Design of Expert System for Digestive Diseases Identification Using Naïve Bayes Methodology for iOS-Based Application

by International Journal Artificial Intelligence and Robotics

Design of Expert System for Digestive Diseases Identification Using Naïve Bayes Methodology for iOS-Based Application

Dewi Salma Salsabila[1], Rinabi Tanamal[2]

[1,2] Department of Information Technology, Universitas Ciputra, Surabaya, Indonesia

[1] dewisalmasalsabila@gmail.com (*)

[2] r.tanamal@ciputra.ac.id

Abstract— Shown symptoms in digestive diseases might be similar, resulting in patient's suspected diseases before and after diagnosis attempt might turn out to be different. This paper aims to build a design of an expert system for digestive disease identification using Naïve Bayes methodology for iOS-based applications. The result from this paper helps medical interns to increase the accuracy in predicting patient's suspected digestive disease. A precise prediction in suspected disease identification can minimalize unnecessary diagnosis attempts, which saves time and reduces cost. Naïve Bayes is chosen because it has a higher accuracy level than other classification methods. This research includes collecting data through literature reviews on digestive diseases and their symptoms, processing the data to be turned into a knowledge base for the expert system, conducting data training using Naïve Bayes by the designed expert system application through this research. The result from the conducted data training using Naïve Bayes methodology shows that the expert system application has a higher accuracy level, which is 84%.

Keywords— digestive disease, expert system, naïve Bayes, iOS, knowledge-based

I. INTRODUCTION

Symptoms like nausea, vomiting, diarrhea, and flatulence are common in digestive diseases [1]. Those symptoms might be shown in the patient who suffers Crohn's disease, gallstone, irritable bowel syndrome (IBS), gastritis, gastroesophageal reflux disease (GERD), peptic ulcer, or ulcerative colitis. Nausea and vomiting are likely to appear in Crohn's disease, gallstone, irritable bowel syndrome (IBS), gastritis, and gastroesophageal reflux disease (GERD) [1]. On the other hand, diarrhea and flatulence are likely to appear in three or more types of digestive diseases [1]. This similarity in symptoms causing the initially suspected disease might turn out different from the actual digestive disease the patient suffers, because making a clinical diagnosis is a great challenge that involves complex, fast, and accurate decision-making [2]. False prediction in determining suspected disease might cause unnecessary medical diagnosis. Hence, an expert system is required to help medical interns in determining the suspected disease the patient might suffer in the early-stage of examination to make an effective diagnosis. With the help of an expert system, the less precise medical diagnosis can be minimalized, which also helps in saving time and reducing costs.

Expert systems are a branch of Artificial Intelligence (AI) [3], in the form of a system that adopts an expert ability to solve problems [4]. An expert is someone who has proficient skills and knowledge in a certain field, which common people don't have [3]. The function of an expert system is to solve a problem or being a support tool in the decision-making process [5].

Various expert systems have been developed and implemented in medical fields since 1961 to date for different healthcare purposes [2]. It was claimed that both logic rules (sets theory and Boolean algebra) and inference calculations (Bayes rules) are required to help doctors to model diagnosis processes [2].

The designed expert system application in this research is to identify suspected digestive disease patients might have. Digestive diseases included in this research scope are Irritable Bowel Syndrome (IBS), ulcerative colitis, Crohn's disease, peptic ulceration, gallstone, gastroesophageal reflux disease (GERD), and gastritis.

II. RESEARCH METHODOLOGY

The research was started by a literature review to discover problems and define the research aim. The discovered problem was unprecise diagnosis attempt might occur in diagnosing digestive diseases due to similar symptoms shown by patients. The difference in prior suspected digestive disease to the actual digestive disease the patient suffers may lead to an unnecessary diagnosis. Hence, this research aims to build an expert system application to help medical interns in determining a more precise patient's suspected digestive diseases using probability calculation. Details of the research methodology in this research are shown in Figure 1 in the form of a flowchart.
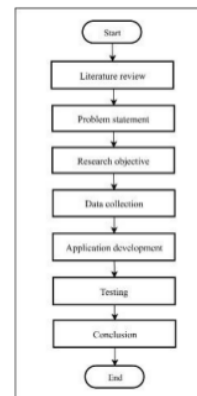

Figure 1 Research Methodology Flowchart

A. Datasets

Dataset to be used as the knowledge base in the designed expert system application consists of relations between symptoms and seven digestive diseases that are included in the scope, which are:

- Irritable Bowel Syndrome (IBS), a functional gastrointestinal disorder which affects 10-20% of the population, characterized by pain or discomfort in the abdomen, followed by altered bowel habit [6].
- Ulcerative colitis, a chronic colorectum inflammatory disorder [7].
- Crohn's disease, a chronic gastrointestinal tract inflammatory disease which is progressive and might cause bowel damage and disability [8].
- Peptic ulcer, an acid peptic injury of the digestive tract, which leads to mucosal break into the submucosa [9]
- Gallstone, a disease suffered by 10-15% of the population in developed countries in the form of solid material formed in the gallbladder, commonly consists of cholesterol [10].
- Gastroesophageal reflux disease (GERD), a chronic condition where gastric content refluxes to the oesophagus and mostly causing heartburn [11].
- Gastritis. an infection and irritation resulting in the inflammation of the mucosa and submucosa of gastric, caused by stress and dietary habit [12].

Datasets used in this research are retrieved from Supplementary Data 3 from an article by the title of Human Symptoms-Disease published by Nature Communications in 2014 [1]. Supplementary Data 3 consists of 147,978 records of relations between 4,219 diseases and 322 symptoms in the form of *.txt file.

Each record contains disease term, symptom term, and frequency of both terms to appear in PubMed citation. PubMed is a full-text archive developed and maintained by the United States National Library of Medicine at the National Institutes of Health, and it provides more than 30 million citations for biomedical literature and life science journals. PubMed is free and can be accessed through its official website at https://pubmed.ncbi.nlm.nih.gov/.

The retrieved file from Supplementary Data 3 is then filtered, resulting in 573 records consisting of 188 symptom terms associated with seven digestive diseases that are included in the research scope. The obtained 573 records from the filtering process can be seen in the attached Supplementary Data A file.

An expert system has important parts playing a crucial role, which are knowledge base containing an expert's knowledge, and an expert's concept of reasoning stored in the inference engine [13]. In order to give the right solution, users need to explain the problem to the expert system [13]. Hence, the designed expert system application has workflow as follows:

- The Application shows options of symptoms related to the digestive diseases based on the dataset
- Medical intern (user) selects the patient's symptoms based on the shown symptom options
- The Application calculates the probability based on the selected symptoms using Multinomial Naïve Bayes method and shows the suspected disease the patient might suffer
- The calculation result could be saved as patient data in the Application

The designed expert system application was developed using Swift programming language in XCode Integrated Development Environment. The resulting Application then went through two stages of tests, the accuracy-test, and the user acceptance test. Lastly, conclusions were drawn. The resulting Application runs in iOS-based devices and can be downloaded through the App Store.

B. Multinomial Naïve Bayes Method

The calculation of probability used in the designed expert system application is based on the methodology of Multinomial Naïve Bayes. Multinomial Naïve Bayes is chosen because it has good enough performance in text classification [14]. Multinomial Naïve Bayes calculates probability based on words' frequency to appear in a document [15]. The general Multinomial Naïve Bayes equation is shown by Equation (1).

$$P(c|d) = P(c) \prod_{i=1}^{n} P(w_i|c) \qquad (1)$$

where:
$P(c|d)$: Probability document d is class c
$P(c)$: Prior probability of class c
$P(w_i|c)$: Probability of term i in class c

The prior probability of class c ($P(c)$) is obtained through the calculation shown by Equation (2).

$$P(c) = \frac{N_c}{N} \qquad (2)$$

where:
N_c: Number of class c documents
N: Total documents

Probability of term i in class c ($P(w_i|c)$) is obtained through the calculation shown by Equation (3).

$$P(w_i|c) = \frac{count(w_i, c) + 1}{count(c) + |V|} \qquad (3)$$

where:
$count(w_i, c)$: Number of term i in class c
$count(c)$: Number of words in class c
$|V|$: Number of unique words

C. Business Process

The Application shows symptoms related to the seven digestive diseases based on the research scope. A medical intern, as the application user, selects any symptoms that the patient has. The designed Application calculates probability based on symptoms selected by the users. The suspected disease from the calculation result can then be saved as patient data, along with the selected symptoms and a supplementary

note if needed. The detail of the business process in Figure 2 in the form of a flowchart.
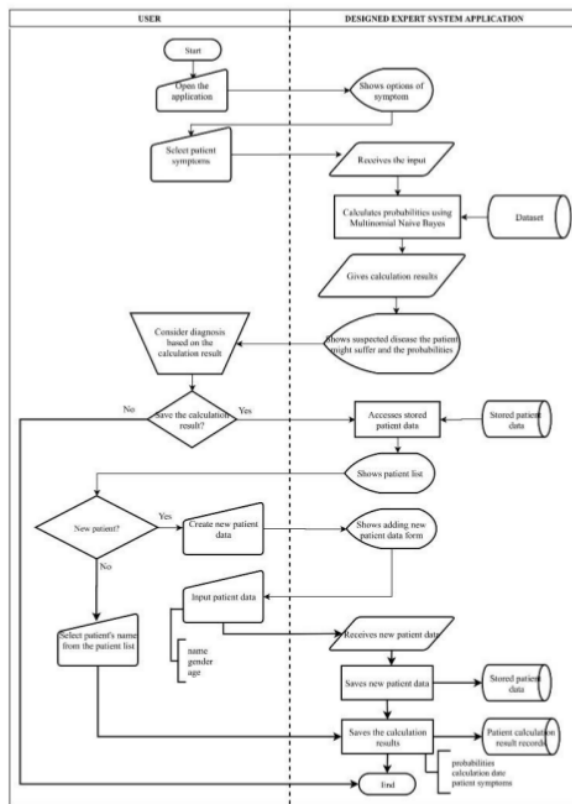

Figure 2. The flow of Business Process

Users open the Application, and options of symptoms are shown by the Application. Users select any from the provided options based on symptoms shown by the patient. The Application receives the selected symptoms as inputs and does calculations based on the stored dataset using Multinomial Naïve Bayes. The calculation results—which are the suspected digestive disease the patient might suffer and the probabilities are then shown to the users as a consideration to make a diagnosis. Users could save the resulting results as patient data in the Application.

A new patient data form needs to be filled in order to save the results to a new patient. Data that needs to be inputted in the new patient data form are the patient's name, age, and gender. While saving the results to an already stored patient data can be done by selecting the patient's name from the Patient List. The results that are stored contains information about symptoms the patient had, the date when the calculation was conducted, and the suspected digestive disease the patient might suffer based on probability calculation.

III. RESULT AND DISCUSSION

The filtered 573 records consisting of 188 symptoms dataset are used as the knowledge base of the designed expert system application to calculate the probability of suspected digestive diseases using Multinomial Naïve Bayes. The used dataset for this research can be seen in the attached Supplementary Data A file. The obtained dataset was fitted to the use of Multinomial Naïve Bayes.

A. Prior Probability (P(c))

Calculation of prior probability is by the equation of $P(c) = \frac{N_c}{N}$, with the number of documents for class c (N_c) is obtained by the sum of PubMed occurrences in class c, and total documents (N) is obtained by the sum of PubMed occurrences in every class. The prior probability for each class is in Table I.

TABLE I
PRIOR PROBABILITY OF EACH CLASS

Class	N_c	P(c)
Crohn's Disease	1168	0.13796
Gallstone	1170	0.13820
Gastritis	698	0.08245
GERD	2630	0.31065
IBS	1122	0.13253
Peptic Ulcer	825	0.09745
Ulcerative Colitis	853	0.10076
Total Documents (N)	8466	1

B. Number of Words in Class (count(c))

In the used dataset, every document consists of two words, which are a symptom term and a disease term, the number of words for each class in Table II.

TABLE II
NUMBER OF WORDS IN EACH CLASS

Class	N_c	count(c)
Crohn's Disease	1168	2336
Gallstone	1170	2340
Gastritis	698	1396
GERD	2630	5260
IBS	1122	2244
Peptic Ulcer	825	1650
Ulcerative Colitis	853	1706

C. Number of Unique Words (|V|)

A word that is not conjunction is regarded as a unique word. The dataset that is used in the research does not contain any conjunction. Hence, the number of unique words is obtained by the sum of disease terms and symptom terms. The number of disease terms based on the research scope is 7, and the number of symptom terms based on the filtering process done previously is 188. Hence, the number of unique words in the used dataset is 195 words.

The following is an example of the implementation of a patient with symptoms of nausea, vomiting, and chest pain. Data of each symptom can be seen in Table III.

TABLE III
DATA OF NAUSEA, VOMITING, AND CHEST PAIN IN DATASET

Symptom	PubMed Occurrences						
	Crohn's disease	Gallstone	Gastritis	GERD	IBS	Peptic ulcer	Ulcerative colitis
Nausea	24	15	17	19	7	9	17
Vomiting	22	37	37	180	5	15	13
Chest pain	3	5	6	226	0	5	4

Probability of Crohn's Disease as the Suspected Disease. The probability calculation of Crohn's disease as the suspected disease of patients with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$P(crohn's\ disease|nausea, vomiting, chest\ pain)$
$= P(crohn's\ disease)P(nausea|crohn's\ disease)P(vomiting|crohn's\ disease)P(chest\ pain|crohn's\ disease)$
$= P(crohn's\ disease)\left(\frac{count(nausea, crohn's\ disease) + 1}{count(crohn's\ disease) + |V|}\right)\left(\frac{count(vomiting, crohn's\ disease) + 1}{count(crohn's\ disease) + |V|}\right)\left(\frac{count(chest\ pain, crohn's\ disease) + 1}{count(crohn's\ disease) + |V|}\right)$
$= (0,13796)(\frac{24+1}{2336+195})(\frac{22+1}{2336+195})(\frac{3+1}{2336+195})$
$= (0,13796)(0,00988)(0,00909)(0,00158)$
$= 0,0000000$

Probability of Gallstone as the Suspected Disease. The probability calculation of gallstone as the suspected disease of patients with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$P(gallstone|nausea, vomiting, chest\ pain)$
$= P(gallstone)P(nausea|gallstone)P(vomiting|gallstone)P(chest\ pain|gallstone)$
$= P(gallstone)\left(\frac{count(nausea, gallstone)+1}{count(gallstone)+|V|}\right)\left(\frac{count(vomiting, gallstone)+1}{count(gallstone)+|V|}\right)\left(\frac{count(chest\ pain, gallstone)+1}{count(gallstone)+|V|}\right)$
$= (0,13820)(\frac{15+1}{2340+195})(\frac{37+1}{2340+195})(\frac{5+1}{2340+195})$
$= (0,1382)(0,00631)(0,01499)(0,00237)$
$= 0,000000031$

Probability of Gastritis as the Suspected Disease. The probability calculation of gastritis as the suspected disease of patients with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$P(gastritis|nausea, vomiting, chest\ pain)$
$= P(gastritis)P(nausea|gastritis)P(vomiting|gastritis)P(chest\ pain|gastritis)$
$= P(gastritis)\left(\frac{count(nausea, gastritis)+1}{count(gastritis)+|V|}\right)\left(\frac{count(vomiting, gastritis)+1}{count(gastritis)+|V|}\right)\left(\frac{count(chest\ pain, gastritis)+1}{count(gastritis)+|V|}\right)$
$= (0,08245)(\frac{17+1}{1396+195})(\frac{37+1}{1396+195})(\frac{6+1}{1396+195})$
$= (0,08245)(0,01131)(0,02388)(0,0044)$
$= 0,000000098$

Probability of Gastroesophageal Reflux Disease (GERD) as the Suspected Disease. The probability calculation of GERD as the suspected disease of patients with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$P(GERD|nausea, vomiting, chest\ pain) = P(GERD)P(nausea|GERD)P(vomiting|GERD)P(chest\ pain|GERD)$
$= P(GERD)\left(\frac{count(nausea, GERD)+1}{count(GERD)+|V|}\right)\left(\frac{count(vomiting, GERD)+1}{count(GERD)+|V|}\right)\left(\frac{count(chest\ pain, GERD)+1}{count(GERD)+|V|}\right)$
$= (0,31065)(\frac{19+1}{5260+195})(\frac{180+1}{5260+195})(\frac{226+1}{5260+195})$
$= (0,31065)(0,00367)(0,03318)(0,04161)$
$= 0,000001574$

Probability of Irritable Bowel Syndrome (IBS) as the Suspected Disease. The probability calculation of IBS as the suspected disease of patients with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$P(IBS|nausea, vomiting, chest\ pain) = P(IBS)P(nausea|IBS)P(vomiting|IBS)P(chest\ pain|IBS)$
$= P(IBS)\left(\frac{count(nausea, IBS)+1}{count(IBS)+|V|}\right)\left(\frac{count(vomiting, IBS)+1}{count(IBS)+|V|}\right)\left(\frac{count(chest\ pain, IBS)+1}{count(IBS)+|V|}\right)$
$= (0,13253)(\frac{7+1}{2244+195})(\frac{5+1}{2244+195})(\frac{0+1}{2244+195})$
$= (0,13253)(0,00328)(0,00246)(0,00041) = 0,000000000$

Probability of Peptic Ulcer as the Suspected Disease. The probability calculation of peptic ulcer as the suspected disease of patient with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$$P(peptic\ ulcer|nausea, vomiting, chest\ pain)$$
$$= P(peptic\ ulcer)P(nausea|peptic\ ulcer)P(vomiting|peptic\ ulcer)P(chest\ pain|peptic\ ulcer)$$
$$= P(peptic\ ulcer)\left(\frac{count(nausea, peptic\ ulcer) + 1}{count(peptic\ ulcer) + |V|}\right)\left(\frac{count(vomiting, peptic\ ulcer) + 1}{count(peptic\ ulcer) + |V|}\right)\left(\frac{count(chest\ pain, peptic\ ulcer) + 1}{count(peptic\ ulcer) + |V|}\right)$$
$$= (0,09745)(\frac{9+1}{1650+195})(\frac{15+1}{1650+195})(\frac{5+1}{1650+195})$$
$$= (0,09745)(0,00542)(0,00867)(0,00325)$$
$$= 0,000000015$$

Probability of Ulcerative Colitis as the Suspected Disease. The probability calculation of ulcerative colitis as the suspected disease of patients with symptoms of nausea, vomiting, and chest pain using Multinomial Naïve Bayes.

$$P(ulcerative\ colitis|nausea, vomiting, chest\ pain)$$
$$= P(ulcerative\ colitis)P(nausea|ulcerative\ colitis)P(vomiting|ulcerative\ colitis)P(chest\ pain|ulcerative\ colitis)$$
$$= P(ulcerative\ colitis)\left(\frac{count(nausea, ulcerative\ colitis) + 1}{count(ulcerative\ colitis) + |V|}\right)\left(\frac{count(vomiting, ulcerative\ colitis) + 1}{count(ulcerative\ colitis) + |V|}\right)\left(\frac{count(chest\ pain, ulcerative\ colitis) + 1}{count(ulcerative\ colitis) + |V|}\right)$$
$$= (0,10076)(\frac{17+1}{1706+195})(\frac{13+1}{1706+195})(\frac{4+1}{1706+195})$$
$$= (0,10076)(0,00947)(0,00736)(0,00263)$$
$$= 0,000000018$$

Based on the seven calculations, gastroesophageal reflux disease (GERD) has the highest probability. Hence, the patient with symptoms of nausea, vomiting, and chest pain might suffer from GERD.

There were two tests conducted during this research, one for an internist as an expert and one for medical interns as users. The first test was conducted to measure the accuracy of the resulting suspected diseases calculated by the designed Application by comparing them with the internist's data. The second test was conducted to measure the acceptance of medical interns as the user towards the designed Application.

D. Accuracy Test

The accuracy test uses patient symptoms data, suspected disease data estimated by an internist, and diagnosis results. The test compares suspected diseases—both from internist estimation and calculation output from the designed Application—to diagnosis result. The test was conducted by the help of Dr. Didiet Pratignyo, SpPD, FINASIM, an internist in RSUD Kota Cilegon, Banten, Indonesia. The comparison results in Table IV.

Based on Table IV, 72% suspected diseases estimated by the internist were correct, which is 18 out of 25. On the other hand, 84% suspected diseased from the calculation result of the designed expert system application was correct, which is 21 out of 25. Hence, by the use of the designed expert system application, the suspected disease has higher accuracy.

E. User Acceptance Test: User Acceptance Test (UAT)

The process to ensure the solution works for its users by gathering input from those who have experience with the business processes and will be using the designed system [16]. UAT is conducted to measure the level of user acceptance towards the designed expert system application. A simple experiment with 10-20 samples could be successful through strict control [17]. The test was done with the help of 13 medical interns. Medical interns were asked to do certain user scenarios and finished by filling the provided questionnaire. Likert scale is used as the rating system in the provided questionnaire. The Likert scale is a popular scale used to measure five points of attitudes, ranging from strongly agree, agree, neutral, disagree, and strongly disagree [18]. The provided questionnaire uses numbered scales ranges from 1 to 5, which 1 represents strongly disagree and five represents strongly agree. The interval for each score was calculated using the calculation shown by Equation (4).

$$I = \frac{100}{Total\ Point} \qquad (4)$$

The total point used in the provided questionnaire for this test is 5. Hence, the interval is 20. Details of the score interval are shown in Table V.

TABLE V
SCORE INTERVAL

Score	Result
0% - 19.99%	Strongly Disagree
20% - 39.99%	Disagree
40% - 59.99%	Neutral
60% - 79.99%	Agree
80% - 100%	Strongly Agree

The calculation of user acceptance level result is shown by Equation (5).

$$index(\%) = \frac{Total\ Score}{Maximum\ Score} * 100 \qquad (5)$$

TABLE VI
USER ACCEPTANCE TEST RESULT

No	Statement	Score	Result
1	The Application is easy to understand	86%	Strongly Agree
2	The Application is easy to use	88%	Strongly Agree
3	The how-to-use information of the Application is precise and easy to understand	85%	Strongly Agree
4	The user interface is attractive	86%	Strongly Agree
5	The Application is useful	89%	Strongly Agree

The maximum score is obtained by the multiplication of the highest score—which is 5, and the number of respondents, which is 13. Hence, the maximum score is 65. The results of the test are shown in Table VI.

Based on Table VI, all of the statements listed on the questionnaire used for the user acceptance test were strongly agreed on. Hence, the designed expert system application is easy to use and indeed useful for its users.

TABLE IV
COMPARISON RESULT IN ACCURACY TEST

No.	Patient Symptoms	Internist Estimation	Application Output	Diagnosis Result
1	Nausea, abdominal pain, vomiting, hematemesis	Gastritis	Gastritis	Gastritis
2	Abdominal pain, dizziness, hematemesis	Gastritis	Gastritis	Gastritis
3	Abdominal pain, jaundice, fever	Gallstone	Gallstone	Gallstone
4	Acute abdomen, diarrhea, weight loss	Crohn's disease	Crohn's disease	Crohn's disease
5	Abdominal pain, nausea, vomiting, dizziness	GERD*	Gastritis	Gastritis
6	Chest pain, heartburn, nausea, asthenia, abdominal pain	GERD	GERD	GERD
7	Chest pain, heartburn, nausea	GERD	GERD	GERD
8	Diarrhea, flatulence, abdominal pain, headache	Crohn's disease*	IBS	IBS
9	Chest pain, dysgeusia	GERD	GERD	GERD
10	Abdominal pain, nausea, vomiting	Gastritis	Gastritis	Gastritis
11	Nausea, vomiting, abdominal pain, hematemesis	Gastritis	Gastritis	Gastritis
12	Nausea, vomiting, flatulence, heartburn, asthenia	GERD*	GERD*	Peptic ulcer
13	Chest pain, heartburn, dysgeusia	GERD	GERD	GERD
14	Fatigue, back pain, constipation	IBS	IBS	IBS
15	Dizziness, nausea, flatulence, diarrhea	IBS	IBS	IBS
16	Acute abdomen, diarrhea, fatigue, weight loss	Crohn's disease*	Crohn's disease*	Ulcerative colitis
17	Chest pain, heartburn, sleep disorders	GERD	GERD	GERD
18	Abdominal pain, nausea, vomiting	Gastritis	Gastritis	Gastritis
19	Nausea, fever, fatigue	Gastritis*	Crohn's disease	Crohn's disease
20	Abdominal pain, jaundice, nausea, vomiting	Gallstone	Gallstone	Gallstone

*suspected disease is different from diagnosis result

IV. CONCLUSION

In this research, an IOS-based expert system application was made to help medical interns to identify patient's digestive disease in the early-stage examination. The provided features were made to fulfill the needs of medical interns as its users. Through the accuracy test, the designed Application shows higher accuracy, which is 84% compared to the internist estimation, which is 72%. And by conducting the User Acceptance Test and the use of a Likert scale, the designed expert system application scores 86% on the ease to understand, 88% on ease of use, 85% on how-to-use information, 86% on user interface attractiveness, and 89% on the usefulness. The designed expert system application made through this research is available on the App Store by the name of "Gastrome" in Bahasa Indonesia and can be downloaded from the following link: https://apps.apple.com/us/app/gastrome/id1497431650

which will be directed to the "Gastrome" page on App Store Preview page in Figure 3,

Figure 3. "Gastrome" on the App Store Preview page

REFERENCE

[1] X. Zhou, J. Menche, A.-L. Barabási och A. Sharma, "Human symptoms-disease network," *Nature Communications, vol. 5, article number: 4212*, 2014.

[2] M. Mirmozaffari, "Presenting a Medical Expert System for Diagnosis and Treatment of Nephrolithiasis," *EJMED, European Journal of Medical and Health Sciences, vol. 1, no. 1*, pp. 1-3, 2019.

[3] N. A. Hasibuan, H. Sunandar, S. Alas och S. , "Sistem Pakar Mendiganosa Penyakit Kaki Gajah Menggunakan Metode Certainty Factor," *Jurnal Riset Sistem Informasi Dan Teknik Informatika (JURASIK)*, pp. vol. 2, no. 1, 29-39, 2017.

[4] R. R. Fanny, N. A. Hasibuan och E. Buulolo, "Perancangan Sistem Pakar Diagnosa Penyakit Asidosis Tubulus Renalis Menggunakan Metode Certainty Factor dengan Penulusuran Forward Chaining," *Media Informatika Budidarma, vol. 1, no. 1*, pp. 13-16, 2017.

[5] M. K. Rosananda och R. Tanamal, "Android-Based Dental and Oral Health Diagnostic Expert System," *Jurnal Informatika Universitas Pamulang, Vol. 3, No. 4*, pp. 5-13, 2018.

[6] L. Böhn, S. Störsrud, T. Liljebo, L. Collin, P. Lindfors, H. Törnblom och M. Simrén, "Diet low in FODMAPs Reduces Symptoms of Irritable Bowel Syndrome as Well as Traditional Dietary Advice: A Randomized Controlled Trial," *Gastroenterology, vol. 149, issue 6*, pp. 1399-1407, 2015.

[7] P. Moayyedi, M. G. Surette, P. T. Kim, J. Libertucci, M. Wolfe, C. Onischi, D. Armstrong, J. K. Marshall, Z. Kassam, W. Reinisch och C. H. Lee, "Fecal Microbiota Transplantation Induces Remission in Patients With Active Ulcerative Colitis in Randomized Controlled Trial," *Gastroenterology 2015, vol. 149, issue 1*, p. 102–109, 2015.

[8] J. Torres, S. Mehandru, . J.-F. Colombel och L. Peyrin-Biroulet, " Crohn's Disease," *The Lancet, vol. 389, issue 10080*, pp. 1741-1755, 2017.

[9] A. Lanas och F. K. L. Chan, "Peptic Ulcer Disease," *The Lancet, vol. 390, issue 10094*, pp. 613-624, 2017.

[10] E. Ferkingstad, A. Oddsson, S. Gretarsdottir, S. Benonisdottir, G. Thorleifsson, A. M. Deaton, S. Jonsson, O. A. Stefansson, G. L. Norddahl, F. Zink, G. A. Arnadottir, B. Gunnarsson, G. H. Halldorsson, A. Helgadottir, B. O. Jensson, R. P. Kristjansson, G. Sveinbjornsson, D. A. Sverrisson, G. Masson, I. Olafsson, G. I. Eyjolfsson, O. Sigurdardottir, H. Holm, I. Jonsdottir, S. Olafsson, T. Steingrimsdottir, T. Rafnar, E. S. Bjornsson, U. Thorsteinsdottir, D. F. Gudbjartsson, P. Sulem och K. Stefansson, "Genome-wide association meta-analysis yields 20 loci associated with gallstone disease," *Nature Communications, vol. 9, article number: 5101*, 2018.

[11] M. D. Mello, A. R. Shriver, Y. Li, A. Patel och C. P. Gyawali, "Ineffective esophageal motility phenotypes following fundoplication in gastroesophageal reflux disease," *Neurogastroenterol Motil*, p. 292–298, 2016.

[12] W. Tussakinah, M. och I. R. Burhan, "Hubungan Pola Makan dan Tingkat Stres terhadap Kekambuhan Gastritis di Wilayah Kerja Puskesmas Tarok Kota Payakumbuh Tahun 2017," *Jurnal Kesehatan Andalas, vol. 7, no. 2*, pp. 217-225, 2018.

[13] D. S. Maylawati, W. Darmalaksana och M. A. Ramdhani, "Systematic Design of Expert System Using Unified Modelling," *IOP Conference Series: Materials Science and Engineering*, vol. 288, nr 012047, 2018.

[14] R. A. Pane, M. S. Mubarok, N. S. Huda och A. , "A Multi-lable Classification on Topics of Quranic Verses in English Translation using Multinomial Naive Bayes," i *6th International Conference on Information and Communication Technology (ICoICT)*, Bandung, Indonesia, 2018.

[15] F. Rosi, M. A. Fauzi och R. S. Perdana, "Prediksi Rating Pada Review Produk Kecantikan Menggunakan Metode Naive Bayes dan Categorical Proportional DIfference (CPD)," *Junal Pengembangan Teknologi Informasi dan Ilmu Komputer*, pp. 1991-1997, 2018.

[16] S. A. Sualim, N. M. Yassin och R. Mohamad, "Comparative Evaluation of Automated User Acceptance Testing Tool for Web Based Application," *International Journal of Software Engineering and Technology, vol. 2, no. 2*, pp. 1-6, 2016.

[17] I. Alwi, "Kriteria Empirik dalam Menentukan ukuran Sampel pada Pengujian Hipotesis Statistika dan Analisis Butir," *Jurnal Formatif 2, vol. 2*, pp. 140-148, 2015.

[18] S. Y. (. Chyung, K. Roberts, I. Swanson och A. Hankinson, "Evidence-Based Survey Design: The Use Of A Midpoint On The Likert Scale," *Performance Improvement*, vol. 56, nr 10, pp. 15-23, 2017.

Design of Expert System for Digestive Diseases Identification Using Naïve Bayes Methodology for iOS-Based Application

8   Submitted to University of Birmingham
Student Paper   1%

9   Yehia Ibrahim Alzoubi, Asif Qumer Gill. "An
Empirical Investigation of Geographically
Distributed Agile Development: The Agile
Enterprise Architecture is a Communication
Enabler", IEEE Access, 2020
Publication   1%

10 Ayu Latifah, Hilmi Aulawi, Muhammad Ali
Ramdhani. "Design of the automatic shoe
dryer", MATEC Web of Conferences, 2018
Publication   1%

11 Mirpouya Mirmozaffari. "Presenting a Medical
Expert System for Diagnosis and Treatment of
Nephrolithiasis", European Journal of Medical
and Health Sciences, 2019
Publication   1%

12 ejournal.medistra.ac.id
Internet Source   1%

13 Submitted to Universitas Amikom
Student Paper   1%

14 onlinelibrary.wiley.com
Internet Source   1%

15 repo.iain-tulungagung.ac.id
Internet Source   1%

16 www.thefreelibrary.com
Internet Source <1%

17 Yu-Bing Li, Xue-Zhong Zhou, Run-Shun Zhang, Ying-Hui Wang et al. "Detection of Herb-Symptom Associations from Traditional Chinese Medicine Clinical Data", Evidence-Based Complementary and Alternative Medicine, 2015
Publication <1%

18 Márcia Fernanda Correia Jardim Paz, Marcus Vinícius Oliveira Barros de Alencar, Rodrigo Maciel Paulino de Lima, André Luiz Pinho Sobral et al. "Pharmacological Effects and Toxicogenetic Impacts of Omeprazole: Genomic Instability and Cancer", Oxidative Medicine and Cellular Longevity, 2020
Publication <1%

19 ejournal.kopertis10.or.id
Internet Source <1%

20 Submitted to Cardiff University
Student Paper <1%

21 Submitted to University of Wales Swansea
Student Paper <1%

22 journal.ubm.ac.id
Internet Source <1%

23 Submitted to University of Leeds
Student Paper <1%

24 www.ccts.uky.edu
Internet Source
<1%

25 Egil Ferkingstad, Asmundur Oddsson, Solveig Gretarsdottir, Stefania Benonisdottir et al. "Genome-wide association meta-analysis yields 20 loci associated with gallstone disease", Nature Communications, 2018
Publication
<1%

26 Submitted to University of London External System
Student Paper
<1%

27 Mohamed Atef Mosa. "chapter 4 Data Text Mining Based on Swarm Intelligence Techniques", IGI Global, 2020
Publication
<1%

28 Submitted to Furness College
Student Paper
<1%

29 ketchum.libguides.com
Internet Source
<1%

30 Mello, M. D., A. R. Shriver, Y. Li, A. Patel, and C. P. Gyawali. "Ineffective esophageal motility phenotypes following fundoplication in gastroesophageal reflux disease", Neurogastroenterology & Motility, 2015.
Publication
<1%

31	Submitted to Ain Shams University Student Paper	<1%
32	e-journals.unmul.ac.id Internet Source	<1%
33	www.abundanthealthclinic.org Internet Source	<1%
34	riset.unisma.ac.id Internet Source	<1%
35	drops.dagstuhl.de Internet Source	<1%
36	www.td.org Internet Source	<1%
37	www.science.gov Internet Source	<1%
38	Submitted to University of Wales Institute, Cardiff Student Paper	<1%
39	crohnsdiseaseblog.info Internet Source	<1%
40	www.vohar.com Internet Source	<1%
41	F. Geheb. "A knowledge-based system for arrhythmia detection", Computers in Cardiology 1996 CIC-96, 1996	<1%

Publication

42 Reynaldi Ananda Pane, Mohamad Syahrul Mubarok, Nanang Saiful Huda, Adiwijaya. "A Multi-Lable Classification on Topics of Quranic Verses in English Translation Using Multinomial Naive Bayes", 2018 6th International Conference on Information and Communication Technology (ICoICT), 2018
Publication

<1%

43 Submitted to Indian Institute of Management
Student Paper

<1%

44 Submitted to Universitas Negeri Surabaya The State University of Surabaya
Student Paper

<1%

45 epdf.tips
Internet Source

<1%

46 Submitted to University of Greenwich
Student Paper

<1%

47 Gun-Woo Kim, Dong-Ho Lee. "Intelligent Health Diagnosis Technique Exploiting Automatic Ontology Generation and Web-Based Personal Health Record Services", IEEE Access, 2019
Publication

<1%

48 V O Tama, Y Sibaroni, Adiwijaya. "Labeling Analysis in the Classification of Product Review Sentiments by using Multinomial Naive Bayes

<1%

Algorithm", Journal of Physics: Conference Series, 2019
Publication

49   M. Ali Fauzi. "Random Forest Approach for Sentiment Analysis in Indonesian Language", Indonesian Journal of Electrical Engineering and Computer Science, 2018
Publication   <1%

50   Submitted to King's College
Student Paper   <1%

51   Submitted to Hasan Kalyoncu Üniversitesi
Student Paper   <1%

52   Weimin Xue, Yanan Sun, Yuchang Lu. "Research and Application of Data Mining in Traditional Chinese Medical Clinic Diagnosis", 2006 8th international Conference on Signal Processing, 2006
Publication   <1%

53   Submitted to University of Hertfordshire
Student Paper   <1%

54   Submitted to Swansea College
Student Paper   <1%

Exclude quotes   Off   Exclude matches   Off

Exclude bibliography   Off