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Analysis and Design of Disease Diagnosis Systems and Patient Medicine Recommendations with Forward Chaining Method

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Abstract

Technological developments have had a significant impact on many aspects of life, one of which is patient care in hospitals. Apart from using technology in patient care, technology also provides access to effective and efficient information storage and management to record patient data for treatment purposes. In outpatient services at hospitals, there are often complaints from employees regarding the health recording system which is less than optimal. Therefore, a system that manages disease diagnoses and patient treatment recommendations is something that needs to be developed, with the hope of speeding up the performance of medical personnel, so that they can help more patients who need help. The application system design aims to help manage information related to disease diagnosis and patient drug recommendations, where this system uses Forward Chaining to assist users in identifying diseases and prescribing drugs according to the diagnosis the patient is complaining about. By using the Forward Chaining methodology, medical personnel are able to obtain patient diagnosis results more quickly. The result is an application that can help medical personnel in serving outpatients from registration, examination, to exchanging medicines. This application has been tested using black-box testing involving several respondents, where respondents can feel that this application works well and helps hospital staff in examining patients.

I. INTRODUCTION

The role of technology and information can be felt in various aspects of our lives. Starting from daily activities to the business activities of a company. The public has been eagerly waiting advances in technology and information in the health sector. Running a hospital business unit cannot be separated from the use of technology and information. This is also regulated in the 2019 Minister of Health Regulation [1], where it is necessary to manage information which can be used at any time in the future. According to Minister of Health Regulation [2] in 2022, the government requires data to be managed in such a way as to produce data that is accurate, up-to-date, integrated and accountable, and easily accessible and disseminated to the public by central and regional institutions. There are many things that can be achieved by information systems, for example: tidying up patient data, personal biographical data on patient health, as well as administering medicines, and also the security of information data held by patients that creates confidence in the hospital. Examples of the application of technology and information in hospitals are managing information on patients being treated, diagnosing disease, and providing treatment recommendations based on the results of the patient's disease diagnosis. In general, patient registration can be done online, however, further improvement can be applied to achieve a better patient service, especially in the outpatient examination section. Expert System is a system that tries to adopt the knowledge of an expert, which will help draw conclusions like an expert [3]. The expert system can be adapted into parts of the application, which can help medical personnel detect diseases faster. It is hoped that with the help of the new application that will be implemented in hospitals, the time required to receive patient diagnosis results could be

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decreased. Thus, medical personnel are able to serve more outpatients who need treatment and obtain a level of satisfaction from patients and the community.

II. METHODS

A. *Expert System*

According to Giarratano and Riley [4], expert systems are one branch of Artificial Intelligence that specifically uses knowledge to solve problems at the expert level. An application can be said to contain an expert system, if the application can adopt the knowledge of an expert into the computer, so that it is capable of modeling problem capabilities and providing solutions like experts [5]. A good expert system should have the following characteristics [6]:

1) Useful, the system should be developed according to needs.
2) Can be used, the system should be designed so that users who are still new to it can easily use it.
3) Educational, expert systems can be used by non-expert users who are expected to improve their expertise by using such expert systems.
4) Can explain the results of suggestions, the expert system can explain the reasoning behind the advice given by the system.
5) Using heuristic methods, this method is used to narrow down the search area.

In this study, an expert system was used to assist medical personnel in identifying what diseases suffered by patients, based on what diagnoses were experienced by patients and had been confirmed by medical personnel. With the help of an expert system, it is expected to be a tool for medical personnel to examine patients faster without reducing the accuracy of the examination.

B. *Forward Chaining*

According to Carolina and Adi [7], Forward Chaining is a search method, where the search process is carried out by tracking forward, allowing a process to start from collecting previously available information, then combine it with rules that have been designed to get results in the form of conclusions.

According to Rofiqoh et al [8], the Forward Chaining algorithm is one of the main reasoning methods when using decision-making machines, and can be described as a repeating application of modus ponens (a set of inference rules and valid arguments). Here are the steps to take when creating an expert system using the Forward Chaining method [9]:

1) Defining the problem, this stage begins with domain selection and knowledge acquisition.
2) Defining input data, where the Forward Chaining algorithm requires initial data before starting inference.
3) Defining the structure of application data control, which requires additional premises to help control the activation of a rule.
4) Initial code writing to ensure effective capture of knowledge domains within a regulated rule structure.
5) Test the system with some example rules in the hope that the system runs correctly.
6) Design of interfaces built according to the knowledge base.
7) System development by adding interfaces and knowledge as designed.
8) Evaluate the system by testing using real problems.

The choice of the Forward Chaining method used in this study is with the consideration, that the concept of Forward Chaining which starts from reasoning facts towards an end goal, can be represented as diagnoses suffered by patients caused by a disease.

C. *Waterfall*

According to Irwanto [10], the Waterfall method is a description of the development of a model, where this model presents the process of software life rules with a sequential system, starting from the process of analysis, design, software development, testing, to supporting parts.

The Waterfall method can be said to be the earliest SDLC (System Development Life Cycle) approach to software development, where systems that use SDLC when built are expected to make it easier to identify problems and design systems according to the needs of users and solve problems arising from these needs [11]. The stages in this method are:

1) Requirements Analysis and Definition
2) System and Software Design
3) Implementation and Unit Testing
4) Integration and System Testing
5) Operation and Maintenance

D. *Black-box Testing*

According to Wijaya and Astuti [12], black box testing is the quality testing of a piece of software, which focuses on the functionality of the software; tests for malfunctions of software, interfaces, data structures, performance, as well as initialization and termination.

Meanwhile, according to Abdi and Nursari [13], black box testing is a method that relies on testing software functions, which interprets the set of input conditions and tests the function of the software by analyzing the output results.

E. *Technology Acceptance Model*

According to Wibowo [14], Technology Acceptance Model (TAM) is a method that explains in detail, how there are various factors that can affect how a user can accept and adapt to an information technology. The Technology Acceptance Model (TAM) itself has several constructs in running this method, namely [15]:

1) *Perceived ease of use*
   In measuring technology acceptance, this category is defined as a measure of how confident users are in the ease with which the system can be understood and used. Users are expected to experience a reduction in the effort required in carrying out their duties when using the system.
2) *Perceived usefulness*
   Defined as a measure of how useful it is to users when using the application. Usually measured by indicators such as improved performance, ease of work, and benefits provided by technology as a whole.
3) *Attitude toward using*
   Defined as a measure of the attitude of a user when using the application, whether in the form of acceptance or rejection.
4) *Behavioral intention to use*
   Defined as a measure of a user's propensity after using the application; whether the user will reuse it, the desire to recommend the application to others, and the desire to add additional peripherals to support the performance of the application.
5) *Actual system use*
   Defined as measures in actual usage during direct application implementation, such as duration of use, usage procedures, and external responses from users.

The use of the Technology Acceptance Model method is to consider that in this study, what is tested is a system. The TAM method itself is quite familiar in system testing circles, and understanding in designing the statements used in questionnaires can be fairly easy to understand.

III. RESULTS

A. *Elicitation of Needs*

The study was conducted at Medika Lestari Hospital, where interviews were conducted with several resource persons, namely an IT expert, a nurse, and a doctor. After the interview, the elicitation of needs for the hospital was obtained, and the results of the elicitation process are as listed in Table 1.

TABLE 1
ELICITATION LIST TABLE

	Elicitation of Needs
No	**I want to:**
1	When performing a diagnosis on a patient, the system can display all possible diagnoses.
2	When diagnosing a patient, the system can display other possible diagnoses, according to the disease suffered.
3	When diagnosing patients, the system can display supporting examinations.
4	When diagnosing patients, nurses are given input to enter nursing diagnoses, (such as checking height, weight, blood pressure, and so on).
5	When filling out a patient complaint, a nursing diagnosis (such as BMI) is immediately displayed.
6	Master Data can only be accessed by the selected user.
7	Master data can be accounted for its contents.
8	The system can import Master Data from an existing hospital system.

B. *Forward Chaining Method*

In the application of the expert system, a knowledge base is needed provided by an expert, in this study is a doctor. This knowledge base contains a list of diagnoses, a list of diseases, and a decision table that links those diagnoses to the disease corresponding to that diagnosis. Based on the results of the interview, the knowledge base depicted in the Tabel 2, Table 3, and Table 4.

Tabel 2
DIAGNOSIS LIST TABLE

Diagnosis Code	Diagnosis Name
KG001	Weight Higher than Normal
KG002	Weight Average
KG003	Weight Lower than Normal
KG004	High Blood Pressure
KG005	Average Blood Pressure
KG006	Low Blood Pressure
KG007	Normal Oxygen Saturation
KG008	Low Oxygen Saturation
KG009	High Body Temperature
KG010	Normal Body Temperature
KG011	Low Body Temperature
KG012	Limp
KG013	Night Urination
KG014	Wounds are Difficult to Heal
KG015	Headache
KG016	Coughs
KG017	Cough for an Extended Time
KG018	Night Sweats
KG019	Abdominal pain
KG020	Nausea and Vomiting
KG021	Nosebleed
KG022	Red Spots

Table 2 illustrates how diagnosis list data is stored in a database. This data is entered based on the diagnoses commonly experienced by patients who consult a doctor.

TABLE 3.
TABLE OF DISEASES LIST

Disease Code	Disease Name	Explanation
KP001	Diabetes	Is a common type of disease caused by a high sugar content in the blood.
KP002	Hypertension	Is a type of disease where blood pressure is higher than normal.
KP003	TBC	Tuberculosis, is a lung disease caused by the Mycobacterium Tuberculosis virus.
KP004	Tifus	Referred to as typhoid fever, is a disease caused by infection with the bacterium Salmonella Typhi.
KP005	DBD	Dengue fever, is a disease transmitted through mosquitoes, and is common in tropical and subtropical regions.

Table 3 illustrates how disease list data is stored in a database. This data is entered based on the diseases suffered by the patient, identified by the doctor at the time of consultation.

TABLE 4.
DECISION TABLE

Diagnosis	Diseases				
	Diabetes	**Hypertension**	**TBC**	**Tifus**	**DBD**
Weight Higher than Normal					
Weight Average		x		x	x
Weight Lower than Normal	x		x		
High Blood Pressure	x	x			
Average Blood Pressure			x	x	x
Low Blood Pressure					
Normal Oxygen Saturation	x	x	x	x	x
Low Oxygen Saturation					
High Body Temperature			x	x	x
Normal Body Temperature	x	x			
Low Body Temperature					
Limp	x	x		x	x
Night Urination	x				
Wounds are Difficult to Heal	x				
Headache		x		x	x
Coughs					
Cough for an Extended Time			x		
Night Sweats			x		
Abdominal pain				x	
Nausea and Vomiting				x	x
Nosebleed					x
Red Spots					x

Table 4 illustrates how the diagnosis list relates to the disease list in a database. This data is included based on diagnoses associated with a particular disease, as well as explaining what diagnoses patients can experience when exposed to a disease. Then this table is being drawn into a diagram based on Forward Chaining method, that being illustrated by Figure 1.

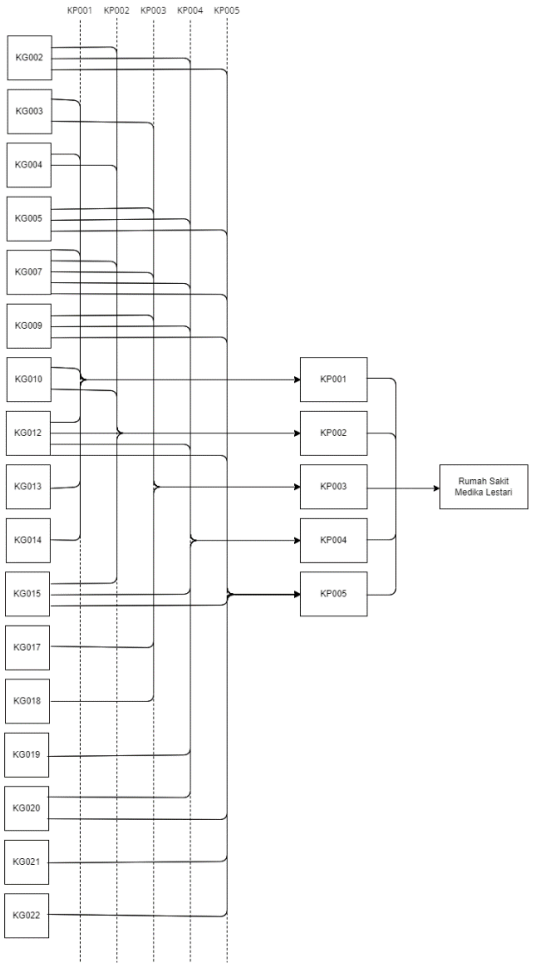

Fig 1. Forward Chaining Method Diagram

In the system to be designed, the application of Forward Chaining as an expert system method is on the menu when the doctor examines the patient;

a. The doctor (assisted by the nurse) starts by checking the vital signs of the patient being consulted. These vital signs are weight, height, blood pressure, oxygen saturation, and body temperature of the patient. The results of the vital signs examination are entered into the system.
b. Then the doctor began to ask what are the complaints suffered by the patient. Complaints that have been confirmed by the doctor are then entered into the system.
c. Then the doctor began to ask what are the complaints suffered by the patient. Complaints that have been confirmed by the doctor are then entered into the system as diagnoses.
d. If there is only one possible disease left related to the results of the examination, then the system will provide the doctor with the results of what disease the patient has, as well as medicine recommendations for the disease.

C. System Design

After the system design stage is carried out in accordance with the elicitation of needs and knowledge base obtained from the resource persons, the following are the results of hospital application design using Forward Chaining as an expert system method:

a. Waitlist Display
This page displays a list of patients on the waiting list, containing details such as the patient's name, doctor's name and referral poly. From this page, doctors can access the diagnosis results input page. The final design for the Waitlist Display can be seen in Figure 2.

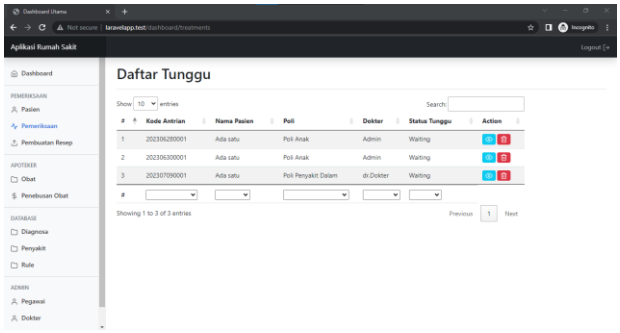

Fig 2. Waitlist View

b. Display of Diagnostic Results Input
This page is a page filled in by doctors to record the results of the patient's diagnosis. On this page there is also a section entering the diagnosis experienced by the patient which then the system will display the disease suffered based on these diagnoses. The final design for the Diagnostic Results Input can be seen in Figure 3.

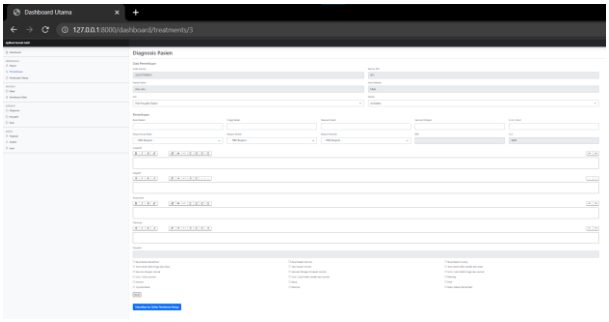

Fig 3. Diagnostic Input Display

c. List View of Patient Examination Results
This page displays a list of the results of the diagnosis that has been made by the doctor on the patient. This page is also used to select the results of the diagnosis that want to be prescribed by a doctor. The final design for the Patient Examination Results Input can be seen in Figure 4.

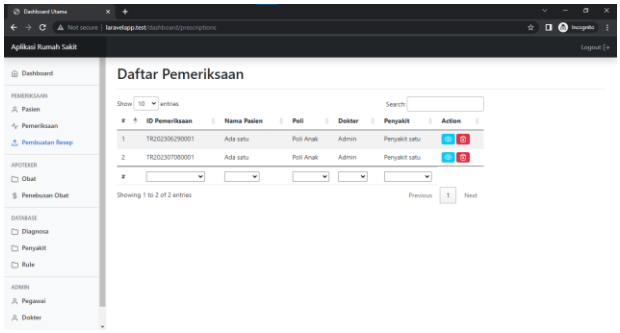

Fig 4. List View of Patient Examination Results

IV. DISCUSSION

The system that has been developed in accordance with the elicitation of needs is then tested by involving respondents, through questionnaires designed with the principle of the TAM method [15]. Respondents were selected based on their position in the hospital where the study was conducted, as well as their involvement in patient care. Here is a list of statements used in the questionnaire listed in table 5.

TABLE 5.

TABLE LIST OF STATEMENTS BY INDICATOR

Variable	No.	Statements
Perceived Ease of Use	1	I don't find it difficult when using this information system.
	2	With this information system, I can achieve the purpose of my work in serving patients.
	3	Overall, I feel that this information system is easy to understand.
Perceived Usefulness	1	This information system makes it easier for me to serve patients.
	2	By using this information system, I can serve patients faster than ever before.
	3	Overall, I feel that this information system provides benefits for me.
Attitude towards using	1	I feel that this system can be used in Medika Lestari Hospital.
	2	There is nothing significant in this information system, which causes me to dislike in using it.
	3	This system is convenient when I use it.
Behavioral Intention to Use	1	I feel that I can continue to use this system in the future.
	2	I feel that I can use this system in various conditions.
Actual System Use	1	This information system is in accordance with the procedures already in place at Medika Lestari Hospital.
	2	I feel that I can use this system in full working time.

The results of the questionnaire that have been distributed to respondents are then processed using SmartPLS to test the hypothesis used in TAM. The following is an overview of the relationship between variables according to the hypothesis used in the TAM method, illustrated by Figure 5 [14].

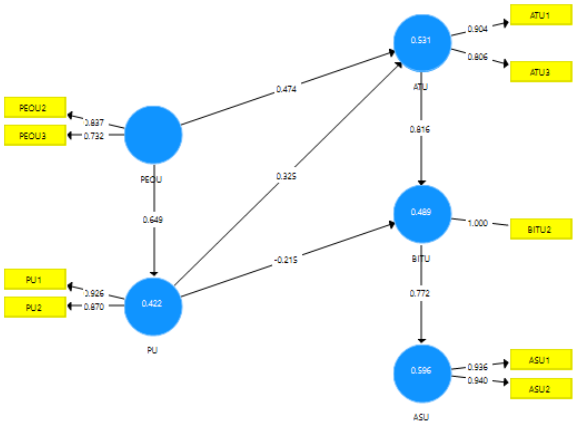

Fig 5. Diagram Results

In comparing between the results of the hypothesis proposed by TAM and the results of the questionnaire, it can be concluded that:

1) The hypothesis proposed by TAM can be used in the design of disease diagnosis systems and patient medicine recommendations.
2) Based on the results of the questionnaire, only the PU variable has a negative relationship with the TU variable, so it can be said that based on this study, the PU variable and the BITU variable do not really affect each other.

As for the result of this study, there are some points that can be taken:

1) The system designed can draw conclusions in the form of diseases suffered and medicines recommendations for the disease, using the Forward Chaining method based on diagnoses inputted into the system, with the decision table as the rule.
2) The system designed using an expert system was accepted by respondents, where respondents considered that the expert system could help medical personnel in serving outpatients faster.

In this study, there are several things that need to be considered, based on the inputs from the respondents:

1) Added new features that can later accommodate other parts of the hospital, such as Inpatient and Emergency Installation. This is due to the focus of this study, which is outpatient, so the system that has been designed only focuses on the outpatient system carried out in the hospital.
2) Consider the increase in the possibility of disease suffered by the patient, considering that patients can experience more than one disease or complication. This was expressed mainly by respondents who were doctors, where they believed that patients could contract more than one type of disease.
3) Added features that are able to handle payment methods using insurance services owned by patients. This was confirmed by respondents in charge of serving patient registration, where they argued that each insurance service tends to have different insurance application system.

V. CONCLUSIONS

Based on this study, it can be concluded that expert systems can assist medical personnel in serving patients related to diagnosis, disease, and medicine recommendations, using the Forward Chaining method (60% said they agree that this system is procedural and can serve more patients). This system is also considered to be able to identify the patient's disease with an expert system in accordance with the rules that have been entered by the doctor.

Some things that need to be considered for future research are as follows: adding new features that can later accommodate other parts of the Hospital, such as Inpatient and Emergency Department; consider the increase in the possibility of illness suffered by the patient, considering that the patient can experience more than one disease or complication; adding a feature that handles the insurance part at the time of redeeming the medicine.

REFERENCES

[1] Peraturan Menteri Kesehatan RI, *Peraturan Menteri Kesehatan Nomor 37 Tahun 2019 tentang Pedoman Pengelolaan Informasi Publik di Lingkungan Kementerian Kesehatan*. 2019. [Online]. Available: https://peraturan.bpk.go.id/Home/Details/138630/permenkes-no-37-tahun-2019

[2] Peraturan Menteri Kesehatan RI, *Peraturan Menteri Kesehatan Republik Indonesia Nomor 18 Tahun 2022 tentang Penyelenggaraan Satu Data Bidang Kesehatan Melalui Sistem Informasi Kesehatan*. 2022. [Online]. Available: https://yankes.kemkes.go.id/unduhan/fileunduhan_1662610931_564143.pdf

[3] J. D. Fitriana, B. Prasetiyo, and R. Arifudin, "Expert System Diagnosis of Urinary System Diseases using Forward Chaining and Dempster Shafer," *Sci. J. Informatics*, vol. 7, no. 1, pp. 143–152, 2020, doi: https://doi.org/10.15294/sji.v7i1.22400.

[4] M. C. Sanjaya and A. Z. Falani, "Sistem Pakar Untuk Menentukan Paket Layanan Tv Kabel Dan Internet Sesuai Dengan Budget Menggunakan Metode Forward Chaining," *U-NET J. Tek. Inform.*, vol. 5, 2021, [Online]. Available: https://ejurnal.univalabuhanbatu.ac.id/index.php/u-net/article/view/335

[5] N. Ahmad and Iskandar, "Metode Forward Chaining untuk Deteksi Penyakit Pada Tanaman Kentang," *J. Inf. Technol.*, vol. 1, 2020, [Online]. Available: https://journal.ar-raniry.ac.id/index.php/jintech/article/view/592

[6] I. Gupta and G. Nagpal, *Artificial Intelligence and Expert Systems*. Dulles: Mercury Learning and Information, 2020.

[7] M. Sidik, B. Gunawan, and D. Anggraini, "Pembuatan Aplikasi Chatbot Kolektor dengan Metode Extreme Programming dan Strategi Forward Chaining," *J. Teknol. Inf. dan Ilmu Komput.*, vol. 8, no. 2, pp. 293–302, Mar. 2021, doi: 10.25126/jtiik.2021824298.

[8] S. Rofiqoh, D. Kurniadi, and A. Riansyah, "Sistem Pakar Menggunakan Metode Forward Chaining untuk Diagnosa Penyakit Tanaman Karet," *Sultan Agung Fundam. Res. J.*, vol. 1, 2020, [Online]. Available: http://jurnal.unissula.ac.id/index.php/safrj/article/view/7772

[9] T. Sugihartono, R. R. C. Putra, and D. Ardiansyah, "Penerapan Aplikasi Diagnosa Penyakit Jantung menggunakan Algoritma Forward Chaining Berbasis Mobile," *J. Inform.*, vol. 19, no. 2, 2019, [Online]. Available: https://jurnal.darmajaya.ac.id/index.php/JurnalInformatika/article/view/1523

[10] A. Nurseptaji, A. Arey, F. Andini, and Y. Ramdhani, "Implementasi Metode Waterfall pada Perancangan Sistem Informasi Perpustakaan," *J. Dialekt. Inform.*, vol. 1, no. 2, pp. 49–57, 2021, doi: 10.24176/detika.v1i2.6101.

[11] D. Mallisza, H. S. Hadi, and A. T. Aulia, "Implementasi Model Waterfall Dalam Perancangan Sistem Surat Perintah Perjalanan Dinas Berbasis Website Dengan Metode SDLC," *J. Tek. Komputer, Agroteknologi dan Sains*, vol. 1, 2022, doi: 10.56248.

[12] Y. D. Wijaya and M. W. Astuti, "Pengujian Blackbox Sistem Informasi Penilaian Kinerja Karyawan PT INKA (Persero) Berbasis Equivalence Partitions," *J. Digit. Teknol. Inf.*, vol. 4, no. 1, pp. 21–26, 2021,

doi: https://doi.org/10.32502/digital.v4i1.3163.

[13] N. F. Abdi and S. R. C. Nursari, "Pengujian Black Box pada Website dengan Metode Robustness Testing (Studi Kasus : Eiger Adventure)," *J. Informatics Adv. Comput.*, vol. 3, no. 2, pp. 93–96, 2022, [Online]. Available: https://journal.univpancasila.ac.id/index.php/jiac/article/view/4410

[14] K. D. P. Novianti, N. K. W. L. Putri, and I. A. G. W. Purnamayanti, "Analisis Penerimaan Sistem Informasi Menggunakan Technology Acceptance Model (Studi Kasus : SIJALAK Desa Pohsanten)," *Inser. Inf. Syst. Emerg. Technol. J.*, vol. 2, no. 2, pp. 113–125, 2021, doi: 10.23887/insert.v2i2.43135.

[15] A. Rahmawati, D. Novita, and I. Pradesan, "Perancangan Kuesioner Analisis Penerimaan E-Tax Menggunakan Technology Acceptance Model (TAM)," *MDP Student Conf.*, vol. 1, no. 1, pp. 512–517, 2022, [Online]. Available: https://jurnal.mdp.ac.id/index.php/msc/article/view/1848