OPEN ACCESS
VOL. 5, NO. 2, PP.104-114, MAY 2023

ISSN : 2622-8106 (ONLINE)
DOI: 10.20895/INISTA.V5I2.1057

Journal of Informatics, Information System, Software Engineering and Applications

Gastric Disease Diagnostic Expert System Application Using the Fuzzy Mamdani Method

Shindy Millati Rachma[*1], M. Nishom [2], Sharfina Febbi Handayai [3]

[*1,2,3] *Prodi Sarjana Terapan Teknik Informatika, Politeknik Harapan Bersama*

Mataram Street No 9 Pesurungan Lor, Margadana Tegal City52147

[*1] shindymr11@gmail.com

[2] nishom@poltektegal.ac.id

[3] sharfina.handayani@poltektegal.ac.id

Received on 30-04-2023, revised on 20-05-2023, accepted on 30-05-2023

Abstract

The level of awareness among Indonesian society regarding the importance of maintaining gastric health is still very low, even though gastric diseases can significantly disrupt daily activities. In a medical examination, a doctor detects diseases in a patient's body based on their symptoms or complaints. The patient's action is to meet the doctor in person, and the doctor asks about the symptoms experienced by the patient. In the manual system, there is a drawback where patients have to visit the doctor for consultation or to have their diseases examined, and they also need to prepare the necessary fees for the examination. Such a manual system can be simplified with an information system where patients don't need to visit the doctor to diagnose their diseases. Therefore, the researcher will develop a gastric disease diagnostic expert system application using the fuzzy Mamdani method. The aim is to make it easier for patients/the public to identify the type of disease based on the symptoms experienced, as well as to provide information on solutions, actions, and medication for the disease. The methodology used in developing the gastric disease diagnostic expert system application involves four stages: fuzzification process, implication function, inference process (rules), and defuzzification. The research flow includes data collection through interviews and data sampling, data analysis, calculation using the fuzzy Mamdani method, implementation, and testing using a black box. The result of this research is a gastric disease diagnostic expert system application using the fuzzy Mamdani method with an accuracy of 65%. This application can help individuals to identify the type of disease based on the symptoms experienced without having to immediately consult a doctor, thus avoiding potential issues.

Keywords: Diagnostic, Expert System, Fuzzy Mamdani, Gastric Disease

Corresponding Author:
*Shindy Millati Rachma
Informatics Engineering, Polytechnic Harapan Bersama Tegal
KH Mukhlas Street No.43, 52122, Tegal City, Indonesia
Email: shindymr11@gmail.com

I. INTRODUCTION

The level of public awareness in Indonesia regarding the importance of maintaining gastric health is still very low, even though gastric diseases can greatly disrupt daily activities. Often, the public treats gastric diseases lightly, such as the case of ulcer or gastritis. Cases of gastritis, which are often experienced by the community, are caused not only by lifestyle and stress, but also by a lack of concern and tendency to underestimate this disease. Therefore, it is important for the public to be aware of gastric diseases [1].

According to data from the World Health Organization (WHO), the incidence rate of gastritis worldwide in several countries is as follows: United Kingdom with a percentage of 22%, China with a percentage of 31%, Japan with a percentage of 14.5%, Canada with a percentage of 35%, and France with a percentage of 29.5%. Globally, the incidence of gastritis is approximately 1.8-2.1 million people per year, and in Southeast Asia, it is around 583,635 cases per year based on the population. According to data from the Indonesian Ministry of Health, the percentage of gastritis cases in Indonesia is 40.8%. The incidence of

gastritis in several regions in Indonesia itself is quite high, with a prevalence of 274,396 cases out of a population of 238,452,952 [2].

Meanwhile, according to data from one hospital in Brebes Regency, RSUD Brebes, gastric diseases are among the top 10 most common diseases among inpatients. In 2021, the number of patients with gastric diseases reached 144 people. In 2022, the number of gastric disease cases increased to 543 people. And in early 2023, until March, the number of patients affected by gastric diseases has already reached 201. The high incidence of gastric diseases can lead to decreased work productivity and increased expenses for gastric treatment. Failure to promptly address gastric issues can result in worsening ulcer conditions and gastric bleeding.

In a medical examination, a doctor will detect a disease present in a patient's body based on the patient's symptoms or complaints. The patient must meet with the doctor in person and the doctor will ask about the symptoms that have arisen. This manual system has a weakness where patients must visit a doctor to consult or diagnose their disease, and patients must also prepare the necessary funds to check their disease. This manual system can be simplified with an information system where patients do not need to visit a doctor to diagnose their disease. By using an expert system, patients can save time and improve patient services [3].

Creating an expert system for diagnosing gastric diseases is important as it can improve the accuracy and efficiency of diagnosis, incorporate the latest medical knowledge, reduce errors and inconsistencies, and provide reliable diagnostic tools in areas with limited medical resources.

Based on the existing problems, it is necessary to develop a system that can be an alternative for patients in handling the initial diagnosis of gastric diseases. This application can be used for consultation or examination of a patient's disease without having to go to a doctor, thus saving time and cost. Additionally, this application can also provide solutions for treating the patient's disease and recommend which medications should be taken.

In developing this application, the researcher chose to use the fuzzy Mamdani method because the Mamdani inference system is suitable for human input, has higher accuracy in evaluating the security of block cipher algorithms, is easier to implement compared to other methods, and allows flexibility in the rules and membership functions used to define the system, making it easier to adapt to various types of problems and situations.

A. Previous Research

The research on diagnosing stomach diseases is based on references from previous studies. Study [4] discussed the diagnosis of stomach diseases using Case-Based Reasoning (CBR) method, which was able to diagnose 3 stomach diseases (Gastritis, Dyspepsia, GERD) by calculating certainty factor values using the CBR method for similarity measurement. Meanwhile, study [5] discussed early detection of diseases in corn plants using Naïve Bayes method, where the accuracy level of the application system obtained from accuracy testing data using the Naïve Bayes method was 92%.

Previous studies diagnosed more specific stomach diseases in humans, such as gastritis, ulcers, stomach cancer, stomach tumors/polyps, dyspepsia, GERD, gastroparesis, and gastroenteritis. With more specific symptoms, the possibility of being infected with stomach diseases is higher. This study uses the Fuzzy Mamdani method to help minimize the role of doctors in diagnosing stomach diseases so that patients can detect what type of stomach disease they have earlier. The results of this study can detect the type of stomach disease, its symptoms, and its treatment solutions [6].

The research is about an expert system for diagnosing diabetes, which is useful for determining whether a person is affected by diabetes or not. Early diagnosis is essential for providing appropriate treatment and prevention measures for the disease. The method used in this research is the fuzzy Mamdani inference method, also known as the MAX-MIN or MAX-PRODUCT method. This method is employed in the analysis of production quantity determination. The use of fuzzy logic in determining production quantity is considered capable of mapping inputs to outputs without neglecting relevant factors. The fuzzy Mamdani inference has been widely used to capture expert knowledge, allowing for a more intuitive representation of expert expertise, resembling the decision-making process of experts. This method is believed to be highly flexible and tolerant of available data [7].

Similar research was conducted in the detection of human diseases through symptoms and lifestyle patterns to determine the level of disease risk in patients caused by irregular lifestyle patterns. The method used in designing this application is the fuzzy Mamdani method, which displays the symptoms experienced by the patient and the patient's lifestyle patterns in their daily lives. This application provides information on the risk of the disease being experienced and helps medical professionals or patients to determine the follow-up treatment for the disease [8].

Based on previous research, the author can take several things that can support the research to be conducted. Some of the conclusions include the fact that expert systems can help patients diagnose stomach diseases and provide convenience for users to consult about stomach diseases without having to meet with doctors directly. The research method used is Fuzzy Mamdani and has produced good results, which is relevant to the research that will also use the Fuzzy Mamdani method.

B. Expert System

An expert system is a computer-based system that uses knowledge, facts, and reasoning techniques to solve problems that typically can only be solved by an expert in the field. Expert systems are a branch of Artificial Intelligence (AI) that has been around for a long time, as this system began to be developed in the mid-1960s. Expert systems generally aim to adopt human knowledge to computers, so that computers can solve problems as experts do [9].

An expert system encompasses several types of knowledge:

a. Facts related to a specific problem domain.
b. Theories relevant to a specific problem domain.
c. Rules and procedures pertaining to a specific problem domain.
d. Strategies for solving global problems.
e. Knowledge about knowledge (meta-knowledge).

The purpose of an Expert System is to transfer expertise from an expert into a computer and then disseminate it to non-experts. This process involves four steps: knowledge acquisition (from experts or other sources), knowledge inference, knowledge representation (in the computer), and knowledge transfer to the user. Inference is a procedure (program) that has the ability to perform reasoning. Inference is implemented in a component called an inference engine, which includes procedures for problem-solving [10].

C. Gastric Disease

The stomach is one of the organs in the human digestive system that functions to digest food and absorb some of the nutrients. In the stomach, there are enzymes such as renin, pepsin, and hydrochloric acid. The stomach will grind the food until it is completely broken down like porridge. Stomach acid often causes stomach diseases if it is produced excessively. Here are various types of stomach diseases [11].

1. Gastritis (Stomach Irritation/ Gastric Ulcer)

Gastritis, which is commonly called gastric ulcers by laypeople, is inflammation that occurs in the stomach due to increased secretion of stomach acid, irritation/abrasion in the stomach.

2. Dyspepsia (Poor Digestion)

Dyspepsia is a medical condition characterized by pain or discomfort in the upper abdomen or chest that usually occurs after eating. Gastroesophageal reflux disease (GERD) is one of the most common causes of dyspepsia. Other major causes include overeating, eating too quickly, and ignoring the process of chewing and digestion through saliva glands of the right food. Dyspepsia occurs when the muscles of the digestive tract organs or nerves that control these organs do not function properly. Dyspepsia is a chronic disease that usually lasts for years, even a lifetime.

3. Gastroesophageal Reflux Disease (GERD)

GERD is a recurrent backflow process, with or without mucosal complaints but causing disruption to human quality of life. In GERD, stomach acid and enzymes flow back from the stomach into the esophagus, causing inflammation and pain in the esophagus. GERD is a common phenomenon that can occur in anyone at any time. In normal people, this reflux occurs in an upright position after eating. Because the upright position is assisted by the presence of primary peristaltic contractions, the contents of the stomach that flow into the esophagus are immediately returned to the stomach. Typical complaints of GERD are pain behind

the breastbone (heartburn) radiating to the throat, regurgitation or sour taste in the mouth, and typical complaints of chest pain [12].

4. Stomach Cancer

Another dangerous stomach disease is stomach cancer. This cancer occurs when cancer cells form in the lining of your stomach. These cells can grow into a tumor and usually grow slowly over many years. The exact cause of this disease is not yet known. However, there are several factors that can increase your risk of developing stomach cancer, including Helicobacter pylori bacterial infection, smoking, obesity, being over 55 years old, eating red meat, salt, and rarely consuming fiber.

5. Stomach Ulcers

Stomach ulcers are wounds that occur in the stomach wall due to erosion of the stomach lining. This wound can also appear in the upper part of the small intestine. The most common causes are Helicobacter pylori bacterial infection and the long-term use of nonsteroidal anti-inflammatory drugs, such as aspirin. If you like spicy food, smoke, or consume alcoholic beverages, you should limit them. Because these things can affect existing symptoms.

The symptoms are severe pain in the upper abdomen, bloating, belching, loss of appetite, weight loss, feeling full quickly, nausea and vomiting, discomfort in the stomach after consuming fatty foods, and bloody bowel movements.

6. Gastroparesis

Gastroparesis is a condition in which the stomach takes longer to digest food. This condition, which disrupts the function of the stomach, occurs when the muscles in the stomach wall do not work properly, thus disrupting the digestive function of the stomach.

Gastroparesis occurs due to a disturbance in the nerves of the stomach. There are several risk factors that can increase the likelihood of someone developing this condition, such as diabetes, thyroid disorders, a history of surgery on the digestive tract, radiation therapy to the abdomen for cancer cases, and the side effects of drugs, such as narcotic pain relievers.

D. Fuzzy Mamdani Method

The Mamdani fuzzy logic is one of the most commonly used inference methods for fuzzy logic control problems. It was proposed by Mamdani and Assilian in 1975. The Mamdani method has an intuitive nature that is suitable for the process of human information input and covers a wide range of fields, which is an advantage compared to other fuzzy methods. Known as the Max-Min method, this inference system is more similar to human thinking patterns because the implication function between the antecedent and consequent is both in fuzzy sets [13].

The Fuzzy Mamdani method requires four stages to compute the control output:

a. Fuzzification process to determine the input and output variables and their fuzzy sets. In the Mamdani method, input and output variables are separated into one or more fuzzy sets.
b. Implication function using the MIN function. In this method, the implication function used is MIN.
c. Composition rule in the Mamdani method is obtained from the inference process. There are three inference methods: max, additive, and probabilistic OR. The inference method used is max.
d. Defuzzification in the Mamdani fuzzy rule composition uses the centroid of area (COA) method, which can be written as equation.

$$y \cdot = \frac{\sum y \mu R(y)}{\sum \mu R(y)} \quad (1)$$

Where:
y* = crisp value
μR(y) = degree of membership of y

E. Website

A website is a part of internet technology, where technology is a system created by humans for specific purposes to make it easier for humans to reduce their efforts, improve their results, and save energy and

resources. Websites are built using Hypertext Markup Language (HTML) and utilize the Hypertext Transfer Protocol (HTTP) communication protocol located in the application layer of the OSI reference layer [14].

F. PHP Programming Language

PHP is a programming language designed to run through web pages, generally used for processing information on the internet. In another sense, PHP stands for Hypertext Preprocessor, which is an open source or free web server-side programming language. PHP is a script that is integrated with HTML and resides on the server [15].

Here are some advantages of PHP:

1. Fast access, because it is written in the middle of HTML code, so the program response time is faster.
2. Cheap, even free, there is no need to pay for this software to use it.
3. Easy to use, complete with features and functions, suitable for creating dynamic web pages.
4. Can run on various operating systems, such as Windows, Linux, Mac OS, and various Unix variants.
5. Technical support is widely available. Even many forums and websites are dedicated to troubleshooting various issues related to PHP.
6. Secure, visitors cannot see PHP code.
7. Supports many databases.
8. Customizable. Because this software is open source.

II. RESEARCH METHOD

A. Research Materials

The data used as research materials are patient medical records (variables related to stomach disease risks) that will be processed to produce rules that will be used to build an inference system.

B. Research Tools

In the research to be conducted, the researcher requires main equipment as well as supporting equipment during the system design. The equipment used in the system design includes:

1. Hardware
   - Asus Laptop
   - 512 GB SSD
   - 4 GB RAM
   - amd8 Processor
2. Software

   The following are some of the software needs used in this research:

Table I. Software Tools

No.	Type of Software	Function
1.	Windows 10	Operating System
2.	Jupyter Lab/Google Colab	Tools Development
3.	Visual Studio Code	Text Editor
4.	Chrome	Web Browser
5.	Xampp	Server
6.	Python, PHP	System Design

C. Research Flowchart

Before creating this expert system application, the data used must be preprocessed, which can be seen from the flowchart diagram in Figure 1.

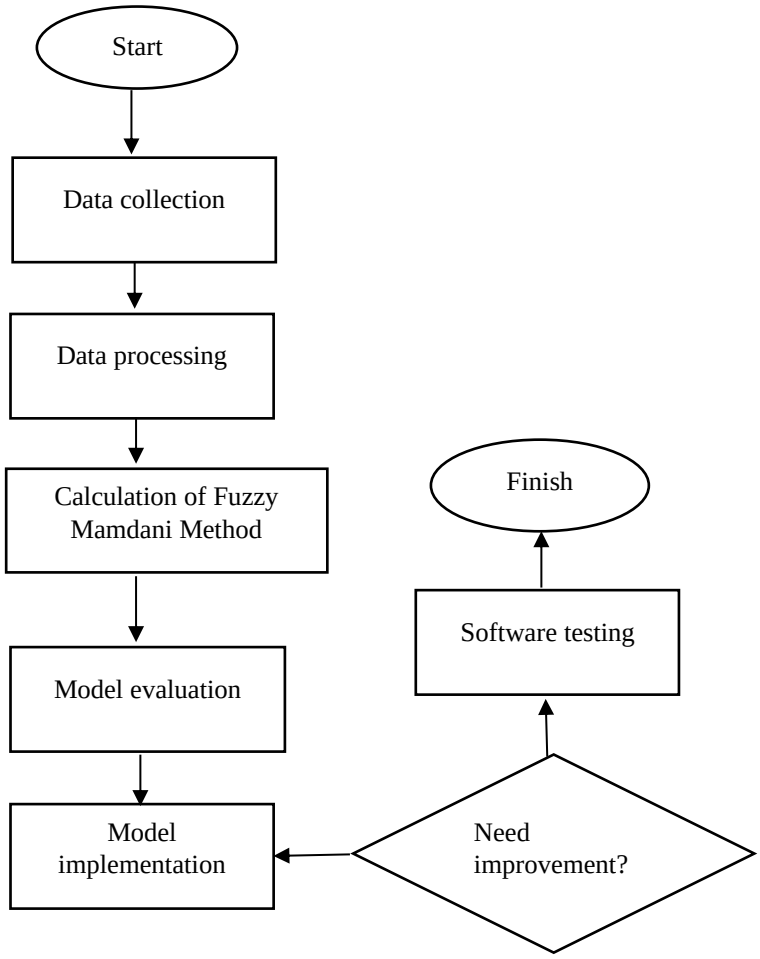

Figure 1. Research Flowchart

a. Data Collection

The data or information obtained is directly from an expert in this case a specialist doctor in internal medicine or a general practitioner. The data collection technique is as follows:

1. Interview Method

The interview method is a direct interview or question and answer technique with related parties, in this case a specialist doctor in internal medicine or a general practitioner, in order to obtain accurate data so that the design is in accordance with the original purpose.

2. Data Sampling Method

Sampling data is based on determining variables (risk factors for gastric disease) from patient medical records. Data samples are used to identify and select existing variables.

b. Data Analysis

Data analysis will be carried out to filter out data that can be used and those that cannot be used. After that, the data can be used by the system and ready for modeling.

c. Modeling

The previously successfully collected data will go through an initial processing stage where this stage will create a model. Model formation is made using PHP programming language with Fuzzy Mamdani algorithm.

d. Implementation & Testing

At the implementation stage, the system will be hosted and used by several testers with Black Box and Usability Testing methods.

III. RESULTS AND DISCUSSION

The implementation of the fuzzy mamdani method in the development of a web-based expert system application for the diagnosis of stomach diseases is as follows:

1. Functional Requirement

Analysis involves determining the functional requirements for building a gastric disease diagnostic expert system application that can be obtained from interviews and observations. There are two users in this application, namely Admin and Patient/Public. The results of the functional requirement analysis are presented in Table 2.

Table 2. Functional Requirement

User	CRUD	Information
Admin	Create & Delete	a. Disease Symptoms
		b. The type of disease
		c. Solutions and Cures from Diseases
	Update & Read	a. Patient/user data
		b. History of diagnostic results
	Print Out	a. Patient data report
		b. Diagnostic report
Patient/Public	Read	Diagnostic History
	Update	Select Symptoms

2. System Design

After gathering the functional requirements, the next step is to design the system architecture and user interface. This involves creating a structure for the expert system application and designing an intuitive and user-friendly interface for both Admin and Patient/Public users.

3. Knowledge Acquisition

In this step, the necessary knowledge about gastric diseases is acquired from domain experts or other reliable sources. This knowledge includes symptoms, diseases, solutions, medications, and follow-up actions related to gastric diseases.

4. Fuzzification

Fuzzification is the process of converting crisp input values (such as symptoms) into fuzzy sets using linguistic variables. This step involves defining membership functions to represent the degree of membership of each symptom in its respective fuzzy set.

5. Rule Base

The rule base is created based on the acquired knowledge. It consists of a set of IF-THEN rules that relate the fuzzy sets of symptoms to the fuzzy sets of diseases. These rules are designed to capture the expertise of the domain experts.

6. Inference Engine

The inference engine applies the fuzzy Mamdani method to perform reasoning based on the input symptoms and the defined rule base. It uses fuzzy logic to calculate the degree of membership of each disease for a given set of symptoms.

7. Defuzzification

Defuzzification is the process of converting fuzzy output values (degree of membership of diseases) into crisp values (specific diseases). This step involves selecting a defuzzification method, such as centroid or maximum membership, to determine the most likely diagnosis.

8. User Interface Implementation

The user interface for both Admin and Patient/Public users is implemented according to the design created in the system design phase. This includes creating forms, buttons, and other interactive elements for inputting symptoms and displaying the diagnosis and related information.

9. Testing and Evaluation

The developed application is tested to ensure its functionality, accuracy, and usability. It is evaluated using test cases and user feedback to identify and fix any issues or improvements needed.

10. Deployment

Once the application is tested and deemed ready, it is deployed to a web server to make it accessible to users. The application can be accessed through a web browser, allowing patients/public to input their symptoms and receive a diagnosis.

By following these steps, a web-based expert system application for diagnosing gastric diseases can be developed using the fuzzy mamdani method.

11. Coding

After the system design is created, the next process is coding. At this stage, we create program scripts and make the database for this expert system application so that it can function according to user needs. Here are the implementation results:

A. Login Page

Display the login page first and click on "register" to create an account if you do not have one yet. This can be seen in Figure 2.

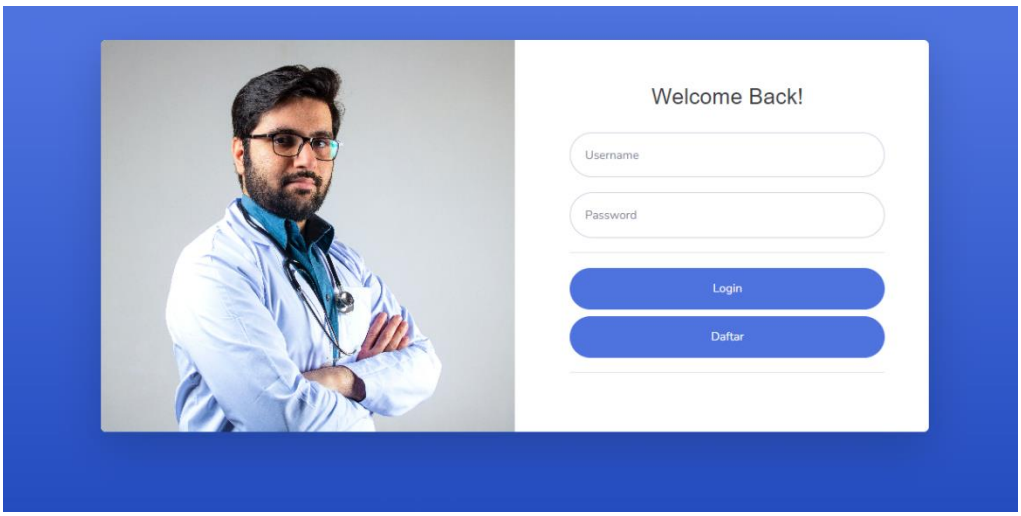

Figure 2. Login Page

B. Home Page to Patient/Public

In the home display, to log in as a patient/public, there are menus for diagnosis, disease information, about, and logout. If the diagnosis menu is clicked, symptoms will appear and will be selected according to what the patient is experiencing. Then, the diagnosis will be processed and the results will be displayed. In the disease information menu, there is an explanation of the types of diseases and their solutions. The home display can be seen in Figure 3, Figure 4. Form Symptoms, and Figure 5. Diagnostic Results.

Figure 3. Home Page to Patient/Public

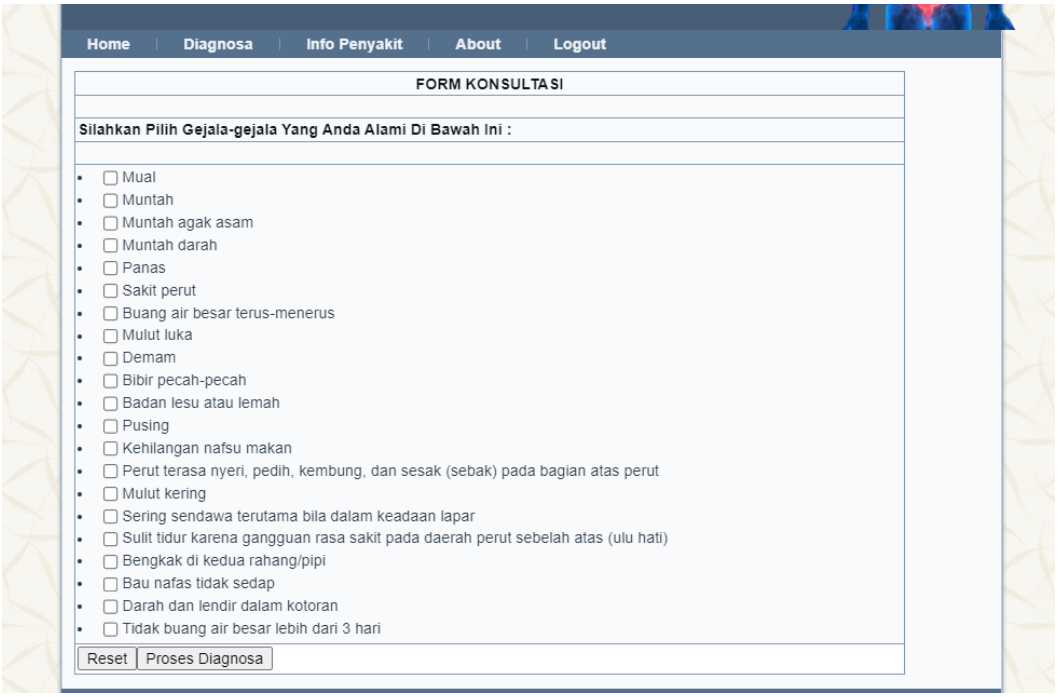

Figure 4. Form Symptoms

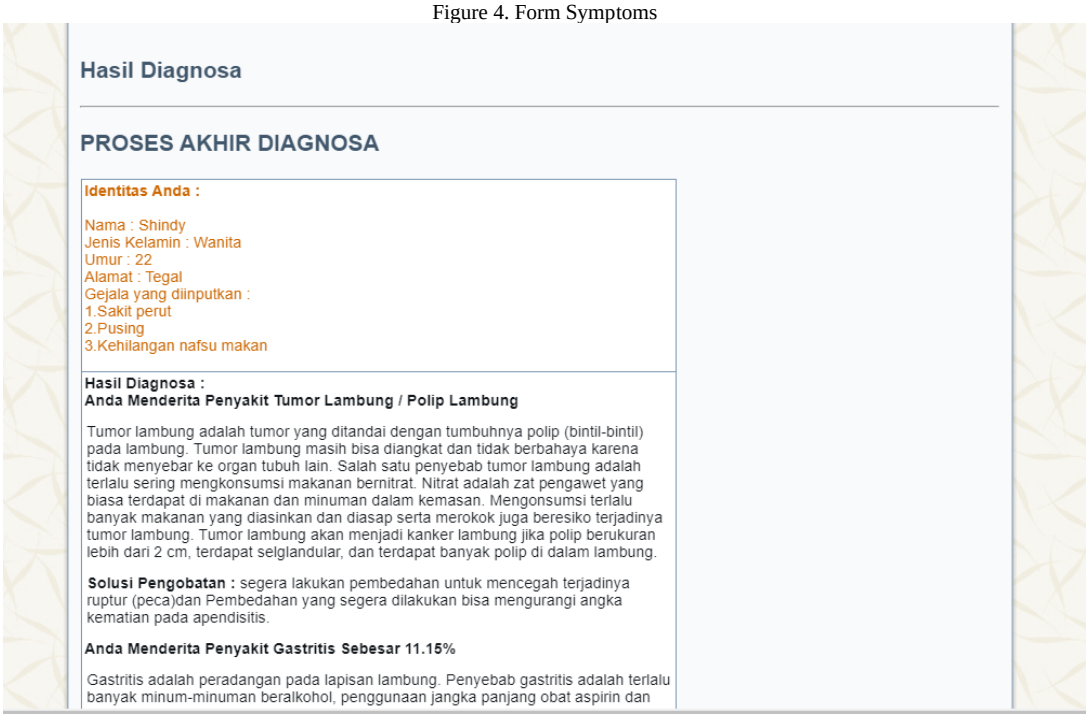

Figure 5. Diagnostic Results

C. Home Page to Admin

In the home display for login as an admin, there are menus for "penyakit&solusi", "gejala", "relasi", "laporan gejala", "laporan user", and "logout". In the "penyakit&solusi" menu, there are various types of diseases along with their explanations and solutions. In the "laporan user" menu, there are user data who have used this application. The difference in the use of this application between patients/citizens and admins is that admins can create, update, and delete existing data. This display can be seen in Figure 4 below.

Figure 4. Home Page to Admin

IV. CONCLUSION

The conclusion of this research is that the use of the fuzzy Mamdani algorithm method can be applied to create an expert system application for diagnosing gastric diseases based on a website, with an accuracy rate of 80%. The existence of this website-based expert system application helps the community to identify the type of disease based on their symptoms without the need to directly consult a doctor, thus preventing potential problems. Additionally, this expert system application provides information on solutions, medications, and further actions for the disease. A novel feature in the gastric disease diagnosis expert system application using the fuzzy Mamdani method is the inclusion of an NLP Chatbot, which can be used to inquire about gastric diseases. It is recommended for future research to enhance the expert system application by adding more features and making it mobile-based.

ACKNOWLEDGMENT

The Applied Bachelor Program in Informatics Engineering at Harapan Bersama Polytechnic in Tegal City has provided assistance and facilities to facilitate the implementation of this research.

REFERENCES

[1] W. A. C. N. Suwindiri, Yulius Tiranda, "Faktor Penyebab Kejadian Gastritis di Indonesia : Literaturre Review Mahasiswa IKEST Muhammadiyah Palembang , Sumatera Selatan , Indonesia IKEST Muhammadiyah Palembang , Sumatera Selatan , Indonesia", *J. Keperawatan Merdeka*, vol Vol.1, no November, bl Hal 209-223, 2021.

[2] Mustakim, Y. Rimbawati, en R. Wulandari, "Edukasi Pencegahan Dan Penanganan Gastritis Pada Siswa Bintara Polda Sumatera Selatan", *Pengabdi. Kpd. Masy.*, vol Vol.3, no 2, bl Hal 1-4, 2021.

[3] Azwar en Anas, "Sistem Pakar Diagnosa Awal Penyakit Lambung Menggunakan Metode Bayes", no 17, bl Hal 1-9, 2019.

[4] Amrina, D. W. Nugraha, en Rahmatanti, "Menggunakan Metode Case Based Reasoning Berbasis Web", vol Vol.5, no 1, 2020.

[5] Budianto, I. Fitri, en Winarsih, "Sistem Pakar Deteksi Dini Penyakit Pada Tanaman Jagung Menggunakan Naive Metode Bayes", *Mobile-Based Natl. Univ. Online Libr. Appl. Des.*, vol Vol.3, no 2, bl Hal 10-19, 2019.

[6] W. Andriyan, S. S. Septiawan, en A. Aulya, "Perancangan Website sebagai Media Informasi dan Peningkatan Citra Pada SMK Dewi Sartika Tangerang", *J. Teknol. Terpadu*, vol Vol.6, no 2, bl Hal 79-88, 2020, doi: 10.54914/jtt.v6i2.289.

[7] S. Bacin, "RESOLUSI : Rekayasa Teknik Informatika dan Informasi Sistem Pakar Untuk Mendiagnosa Penyakit Diabetes Menggunakan Metode Inferensi Fuzzy Mamdani", *Media Online)*, vol Vol.1, no 3, bl Hal 188-194, 2021.

[8] Hidayat Abdurahman et al., "Membangun Website SMA PGRI Gunung Raya Ranau Menggunakan PHP dan MySQL", *JTIM J. Tek. Inform. Mahakarya*, vol Vol.2, no 2, bl Hal 41-52, 2019.

[9] A. Anggilina en A. Eviyanti, "Web-Based Expert System for Diagnosing Gastric Disease Using Bayes Theorem Method", *Procedia Eng. Life Sci.*, vol Vol.1, no 2, 2021, doi: 10.21070/pels.v1i2.944.

[10] Y. Yuliyana en A. S. R. M. Sinaga, "Sistem Pakar Diagnosa Penyakit Gigi Menggunakan Metode Naive Bayes", *Fountain Informatics J.*, vol Vol.4, no 1, bl Hal 19, 2019, doi: 10.21111/fij.v4i1.3019.

[11] M. Indah en S. V. Dewi, "Rancangan Sistem Pakar Mendiagnosa Penyakit Lambung Menggunakan Metode Forward Chaining", *J. Informatics Comput. Sci.*, vol Vol.4, no 2, bl Hal 147, 2019, doi: 10.33143/jics.vol4.iss2.541.

[12] F. S. Nurhaidah *et al.*, "Pengetahuan Mahasiswa Universitas Airlangga Mengenai Dispepsia, Gastritis, Dan Gerd Beserta Antasida Sebagai Pengobatannya", *J. Farm. Komunitas*, vol Vol.8, no 2, bl Hal 57, 2021, doi: 10.20473/jfk.v8i2.24116.

[13] R. Rizdania, "Sistem Pendukung Keputusan (SPK) Pemilihan Jurusan Perguruan Tinggi Menggunakan Algoritma Fuzzy Mamdani", *J. Tecnoscienza*, vol Vol.6, no 1, bl Hal 30-42, 2021, doi: 10.51158/tecnoscienza.v6i1.529.

[14] M. Silmi, E. A. Sarwoko, en F. Chaining, "Sistem Pakar Berbasis Web Dan Mobile Web Untuk Mendiagnosis Penyakit Darah Pada Manusia Dengan Menggunakan Metode Inferensi Forward Chaining", *Masy. Inform.*, vol Vol.4, bl Hal 31-38, 2019.

[15] Muhammad Romzi en B. Kurniawan, "Pembelajaran Pemrograman Python Dengan Pendekatan Logika Algoritma", *JTIM J. Tek. Inform. Mahakarya*, vol Vol.03, no 2, bl Hal 37-44, 2020.