



Development of an Expert System for Early Detection of Heart Disease Using The Bayes Theorem Method

Fristi Riandari¹, Ritha Zahara Tarigan²

^{1,2}Manajemen Informatika

^{1,2}STMIK Pelita Nusantara Medan Jln. Iskandar Muda No. 1, 20154, Indonesia

Email: fristy.rianda@gmail.com

ARTICLE INFO

Article history:

Received: 12/10/2020

Revised: 22/10/2020

Accepted: 30/11/2020

Keywords:

Bayes Theorem,
Cardiovascular Disease,
Expert System,
Web.

ABSTRACT

Coronary heart disease (CHD) is the leading cause of death and disability in developed and developing countries. In 2014 it was also reported that coronary heart disease is one of the causes of death for both men and women, starting in the 25-29 age group and increasing with age. The highest prevalence of coronary heart disease as a cause of death in the 60-64 year age group and in the 70-74 year age group. The development of science and technology has made information technology usable in various fields including health. So it is hoped that by making an application that can make it easier for users to detect heart disease early and independently. The purpose of this study is to build an application by implementing an expert system using the website-based Bayes Theorem method as a tool for diagnosing heart disease. This application was built using the web programming language & MySQL database. Expert system application to help detect heart disease early.

Copyright © 2020 Jurnal Mantik.
All rights reserved.

1. Introduction

The industrial revolution 4.0 currently demands a lot of changes in the mindset and human life, especially in technological developments. The industrial revolution 4.0 can create many innovative technological products that can exchange data in a short time, this is of course a concern for various fields, one of which is in the health sector. Internal disease is a disease related to many vital organs in the human body, one of which is the heart organ. The heart is an organ that is very important for the body because it functions to pump blood throughout the body. Coronary heart disease (CHD) is a leading cause of death and disability in both developed and developing countries [16]. Although the mortality rate has been steadily decreasing over the last few decades in western countries, it still accounts for about one-third of all deaths in persons over 35 years of age [1]. The existence of rapid globalization, urbanization, increasing people's life expectancy, and increasing chronic disease are new challenges for the modern health care system [22]. Coronary heart disease could have been prevented, but the increasing risk of lifestyle such as lack of physical activity, nicotine use and poor nutrition [2] is causing an increase in the prevalence of PTM in most countries [10]. Social inequalities and negative lifestyles, including lack of physical activity among obese, can increase the coronary heart disease mortality rate [12]. In 2014, it was also reported that CHD is one of the causes of death for both men and women, starting in the age group 25-29 years and increasing continuously with increasing age. The prevalence of CHD as a cause of death is highest in the 60-64 years age group and in the 70-74 years age group [9]. According to Riskesdas 2013, the prevalence of CHD based on interviews that have been diagnosed by health workers or have subjective symptoms of CHD in Indonesia is 1.6% [10]. The results of the study in Bogor City showed that women with abdominal circumference > 80 cm with a relative risk of 1.5 times (95% CI: 1,147-2,221) of developing CHD compared to women with abdominal circumference ≤ 80 cm [14]. Along with the development of science and technology, the above should be able to be overcome by the use of information technology. Expert system is a field of computer science that utilizes computers so they can behave intelligently like humans. This system tries to adopt human knowledge into computers, so that computers can solve problems as usually done by experts. The expert system will provide a list of symptoms until it can identify an object based on the answers received. In particular, this study aims to help the wider community through an application that will be built which adopts a cardiologist to be able to detect as early as possible the



symptoms of heart disease that are suffered so that it can quickly and definitely treat and overcome it and even prevent it.

2. Theoretical Basis

A. Expert system

Expert systems are a branch of Artificial Intelligence (AI) which is quite old because this system was developed in the mid-1960s. The term expert system comes from the term knowledgebased expert system. This term arises because to solve problems, an expert system uses the knowledge of an expert that is entered into a computer. Someone who is not an expert uses an expert system to improve problem-solving abilities, while an expert uses an expert system for knowledge assistants. Here are some definitions of an expert system [18].

B. Basic Concept of Expert System

- a) Expertise
Expertise is a mastery of knowledge in a certain field obtained from training, reading or experience. The expertise itself includes the following knowledge:
 - a. Facts on specific problem areas.
 - b. Theories on specific problem areas.
 - c. Rules and procedures relating to specific problem areas.
 - d. Strategies to solve global problems.
 - e. Knowledge of knowledge (meta knowledge)
- b) Experts
An expert is someone who has certain knowledge and is able to explain a response, learn new things about the topic of the problem, rearrange the knowledge obtained and can sort out the rules and determine the relevant expertise. An expert must be able to perform the following activities:
 - a. Identify and formulate problems
 - b. Solve problems quickly and precisely
 - c. Stringing the solution
 - d. Learn from experience
 - b. Restructuring knowledge
 - c. Break the rules
 - d. Determine relevance
- c) Transfer of expertise
The purpose of the Expert System is to transfer the expertise of an expert to the computer, then transfer it to other people who are not experts. This process involves four processes, namely:
 - a. Additional knowledge (from experts or other sources)
 - b. Knowledge infrared
 - c. Representation of knowledge (on computers) Transfer of knowledge to users.
- d) Inference
Inference is a procedure (program) that has the ability to do reasoning. Inference is displayed on a component called an inference engine which includes procedures regarding troubleshooting.
- e) Rules
Most Expert System software is a rule-based system, where knowledge is stored mainly in the form of rules, as problem-solving procedures [18].

C. Bayes Theorem

Bayes probability is one way to overcome data uncertainty by using the Bayes formula which is stated by [13]:

$$P(H_i|E) = \frac{(E|H_i) * (P(H_i))}{\sum_{k=1}^n P(E|H_k) * (P(H_k))}$$

3. Discussion

A. Application of Bayes Theorem

1. Disease Data Provisions

The following table shows the disease data contained in the heart, complete with the disease code and the name / type of disease.

Table 1.
Disease Data Table

Code	Disease Name
P01	Coronary heart
P02	Rheumatic Heart
P03	Heart failure
P04	Heart Valve Abnormalities
P05	Leaking Heart
P06	Heart Muscle Abnormalities
P07	Cardiac Arrhythmias
P08	Built-in Heart

2. Percentage of Bayes Value Conclusion

As for the logic of the Bayes theorem method in the system consultation session, the user is given a choice of answers that have their respective weights such as table 2. and table 2. for the percentage of their disease conclusions.

Table 2.
Conclusion Percentage Table

Percentage Level	Value
0-50%	Little or little possibility
51-79 %	Possibility
80-99%	Most likely
100%	Very confident

3. Case Example:

A person experiences symptoms of heart disease, namely:

Table 3.
Table of Symptoms Experienced by Patients

Code	Symptom	Description of symptoms experienced
G01	The presence of blockage in the coronary arteries is called chest pain	√
G02	Shortness of breath in the chest	
G03	Weight gain	
G04	Tiring easily	
G05	Irregular cholesterol	
G06	Lips or nail tips are bluish	
G07	Shortness of breath in the chest	
G08	Swelling of the abdomen and legs	
G09	Blue nails on the hands and feet	√
G10	Swelling of the feet and hands	
G11	Out of breath	
G12	Out of breath	
G13	Feel pain in the chest	
G14	Fatigue	
G15	Tired easily	
G16	Out of breath	
G17	Excessive headaches	√
G18	Tired all the time	
G19	Leaked valve on wall	
G20	The heart stops suddenly	
G21	Weakness of the heart muscle	
G22	Fluttering feeling in the chest	
G23	Irregular breathing	
G24	Excessive headaches	
G25	Stunted growth and development	
G26	Slower beat rate	
G27	The breath becomes fast and short	

1) Calculations using Bayes' Theorem

a. Determining the probability value: First define the probability value of each evidence for each based on the available sample data using the Bayes probability formula.

- a) P05 = Leaking Heart
- G09 = P (E|H9) = 0.7

- b) P06 = Heart Muscle Abnormalities

$$G01 = P (E|H1) = 0.8$$

$$G17 = P (E|H17) = 0.9$$

- b. Determining the Value of the Universe

Determine the value of the universe by finding the value of the universe by adding up hypotheses.

Menentukan nilai semesta dengan mencari nilai semesta dengan menjumlahkan hipotesa.

$$\sum_{Gn}^n = G1 + \dots + Gn$$

- a) P05 = Leaking Heart

$$G09 = P (E|H9) = 0.7$$

$$\sum_{Gn}^n = 0.7$$

- b) P06 = Heart Muscle Abnormalities

$$G01 = P (E|H1) = 0.8$$

$$G17 = P (E|H17) = 0.9$$

$$\sum_{Gn}^n = 0.8 + 0.9 = 1.7$$

- c. After the sum is known, the value of the universe is found using the formula for calculating the value of the universe, namely:

$$P (Hi) = \frac{P (Hi)}{\sum_{Gn}^n}$$

- a) P05 = Leaking Heart

$$G09 = P (H9) = \frac{0.7}{0.7} = 1$$

- b) P06= Heart Muscle Abnormalities

$$G01 = P (H1) = \frac{0.8}{1.7} = 0.47$$

$$G17 = P (H17) = \frac{0.9}{1.7} = 0.52$$

- d. Determine the Probability Value Hypothesis P (Hi)

Determining the probability value of the hypothesis P (Hi), after the P value (Hi) is known, the probability value of the hypothesis H is regardless of any evidence.

- a) P05 = Leaking Heart

$$\sum_{Gn}^n = (1 * 0.7) = 0.7$$

- b) P06 = Heart Muscle Abnormalities

$$\sum_{Gn}^n = (0.47 * 0.8) + (0.52 * 0.9) = 0.84$$

- e. Determining Value P (Hi|E)

Looking for the P value (Hi | E) or the probability that the hypothesis Hi is true if evidence E.

$$P (Hi | Ei) = \frac{P(Hi)*P(E|Hi)}{\sum_{Gn}^n}$$

- a) P05 = Leaking Heart

$$P (H9|E) = \frac{1*0.7}{0.7} = 1$$

- b) P06 = Heart Muscle Abnormalities



$$P(H1|E) = \frac{0.47 \cdot 0.8}{0.84} = 0.44$$

$$P(H17|E) = \frac{0.52 \cdot 0.9}{0.84} = 0.55$$

f. Determining Bayes Values

After all P values ($H_i|E$) are known, then add up all Bayes values with the following formula: $\sum_{Gn}^n Bayes = P(E|H1) * P(H1|E1) + \dots + P(E|Hi) * P(Hi|Ei)$

a) P05 = Leaking Heart

$$\sum_{Gn}^n Bayes = 0.7 * 1 = 0.7$$

b) P06 = Heart Muscle Abnormalities

$$\sum_{Gn}^n Bayes = (0.8 * 0.44) + (0.9 * 0.55) = 0.84$$

From the calculation process using the Bayes method above, it can be seen that people with heart disease suffer from muscle disorders with a confidence value of 0.84 or 85%, which if seen in the Conclusion Percentage Table, it can be seen that there is a high probability of suffering from heart muscle disease.

B. System Implementation

System implementation is a stage in operating applications that have been built.



Fig. 1 Main Display

4. Conclusion

Based on the results, the following conclusions can be drawn:

- a. Expert systems with the Bayes theorem method can be used to detect types of heart disease.
- b. Implementation of an expert system using the Bayes theorem method, an application that can be used as an alternative to convey information to the wider community to detect early causes and symptoms of heart disease so that it can be treated early and even prevented.

5. References

- [1] Cardio Pulse. (2014). European Heart Journal, 35(42),2929–2933. doi:10.1093/eurheartj/ehu378
- [2] Danaei, G., Ding, E. L., Mozaffarian, D., Taylor, B., Rehm, J., Murray, C. J. L., & Ezzati, M. (2009). The Preventable Causes of Death in the United States: Comparative Risk Assessment of
- [3] Desak Putu Siska Dewi , Sistem Pakar Diagnosa Penyakit Jantung dan Paru dengan Fuzzy Logic dan Certainty Factor”, MERPATI VOL. 2, NO. 3, pp.361-370, Desember 2014.
- [4] Dietary, Lifestyle, and Metabolic Risk Factors. PLoS Medicine, 6(4), e1000058. doi:10.1371/journal.pmed.1000058.
- [5] Horton, R. (2015). Offline: Chronic diseases—the social justice issue of our time. The Lancet, 386(10011), 2378. doi:10.1016/s0140-6736(15)01178-2.
- [6] H. T. Sihotang and F. Riandari, “Application expert system diagnoses chickenpox disease in children using case based reasoning method,” J. Crit. Rev., vol. 7, no. 7, pp. 574–579, 2020.
- [7] H. T. Sihotang, F. Riandari, and S. Indri Gita Margareth, “Expert system to different mixed disease in baby using CBR (case base reasoning) method,” J. Crit. Rev., vol. 7, no. 5, pp. 48–51, 2020.
- [8] H. T. Sihotang, F. Riandari, R. M. Simanjorang, A. Simangunsong, and P. S. Hasugian, “Expert System for Diagnosis Chicken Disease using Bayes Theorem,” J. Phys. Conf. Ser., vol. 1230, no. 1, 2019.

- [9] Kementerian Kesehatan. Laporan Riset Kesehatan Dasar (Riskesdas) 2013 Bidang Biomedis. Jakarta: Badan Litbangkes, Kemenkes RI; 2014.
- [10] Kosen S, Tarigan IU, Rosita T, Indriasih E, Usman Y, dkk. Indonesia: Sample registration System 2014. Jakarta : The National Institute of Health Research and Development; 2015.
- [11] L. Situmorang and F. Riandari, "Expert System Mediagnosa Hama On Phon Oil With Certainty Factor Method," J. Comput. Networks, Archit. High Perform. Comput., vol. 2, no. 2, pp. 268–274, 2020.
- [12] Leischik R, Dworrak B, Strauss M, et al. Plasticity of Health. German Journal of Medicine 2016;1:1-17
- [13] Merlina N, (2012). Perancangan Sistem Pakar, Penerbit Ghalia Indonesia
- [14] Oemiati R, Rustika. Faktor risiko penyakit jantung koroner (PJK) pada perempuan. Buletin Penelitian Sistem Kesehatan. 2015;18(1): 47–55.
- [15] P. Jadianan, P. Viktor H, P. Dwimaryuga, "Sistem Pakar Diagnosa Penyakit Jantung Menggunakan Metode Certainty Factor Berbasis Web", Seminar Nasional Informatika 2012 (semnasIF 2012), pp 54-61, Juni 2012
- [16] Roger, V. L. (2007). Epidemiology of Myocardial Infarction. Medical Clinics of North America, 91(4), 537–552. doi:10.1016/j.mcna.2007.03.007
- [17] R. Joko S Dwi, D. Damdan, S. Lioe, "Perancangan Sistem Pakar Diagnosa Penyakit Jantung dengan Metode Forward Chaining Berbasis Android", Jurnal Sisfotek Global, Vol. 7 No. 2, pp 102-107, Sep. 2017
- [18] Sutojo, (2011). Kecerdasan Buatan. Bandung, 1st Published
- [19] F. Riandari and A. C. Panjaitan, "Expert System to Diagnose Extra Lung Tuberculosis Using Bayes Theorem," J. Mantik, vol. 3, no. January, pp. 31–38, 2019.
- [20] T. Derist, F. Erick, S. Pandapotan, Dkk, "Sistem Pakar Mendiagnosis Penyakit Jantung dengan Metode Fuzzy Set", Seminar Nasional Aplikasi Teknologi Informasi (SNATI), Juni 2014.
- [21] W. Eka, H. Sri, "Case-Based Reasoning untuk Diagnosis Penyakit Jantung", IJCCS, Vol.11, No.1, pp. 1-10, January 2017
- [22] W.E. Gustri, P. Widodo, "Prototype Sistem Pakar untuk Mendeteksi Tingkat Resiko Penyakit Jantung Koroner dengan Metode Dempster Shafer (Studi Kasus: RS. PKU Muhammadiyah Yogyakarta)", IJCCS, Vol.7, No.2, pp. 133-144 , July 2013.
- [23] World Health Organisation. World Health Report. 2013. [Cited 2016 June 23]. Available from : <http://www.who.int/whr/2013/report/en/>.
- [23] Y. Simare-mare and F. Riandari, "Expert System For Personal Computer Mendiagnosakerusakan Method Using Certainty Factor," J. Comput. Networks, Archit. High Perform. Comput., vol. 2, no. 2, pp. 195–202, 2020.

