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ALGORITHM FORWARD CHAINING AND BACKWARD CHAINING FOR DIAGNOSING DIABETES MELLITUS

[1]HANDRIZAL, [2]HAYATUNNUFUS, [3]MUHAZIR FANDI

[1,2,3]Department of Computer Science, Faculty of Computer Science and Information Technology, Universitas Sumatera Utara, Jl. University No. 9-A, Medan 20155, Indonesia

E-mail: handrizal@usu.ac.id

ABSTRACT

Diabetes Mellitus is a chronic disease or disorder with various causes characterized by high blood sugar levels accompanied by impaired carbohydrate, lipid, and protein metabolism due to a lack of insulin function. There are three types of diabetes mellitus, namely diabetes mellitus type I (the human body fails to produce insulin), type II (cells fail to use insulin), and gestational (high blood sugar levels during pregnancy). Diabetes Mellitus is a disease that is often underestimated by some people due to the lack of knowledge about diabetes mellitus them knowing diabetes mellitus is a disease that must be considered because it can cause death slowly, especially in the elderly and pregnant women. It is necessary to build an expert system that can diagnose diabetes mellitus, the system will be built using forward chaining and backward chaining algorithms, and can function to diagnose and provide good treatment for diabetes mellitus. An expert system is a specialized piece of software or computer program, that stores expert knowledge about a particular problem domain, often in the form of IF-THEN rules that are capable of solving problems at a level equal to or greater than that of human experts. With this expert system, even ordinary people can solve quite complex problems that can only be solved with the help of experts. Then for doctors, this expert system is also very helpful in their activities as very experienced assistants. The data used in this test are 50 data for diagnosis and 50 data for treatment, so the total data is as many as 100. The results of the comparison test all data match the results of expert test data and system results. Then the level of accuracy of this system is 100%. The results of this study succeeded in increasing the accuracy of previous studies, namely from 90% to 100%.
Keywords: *Diabetes mellitus, Expert System, Forward Chaining, Backward Chaining*

1. INTRODUCTION

Diabetes Mellitus is a scary disease because diabetes mellitus cause complications for sufferers if not treated immediately, about 90-95% of people in the whole world are affected by diabetes mellitus day by day diabetes mellitus continues is increasing rapidly, diabetes mellitus is a disease that is often underestimated by some people due to lack of knowledge about diabetes mellitus without them knowing diabetes mellitus is a disease that must be attention because it can cause death slowly, especially in the elderly and mothers pregnant[1].

Diabetes Mellitus is a chronic disease or disorder with various causes characterized by high blood sugar levels accompanied by disturbances in carbohydrate, lipid, and metabolism protein due to a lack of insulin function[2]. The journal[3] entitled “Mamdani Fuzzy Inference System (FIS) for Early Diagnosis of Diabetes Mellitus (DM) and Calorie Needs” Explains that there are three types of diabetes mellitus, namely diabetes mellitus type I (human body fails to produce insulin), type II (cells fail to use insulin) and gestational (high blood sugar levels during pregnancy), Types of diabetes mellitus The most common is type II diabetes mellitus caused by elevated blood sugar levels or impaired insulin function. The emergence of disease is caused by people who have habits of physical activity with a diet high in calories and fat that does not contain enough fiber in the diet[3].

In the journal[2]. Entitled "Expert System for Diabetes Mellitus" Detection and Handling Using Certainty Factor on Android-Based Mobile Device” Explained that when diabetes mellitus is not treated properly, it will cause chronic complications such as stroke, heart attack, peripheral nerve disorders, and amputation. As a disease chronically, accumulation of glucose in the bloodstream (hyperglycemia) causes disease complications in others, but these complications can be overcome with proper self-control

management done regularly and well. The self-control of diabetes mellitus is very important for patients to do because they can monitor their health, and self-control can be done with medication, diet, exercise, and blood sugar levels. Diabetes Mellitus cannot be cured completely, diabetes mellitus treatment is only used to treat diabetes mellitus and control or regulate blood sugar levels in the body to remain normal[2]. The certainty factor method was successfully implemented in this Diabetes Mellitus expert system and can provide results an accuracy of detection with the highest value of 90% [2].

In this case, the use of expert systems is very influential and can help in the field of health, one of which is an expert system that can diagnose diabetes mellitus, Detecting the disease at an early stage can make it possible to treat and treat it accurately, identify treatment accurately depending on the method used in diagnosing disease. Expert systems can be very helpful in identifying diseases and explaining methods of treatment that will be carried out taking into account the ability of users to handle and interact with the expert system easily and clearly[4]. An expert system is a special piece of software or computer program that stores knowledge about a particular problem domain, often in the form of rules IF – THEN capable of solving problems at a level equal to or greater than human experts[5].

The Expert System has had successful applications in the field of consulting and retrieval decisions in management and problem-solving medical diagnosis. An expert System is a smart computer program that uses knowledge and inference methods to solve problems that generally require considerable human expertise, the same as someone comes to his knowledge for decision-making, after examination with the inference method required to select and present a particular case, the expert system also provides guidance and solutions using a knowledge base and review[6]. Expert systems are one way to achieve results more quickly and easily. The expert system here contains knowledge that first comes from real-life experience. The knowledge comes directly from experienced experts who have worked for years in the discipline, i.e. knowledge that comes from "learning from experience"[7].

The Expert System uses knowledge and deduction measures to solve problems that require significant human expertise for solutions. An expert system is a branch of Artificial Intelligence (AI) invented by the AI community in the 1960s[8]. The basic principle behind expert systems is based on the expertise of expert systems as a tool efficient way to retain the knowledge essential to manufacturing competitiveness and used for training, and knowledge dissemination within an organization, expert systems allow to transfer of simplified knowledge at minimum cost. The power of expert systems comes from knowledge rather than specific information[8].

Consulting someone who has certain expertise is the right choice to get the right answers, solutions, and conclusions. But with limitations the time a doctor has and the costs incurred by the community sometimes become an obstacle, therefore the expert system is presented as an alternative to solve a problem other than an expert in various fields of technology utilization. To optimize the services provided by doctors, it is necessary to use technology that can facilitate and reduce the costs incurred by ordinary people, one of which is by implementing an expert system. With this expert system, even ordinary people can solve quite complex problems that actually can only be solved with the help of an expert than system doctors This expert is also very helpful in his activities as a very experienced assistant[9]. Therefore, the role of information technology is very useful to be able to develop the health sector.

Based on the above background, how to increase the accuracy of detection of an expert system that able is to diagnose diabetes mellitus like a specialist or experts in the field of diabetes mellitus? The method that will be used in making this expert system is forward chaining and backward chaining. Forward Chaining by starting the search from the facts by looking for rules that match the existing assumptions/hypotheses leads to conclusions. And Backward Chaining by starting backward tracking which starts its reasoning from the conclusion (goal), by looking for a set of hypotheses towards facts that support this set of hypotheses.

2. FORMULATION OF THE PROBLEM

The formulation of the problem in this study is how to increase the accuracy of detection of an expert system that able is to diagnose diabetes mellitus like a specialist or experts in the field of diabetes mellitus

for the number of people who are unfamiliar and underestimate the impact of diabetes mellitus.

3. SCOPE OF PROBLEM

The limitations of the problem in this study are as follows:

1. The method used is Forward Chaining and Backward Chaining.
2. This expert system was built only to diagnose Diabetes Mellitus.
3. The application built is based on Android.
4. Using the Java programming language and MYSQL.
5. Only using data - data on Diabetes Mellitus.

4. THEORETICAL FRAMEWORK

4.1 Diabetes Mellitus

In the journal[3]. The title "Mamdani Fuzzy Inference" System (FIS) for Early Diagnosis of Diabetes Mellitus (DM) and Calorie Needs" Defining Diabetes Mellitus as a chronic disease or disorder with various causes characterized by high blood sugar levels accompanied by metabolic disorders carbohydrates, lipids, and proteins as a result of a lack of insulin function. According to the site ristekdikti.go.id. DM is still a serious health problem in the world, Indonesia is ranked fourth with the highest diabetes prevalence in the world after India, China, and the United States. Even the number of people with diabetes continues to increase year after year, especially for type 2 DM. Among degenerative diseases, diabetes is one of the non-communicable diseases that will increase in the future[3]. Diabetes Mellitus comes from the Latin word Diabetes which means to drain and Mellitus means to drain which means sweet, this disease arises due to metabolic disorders in the body that blood levels increased blood sugar (hyperglycemianda), metabolic disorders occur if the pancreas cannot produce enough insulin to meet the body's needs. The hormone insulin has a function that keeps blood sugar levels in balance so that the metabolism of carbohydrates, fats, and protein is converted into energy needed by the human body[3].

4.2 Expert System

Professor Edward Feigenbaum (1982: 1) from Stanford University was an early pioneer of expert system technology in journals (Nelly, 2017), entitled "Expert Systems with Genetics Probability". defines an expert system as an intelligent computer program that uses knowledge and inference procedures to solve problems problem that is difficult enough that it requires someone who is an expert to solve it, the expert system will be used by the user to find out the answers from the problems it faces[10]. According to. (Suryadi, 1994) the notion of expert systems in research journal articles (Hakim et al al.,) in 2020. Entitled "Android-Based Expert System Application for Diagnosis". COVID-19 Disease: Cases Study of Banyumas Regency "expert system is a computer system that imitates his ability to make decisions in place of human experts. It also includes a set of intelligence programs that use knowledge and inference procedures to solve a fairly difficult problem that requires an adequate human expert to finish it. The Expert System in question is to act in all aspects like human experts[9].

4.3 Expert System Structure

An expert system is a computer program that knows a particular domain, and can process, manipulate and reason with knowledge intent to solve problems and achieve certain goals.

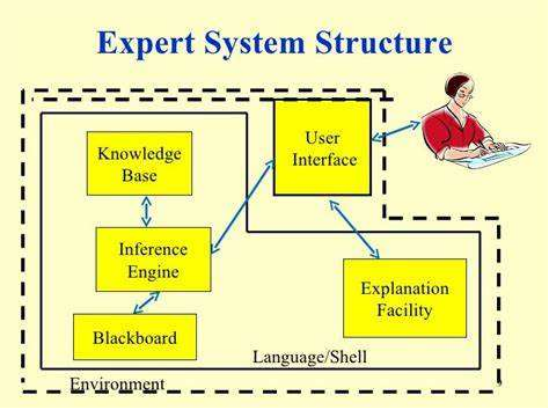

Figure 1. Expert System Structure

The components contained in the expert system are as contained in the image above, namely:

1. The User Interface allows non-expert users to interact with the expert system and find a solution to the problem.
2. Knowledge-Based contains knowledge base knowledge usually stored in terms of an if-then rule (IF-THEN). For understanding Formulation, and problem-solving. This expert system component is composed of two basic elements: facts and rules. Facts are information about objects in the area of certain problems, while rules are information about how to obtain new facts from known facts.

3. Knowledge Acquisition (Knowledge Acquisition) allows expert systems to obtain more knowledge from various sources and store it in the knowledge base.
4. The Inference Engine is a generalized control mechanism that applies axiomatic knowledge in the knowledge base for a specific data task to arrive at some solution or conclusion. Inference in the production system is carried out by the process of assembling rules recursively, either in a forward or backward flow until a conclusion is reached.
5. Explanation subsystem allows the program to explain the reasons to the user. The explanation can range from how the final or intermediate solution was obtained to justifying the need for additional data.

4.3 Expert System Features

A good Expert System must meet the following characteristics[9]. :

1. The system must be able to respond at a level of competence equal to or better than the expert system in the field. The quality of the advice given by the system must have a high level of integrity and the performance ratio must also be very high.
2. The system must be understandable, that is, it can explain the steps of reasoning when operating. The Expert System must have an explanatory ability similar to the reasoning ability of a human expert.
3. Real experts not only come up with good solutions but also find them fast. So expert systems must be skilled in applying their knowledge to produce efficient and effective solutions using human expert intelligence.
4. The Expert System can explain how certain conclusions were reached and why the requested information is required during the consultation. This is very important because provides opportunities for users to access and understand the capabilities of system reasoning, thereby increasing user confidence in the system.
5. Have the ability to learn to adapt.

4.4 Machine Inference Forward Chaining and Backward Chaining Method

The Forward Chaining method described in the journal[7], entitled "Analysis And Design Expert System To Identify Injuries Because Of Sports" is an inference engine method by starting reasoning or searching data in the form of facts that lead to a conclusion. Forward Method Chaining is also known as Data Drive. The main advantage of the Forward Chaining method is this method works well when the problem comes from collecting or gathering information and drawing conclusions from that information. While the Backward Chaining Method is method is a search strategy whose direction is the opposite of forward chaining. The search process starts from the goal, namely conclusions that become solutions to the problems at hand. Search in the opposite direction from forward chaining. Experiment with facts or statements starting from the other side right (then first). In other words, reasoning starts from the hypothesis first, and to test the truth of the hypothesis, it is necessary to look for the facts in the knowledge base. The search process starts from the goal, namely the conclusion is the solution to be achieved, then from the obtained rules, each conclusion is a Backward Chaining path which leads to the conclusion is the solution is being sought, and if it is not suitable then the conclusion is not the solution sought. Backward Chaining starts the process of search with a goal so this strategy is also called Goal-Driven.

4.5 Android

Android is an Operating System (OS) on a mobile phone device based on Android Linux. Android in this case presents various platforms that are open source so that user developers can create applications for themselves that can later be used in various applications on mobile devices. Android was originally developed by Android Inc., and is financially supported by Google, in 2005 Android itself was acquired by Google Company in July 2005 google bought android at 50 for million USD, in the end, the android executives also agreed to join google to lead this android project. Google himself bought android by making a prototype. In addition, the prototype is a smartphone that has a keyboard like a BlackBerry[12].

4.6 Android studio

In this study, the authors built a system using Android studio software. Android Studio is an IDE (Integrated Development Environment) for android application development, this application was published by Google on 16 May 2013 and is available for free under the Apache 2.0 license, this Android studio

replaces the software The previous android development was Eclipse[13].

4.7 Java

In completing this research, the author will build a system using the JAVA programming language. In computer science, Java is one of the object-oriented programming languages introduced in 1995 by Sun Microsystems Inc., which when Java was created, was led by James Gosling. Java programming language was created starting by the company Sun Microsystems which wanted to create a language programming that can run on all devices without being bound by the platform used by this device, a project pioneered by Patrick Naughton, James Gosling, Mike Sheridan, and Bill Joy in 1991, thus creating the Java programming language which was originally named "Oak". Java is a technology where in that technology includes java as a programming language that has syntax and programming rules itself, also includes Java as a platform where this technology has a virtual machine and libraries needed to write and run programs written in the language Java programming, the biggest reason for making Java programming language is desire will form a programming language that can run on various devices without having to bound by the platform, so Java is portable and platform independent machine or operating system[13].

4.8 MySQL

In this study, the authors apply MYSQL as a database. MySQL is a Database Management System (DBMS) that uses Structured Query Language commands (SQL), widely used today in making web-based applications. MySQL can run on almost all platforms, including Linux, Mac OS, and Windows. Even though you can use it in various applications, MySQL is often associated with web applications and publishing online. MySQL is divided into two licenses, the first is Free Software where software can be accessed by anyone and the second is Shareware where the software has limitations in its use. MySQL is included in the Relational Database Management System (RDBMS) so that it uses a table, column, and row components in its database structure.

5. PROBLEM ANALYSIS

System analysis is part of the research stage in system design that is carried out and has the aim of outlining needs and finding problems that may occur in the system, this facilitates the process of designing the latest system and modifying the existing system, by fulfilling the requirements in designing the system. In this study. In this study, the problem to be analyzed is how to overcome the many people who are still laying and underestimate the impact of diabetes Mellitus, without them knowing Diabetes Mellitus is a disease that must be considered, because it can cause death slowly, especially in the elderly and pregnant women. So to overcome this problem, a system was built that can help the community to diagnose Diabetes Mellitus by using the method of Forward Chaining (FC) and Backward Chaining (BC) based on data from facts or symptoms as well as complaints. Identification of problems in this study will use the Ishikawa diagram, Ishikawa diagram is a method of identifying problems from various kinds of causes that are made in the form of symbols (diagrams).

6. IMPLEMENTATION AND TESTING

System implementation is the implementation and testing of systems that are carried out together based on the results and designs that have been made in chapter 3. To find out whether the system that has been designed can run or operate normally, therefore it is necessary for system testing has been completed. In this study, the system was built using JAVA and MYSQL programming languages as a database management system (DBMS). The implementation of an expert system to diagnose Diabetes Mellitus consists of several steps menus and pages. Here's the explanation:

6.1 Main page

The main menu is the page that is first displayed to the user when the system is run, where on this page there are four menus displayed, namely "Menu Diagnosis", "Maintenance Menu", "Expert Login Menu" and lastly there is an "About menu Application".

6.2 Diagnosis Page

This page will be displayed when the user selects the "Disease Diagnosis" menu for Diabetes mellitus. On this diagnostic page, the user will answer several questions question the symptoms of the disease according to what they are experiencing, after the user answers the question then the system will display the results of the diagnostics that have been carried out.

6.3 Care Page

This treatment page will be displayed when the user selects the menu "Diabetes Mellitus Treatment" In this menu, the user will be presented with a display in the form of a choice of disease type Diabetes Mellitus and must answer several questions according to the complaints they experience. After the user answers a few questions, the system will display the results of the Search in the maintenance menu, the system will display output in the form of results and solutions as well as recommendations that can be done by people with Diabetes Mellitus.

6.4 Expert Login Page

This expert login page can only be used by diabetes experts or doctors with Mellitus, when the expert runs the system and selects the "Expert Login" Menu then the system will display a display that says "Enter PIN" after the expert enters the PIN and the PIN is correct then the system can be run, in this menu the expert can make changes to the data in the system.

6.5 About Page

This about page will be displayed when the user selects the "About" menu on the page this information contains an explanation of Diabetes Mellitus and the author's history.

7. SYSTEM TEST RESULTS

Here are the results of testing the diagnostic system based on the comparison of the results of the conclusion data Diabetes Mellitus, a comparison was made between the diagnoses made by experts and diagnoses carried out with the system, the data used in this test are: there are 50 data for diagnosis and 50 data for treatment, so the total number of data is as many as 100 data. The results of the comparison test are shown in Table 1:

Table 1. Test Results Diagnostic System

Patient	Expert Diagnostic	System Diagnostic	Result
Patient 1	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 2	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 3	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 4	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 5	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 6	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 7	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 8	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 9	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 10	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 11	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 12	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 13	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 14	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 15	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 16	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 17	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 18	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 19	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 20	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 21	*Diabetes Type* Gesrtational	*Diabetes Type* Gestational	Matching
Patient 22	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 23	*Diabetes Type* 2	*Diabetes Type 2*	Matching
Patient 24	*Diabetes Type* 1	*Diabetes Type* 1	Matching
Patient 25	*Diabetes Type* 2	*Diabetes Type 2*	Matching

Patient 26	*Diabetes Type* Gesrtational	*Diabetes Type* Gestational	Matching
Patient 27	*Diabetes Type*	*Diabetes Type*	Matching
Patient 28	*Diabetes Type*	*Diabetes Type*	Matching
Patient 29	*Diabetes Type*	*Diabetes Type*	Matching
Patient 30	*Diabetes Type*	*Diabetes Type*	Matching
Patient 31	*Diabetes Type*	*Diabetes Type*	Matching
Patient 32	*Diabetes Type* Gesrtational	*Diabetes Type* Gestational	Matching
Patient 33	*Diabetes Type*	*Diabetes Type*	Matching
Patient 34	*Diabetes Type*	*Diabetes Type*	Matching
Patient 35	*Diabetes Type*	*Diabetes Type*	Matching
Patient 36	*Diabetes Type*	*Diabetes Type*	Matching
Patient 37	*Diabetes Type*	*Diabetes Type*	Matching
Patient 38	*Diabetes Type*	*Diabetes Type*	Matching
Patient 39	*Diabetes Type*	*Diabetes Type*	Matching
Patient 40	*Diabetes Type*	*Diabetes Type*	Matching
Patient 41	*Diabetes Type*	*Diabetes Type*	Matching
Patient 42	*Diabetes Type* Gesrtational	*Diabetes Type* Gestational	Matching
Patient 43	*Diabetes Type*	*Diabetes Type*	Matching
Patient 44	*Diabetes Type*	*Diabetes Type*	Matching
Patient 45	*Diabetes Type*	*Diabetes Type*	Matching
Patient 46	*Diabetes Type*	*Diabetes Type*	Matching
Patient 47	*Diabetes Type*	*Diabetes Type*	Matching
Patient 48	*Diabetes Type* Gesrtational	*Diabetes Type* Gestational	Matching
Patient 49	*Diabetes Type*	*Diabetes Type*	Matching
Patient 50	*Diabetes Type*	*Diabetes Type*	Matching

Based on table 1, all data match the results of expert test data and system results. Then the level of accuracy of this system is 100%. The results of this study succeeded in increasing the accuracy of previous studies, namely from 90% to 100%.

8. CONCLUSION

8.1 Conclusion

In this research, after analyzing, designing, testing the system, and Implementation of Forward Chaining and Backward Chaining Algorithms to diagnose diseases Diabetes mellitus. In this study, the researchers obtained several conclusions, including, Forward Chaining and Backward Chaining algorithms can be implemented by the system experts as a method in system development. The data used in this test are 50 data for diagnosis and 50 data for treatment, so the total data is as many as 100. The results of the comparison test all data match the results of expert test data and system results. Then the level of accuracy of this system is 100%. The results of this study succeeded in increasing the accuracy of previous studies, namely from 90% to 100%.

8.2 Future Research

Based on the research that the researchers have done in this study, there are several suggestions for further development of this system, namely, the system is developed in various types of hardware and other operating systems to make it more accessible to users. Then the system built in the future can be developed by adding features for doctors and patients so that they can directly communicate in the application system.

REFERENCES

[1]. S. Islam Ayon and M. Milon Islam, “Diabetes Prediction: A Deep Learning Approach,” Int. J. Inf. Eng. Electron. Bus., vol. 11, no. 2, pp. 21–27, 2019, doi: 10.5815/ijieeb.2019.02.03

[2]. R. Isnanto, D. Eridani, and S. S. Y. W. Simbolon, “Expert System for Diabetes Mellitus Detection and Handling Using Certainty Factor on Android-Based Mobile Device,” Int. J. Heal. Med. Sci., vol. 4, no. 2, pp. 28–39, 2018, doi: 10.20469/ijhms.40001-2.

[3]. H. K. Wardana, I. Ummah, and L. A. Fitriyah, “Mamdani Fuzzy Inference System (FIS) for Early Diagnosis of Diabetes Mellitus (DM) and Calorie Needs,” vol. 196,

no. Ijcse, pp. 387–394, 2020, doi: 10.2991/aer.k.201124.070.

[4]. P. S. K. Patra, D. P. Sahu, and I. Mandal, "An Expert System for Diagnosis of Human Diseases," Int. J. Comput. Appl., vol. 1, no. 13, pp. 71–74, 2010, doi: 10.5120/279-439.
H. Saleem, A. R. Khan, and T. A. Jilani, "Expert System for Diagnosing Mobile and Immobile Nutrients Deficiency of Plants," Int. J. Acad. Inf. Syst. Res., vol. 4, no. 8, pp. 10–15, 2020.

[5]. M. Mirmozaffari, "Presenting an expert system for early diagnosis of gastrointestinal diseases," Int. J. Gastroenterol. Sci., vol. 1, no. 1, pp. 21–27, 2020.

[6]. H. Noviyarto and Y. S. Sari, "Analysis And Design Expert System To Identify Injuries Because Of Sports," Int. Educ. J. Sci. …, pp. 1–6, 2019, [Online]. Available: http://iejse.com/journal/index.php/iejse/article/view/45.

[7]. S. P. Leo Kumar, "Knowledge-based expert system in manufacturing planning: state-of-the-art review," Int. J. Prod. Res., vol. 57, no. 15–16, pp. 4766–4790, 2019, doi: 10.1080/00207543.2018.1424372.

[8]. R. R. Al-Hakim, E. Rusdi, and M. A. Setiawan, "Android Based Expert System Application for Diagnosing COVID-19 Disease: Cases Study of Banyumas Regency," J. Intell. Comput. Heal. Informatics, vol. 1, no. 2, p. 26, 2020, doi: 10.26714/jichi.v1i2.5958.

[9]. H. A. et Al, "EXPERT SYSTEMS WITH GENETICS PROBABILITY," Expert Syst. WITH Genet. Probab., vol. 3, no. 2, pp. 2394–8299, 2017, doi: 10.1016/j.eswa.2004.10.010.

[10]. B. Herawan Hayadi, A. Bastian, K. Rukun, N. Jalinus, Y. Lizar, and A. Guci, "Expert system in the application of learning models with Forward Chaining Method," Int. J. Eng. Technol., vol. 7, no. 2.29 Special Issue 29, pp. 845–848, 2018, doi: 10.14419/ijet.v7i2.29.14269.

[11]. T. K. Darsih and E. L. S. Lubis, "The Development of Android-Based Learning Media for Basic Accounting Subjects for Class X AKL at Al Ikhlas Vocational High School, Pangkalan Susu, Langkat Regency," Budapest Int. Res. Critics Institute-Journal, vol. 4, no. 3, pp. 6219–6230, 2021, [Online]. Available: http://www.bircu-journal.com/index.php/birci/article/view/2430.

[12]. Mufadhol, M., Hartono, B., Sulartopo, S., Dewi, M. U., Danang, D., & Aryotejo, G. (2021). The calculation of point quantity for lighting based on android OS using ionic framework and rule-based expert system. Bulletin of Electrical Engineering and Informatics, 10(6), 3444-3451.

[13]. Mardiyanto, M., Fahmi, F., & Satria, F. (2021). Expert System For Diagnosing Diseases In Betta Fish Based On Android. International Journal of Artificial Intelligence and Robotic Technology, 1(2), 35-44.

[14]. Zofishan, M., Islam, K. A., & Ghazal, F. (2021). Machine Learning Based Cloud Music Application With Facial Recognition Using Android Studio (Musync). American International Journal of Sciences and Engineering Research, 4(1), 36-52.