

Expert System for Diagnosing Gastric Diseases with the Application of the Fuzzy Logic Sugeno Method (Case Study: Delia General Hospital)

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Abstract

Stomach diseases, such as gastritis, GERD, and gastric ulcers, are digestive disorders with a high prevalence and have the potential to reduce the quality of life of sufferers. Conventional diagnosis still faces obstacles, including limited medical personnel, the length of examination procedures, and the similarity of symptoms between diseases. This study developed a web-based expert system with *the Fuzzy Logic Sugeno method* to assist in the early diagnosis of gastric diseases. Symptom data was obtained from literature and consultation with specialist doctors at Delia General Hospital. The system is designed with the stages of needs analysis, UML modeling, database design, and the implementation of fuzzy algorithms (fuzzification, inference, defuzzification).

The simulation results showed that the system was able to provide diagnostic recommendations with a membership rate of 28% for gastritis, 62% for GERD, and 80% for gastric ulcers. The implementation of a web-based interface allows users to select the symptoms they are experiencing, then the system displays the results of the diagnosis along with their severity. This study shows that the Fuzzy Sugeno method is effective in handling vague symptom data, as well as acting as a consistent and efficient early diagnosis tool.

Keywords: *Diagnosis; Fuzzy Suggests; gastric diseases; Expert System; Web-based*

1. Introduction

Stomach disease is one of the digestive disorders that are widely found in the community. Gastritis, GERD (Gastroesophageal Reflux Disease), and gastric ulcers are the three most common types, with symptoms such as heartburn, nausea, vomiting, bloating, and chest heat. Based on the Global Burden of Disease (GBD) report, more than 4.6 billion cases of indigestion occur every year, making stomach disease one of the main contributors to the global health burden[1].

Conventional diagnosis of gastric disease generally requires patient interviews, physical examinations, and laboratory tests. However, the accuracy of the diagnosis is often influenced by the doctor's experience, which has the potential to cause differences in outcomes between medical personnel[2]. The limited number of specialist doctors, especially in the regions, further increases the urgency of technology-based solutions.

Expert systems, as a branch of artificial intelligence, are able to mimic the way experts think and provide rules-based decisions. One relevant method is Fuzzy Logic, as it is able to handle vague and uncertain symptom data[3]. Several studies have shown that the application of fuzzy methods in the medical field can increase diagnostic accuracy by up to 89%[4]. However, its application in cases of gastric disease is still limited[5].

Based on this, this research was conducted to design and implement a web-based expert system using the Fuzzy Sugeno method. This system is expected to be able to help the early diagnosis of gastric diseases more quickly, accurately, and consistently, as well as support medical personnel and the community.

2. Theoretical Foundation

2.1. Gastric Diseases

Stomach diseases occur due to various factors, such as *Helicobacter pylori bacterial infection*, diet, stress, or the consumption of certain medications. The three diseases that are the focus of this study are gastritis, GERD, and gastric ulcers. Gastritis is characterized by inflammation of the gastric mucosa[6], GERD is characterized by an increase in stomach acid into the esophagus[7], while gastric ulcers are in the form of lesions on the gastric wall due to an imbalance of aggressive and defensive factors[8].

2.2. Fuzzy Sugeno Method

This study uses the Fuzzy Logic method Sugeno (Takagi-Sugeno-Kang, 1985) which is widely used to produce numerical output. This method is more efficient than Mamdani, more flexible than Tsukamoto's, and has a simple, fast, and stable inference process. These characteristics are in accordance with the needs of the diagnosis of gastric diseases that have complex and overlapping symptoms. The Sugeno system fixes the weaknesses of other fuzzy methods by adding simple numerical calculations to the THEN section. The input is processed through fuzzy membership functions, one of which is a triangle function with parameters a,b,c:

$$\mu_A(X) = \begin{cases} 0 & x < a \\ \frac{x-a}{b-a} & a \leq x < b \\ \frac{c-x}{c-b} & b \leq x < c \\ 0 & x \geq c \end{cases}$$

Where:

- $\mu_A(x)$ is the degree of membership of the input xxx to the set fuzzy A.
- a,b,c is the parameter of the triangle function.

2.3. Web-Based Diagnosis System

Web-based technology is becoming an important platform in health diagnostics because it supports data integration, global accessibility, and high efficiency. This system allows users to access services at any time via the internet, has good scalability, and facilitates the consolidation of medical data in one integrated system. Research shows that web-based diagnostics improve speed, accuracy, and efficiency, as well as enable *real-time diagnosis* with an ever-updated knowledge base[9]. Additionally, the system saves time and costs because it reduces the need for direct consultation with experts.

2.4. XAMPP and Its Key Components

XAMPP is an acronym for X (cross-operating system), Apache, MySQL, PHP, and Perl. XAMPP is an open source software designed to be compatible across multiple operating systems and integrates several important programs in a single installation package. As such, XAMPP makes it easy for users to set up a web development environment without having to install each component separately[10].

The main components of XAMPP consist of Apache as a web server, MySQL as a database management system, and PHP as a programming language. MySQL is an open source Database Management System (DBMS) that supports both multiuser and multithreaded. MySQL allows users to create, manage, and manipulate data in relational databases through the SQL language (Noviana, 2022). PHP (PHP: Hypertext Preprocessor) is a server-side programming language first developed by Rasmus Lerdorf in 1994. PHP is currently widely used in web development because it is flexible and easy to integrate with databases[11].

3. Research Method

3.1. Research Flow

This stage of research is systematically arranged so that the results obtained can be measured and in accordance with the objectives. Each stage is carried out sequentially, starting from preparation to the final stage, so that the research runs in a directional manner. The flow of the research stages can be seen in the following Figure.

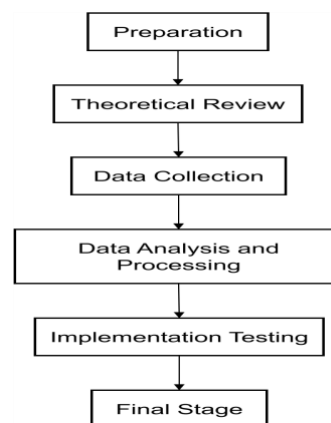


Fig. 1: Research Workflow

The explanation of the research workflow above is as follows:

- 1) Preparation: Establish the issue of the need for fast, precise, efficient gastric diagnosis, and choose the Fuzzy Sugeno method to overcome medical uncertainty.

- 2) Theoretical Review: Reviewing the literature related to expert systems, fuzzy logic, Fuzzy Sugeno, and the theory of gastric diseases as a conceptual basis.
- 3) Data Collection: Collect data through physician interviews, case studies, and medical documents related to disease symptoms and parameters.
- 4) Data Analysis and Processing: Compile fuzzy rules and membership functions, then design a Fuzzy Sugeno model to generate a diagnosis.
- 5) Implementation Testing: Compares the system's diagnostic results with that of doctors to assess accuracy and performance.
- 6) Final Stage: Evaluate, draw conclusions, and make development recommendations.

3.2. Flowchart

The following flowchart shows the flow of gastric disease diagnosis with the Fuzzy Sugeno method

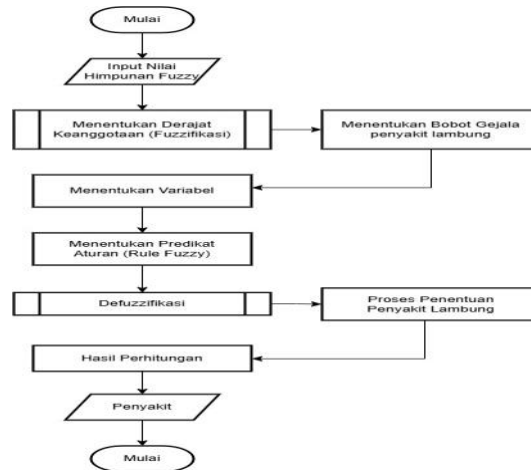


Fig. 2: Sugeno Fuzzy Logic Flowchart

In the picture above, it can be explained as follows:

- 1) Mulai : The process of the diagnosis system is initiated by the user.
- 2) Input Nilai Himpunan Fuzzy : The user enters symptom data that will be analyzed by the system.
- 3) Menentukan Derajat Keanggotaan (Fuzzifikasi) : Symptom values are converted into membership degrees, such as mild, moderate, or severe.
- 4) Menentukan Bobot Gejala Penyakit Lambung : Each symptom is weighted according to the degree of its influence on gastric diseases.
- 5) Menentukan Variabel : The system determines the symptom variables used in the diagnosis process.
- 6) Menentukan Predikat Aturan (Rule Fuzzy) : The if-then rule is applied based on a combination of variables and symptoms.
- 7) Defuzzifikasi : The results of the rule inference are converted into an exact value by the weighted average method.
- 8) Proses Penentuan Penyakit Lambung : The system processes the results of defuzzification to determine the type of gastric disease.
- 9) Hasil Perhitungan : The final value of the calculation is displayed by the system.
- 10) Penyakit : The output of the diagnosis of gastric disease is displayed to the user.
- 11) Selesai : The process ends, the results can be saved or printed as needed.

3.3. Context Diagram

A context diagram designed on the gastric disease diagnostic system using *the fuzzy sugeno* method can be seen in the following image.

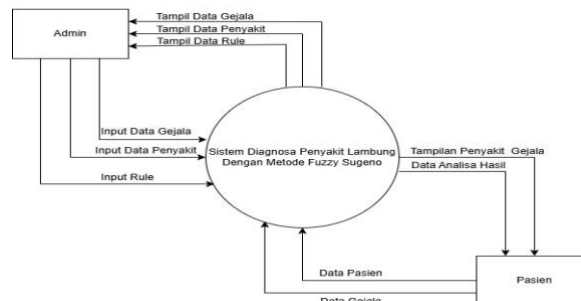


Fig. 3: Gastric Diagnosis System Context Diagram

In the picture above, it can be explained as follows:

- 1) Admin inputs symptom data, disease data and rule data into the system. Then the system will store symptom data, disease data and rule data which will then appear in the form of symptom data, disease data and rules.
- 2) Admins can change data ranging from adding data, deleting data, and editing data.
- 3) Users must fill in the data first before diagnosing the symptoms of the disease.
- 4) In the consultation menu, there is data that must be filled in first by the user, namely gender and age.

- 5) When the data has been filled in by the user, the system will display symptoms of gastric disease.
- 6) The user is required to choose the symptoms of gastric disease according to what the user feels. If the symptoms of gastric disease have been selected, the system automatically provides gastric disease data, symptoms, solutions, user data, dates and percentages.

3.4. Data Flow Diagram (DFD) Level 0

The data flow diagram (DFD) that will be designed for the gastric disease diagnosis system can be seen in the figure below.

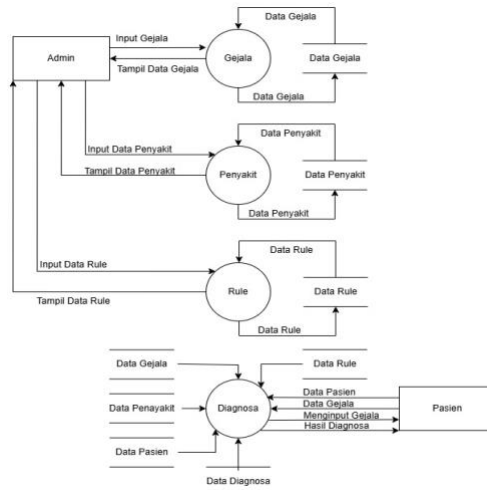


Fig. 4: DFD Level 1 Gastric Disease Diagnostic System

In the picture above, it can be explained as follows:

- 1) On the menu gejala, Admins can input symptom data and view all symptom data.
- 2) On the menu penyakit, Admins can input disease data and view all disease data.
- 3) On the menu rule, admins can input rule data and view all data rule.
- 4) On the menu Diagnosa, The patient can find out what disease they are suffering from. By filling in the symptoms felt in the system. The system will diagnose the disease suffered by the patient and provide results in the form of diagnostic results.

4. Discussion and implementation

4.1. Interface Discussion

In the discussion of this interface, it will be displayed and explained about the results of the program design as follows.

- 1) Home Menu

The Home menu serves as the system's initial interface for experts, providing key navigation to features such as disease information, consultations, and admin logins, as well as presenting a welcome word to the user.



Fig. 5: Home Menu

- 2) Admin Login Menu

In this admin login menu, only admins can access this menu.

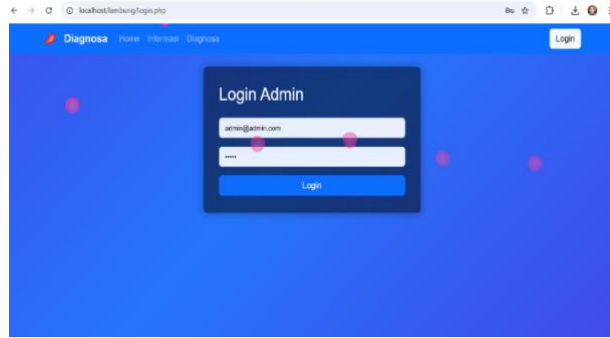


Fig. 6: Admin Login Menu

3) Consultation Menu

The Consultation menu displays the entire list of symptoms of gastric diseases that users can choose as the first step in making a diagnosis. Users can choose the symptoms they feel to get the appropriate consultation results.

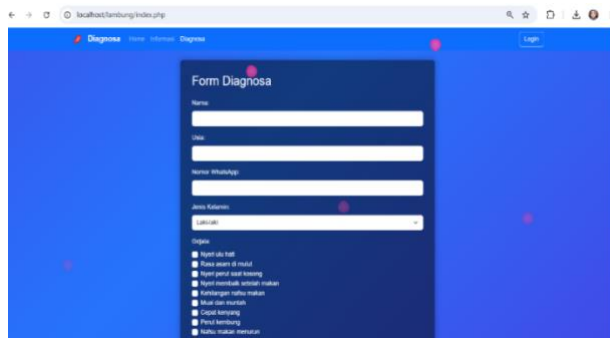


Fig. 7: Consultation Menu

5. Diagnostic Results Display

In this view, users can see the results of the diagnosis of symptoms that have been done before. The results of the diagnosis include the username or patient's name, the symptoms that have been chosen, the percentage of how much the gastric disease is affected, the description of the stomach, and the solution given.

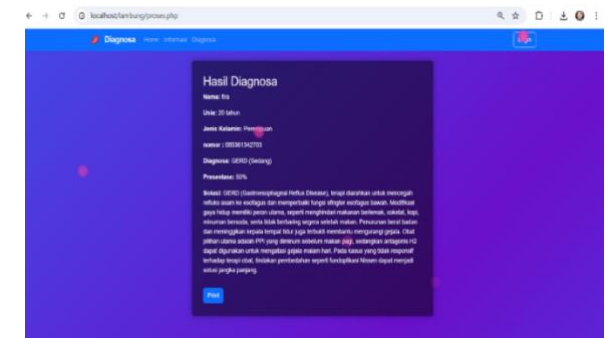


Fig. 8: Diagnostic Results Display

6. Consultation History

The consultation history menu presents data on the results of consultations that have been carried out previously, including the username, date of consultation, results of symptoms selected by the patient, and the type of disease detected.

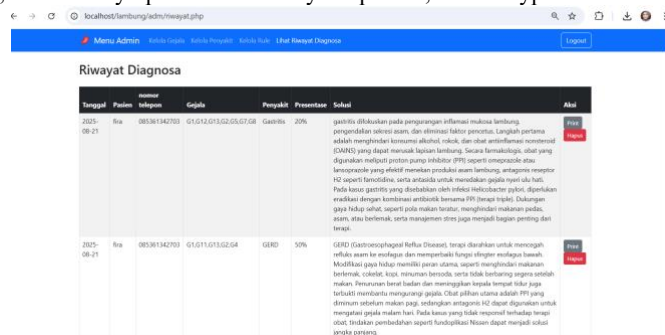


Fig. 9: Consultation History

4.2. Discussion of Test Results

Fuzzy Sugeno-based expert system testing shows that this method is able to process symptom data in a structured manner to produce an initial diagnosis that is close to an expert's decision.

In the first scenario, a combination of symptoms of heartburn, nausea, rapid satiety, decreased appetite, and a feeling of heat in the chest resulted in a diagnosis of Gastritis with a membership rate of 28%. These results indicate that the system can recognize patterns of symptoms with mild severity.

The second scenario, which involves symptoms of rapid satiety, acid regurgitation, sharp abdominal pain, and loss of appetite, results in a diagnosis of GERD with a percentage of 62%. This value indicates moderate severity and confirms the system's ability to identify more complex symptoms with a higher membership weight than the first case.

Meanwhile, in the third scenario with symptoms of heartburn, bloating, acid regurgitation, difficulty swallowing, chronic cough, sour taste in the mouth, and pain that improves after eating, the system produces a diagnosis of Gastric Ulcer with a value of 80%. This high percentage illustrates the severity of severity, as well as proving the effectiveness of the system in detecting diseases with more layered symptoms.

Overall, the test results show the consistency of the system in mapping symptoms into membership functions, processing them through fuzzy rules, to produce rational defuzzification values. The accuracy levels shown are 28%, 62%, and 80%, reflecting that the Fuzzy Sugeno method is able to provide a logical, measurable, and relevant diagnosis with an expert knowledge base. Thus, this system has the potential to be a medical aid in accelerating the early identification of gastric diseases and supporting the efficiency of clinical decision-making.

5. Conclusion and Recommendations

5.1. Conclusion

This research successfully designed a web-based expert system using the Fuzzy Sugeno method to help diagnose gastric diseases, including Gastritis, GERD, and Gastric Ulcers. The system is able to process vague symptoms through fuzzification, inference, and defuzzification processes to produce a diagnosis with a level of accuracy that is close to an expert's decision. The test results show that the system can provide relevant initial information for patients while also serving as a tool for medical personnel to speed up the process of identifying gastric diseases. Thus, the research objective of designing, implementing, and evaluating Fuzzy Sugeno-based expert systems was well achieved.

5.2. Recommendations

For further development, the system is recommended to expand the database of symptoms and diseases, integrate with electronic medical records, be equipped with safety features, be tested on a wider population, be developed to mobile platforms, and utilize machine learning so that diagnostic rules can be updated adaptively and accuracy is increased.

References

- [1] F. Wang *et al.*, "Global, regional, and national burden of digestive diseases: findings from the global burden of disease study 2019," *Front. Public Heal.*, vol. 11, p. August, 2023, doi: 10.3389/fpubh.2023.1202980.
- [2] M. Zamri, H. Pandia, and S. Mahara Asat, "Sistem Pakar Diagnosa Penyakit Maag dan Usus Buntu Berbasis Web," *JEKIN - J. Tek. Inform.*, vol. 2, no. 1, pp. 24–34, 2022, doi: 10.58794/jekin.v2i1.90.
- [3] U. Athiyah, A. P. Handayani, M. Y. Aldean, N. P. Putra, and R. Ramadhani, "Sistem Inferensi Fuzzy: Pengertian, Penerapan, dan Manfaatnya," *J. Dinda Data Sci. Inf. Technol. Data Anal.*, vol. 1, no. 2, pp. 73–76, 2021, doi: 10.20895/dinda.v1i2.201.
- [4] S. Hidayah and Y. R. Sipayung, "Expert System-Based Gastroenteritis Diagnosis Using the Fuzzy Method and Certainty Factor," *J. Komput. Dan Inform.*, vol. 11, no. 1, pp. 14–20, 2023, doi: 10.35508/jicon.v11i1.9849.
- [5] R. Saragih, "Sistem Pakar Diagnosa Penyakit Hipertrofi hidung Menggunakan Metode Certainty Factor." 2024.
- [6] M. J. Nikmah, N. I. Fatihah, and A. Fadholah, "Pengaruh Penyuluhan Kesehatan terhadap Perilaku Pencegahan Kekambuhan Gastritis pada Santriwati PMDG Putri 2," *Pharm. J. Islam. Pharm.*, vol. 6, no. 1, p. 66, 2022, doi: 10.21111/pharmasipha.v6i1.8705.
- [7] M. A. Mile, F. M. Suranata, and I. made Rantiasa, "Gambaran Stres Dan Pola Makan Pada Penderita Gastroesophageal Reflux Disease (GERD) Di Wilayah Kerja Puskesmas Ranomut Manado," *J. Kesehat. Amanah Prodi Ners Univ. Muhammadiyah Manad.*, vol. 4, no. 1, pp. 13–19, 2020.
- [8] N. S. Raehana, "Efek Gastroprotektif pemberian Rimpang Kunyit (*Curcuma domestica* Val.) dari Ulkus Lambung yang diinduksi oleh NSAID," *J. Med. Hutama*, vol. 2, no. 4, pp. 1053–1059, 2021, [Online]. Available: <http://jurnalmedikahutama.com>
- [9] M. A. Hasanah, S. Soim, and A. S. Handayani, "Implementasi CRISP-DM Model Menggunakan Metode Decision Tree dengan Algoritma CART untuk Prediksi Curah Hujan Berpotensi Banjir," *J. Appl. Informatics Comput.*, vol. 5, no. 2, pp. 103–108, 2021, doi: 10.30871/jaic.v5i2.3200.
- [10] R. Roza, M. N. Fauzan, and W. I. R., "Tutorial Sistem Informasi Prediksi Jumlah Pelanggan Menggunakan Metode Regresi Linier Berganda Berbasis Web Menggunakan Framework Codeigniter," in *Tutorial Sistem Informasi Prediksi*, M. Maaulana and R. Awangga, Eds., Kreatif Industri Nusantara, 2020, pp. 82–88. [Online]. Available: <https://books.google.co.id/books?hl=id&lr=&id=ixH9DwAAQBAJ&oi=fnd&pg=PA6>
- [11] R. Noviana, "Pembuatan Aplikasi Penjualan Berbasis Web Monja Store Menggunakan Php Dan Mysql," *J. Tek. Dan Sci.*, vol. 1, no. 2, pp. 112–124, 2022, doi: 10.56127/jts.v1i2.128.