# Fuzzy Expert System Generalised Model for Medical Applications: Literature Reviews

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***Abstract***

*The rapid development of computers, it has led to the emergence of systems that can imitate the expertise of experts in certain fields. This can make it easier for ordinary people to solve problems in certain areas without needing help from experts. This study aims to determine the defuzzification method that can be added to the Generalized Fuzzy Expert System model so that the system can produce better output. The research method used in this is a literature review that uses the PRISMA approach. As a result, there are three defuzzification methods that are widely used in fuzzy research, namely Center-of-Gravity (CoG), Mean-of-Maxima (MoM), and Distance-Based Methods. Each method has its own advantages and disadvantages. Center-of-Gravity (CoG) has high accuracy but is more complex, Mean-of-Maxima (MoM) is faster but less accurate, whereas Distance-Based Methods are efficient based on distance but are prone to data inaccuracies.*

*Keywords*: *Center of Gravity, Defuzzification, Distance-Based, Generalized Fuzzy Expert System, Mean of Maxima.*

## 1. Introduction

Computers are one of the technologies that have developed very rapidly in recent decades. Computers now have an extraordinary ability to process information and knowledge. This development has brought great changes to humanity, such as in the field of health that initially relied only on medical experts can now be solved by computer programs. This can certainly increase work efficiency and help the progress of the health sector.

Computer systems that are designed to solve problems by utilizing the knowledge and expertise of an expert in a particular field are called expert systems. This system allows laypeople to solve certain problems without needing direct help from experts in the field. Meanwhile, for experts, this system can function as an experienced support tool[1].

With a system that can mimic the abilities of experts, there is a need for logic that can handle ambiguity in the decision-making process similar to decision-making by experts. The logic used by the expert system in the study [2] as the main source in this study is fuzzy logic.

Fuzzy logic comes from set theory, where each element has a membership level that ranges from 0 to 1. This approach is used to deal with uncertainty or ambiguity. In simple terms, fuzzy logic is a method that uses linguistic variables as an alternative to number-based calculations[3].

A system based on fuzzy rules has three main components [4], which are:

a. Fuzzification
   Fuzzification is the process of converting crisp inputs into fuzzy inputs or uncertain values. This value is determined based on certain rules using membership functions.
b. Inference
   Inference performs a reasoning process using fuzzy inputs and predetermined fuzzy rules to produce outputs in the form of functions.
c. Defuzzification
   Defuzzification is used to convert fuzzy outputs or uncertain outputs into crips values based on the specified membership function.

In [2] as the main research chose to develop a generalized fuzzy expert system. This means that they developed fuzzy models that are more general or generic, rather than specific fuzzy models. Previous research decided to develop a generalized fuzzy expert system for the following reasons:

a. There are many researchers who have made expert systems using special fuzzy models, so previous research wants to know how common patterns and components are in special fuzzy models.

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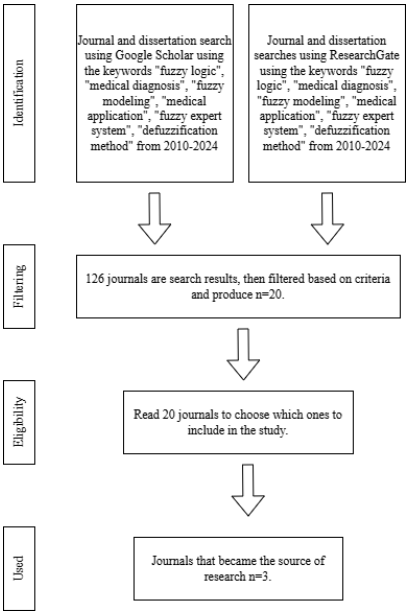
b. With the generalized fuzzy model, it is no longer necessary to create an expert system from scratch, so it only needs to develop a general model into a special model according to needs.
c. Allows for the integration of input parameters (medical symptoms) that are related but have different degrees of uncertainty.

Even so, in research [2] there are still some shortcomings that are expected to be resolved in further research. One of the shortcomings that will be discussed in this study is the addition of defuzzification methods to the generalized fuzzy expert system. The research focuses on three methods that can be considered as additional defuzzification methods, namely center-of-gravity (CoG), mean-of-maxima (MoM), and distance-based.

## 2. Research Methods

The research method used in this study is to use the literature review method whose sources come from journals and dissertations. The approach used in this research method is to use the prism method. This method is carried out by searching for journals related to the defuzzification method in medicine, the search was carried out in two databases, namely Google Scholar and ResearchGate. The keywords used in the search are "fuzzy logic", "medical diagnosis", "fuzzy modeling", "medical application", "fuzzy expert system", "defuzzification method". Because journals that are in accordance with this study are rather difficult to find, the year range is expanded from 2010-2024.

The process of searching for journals and dissertations to obtain selected journals are:




From this process, it is hoped that a finding can be produced that is able to answer the problems in this study.

## 3. Result and Discussions

In medical applications based on Generalized Fuzzy Expert Systems, the defuzzification method plays an important role in converting the output from the initial form of a fuzzy set to a crisp value that is more useful for decision-making. Various defuzzification methods have been developed, including Center-of-Gravity (CoG), Mean-of-Maxima (MoM), and Distance-Based Methods. Each of these methods has different characteristics, which affect how they are applied according to the type of application and the desired result.

Three journals[5]-[7] were obtained as search results using literature reviews that have been carried out. Reviews on the three journals will be presented in table 1 below.

Table 1. Table Review

| Year | Author | Title | Method | Research Results |
|---|---|---|---|---|
| 2016 | H. Choi et al. | A fuzzy medical diagnosis based on quantiles of diagnostic measures. | Max-min composition, Distance-based method. | In normal-based diagnosis, the results between max-min and distance-based differ, but when using quantile-based diagnosis the results can reduce the difference in outcomes of diagnosis between max-min and distance-based. |
| 2011 | A. Zainal. | Two Case Studies of Using Fuzzy Modeling for a Classification System in Medical Application. | Center-of-Gravity (CoG). | CoG results in a more accurate medical diagnosis, allowing for treatment adjustments based on the calculated severity. |
| 2011 | X.Y. Djam et al. | A Fuzzy Expert System for the Management of Malaria. | Center-of-Gravity (CoG), MoM (Mean-of-Maxima). | The fatigue classification system is effective with an accuracy of 86.54%. Relevant CoG and MoM methods are used in medical application fuzzy expert systems, can produce accurate crisp output. |

Based on the review of the three studies, it is known that the Center-of-Gravity method performs the defuzzification stage by calculating the center point of the fuzzy area to obtain the crisp value, while the Mean-of-Maxima method performs defuzzification by taking the average of the points with the highest membership in the fuzzy set to determine the crisp value. Finally, the distance-based method uses the measurement of the distance between the input data and the rules in the fuzzy rule base to produce the output.

Each of the methods has its advantages and disadvantages when applied to fuzzy logic. The advantage of the Center-of-Gravity method is that it can provide more accurate results because it often uses discrete variables and weighted averages from the center of the fuzzy set, but CoG requires more complex calculations so it is slower. Mean-of-Maxima can produce quick decisions using only the most important points in the fuzzy set, but because it only uses the most important points in the fuzzy set, it will produce less accurate decisions. The advantages of distance-based are that it is suitable for data that requires distance comparison and is efficient based on the distance between the fuzzy representation and the reference set, however, this method is sensitive to data inaccuracies and different data scales that can affect the outcome of the decision.

## 4. Conclusion

Center-of-gravity (CoG), mean-of-maxima (MoM), and distance-based defuzzification methods can be used in generalised fuzzy expert system models for medical applications but depend on the main function of the system. Because accurate decisions, speed, and flexibility are required in the expert system, the generalised model fuzzy expert system can add center-of-gravity (CoG) and mean-of-maxima (MoM) methods. The center-of-gravity (CoG) method will act as accuracy and flexibility, while the mean-of-maxima (MoM) method will act in velocity. The two methods will complement each other, due to their associated disadvantages and advantages so that the generalised model of the fuzzy expert system can achieve a high standard.

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