast his knowledge in rigid rules having abrupt premises [9]. (Buchanan and Shortliffe, 1984). Fuzzy Logic has been found to be very suitable for embedded control applications. Several manufacturers in the automotive industry are using fuzzy technology to improve quality and reduce development time. In aerospace, fuzzy logic enables very complex real time problems to be tackled using a simple approach. In consumer electronics, fuzzy logic improves time to market and helps reduce costs. In manufacturing, fuzzy logic is proven to be invaluable in increasing equipment efficiency and diagnosing malfunctions. [10]. (Emuoyibofarhe and Taiwo, 2012)

The task of medical diagnosis, unlike other diagnostic processes is made more complex because a lot of vagueness, linguistic uncertainty, hesitation, measurement imprecision, natural diversity are all prominently present in medical diagnosis. Using fuzzy logic in medical diagnosis is a promising technique that can easily capture the required medical knowledge and come up with sound diagnosis decisions. Hence, there is need to develop a fuzzy-based system that will assist in determining the level of severity of osteomyelitis, in order to prevent further deterioration of the problem and to deal with the imprecision and uncertainty involved in diagnosing diseases.

This work seeks to develop and implement a fuzzy-based system that will determine the severity level of osteomyelitis based on identified factors (input variables), and to input symptoms in natural language term and not precise values.

II. SYSTEM OVERVIEW

This paper addresses an application that determines the severity level of a disease called osteomyelitis. It presents a Fuzzy Logic Controller that uses fuzzy inference system (FIS). FIS is a popular computing framework based on the concept of fuzzy set theory, fuzzy IF-THEN rules and fuzzy reasoning. The objective of this article is to implement a FLC for determining the severity level of osteomyelitis in adult and children.

2.1 Fuzzy Logic

Fuzzy Logic (FL) is a multi-valued logic that allows intermediate values to be defined between conventional evaluations like True/False, Yes/No, High/Low, etc. Notions like ‘rather tall’ or ‘very fast’ can be formulated mathematically and processed by computers, in order to apply a more human-like way of thinking in the programming of computers (Zadeh, 1984). The concept of Fuzzy Logic (FL) was conceived by Lotfi Zadeh, a professor at the University of California at Berkley (Zadeh, 1965). Fuzzy logic is a branch of logic specially designed for representing knowledge and human reasoning in such a way that it is amenable (agreeable) to processing by a computer. Thus, it is applicable to artificial intelligence, knowledge engineering, and expert systems [11]. (Padhy, 2006). Reference [12] Stancey and Brien (2001) defined fuzzy logic as a method of dealing with imprecise data, uncertainty, with problems that have many answers rather than one. Reference [7] (Radha and Rajagopalan, 2007) describe fuzzy logic as a computational paradigm that provides a mathematical tool for dealing with the uncertainty and imprecision typical (usual) of human reasoning. A prime characteristic of fuzzy logic is its capability of expressing knowledge in a linguistic way, allowing a system to be described by simple, human friendly rules.

2.2 Fuzzy Logic Controllers

Generally, a Fuzzy logic Controller comprises of four principal components: a fuzzification interface, a knowledge base, decision-making logic, and a defuzzification interface [13]. (Chuen, 1990). Fig. 1. shows the basic configuration of a fuzzy logic controller.

***The fuzzification interface*:** The fuzzification module converts the crisp values of the control inputs into fuzzy values, so that they are compatible with the fuzzy set representation in the rule base. The choice of fuzzification strategy is dependent on the inference engine, i.e. whether it is composition based or individual-rule-firing based [14]. (Driankov et al., 1993). The controller of this work is facing the real world, takes the data and converts it to a format that can be processed in inference engine. Input variables are first processed in this work according to input membership functions which are addressed in knowledge base of the Fuzzy Logic Controller. These inputs are converted into appropriate fuzzy sets. The fuzzified inputs are then sent to inference engine to be evaluated as per control rules stored in the fuzzy rule base addressed in knowledge base (see figure 1). The result is fuzzy sets in the universe of discourse.

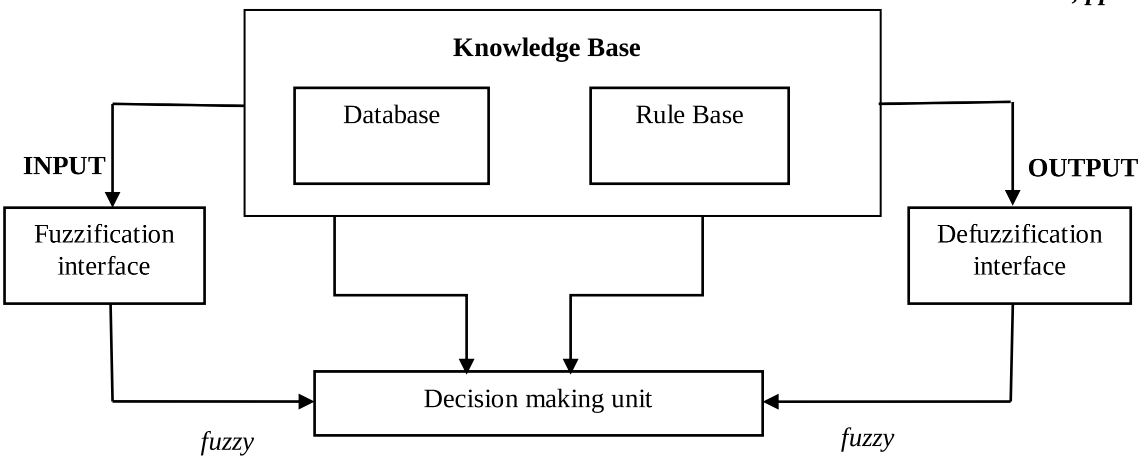


Fig 1: Major Components of a fuzzy-based system (Source: Chuen, 1990)

The input is always a crisp numerical value limited to the universe of discourse of the input variable and the output is a fuzzy degree of membership (always the interval between 0 and 1). So fuzzification really does not amount to anything more than lookup table or functions evaluation [15]. (Jang et al., 1997). The converted variables by fuzzifier are fuzzy linguistic variables.

The Knowledge Base (KB): The knowledge base consists of a database of the plant. It provides all the necessary definitions for the fuzzification process such as membership functions, fuzzy set representation of the input–output variables and the mapping functions between the physical and fuzzy domain [16].(Cirstea et al., 2002).

The kernel of any expert system consists of a knowledge base (also called a long-term memory), a database (also called a short-term memory or a blackboard interface), and an inference engine [17].(Klir et al., 1995).

The knowledge base contains general knowledge pertaining to the problem domain. In fuzzy expert systems, the knowledge is usually represented by a set of fuzzy production rules, which connect antecedents with consequences, premises with conclusions, or conditions with actions. The inference engine may also use knowledge regarding the fuzzy production rules in the knowledge base. This type of knowledge, whose appropriate name is rule base, is located in the unit called rule base. This unit contains rules about the use of production rules in the knowledge base.

For the knowledge base, the expert defines the input and output observation (the descriptive words) and the range (the fuzzy number range). The expert also defines the consequent output for each input (the rule). The designer defines the membership functions for inputs and outputs. The knowledge base is then put into action in an inference engine–a computer program that can take actual inputs, let them fire the rules, and export outputs to the domain system [18] (McNeill et al., 1994).

Creating a knowledge base with the Fuzzy Knowledge Builder follows the five-step design

1. Identify the inputs and their ranges and name them.
2. Identify the output and its ranges and name it.
3. Create the fuzzy membership function for each input and output.
4. Translate the interaction of the inputs and outputs into If–Then rules.
5. Decide on the inference engine that will act on the specific inputs and the knowledge base to produce the specific defuzzified output [18]. (McNeill et al., 1994).

The decision-making logic: This is the kernel of a FLC; it has the capability of simulating human decision-making based on fuzzy concepts and of inferring fuzzy control actions, employing fuzzy implication and the rules of inference in fuzzy logic.

The defuzzification interface: In most cases, the fuzzy output value has very little practical use as most applications require non-fuzzy (crisp) control actions. Therefore, it is necessary to produce a crisp value to represent the possibility distribution of the output. The mathematical procedure of converting fuzzy values into crisp values is known as 'defuzzification'. Over the years, several defuzzification techniques have been suggested. The most frequently used ones are the *centroid or centre of area, centre of sums, and mean of maxima*. This paper adopts the centroid or centre of area defuzzificcation technique as described thus –

In centre of area (COA) defuzzification, the crisp value u is taken to be the geometrical centre of the output fuzzy value μ_{OUT} (u), where $\mu_{OUT}(u)$ is formed by taking the union of the contributions of all the rules whose degree of membership function is greater than zero. The centroid methods are based on finding the balance point of the whole geometric figure. For a discrete universe of discourse, the defuzzified output is defined as

$$u = \frac{\sum_{i=1}^{N} \mu_i \, \mu_{OUT}(u_i)}{\sum_{i=1}^{N} \mu_{OUT}(u_i)} \qquad (1)$$

where the summation is carried out over discrete values of the universe of discourse, μ_i, sampled at N points. The above method is the one adopted for this research work.

2.3 Fuzzy inference system

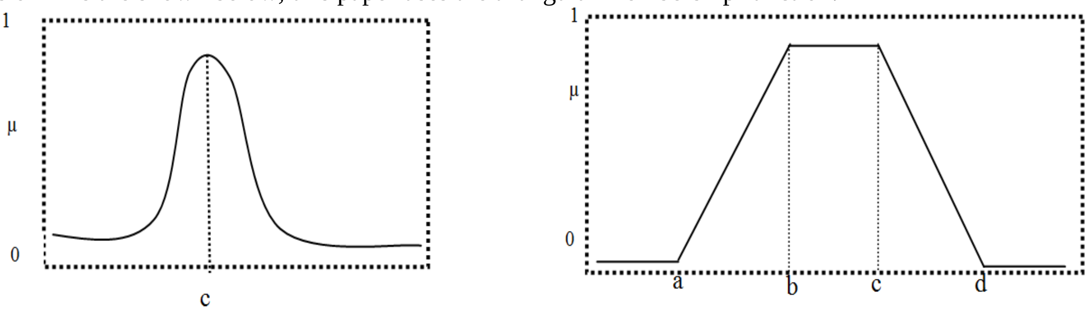
Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The process of fuzzy inference involves: *membership functions*, *fuzzy logic operators* and *if-then rules.* There are two types of fuzzy inference systems that can be implemented in the Fuzzy Logic Toolbox:

- Mamdani-type and
- Sugeno-type.

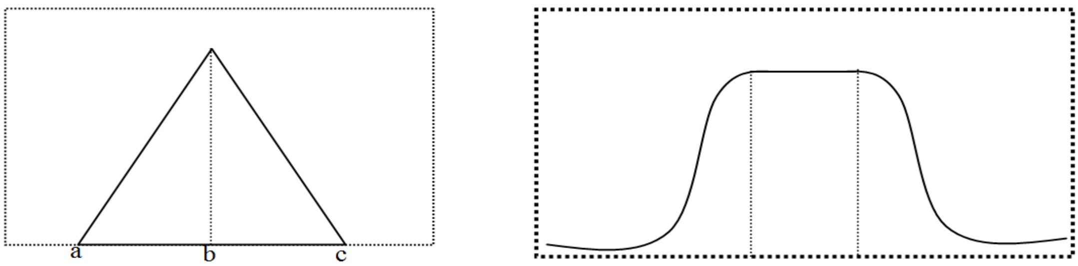
Mamdani's fuzzy inference method is the most commonly seen fuzzy methodology and it expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification. Sugeno-type systems can be used to model any inference system in which the output membership functions are either linear or constant. This paper adopts the Mamdani-type because of the reasons above.

2.3.1 Membership functions

Membership function is the mathematical function which defines the degree of an element's membership in a fuzzy set. Reference [19] Jin and Bimal (2002), defines membership function as a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. It defines the relationship between the grade and the fuzzy variable for each label. Fuzzy Sets are characterized by their Membership Functions. The position and the shape of a Membership Function depend on particular application and the context. Some commonly used types of MFs are shown below, this paper uses the triangular membership function.



(a) Triangular Membership Function (b) Trapezoidal Membership Function



(c) Gaussian Membership Function (d) Two-sided Gaussian Membership Function

Fig. 2 Fuzzy Logic Membership Functions (Source: Jin and Bimal, 2002)

2.3.2 Fuzzy logic operators

The most important thing to realize about fuzzy logical reasoning is the fact that it is a superset of standard Boolean logic. In other words, if the fuzzy values are kept at their extremes of 1 (completely true) and 0 (completely false), standard logical operations will hold. That is, A AND M operator is replaced with minimum - *min* (A,M) operator, A OR M with maximum - *max* (A,M) and NOT M with 1-M.

2.3.3 IF-THEN rules

The rule base is essentially the control strategy of the system. It is usually obtained from expert knowledge or heuristics and expressed as a set of IF-THEN rules. The rules are based on the fuzzy inference concept and the antecedents and consequents are associated with linguistic variables.

Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. Usually the knowledge involved in fuzzy reasoning is expressed as rules in the form:

IF x is A THEN y is B

Where x and y are fuzzy variables and A and B are fuzzy values. The IF-part of the rule "*x* is *A*" is called the *antecedent* or premise, while the THEN-part of the rule "*y* is *B*" is called the *consequent* or conclusion. Statements in the antecedent (or consequent) parts of the rules may well involve fuzzy logical connectives such as 'AND' and 'OR'.

Basically, a rule is activated, or *triggered,* if an input condition satisfies the IF part of the rule statement. This results in a control output based on the THEN part of the rule statement. In a fuzzy logic system, many rules may exist, corresponding to one or more IF conditions. A rule may also have several input conditions, which are logically linked in either an AND or an OR relationship to trigger the rule's outcome.

The IF-THEN rules can be represented in many forms. Two of these forms are the Multi-Input-Single-Output (MISO) form and the Multi-Input-Multi-Output (MIMO) form. The MISO form is

IF x is A and y is B THEN z is C or

IF x is A and y is B and z is C THEN t is D

where x, y, t and z are Linguistic Variables and A, B, C and D are Linguistic values defined by fuzzy sets on their respective universe of discourse. This is the form used in this research work.

The MIMO form is one with consequents that have terms associated with each of the fuzzy controller outputs, that is,

IF x is A and y is B THEN p is C and q is D.

2.4 Fuzzy Conditional Statements and fuzzy Control Rules

The antecedents and the consequents of these IF-THEN rules are usually associated with fuzzy concepts or linguistic terms and hence, they are often called *fuzzy conditional statements*. A fuzzy conditional statement in which the antecedent is a condition in its application domain and the consequent is a control action for the system under control is called *Fuzzy control rule*.

Several linguistic variables might be involved in the antecedents and the conclusions of these rules. When this is the case, the system is referred to as multi-input-multi-output (MIMO) fuzzy system, There are also cases where several linguistic variables might be involved in the antecedents but only one variable is involved in the consequent, this is referred to multi-input-single-output (MISO) [10].(Emuoyibofarhe and Taiwo 2012). In this work, the multi-input-single-output system (MISO) is used

III. DESIGN PROCEDURE

In order to realize the objectives of this research, the researcher carried out the analysis and design of the proposed system in two stages:

i. Systematic observation/analysis of the patient, and
ii. Design of the Fuzzy based system for determining the severity level of osteomyelitis

3.1 Systematic Observation/Analysis of the Patient

Itemized are the methods that will be used to accomplish analyzing/diagnosing the patient:

i. Physical examination
ii. Physical observation of medical records.
iii. Oral interview with the patient
iv. Oral interview with an expert (orthopedic doctor)

The above points is further explained by fig. 3 below

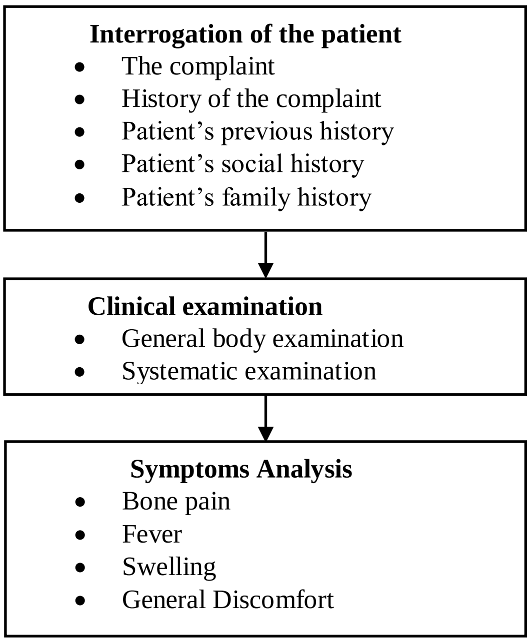


Fig. 3: Model of Fuzzy- Based Determination of Severity Level of Osteomyelitis

3.2 Design of the Fuzzy Based System for Determining The Severity Level of Osteomyelitis

The design of the fuzzy-based system that will determine the severity level of osteomyelitis will be considered under the followings: controller inputs and output, controller linguistic rules, the components of the fuzzy logic controller and the rule base. All these will be discussed in order for one to understand how the output is generated or obtained.

I. The Controller Inputs and Output: The choice of the controller's input(s) and output(s) is a fundamental and vital part of the design since other parts of the design depends on what the inputs and the outputs are.

a. The Controller Inputs: The function of the controller is to determine the severity level of osteomyelitis which can be determined by pain (the major determinant) and any other three of the osteomyelitis symptoms. The membership function of the input *Pain* is shown in the figure below:

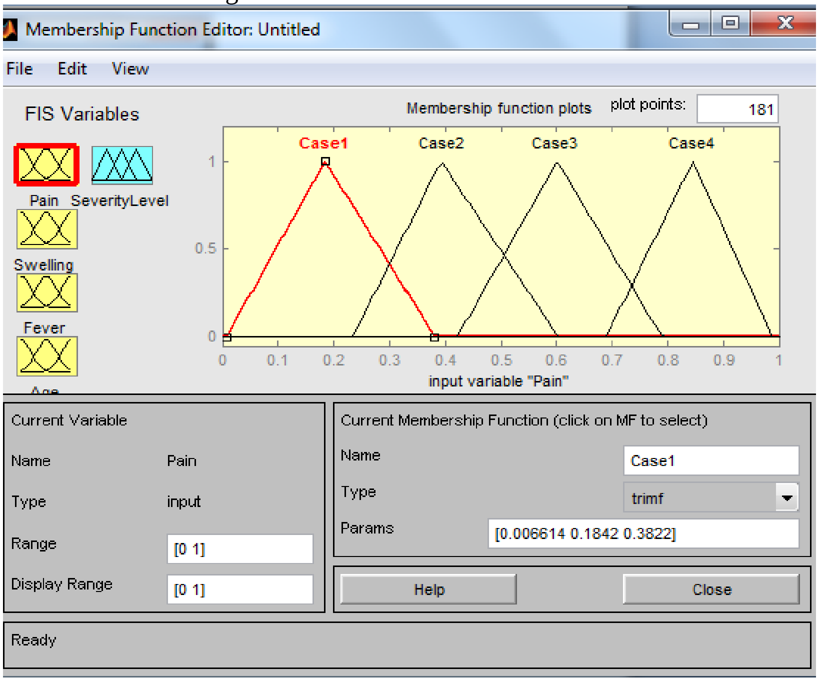


Fig. 4: Membership function for the input 'Pain'

In this work, pain is used as the major determinant, which is graded into four grades:

i. Case1- when the patient can ignore the pain without taking drugs/pain reliever
ii. Case2- when the patient can ignore the pain by taking drugs/pain reliever once in a while
iii. Case3- when the patient can only ignore the pain by consistently taking of drugs/pain reliever (3-4 times daily depending on the prescription)
iv. Case4- when the patient cannot ignore pain, even while consistently taking drugs.

The inputs S*welling***,** and *Fever* use the linguistic variables VeryMild, Mild, Moderate, Severe and VerySevere MF using the triangular MF formulation, while the last input variable *Age* uses the linguistic variables VeryYoung, Young, MiddleAge, Old and VeryOld. The membership function of the inputs *Swelling*, *Fever*, and *Age* pain is shown in the figures below:

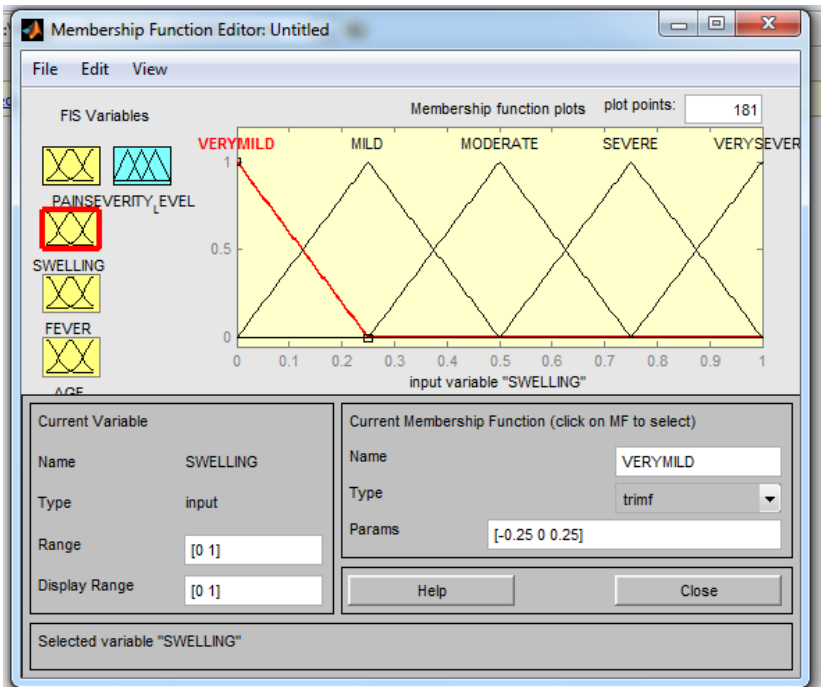


Fig. 5: Membership function for the input 'Swelling'

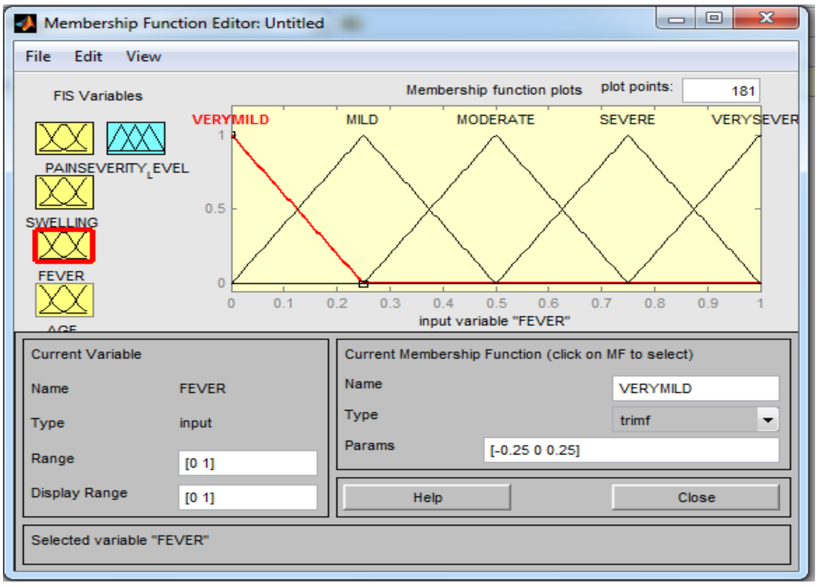


Fig. 6: Membership function for the input 'Fever'

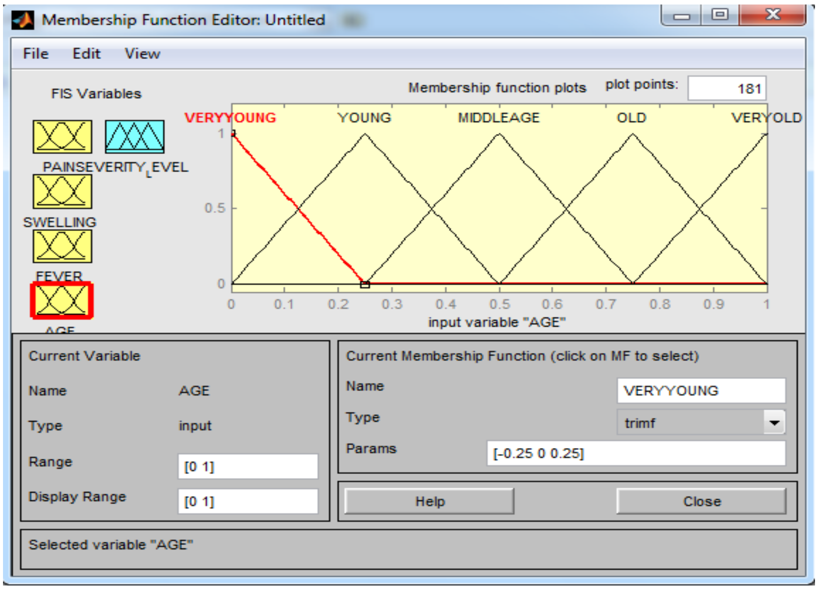


Fig. 7: Membership function for the input 'Age'

b. The Controller Output: In this work, MISO fuzzy system is applied, hence the only output variable used in this work is ***SeverityLevel*** which determine the level of severity of osteomyelitis given the input variables.

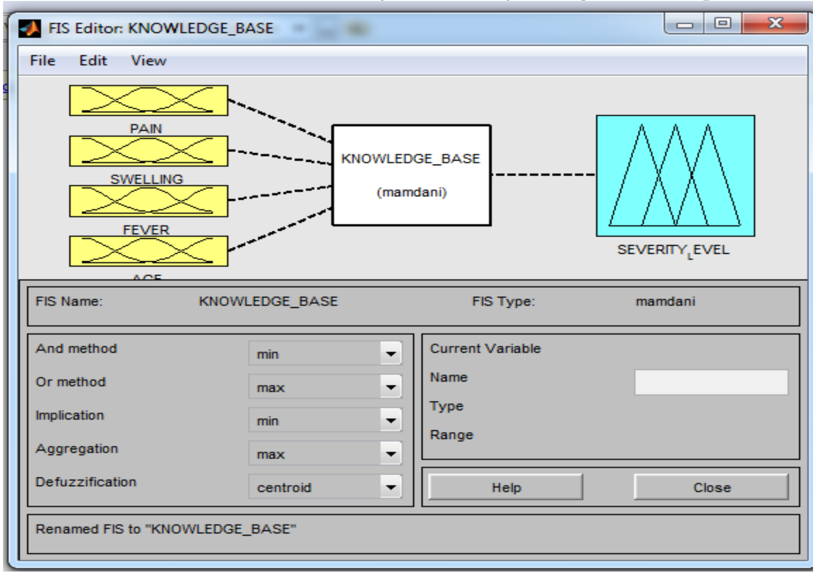


Fig. 8: Multiple-input-Single-Output (MISO) model of the fuzzy control rule

II. The controller's Linguistic Rules (Fuzzy IF-THEN Rules): Based on the choice of inputs and output as discussed above, the following fuzzy IF-THEN rules are extracted from the set of rules that represents an expert knowledge about how best to determine the severity level of osteomyelitis

i. IF (*pain is Case4*) and (*swelling is verysevere*) and (*fever is severe*) and (*age is veryYoung*) THEN (*severityLevel is verysevere*).
ii. IF (*pain is Case3*) and (*swelling is severe*) and (*fever is severe*) and (*age is young*) THEN (*severityLevel is severe*).
iii. IF (*pain is Case2*) and (*swelling is mild*) and (*fever is verymild*) and (*age is middleage*) THEN (*severityLevel is mild*).
iv. IF (*pain is Case3*) and (*swelling is verysevere*) and (*fever is moderate*) and (*age is veryYoung*) THEN (*severityLevel is severe*).
v. IF (*pain is Case4*) and (*swelling is moderate*) and (*fever is moderate*) and (*age is veryYoung*) THEN (*severityLevel is severe*).

The following figure shows the Rule Editor of the knowledge base used in this research work:

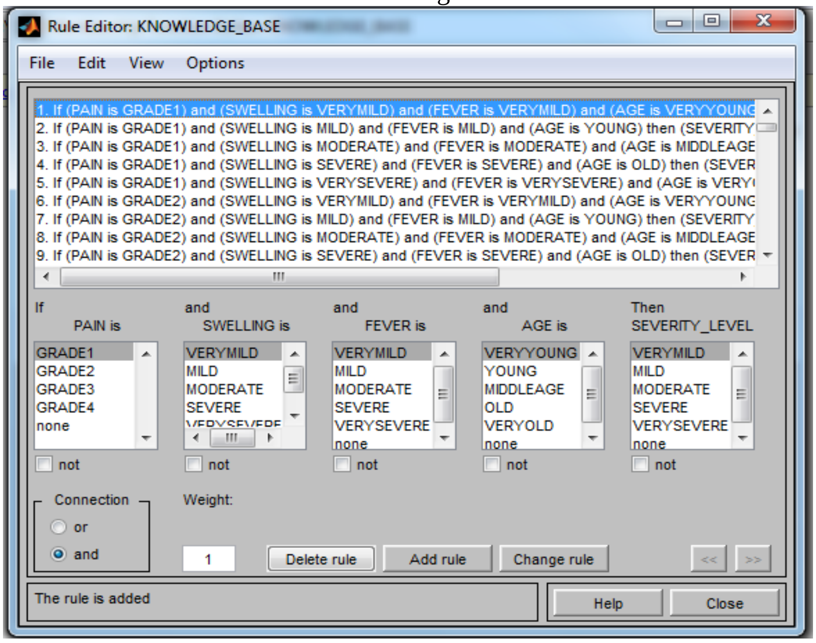


Fig. 9: Rule Editor screen showing some rules used in this research work

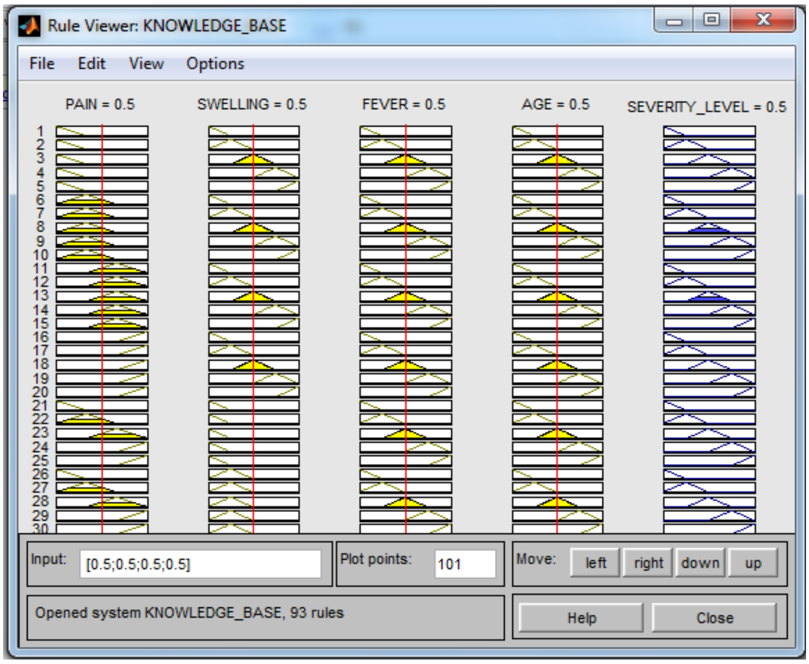


Fig. 10: Rule viewer for the Fuzzy inference system

III. Components of the Fuzzy Logic Controller: The four principal components of the FLC in determining the severity level of osteomyelitis was reviewed here to explain how the controller inputs (swelling, pain, fever, and age) go through the different phases of the FLC to generate the output. They include the following:

a. Fuzzification Interface: The fuzzification converts the input data namely *Pain, Swelling, Fever* and *Age* into suitable linguistic variables. A scale mapping is performed using triangular membership function, which transfer the range of input variables into corresponding universe of discourse (which is the Knowledge Base).

b. Knowledge base: The knowledge base consists of database and rule base. The database provides necessary definitions that are used to define linguistic control rules with syntax, such as: IF <fuzzy proportion> THEN <fuzzy proportion>. The 'IF' part is called the 'antecedent' and the 'THEN' part is called the 'consequent'.

The fuzzy IF-THEN rules provide a methodology to represent some objective and/or human knowledge, hence, each rule is a scheme for capturing knowledge that involve imprecision .

In this work - fuzzy-based system for determining the severity level of osteomyelitis, the antecedents are "pain', 'swelling', 'fever' and 'age' and the consequent is the 'severitylevel'.

c. Decision Making Logic: The decision making logic infers a system of rules through the fuzzy operator 'AND' and generates a single truth value which determines the outcome of the rules (inferred fuzzy control action).

d. Defuzzification Interface: During fuzzification, the fuzzy input variable, 'Pain' ranging from 1 to 10 will be converted into four linguistic grades namely Case1, Case2, Case3 and Case4.

Similarly, the input variable 'Age' will be converted into five linguistic variables namely: VeryYoung, Young, MiddleAge, Old and VeryOld.

The other two fuzzy input variables; 'Swelling' and 'Fever' and the output variable 'SeverityLevel' ranging from 1 to 10 are converted into five linguistic levels namely: VeryMild, Mild, Moderate, Severe and VerySevere. The triangular membership function is used to perform the scale mapping.

IV. Rule Base: The behavior of the control surfaces is defined by the rules that join the fuzzy variables together. In this work, 500 rules was framed with the assistant of an Orthopaedics. All the rules will be presented in the form of a rule base matrix, where the antecedents are the 'Pain', 'Swelling', 'Age' and 'Fever' and the consequent of the rules is 'SeverityLevel'.

The non-fuzzy crisp output from the FLC is obtained from equation (1) as discussed above.

IV. RESULTS & DISCUSSIONS

This work employed four membership functions for the input variable 'pain' and five membership function for each of the remaining three inputs: 'swelling', 'fever' and 'age' (as shown in Fig. 5, 6, and 7 respectively) and are taking together in the process of defuzzification, the effect of each rule on them can be viewed and manipulated via the rule viewer as provided in Fig 10.

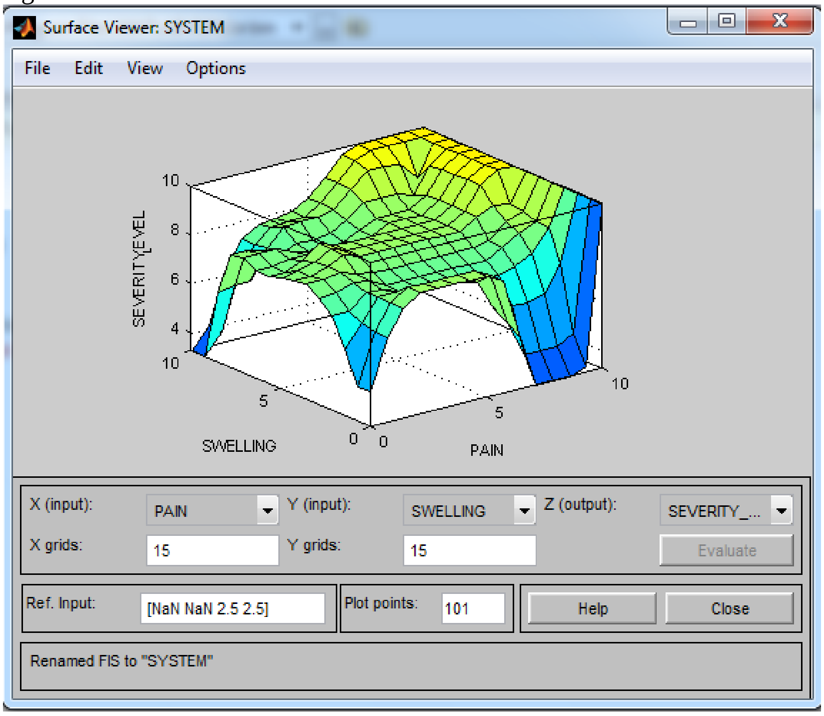


Fig. 11: Surface viewer for swelling versus pain

The effect of 'pain' is plotted against another variable 'swelling' in Fig. 11, it can be seen that the higher the *pain* and swelling, the higher the severity level (*severitylevel*) of the system. The model takes into cognizance factors like fever and age. Peak requirement for high severity level is when both the pain and the swelling are 'verysevere' . The importance of fuzzy inference is the ability to combine the effect of multiple factors and come up with a holistic view of the prevalent scenario. In Fig.11, the system combines adequately factors like 'pain', 'fever' and 'age' amongst other and present the fuzzified results in the level of severity. The presented simulated results are in three-dimensions. This is because presently it is difficult to represent higher dimensions without distorting the figure in Matlab tools.

V. CONCLUSION

This paper has presented a fuzzy inference system designed to determine the severity level of osteomyelitis based on identified factors (input variables – pain, swelling and fever). Osteomyelitis affects mobility; it can be taken care of if diagnosed on time. With this fuzzy based system, severity level of osteomyelitis can be determined and the ailment properly managed based on the usage of linguistic variables and the membership function developed for them. Fuzzy system makes us of linguistic variables which facilitate human description using their natural language unlike expert systems; because of this, osteomyelitis symptoms only need to be inputted in natural language term and not precise values.

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