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PREFACE

We would like to present, with great pleasure, the third issue of Matrix: Jurnal Manajemen Teknologi dan Informatika in Volume 11, 2021. This journal is under the management of Scientific Publication, Research and Community Service Center, Politeknik Negeri Bali and is devoted to cover the field of technology and informatics management including managing the rapid changes in information technology, emerging advances in electrical and electronics and new applications, implications of digital convergence and growth of electronics technology, and project management in electrical, mechanical or civil engineering. The scientific articles published in this edition were written by researchers from Universitas Bumigora, Institut Shanti Bhuana, Politeknik Negeri Malang, Politeknik Unggul LP3M, Universitas Katolik Musi Charitas, Universitas Indonesia, Politeknik Negeri Bali, and Universitas Budi Luhur Jakarta. All articles cover topics in the field of Information Management, including Optimization of Data Integration Using Schema Matching of Linguistic-based and Constraint-based in the University Database, Implementation of Multimarker Augmented Reality on Solar System Simulations, Application Design to Help Predict Market Demand Using The Waterfall Method, Implementation of Human-centered Design Methods in Designing Application Interfaces for Nursing Home Service, Komodo National Park Fiber Optic Network Design and Analysis by Considering Earthquake Epicentre, The Object Detection System of Balinese Script on Traditional Balinese Manuscript with Findcontours Method, Designing An Early Flood Detection System Prototype in Riverbank Settlements. Finally, we would like to thank reviewers for their efforts and hard work in conducting series of review phase thoroughly based on their expertise. It is our hope that the work of the authors in this issue will be a valuable resource for other researchers and will stimulate further research into the vibrant area of technology and information management in specific, and engineering in general.

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Editor-in-chief

Gusti Nyoman Ayu Sukerti, S.S., M.Hum.

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Optimization of data integration using schema matching of linguistic-based and constraint-based in the university database

Rifqi Hammad[1]*, Azriel Christian Nurcahyo[2], Ahmad Zuli Amrullah[3], Pahrul Irfan[4], Kurniadin Abd Latif[5]

[1,3,4,5] *Bumigora University, Indonesia*
[2] *Shanti Bhuana Institute, Indonesia*

*****Corresponding Author: *rifqi.hammad@universitasbumigora.ac.id*

Abstract: University requires the integration of data from one system with other systems as needed. This is because there are still many processes to input the same data but with different information systems. The application of data integration generally has several obstacles, one of which is due to the diversity of databases used by each information system. Schema matching is one method that can be used to overcome data integration problems caused by database diversity. The schema matching method used in this research is linguistic and constraint. The results of the matching scheme are used as material for optimizing data integration at the database level. The optimization process shows a change in the number of tables and attributes in the database that is a decrease in the number of tables by 13 tables and 492 attributes. The changes were caused by some tables and attributes were omitted and normalized. This research shows that after optimization, data integration becomes better because the data was connected and used by other systems has increased by 46.67% from the previous amount. This causes the same data entry on different systems can be reduced and also data inconsistencies caused by duplication of data on different systems can be minimized.

Keywords: university, data integration, schema matching, linguistic, constraint

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Introduction

The use of information technology currently plays an important role in the success of an organization. Digital information storage can assist organizations in accessing information and processing it quickly [1]. One form of the use of information technology is the use of information systems for various organizational activities. Technology plays a role in demanding organizations have information systems that can support management in decision making [2]. Information systems that are supported by integrated data can produce useful information for their users [1]. Data integration is a process carried out to combine data from various sources to support information management [3]. Data integration is one of the things needed to support the planning and development of an organization that will provide added value in competition with competitors. The implementation of integration will provide benefits if the application follows the goals, vision, mission of the organization, and also the strategies that have been determined to align the information system strategy and business strategy [4]. This data integration is needed because with the development of an organization the information needed also develops so that there is some data and information needed from different divisions or units [5]. Data or information needs that are different require the existence of data integration between each division following the needs.

Higher education is one of the institutions that use information systems to achieve their goals. However, most of these information systems are not integrated, it can be seen from the discovery of the same data entry process in different information systems [6]. Such as the re-registration process, students enter the same data as the data that was previously entered into

the registration system, students must register various information systems to get Wi-Fi access, get an email account, access the library, etc. This can cause data duplication and data redundancy. Data duplication can cause data inconsistency [1] and also take up space in the database where it can be used to store other data. Data duplication is caused by the process of entering the same data in different information systems where the process can allow data inconsistencies to occur. This means that the data is the same but it is not consistent so it might be considered different. The impact of the inconsistency of the data is that it can cause discrepancies in the information generated that can be detrimental to those who need the information.

Data integration can solve these problems and reduce the occurrence of data redundancy because data integration can make a relationship where data in an information system can be used on other systems to facilitate the process of sharing data used to support data and information management [7]. In the application of data integration in general there are several obstacles, one of which is the diversity of database schemes used [8]. The diversity of this scheme occurs because the amount of information stored in the database continues to grow, this causes the need for the information to be stored in several different databases, and database integration is a very important aspect in maintaining consistency between these databases on an ongoing basis [9].

In the process of data integration, it is necessary to match the schema of several relationships between the data with each other [10]. Schema matching is one method that can be used to overcome data integration problems caused by database diversity. Schema matching is an important thing and requires sufficient time in the data integration process [11]. Schema matching is used to detect relationships and similarities between elements of two or more schemes [12]. Schema matching has an important role in applications that require interoperability between diverse data sources [13]. Research related to schema matching was conducted by Rachman and Saptawati. The research shows that database integration problems can be solved by using a hybrid matching schema that involves linguistic-based and constraint-based. From several experiments that have been carried out by considering conflicting elements in the identification of the schema, schema matching uses a hybrid approach that can be used for rewriting queries on multiple databases [14]. Another research showed that the linguistic method is one of the schema matching methods that can be used to find similarities between schemes and can be used as material for optimizing database development [1]. Research conducted by Sutanta and colleagues combines two-hybrid schema matching methods to overcome database integration problems caused by database diversity [15].

In this research, the schema matching method used is linguistic and constraint. The constraint is part of an effort to maintain the integrity, consistency, and value of data so that it complies with certain valid limits that have been determined [16]. This constraint method performs matching schema based on attributes, data type, data width, nullity, uniqueness, and domain. Whereas the linguistic-based method matching scheme is one of the matching schema methods related to the similarity or similarity of the element names in a scheme both syntactically and semantically [17]. The linguistic method is a scheme matching method that is carried out by looking at the similarity of the naming of elements in a database [18]. The linguistic method used is N-Gram. N-Gram is an algorithm used to calculate a syntactic similarity. N-Gram has two stages in measuring the similarity between two strings, namely breaking the string into N characters and then calculating the similarity. Whatever the equivalent of N-Gram is as follows

$$Simngram\ (s,t) = \frac{2x|ngram(s)\ \cap \text{ngram (t)}|}{|ngram\ (s) + ngram\ (t)|} \quad (1)$$

s: a symbol that represents a reference database element (Source)
t: a symbol that represents the database element to be matched (Destination)
The similarity tested using this linguistic method is the similarity based on the name of the table between the pair of tables from the source database with the destination.

Methodology

The method used in this research is the linguistic-based schema matching method and the constraint-based method in which the schema matching with the linguistic method is carried out

based on the similarity or similarity of table names between table pairs from source to destination. The flow of research in this research can be seen in Figure 1.

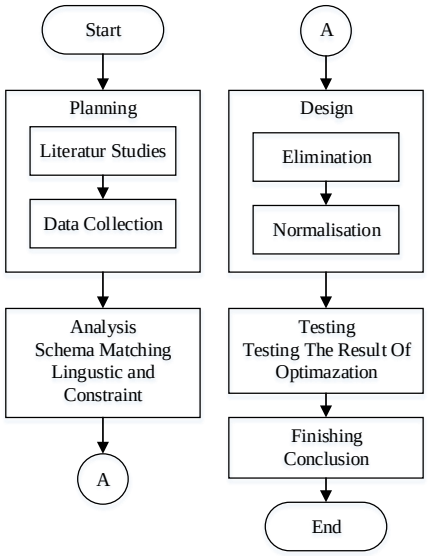

Figure 1. Research flow

Planning

The first stage is the planning stage where at this stage there is a literature study process used to determine the background, formulation of the problem, related research, and solutions to the problem. In addition to the literature study, there is also a data collection process. The data used in this research are databases at tertiary institutions such as administration, academic databases, KPKKNTA (practical work, real work lectures, final projects), ABDIMAS (research and public services), and others. The database used can be seen in Table 1.

Table 1. Database test list

No	Database name	Table	Attribute
1	Administration	26	204
2	Academic	69	453
3	Employee	29	184
4	Payrol	16	96
5	KPKKNTA	3	16
6	Abdimas	9	63
7	Library	52	427

Based on the database scheme obtained in Table 1, an overview of data integration can be seen in Figure 2.

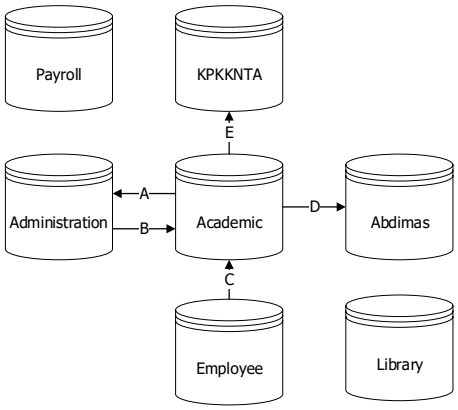

Figure 2. Current data integration design

Which A is data on citizenship, education, lecturers, majors, and types of education. B is religious data, PMB pathways, and districts. C is employee data. D is the faculty data, the field of study, and the study program. And E is the data of majors, students, and lecturers. Figure 2 shows that the administration database requires calling and data A, while academic calls data B from administration and C from Employees, etc. Figure 2 shows that the data integration that is currently running is not optimal yet, this can be seen by the existence of a system that should be integrated but not yet integrated, such as employee information systems, payroll, academic with libraries, and so on. This shows that there is a need to optimize data integration to be better so that it can reduce data redundancy and data inconsistencies and can save data storage space.

Analysis

The second stage is analysis. The database that has been collected at the planning stage is analyzed using the linguistic and constraint methods. The linguistic method used in this research is bigram. Before entering the bigram process it is necessary to carry out the conversion, generalization, and tagging process. The conversion is done by removing the "_" sign and also the prefix table name as can be seen in Table 2.

Table 2. Convert table names and attributes

No	Before		After	
	Table	Attribute	Table	Attribute
1	Adm_ achievement	Achievement_ code, achievement_ name	achievement	Achievement code, achievement name
2	Mst_religion	Religion_ code, religion_ name	religion	Religion code, religion name

The conversion process is carried out the results of the linguistic process carried out more leverage. This is caused by the addition of database names at the beginning of the table which can affect the results of linguistics. For example "adm_program_studi" with "akd_program_studi" which if no conversion is done then the same value is 0.812 and if converted the result is 1. After the conversion process is carried out, the next process is a generalization. This process is carried out on table names and attributes that have acronyms and abbreviations. Generalization is based on the true meaning of the abbreviations and acronyms of the word. An example of the generalization process can be seen in Table 3.

Table 3. Generalization example

Before	After
Prodi	Study program
NIK	Registration number of employees

After the generalization process, the next process is tagging. This process is carried out for the placement of words that have the same food as employees and employees, employees and employees, family and family, and others. So if there is a difference in the language used but has the same meaning then the word is considered the same. The next process is the bigram process. A bigram is a linguistic method that does the solving of two characters. An example of the bigram process can be seen in Table 4.

Table 4. Bigram process

Database	Table	Bigram Similarities
Administration	Religion	Re, el, li, ig, gi, io, on
Academic	Type of education	Ty, yp, pe, eo, of, fe, ed, du, uc, ca, at, ti, io, on
Intersect		-
Similarity		$= \frac{2x0}{7+14} = 0$

Besides bigram, there is also a trigram which is a part of n-gram. An example of a trigram process can be seen in Table 5.

Table 5. Trigram process

Database	Table	Bigram Similarities
Administration	Religion	Rel, eli, lig, igi, gio, ion
Academic	Type of education	Typ, ype, peo, ofe, fed, edu, duc, uca, cat, ati, tio, ion
Intersect		-
Similarity		$= \frac{2x0}{7+14} = 0$

In Table 4 the intersect value is 0, it shows that there is no bigram of the two tables that have similarities so that the similarity value is 0. The similarity value is between 0 to 1. If the similarity value is more than 0.8 then it can be categorized as relevant. After the bigram process. The next process is to analyze in terms of constraints with the constraint method which can be seen in Table 6.

Table 6. Constraint process

No	DB Source Administration			Similarity		DB Source Administration		
	Attribute	Criteria		Same ?	Value ?	Criteria		Attribute
1	Religion Code	Type	Varchar	Y	0.2	Varchar	Type	Education Type Code
		Length	10	Y	0.2	10	Length	
		Null	N	Y	0.2	N	Null	
		Unique	Y	Y	0.2	Y	Unique	

No	DB Source Administration		Similarity		DB Source Administration		
	Attribute	Criteria	Same ?	Value ?	Criteria		Attribute
		Domain -	N	N	-	Domain	
		Similarity Value		0.8			
2	Religion Name	Type Varchar	Y	0.2	Varchar	Type	Education Type Code
		Length 20	N	0	10	Length	
		Null Y	N	0	N	Null	
		Unique N	N	0	Y	Unique	
		Domain -	N	N	-	Domain	
		Similarity Value		0.2			
2	Religion Code	Type Varchar	Y	0.2	Varchar	Type	Education Type Name
		Length 10	N	0	25	Length	
		Null N	N	0	Y	Null	
		Unique Y	N	0	N	Unique	
		Domain -	N	N	-	Domain	
		Similarity Value		0.2			
2	Religion Name	Type Varchar	Y	0.2	Varchar	Type	Education Type Name
		Length 20	N	0	25	Length	
		Null Y	Y	0.2	Y	Null	
		Unique N	Y	0.2	N	Unique	
		Domain -	N	N	-	Domain	
		Similarity Value		0.6			

The similarity value shown in figure 3 is 0.8. This shows that the couple is relevant, but it should not be because the religious code with the type of education code is different. So it can be concluded that the pair of religious tables with the type of education is true negative (TN). The set that states the results of the matching schema is divided into four as seen in the matrix confusion table shown in Table 7 [19].

Table 7. Confusion matrix for matching result

	Relevant	Irrelevant
Relevant Matches	TP	FP
Irrelevant Matches	FN	TN

Table 7 shows that TP stated the outputs of the identified model are relevant, FP stated that the outputs that should have been matched were not, FN stated the outputs that were not supposed to match but it was TN and the results stated that the outputs were not suitable. In this research, to get results that match the set, the addition of logic algorithms is performed. This is because there are two schema matching methods used so that logic is used to help determine whether it is included in the relevant category or not. So we get the categorization as in Table 8.

Table 8. Schema category result match using and logic

Linguistic	Constraint	Linguistic & Constraint
Relevan	Relevan	Relevan
Relevan	Irrelevan	Irrelevan
Irrelevan	Relevan	Irrelevan
Irrelevan	Irrelevan	irrelevan

Table 8 shows that the matching results of the scheme are declared relevant if the matching results are linguistically as well as relevant or suitable constraints. Meanwhile, if outside the value is irrelevant or not suitable. The column shown by linguistics and constraints is used as

a reference to determine the relevant or irrelevant status which is then used to determine the value of the scheme matching set in Table 5. So that if there is a table with the same name, then it needs to be matched to the table structure so that it can be seen that the results are relevant or no. And if there are the same or similar attribute names, it is necessary to check the constraints.

Schema matching results in the form of TP, FN, and FP will be used as material for testing the matching schema model with parameters P (precision), R (recall), and F Measure. The equation to find out the value of P, R, and F measure can be seen in equations (2), (3), and (4).

$$P = \frac{TP}{TP + FP} \quad (2)$$

$$R = \frac{TP}{TP + FN} \quad (3)$$

$$F\ Measure = \frac{2xPxR}{P + R} \quad (4)$$

Optimalize

The results of the schema matching process are then used as material for optimization. The optimization process is done by eliminating one table from each pair of TP values and also eliminating attributes and tables that are considered irrelevant and then normalized. Normalization is carried out until the third form because the third form is already considered a normal form [20].

Testing

At this stage, the database integration design testing process is optimized. Testing is done by providing several sample queries to display data from different databases.

Results and Discussions

The results of the schema matching can be seen in Table 9.

Table 9. Schemat matching result

DB Source	DB Destination	TP	FP	FN	P	R	F Measure
Administration	Academic	3	2	0	0.6	1	0.75
Academic	Administration	3	2	0	0.6	1	0.75
	KPKKNTA	-	1	-	0	-	-
	Abdimas	1	-	-	1	1	1
Employee	Penggajian	3	-	-	1	1	1
	Library	1	2	-	0.33	1	0.5
Payrol	Employee	3	-	-	1	1	1
KPKKNTA	Academic	-	1	-	0	-	-
Abdimas	Academic	1	-	-	1	1	1
Library	Employee	1	2	-	0.33	1	0.5

Table 9 shows that there are several pairs of tables from each database with TP and FP values while others are blank or TN values. After getting the results of the matching schema obtained, the next process is optimization. The database schema optimization process results in changes in the number of tables and attributes in the database schema. Database schema data after optimization can be seen in Table 10.

Table 10. Optimization result

No	Database	Before		After	
		Tabel	Attribute	Tabel	Attribute
1	Administration	26	204	23	137
2	Academic	69	453	72	324
3	Employee	29	184	31	148
4	Payroll	16	96	11	64
5	KPKKNTA	3	16	0	0
6	Abdimas	9	63	11	52
7	Libarary	52	427	43	226

Table 10 shows the decrease in the number of tables and overall attributes where the number of tables before the optimization is 204 and changes to 191 after optimization. While the number of attributes that were previously 1443 became 951 after optimization. There is a big enough change so that it can be said that data integration was not yet optimal because there are still many pairs of tables with TP values and some attributes that are not considered to be relevant so that optimization is needed. Design of data integration results can be optimized.

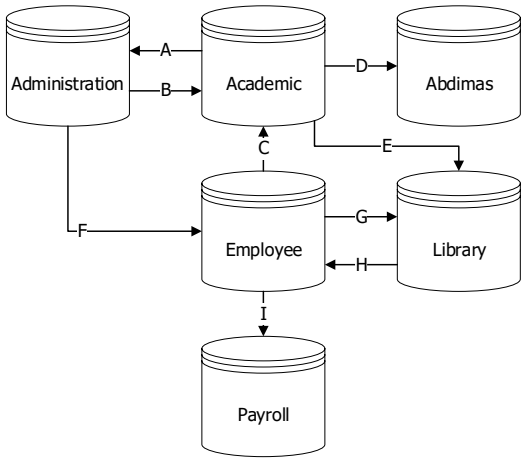

Figure 3. Optimization database integration design

Figure 3 shows the design of data integration after optimization where A is the data of study programs, levels of education, ethnicity, types of education, fields of education, lecturers, education programs. B is district and camaba data. C is SK and employee data. D is the data of students, lecturers, and science. E is student data. F is a data type of work, religion, and diploma. G is a data module. H is the login and employee data. And I is employee data.

Fig 3 shows the difference with Fig 2 (initial integration design). A fairly noticeable difference is that after optimization, all databases have been integrated with other databases wherein the initial integration design 2 databases are not integrated with any system even though it should be able to retrieve data from other systems so there is no need to insert again. The amount of data used on other systems increased from the initial 15 to 22. This shows that previously the data was stored in each database. With the increase in the amount of integrated data by 46.67% from before, data storage in the database becomes more efficient. There was a reduction in the number of databases that previously had 7 databases to 6 databases. This is because the KPKKNTA database after optimization can be removed. After all the data contained in the KPKKNTA database is available in the academic database. The process of entering the same data in different information systems can be reduced so that data inconsistencies can be avoided.

Retrieval of data from other databases can be done by adding attributes to the table from the database system that performs data retrieval. The attribute becomes the foreign key of the table from which the data will be retrieved. For example, in the administrative information system, there is an administrative database in which there is data on prospective students. To display study program data owned by prospective new students, the system needs to retrieve study program data from the academic database because the study program table is in the academic database. Therefore, it is necessary to add the code_program_studi attribute to the table of prospective new students in the administration database and become a foreign key that refers to the primary key of the study program table contained in the academic database.

Tests are carried out to test whether the new database integration design allows for data sharing so that the tests carried out are to give commands to display data from other databases. The command was given to display data after optimization has undergone a few changes. For example, the previous command is "*Select a.attribute_name_1, b.attribute_name_2, and so on from table_name1 a, table_name2 b where condition*". After optimization, if the desired data is in a different database table, the command given is "*Select a.attribute name 1, b.attribute 2, and so on form name_database1.name_table1 a, name_database2.name_tabel2 b where condition* ". The difference lies in putting the database name before the table name. The example after the command after optimization is to display the study program data (academic) through the study program code in the Camaba (prospective new student) table (administration) with the following SQL command "*SELECT a.NO_PENDAFTARAN as Registration_number ,a.nama_camaba as camaba_name ,b.nama_jalur_pmb as PMB_path_name, c.nama_program_studi as name_ of_ study_ program from 01administrasi.adm_camaba a, 01administrasi.adm_jalur_pmb b, 02akademik. akd_ program_studi c where a.kode_jalur_pmb= b.kode_ jalur_ pmb and a.kode_program_studi= c.kode_program_studi*". The results of the order can be seen in Figure 4.

Registration_number	camaba_name	PMB_path_name	name_of_study_program
REG-00002	Dema ML Tobing	Undangan	S2 TEKNIK INFORMATIKA
REG-00003	RACHMAT MAULANA PUTERA	Undangan	S2 TEKNIK INFORMATIKA
REG-00004	DICKY RAMANDA	Undangan	S1 HUBUNGAN INTERNASIONAL
REG-00005	IRFAN SYARIF HIDAYATULLAH	Undangan	S1 PERENCANAAN WILAYAH DAN KOT
REG-00006	RACHMAWATI SETYANINGRUM	Undangan	S1 EKONOMI
REG-00001	Rifqi Hammad	Tes Tulis	S2 TEKNIK INFORMATIKA
REG-00007	EKA HENI SAFITRI	Tes Tulis	S1 PERENCANAAN WILAYAH DAN KOT
REG-00015	BAYU AGUNG PRASETYO UTOMO	Tes Tulis	S1 TEKNIK KOMPUTER
REG-00017	NI LUH PUTU	Tes Tulis	S1 AKUTANSI
REG-00008	TOMY AGUSHERMAWAN	Prestasi	S1 EKONOMI
REG-00009	ZULFIKAR ROMADHONA ADIPUTRA	Prestasi	S2 TEKNIK INFORMATIKA
REG-00016	FRANSISKU AJI PRASETYO	Prestasi	S1 AKUTANSI
REG-00010	MARIA ULFAH NUR ANISAH	PMDK	S1 HUBUNGAN INTERNASIONAL
REG-00011	BONDAN FAJAR WICAKSONO	PMDK	S1 PERENCANAAN WILAYAH DAN KOT
REG-00014	M ARWAN ZULQAEDY	PMDK	S1 TEKNIK KOMPUTER
REG-00012	PASCALL FERDINAN	USM	S1 TEKNIK KOMPUTER
REG-00013	AHMAD ABDULLAH	USM	S1 TEKNIK KOMPUTER

Figure 4. Display program data through camaba data

Conclusion

Based on the results of tests that have been carried out from this research it can be concluded that:

a. The results showed that there were 16 pairs with TP value and 8 pairs with FP value while none had FN value. These results indicate that in data integration (before optimization) there is still duplication of data that can cause data inconsistencies.
b. Database optimization which is done changes the number of tables and attributes of the tables amounted to 204 to 191 and the number of attributes that were previously 1443 to 951. This shows that several tables can be eliminated because they are connected with tables in other databases and also some attributes are can be eliminated.
c. After optimization, data integration is better due to an increase in the amount of data connected to other systems by 46.67% from before. So that the same data entry on different systems can be reduced and also data inconsistency caused by duplication of data on different systems can be minimized.

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Application design to help predict market demand using the waterfall method

Ramen Antonov Purba

Department of Informatics and Management, Politeknik Unggul LP3M, Indonesia

Corresponding Author: *ramenantonovpurba@gmail.com*

Abstract: Covid-19 has not been defeated make the economy unstable. The government increases purchasing power with a stimulus. The government's stimulus for PPnBM 0% of cars is a breath of fresh air. Sales rate increases. Even so, the ups and downs keep happening. Sales are unstable. In one to three months, five cars can be sold. It could also take 3 to 6 months, only 1 unit. Must make a strategy to avoid overcrowding of units. Like PT. Suka Fajar Ltd Medan. Companies engaged in the sale of Mitsubishi cars. As operating costs increase, management limits the acceptance of car shipments. This policy has fatal consequences. When consumers want to buy a particular car unit, it is not available. Incidents like this happened more than five times. The company's image is not good. Researched to design and build applications that can make predictions—collaborated with the linear regression. To be directed and sequential, the waterfall is used. Ensuring the application is suitable for testing with the black box. Research leads to the conclusion that the application is designed and built according to what is needed.

Keywords: sales prediction, linear regression, waterfall, black box, Mitsubishi cars

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Introduction

The situation that hit the world will significantly affect human life like now, where Covid-19 has not been conquered [1], [2]. Economic conditions became unstable. People's purchasing power is also unstable. The government strives to increase people's purchasing power with a stimulus that aims to stabilize economic conditions [3], [4]. Various subsidies are disbursed so that people can buy what they need. The regulation of the economy becomes balanced. One of the stimuli carried out by the government is the issuance of PPnBM regulations of 0% for car category vehicles [5], [6], [7].

The stimulus provided by the government is a great opportunity for business actors engaged in selling and buying cars. The level of sales is increasing because people are starting to buy cars for personal use and business needs [8], [9]. Affordable prices are one of the reasons people buy cars. Nevertheless, the ups and downs of sales still occur. Purchase rates are classified as unstable. In 1 to 3 months, five cars can be sold. However, it could also be in 3 to 6 months only 1 unit; it could even be no sales at all.

Such conditions must, of course, be a concern. Unstable sales do not mean nothing is sold at all. Therefore, a strategy must be made to avoid the accumulation of car units in the Showroom. The accumulation of car units will make conditions uncomfortable, and operational costs will increase. It happened at PT. Suka Fajar Ltd Medan. A business sector that focuses on selling Mitsubishi cars. During the Covid-19 pandemic, car sales were unstable. The company's management continued to take deliveries of new cars, causing a buildup. As operating costs increased, management decided to limit the acceptance of car shipments. This policy is fatal because when consumers want to buy a specific car unit, it is not available, and the consumer has to pivot (make an order and wait for the order to arrive). This kind of incident did not happen once but more than five times. Of course, it is not very good if it is left like that. It could be that the company's image is not good in the community. Computer technology can be a solution to this problem [10]. Ni Luh Windy [11] conducted research to solve problems such as those faced by PT. Suka Fajar

Ltd Me-dan. It is suggested that the application by applying the linear regression method can be a solution. This method can make predictions for future needs [12], [13].

Kurniadi [14] also researched to make predictions regarding what customers' habits are. The goal is to improve service. Kurniadi uses the linear regression method in his research. Alvin [15], in his research, also uses the linear regression method in predicting the durability of high-speed ships. Similarly, research conducted by Rizky et al [16], made predictions to anticipate inventory in warehouses. Also used linear regression method. In addition to using the linear method, research conducted by [11], [15], [16], [14] also utilizes applications built with specific programming languages. So to solve the problems experienced by PT. Suka Fajar Ltd. Medan, it is possible to use applications built using a programming language in collaboration with the linear regression method [17], [18].

The research will be conducted to design and build applications that can predict market demand for car products at PT. Suka Fajar Ltd Medan. To support the strength of the application will be collaborated with the linear regression method [19]. The Waterfall method is used for the stages of designing and building a directed and sequential data application [20]. To ensure whether the application that is built is appropriate and answers the problems experienced by PT. Suka Fajar Ltd Medan will be tested using the black box method [21].

Methodology

In this research, application development will be carried out to make predictions. In building the application in question, linear regression is used to manage forecasts, waterfall to build the system, and a black box to check whether the entire system is desired. The stages or steps that become the method in this research are:

1. Analysis with Linear Regression method

Analysis with linear regression is used to predict the extent of changes in the dependent variable (bound) if manipulation or changes are made to the value of the independent variable (free). Based on this, it is formed by nature [22]:

$$Y = a \times bX \quad (1)$$

With Description:

Y : Independent Variable (Bound) Predicted/Estimated
a : constant (x=0)
b : regression coefficient
x : variable is not dependent (independent)

In order to obtain the value a and value b, the following properties are used:

$$a = \overline{Y} - b.\overline{X} \quad (2)$$

$$b = \frac{\sum XY - n.\overline{X}.\overline{Y}}{\sum X^2 - n.\overline{X}^2} \quad (3)$$

Next is to get the increase in the number of cars sold. To get it by:

$$MS = \frac{Req\ company}{Req\ industry}\ x100\% \quad (4)$$

With Description:

MS : Market Share
Entrepreneur's Req : Request from company
Industrial Req : Demand from industry

2. Waterfall Method

The waterfall method is a step or steps taken to design and build applications. The shape is like Figure 1 [23].

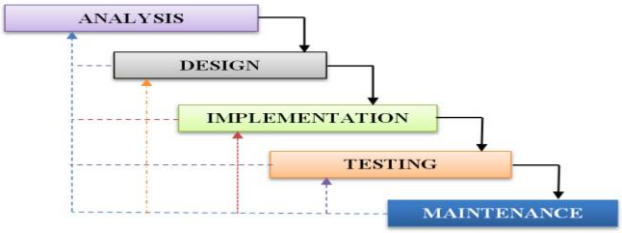

Figure 1. Stages of the waterfall method

The stages contained in Figure 1 have the following explanations: 1) Analysis. It is the first stage in building an application. Where will be seen what the need is; 2) Design. After knowing what the needs are, do the design or design the form of the application; 3) Implementation. Finished in the design or designed, the application is built using a computer-based programming language; 4) Testing. The completed application is tested whether there are still errors or errors in the application menu; 5) Maintenance. If there are still errors, then repairs are made until the application runs appropriately [24].

3. Test Application with Black Box

Test the application, which refers to each part of the application that is built. The application test with a black box is the final test, followed by the validation test.

Results and Discussions

Results

The results were predicted using linear regression method to see the condition of sales. The form is in Table 1.

Table 1. Accumulation of cars sold on a regular basis

Period/Year	Y	X	X^2	XY
Jan until Mar/ 2020	10	-2	4	-20
Apr until Jun/ 2020	11	-1	1	-11
Jul until Sep/ 2020	12	0	0	0
Okt until Des/ 2020	11	1	1	11
Jan until Mar/2021	12	2	4	24
∑	56	0	10	4

So it will be found: X=0/5=0;Y=56/5=11,2. Next : b=(4-5.0.11,2)/(10-5.02)=0.4. Then a=11,2-0,4.0=11.2. The results of linear regression analysis are Y=11,2+0,4X. Prediction results in the following month: Y=11,2+0,4(3). Thus Y=11,2+1,2, Y=12.4. It is concluded that sales for the next month are predicted to be at 12.4, which is then rounded up at 12. Then MS or Market Share, namely demand from companies and demand from industries, is shown in Table 2.

Table 2. Total market share figures

Period/Year	P	I	MS	K
Jan until Mar / 2020	10	100	10%	5%
Apr until Jun / 2020	13	260	5%	5%
Jul until Sep / 2020	15	300	5%	0%
Okt until Des / 2020	17	600	3%	2%
Jan until Mar / 2020	18	900	2%	1%

Next, the context diagram describes the application entity to be built, as shown in Figure 2.

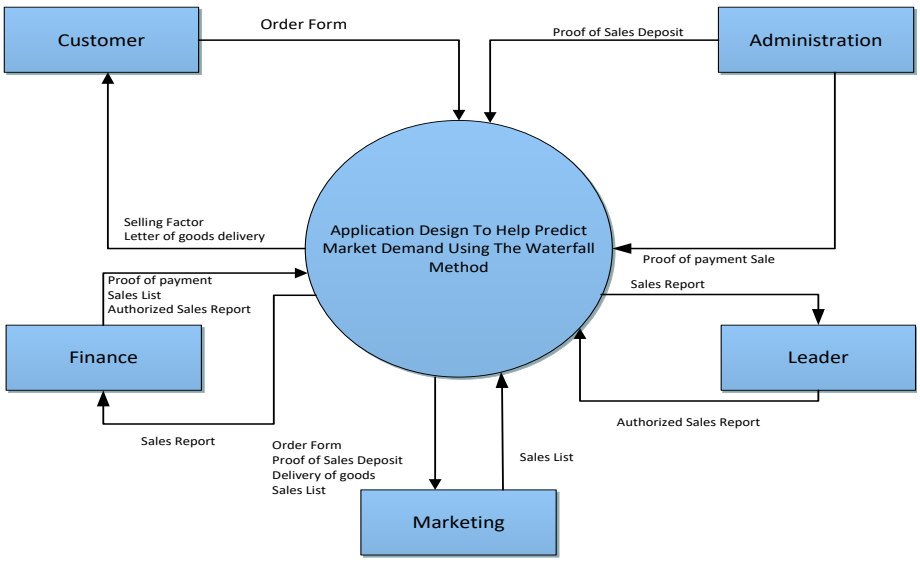

Figure 2. Context diagram actualization

In Figure 2, it can be seen that five entities are part of the application, including; customers, finance, marketing, administration, and leadership. Each entity has an unbroken task and correlation with one another.

Based on the context diagram above, a data flow diagram is then built, as shown in Figure 3:

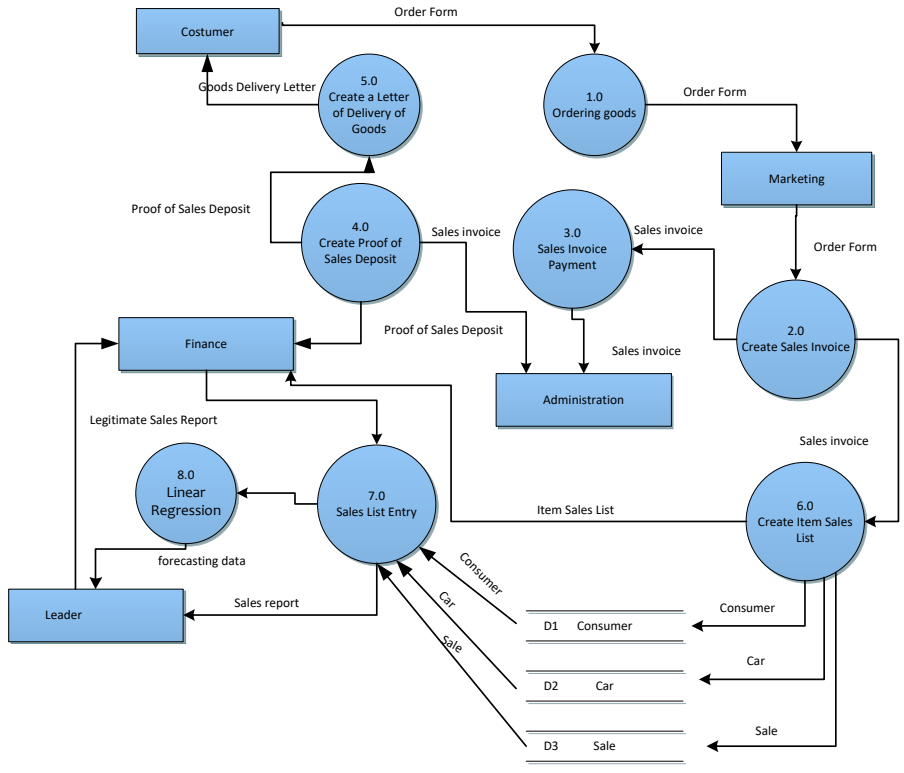

Figure 3. Data flow diagram

The data flow diagram is described in more detail according to the application to be built. The entities are precise, as shown in Figure 2. In Figure 3, each entity is described what its part is.

Based on Figure 2 and Figure 3, the output menu design and data input menu design are shown as follows:

1. Car Type Report Design and Customer Data Report Design
   Car Type Report Design and Customer Data Report Design can be seen in Figure 4.

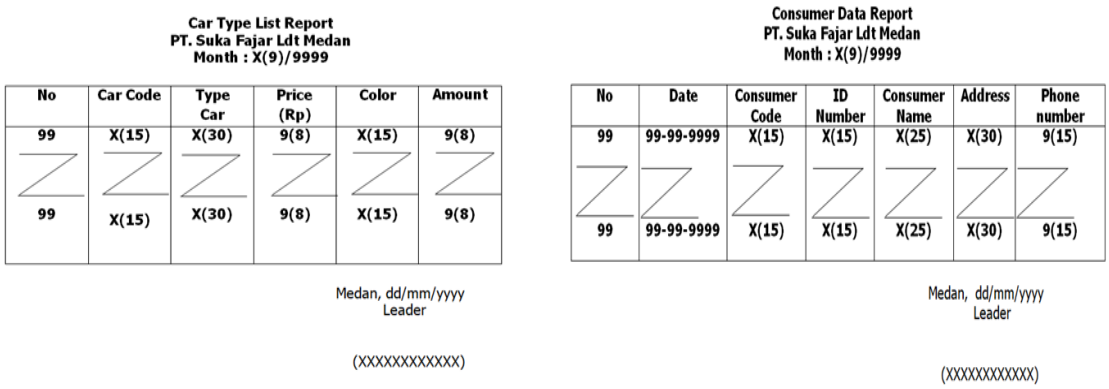

Figure 4. Car type report design and customer data report design

2. Draft Monthly Car Sales Report and Draft Annual Car Sales Report
   Draft Monthly Car Sales Report and Draft Annual Car Sales Report can be seen in Figure 5.

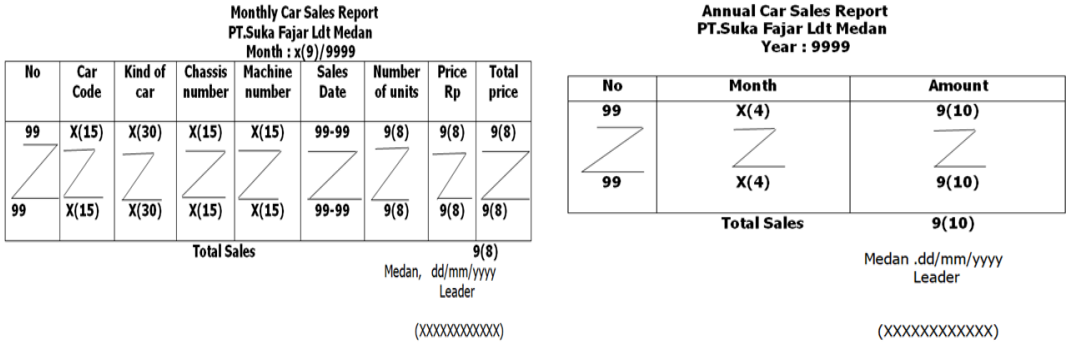

Figure 5. Monthly car sales report design and a draft of annual car sales report

3. Linear Regression Analysis Report Design
   Linear Regression Analysis Report Design can be seen in Figure 6.

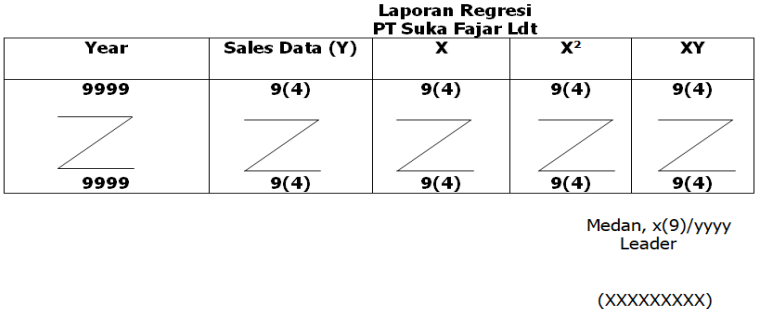

Figure 6. Design of linear regression analysis report

After the report design, there is also a data input menu design. Its function is to input/enter data to be processed according to their needs. As for the plan:

1. Car Data Input Design and Customer Data Input Design
   Car Data Input Design and Customer Data Input Design can be seen in Figure 7.

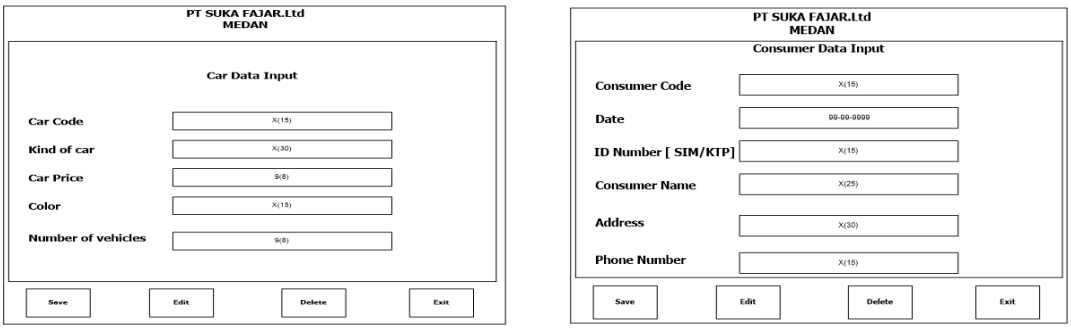

Figure 7. Car data input design and customer data input design

2. Sales Data Input Design
   Sales Data Input Design can be seen in Figure 8.

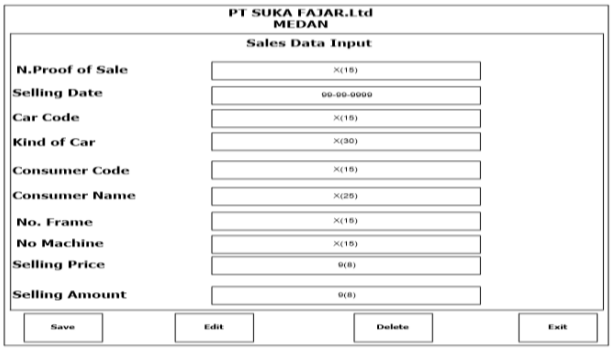

Figure 8. Car data input design and customer data input design

The existence of a report menu design per section according to the application being built, accompanied by an input menu design to enter data as needed, then the application structure is also designed which includes the position of the data input component, the position of the report com-ponent, and the button to exit the application. For the design form in Figure 9:

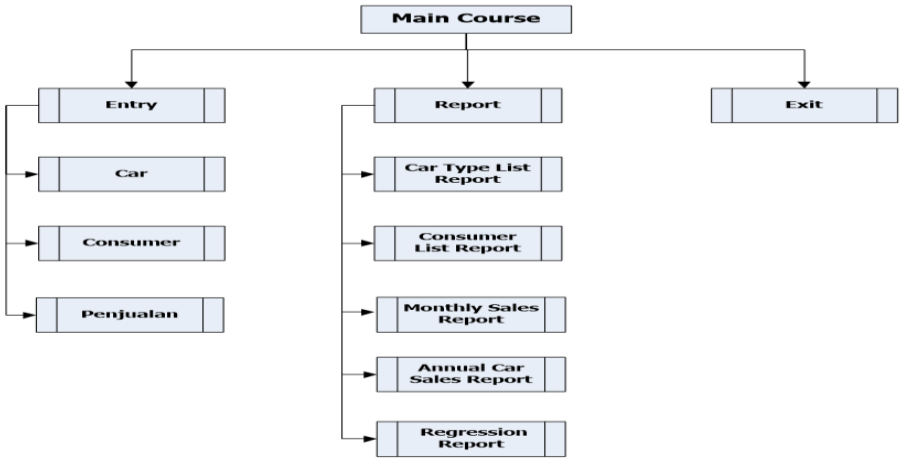

Figure 9. Application main menu design

Discussions

After the design or design is carried out, application development refers to the design or design that has been made. For the application menu in the form of implementation, as follows:

1. Main Menu Actualization Form and Report Menu Actualization Form
   Main Menu Actualization Form and Report Menu Actualization Form can be seen in Figure 10.

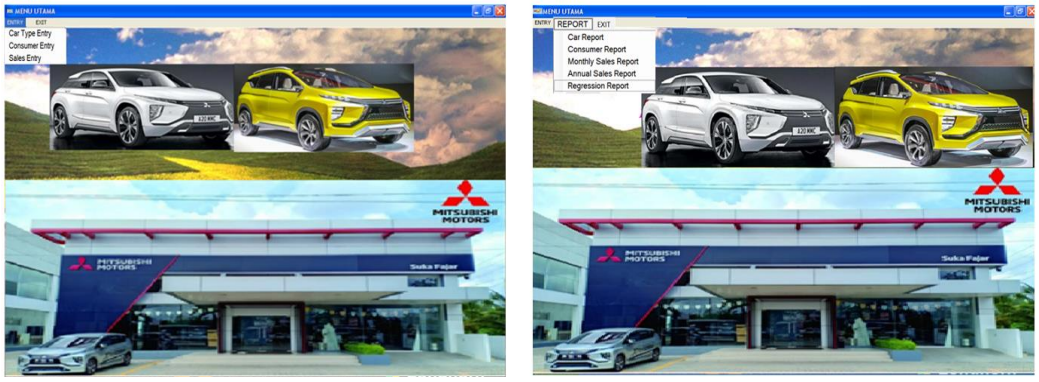

Figure 10. Main menu actualization form and report menu display

2. Car Data Input Actualization Form and Customer Data Input Actualization Form
   Car Data Input Actualization Form and Customer Data Input Actualization Form can be seen in Figure 11.

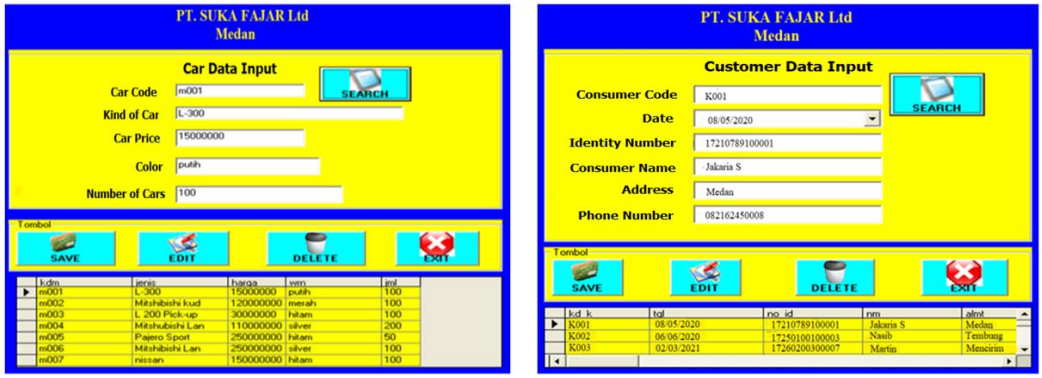

Figure 11. Car data input actualization form and display of customer data input

3. Sales Data Input Actualization Form
   Sales Data Input Actualization Form can be seen in Figure 12.

Figure 12. Car data input actualization form and display of customer data input

4. Update Car Data Report and Update Customer Data Report
   Update Car Data Report and Update Customer Data Report can be seen in Figure 13.

CAR TYPE LIST REPORT
PT. SUKA FAJAR Ltd Medan
Month Mei/2020

No	Car Code	Kind of Car	Price	Color	Amoun
1	n001	L-300	15,000,000	putih	100
2	n002	Mitshibishi kud	120,000,000	merah	100
3	n003	L 200 Pick-up	30,000,000	hitam	100
4	n004	Mitshubishi Lan	110,000,000	silver	200
5	n005	Pajero Sport	250,000,000	hitam	50
6	n006	Mitshibishi Lan	250,000,000	silver	100
7	n007	nissan	150,000,000	hitam	100

CUSTOMER DATA REPORT
PT. SUKA FAJAR Ltd Medan
Month Mei/2020

No	Date	Code	Id Number	Name	Address	Phone
1	08/05/2020	K001	127101100001	Jakaria S	Medan	0821625890
2	01/05/2020	K002	12730101002	Nasib	Tembung	08237568901
3	23/05/2020	K003	127523040003	Martin	Mencirim	0812635352
4	25/05/2020	K004	127202031004	Fadli	Selayang	08526574567
5	27/05/2020	K005	127110110004	Fathoni	Pakam	08116058934
6	30/05/2020	K006	127203040568	Lisa	Paya Geli	08126549023

Figure 13. Car data report actualization and customer data report actualization

5. Update Monthly Sales Report
   Update Monthly Sales Report can be seen in Figure 14.

MONTHLY SALES REPORT
PT. SUKA FAJAR Ltd Medan

Month Mei/2020

No	Car Code	Car Kind	Chassis	Machine	Sale Date	Amount	Price	Total
1	n001	L-300	RNGK90GT	MNJ45GDE	05/Mey/2020	2	17,000,000.00	34,000,000.00
							Total Sales	34,000.000.00

Figure 14. Sales data report actualization

6. Update Linear Regression Analysis Report
   Update Linear Regression Analysis Report can be seen in Figure 15.

LINIER REGRESSION ANALYSIS REPORT
PT. SUKAFAJAR Ltd Medan

Amount	X	X^2	XY
10	-2	4.00	-20.00
11	-1	1.00	-11.00
12	0	0.00	0.00
11	1	1.00	11.00
12	2	4.00	24.00
Sales For Next Year Are			**12.40**

Figure 15. Linear regression analysis report actualization

After the implementation of each part in the application is displayed, the next step is to test the level of suitability for the use of each part in the application. For testing using the black box, the method can be seen in Table 3.

Table 3. Conclusion of Black Box Test

No	Test Type	Decision
1	Executing Apps	No Error
2	Enter Login	No Error
3	Entering Car Data	No Error
4	Entering Sales Data	No Error
5	Entering Customer Data	No Error
6	Show Car Data Report	No Error
7	Display Sales Data Report	No Error
8	Viewing Customer Report	No Error
9	Showing Regression Report	No Error
10	Show Sales per month	No Error
11	Show Sales per year	No Error

After that, a feasibility test is carried out for use. The test is carried out by providing a form to be filled out by the management of PT. Suka Fajar Ltd. Medan and its staff and employees. The number of filling sheets to be filled in was 60 people. The number of questions that must be filled in on the sheet that is distributed is 16 questions. The choice of filling consists of; Strongly Agree, Agree, Still Gray, Disagree, and Strongly Disagree. The results filled in on the question sheet that are distributed are then adjusted using the Likert scale. For adjustments, namely, Strongly Agree (5), Agree (4), Still Gray (3), Disagree (2), and Strongly Disagree (1).

After recapitulation, for each component, the following answers were found; Strongly Agree (231), Agree (537), Still Gray (275), Disagree (95), and Strongly Disagree (2). When added up, the total number is 4320—the number found in the whole accumulation. With the number of numbers accumulated and divided by the number of management, staff, and employees, the number 72 is found. For the number 72, if it is matched with conversion, it is categorized as Eligible. So that a correlation can be drawn if the application is categorized as Eligible.

Conclusion

The stages carried out in the research on Application Design to Help Predict Market De-mand Using the Waterfall concluded that the application designed and built was by what was needed by PT. Suka Fajar Ltd Medan. Part of the application can be appropriately used with the appropriate categories. For utilization, it is also in the Eligible category. The prediction menu can also run as expected. So with this application, PT. Suka Fajar Ltd Medan can exercise control over the sales made.

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Implementation of multimarker augmented reality on solar system simulations

Hendra Pradibta [1]*, Usman Nurhasan[2], Dwi Aldi Rizaldi [3]

[1,2,3] *Information Technology Department, Politeknik Negeri Malang, Indonesia*

*Corresponding Author: *hendra.pradibta@polinema.ac.id s*

Abstract: The solar system is one of the natural phenomena taught at school. However, delivering the material is still text-based. One of the current technology-based learning uses technology Augmented Reality as a support for learning aid. Augmented Reality is an integrated two worlds, the real and the virtual. Augmented Reality for the solar system learning application was developed by applying the concept of the Rule-Based System algorithm as a simple artificial intelligence that aims to help augmented reality systems in simulating knowledge and experience from humans with several rules prepared. The existence of Augmented Reality facilitates the process of learning on specific topics such as the solar system more attractive and interactive, with aims to inspire students to learn the solar system. Based on the testing results at SDN Purwantoro 2 Malang, Indonesia 95% of respondents are interested and captivated by learning media applications using Augmented Reality technology.

Keywords: augmented reality, solar system, learning aid

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Introduction

The solar system is one of the subjects taken from natural science lessons taught at school. Most of the studies are still in a conventional method, textbooks-centered, and lack teaching aids. Students must memorize and imagine, without barely knowing the planets, the solar system, solar eclipse, etc. One of the lessons that have adopted current technology is learning media through AR (Augmented Reality) technology [1].

In recent years, AR (Augmented Reality) technology has grown rapidly and applied in various fields. Augmented Reality is an integrated world between the real and the virtual. Combining these things is expected to help clarify the information provided to make it more exciting and feasible. Augmented Reality development aims to make clear and neat for the present situation of the users, wherein Augmented Reality systems apply media in the real world as markers to create 2D or 3D objects [2]–[4].

By using the concept of the Rule-based method as an Artificial Intelligence that helps Augmented Reality systems run knowledge and experience from humans by following several rules. Simply put, the Rule-Based System method is designed to solve a complex problem using if-else rules. The definition of a Rule-based Expert System is defined in reference [5]: "An Expert System can be defined as a collection of programs that use the human experience as knowledge, that knowledge is stored in a coded form and can solve a problem." The combining concepts of Augmented Reality and Rule-Based systems believes that by combining information that the Rule-Based system has processed, the effectiveness of Augmented Reality increases significantly and makes it easier to perform.

This research will create an Augmented Reality-based application to simulate the Solar System. The purpose of the study is to help elementary students learn the basics of the Solar System; the target of this application is elementary students studying the Solar System by applying Augmented Reality (AR) to make learning activities more fun and interesting through the display of the 3D object.

Methodology

The work structure that will be applied to this system uses concepts and flows taken from the Multimedia Development Life Cycle. The method has 6 (six) stages: concept, design, collecting, assembly, testing, and distribution, as disclosed in reference [6], [7].

Concept

The concept is the initial stage in the MDLC cycle. The concept stage began with determining the purpose of making the application and the user of the application. The purpose of the study is to help elementary students in learning the basics of the Solar System; the target of this application is elementary students who are studying the Solar System by applying Augmented Reality to make learning more fun and engaging through the display of the 3D object.

Design

A mature concept makes it easy to describe what should be done. The design is focused on the process of creating the specifications in detail about the project architecture, the appearance, and the needs of project material and style. In the design stage, several flowcharts describe the flow of the application so that the final results are by the concept stage, namely; Use case diagrams and Flowchart diagrams.

Material Collecting

Collecting material is the stage for collecting materials that are suitable for the student's needs. These materials include 3D objects, markers, animation, video, audio, and text that has been made or that still need to be modified according to existing needs. The author designed 3D objects by utilizing references from books about the solar system in elementary schools, designing as closely as possible according to references.

Assembly

Assembly Stage is the stage of making all multimedia materials. The application to be created is based on the design stage, and according to the design of the Flow Chart. Some applications used in this stage are Unity, Vuforia Database, 3Ds Max, and Corel Draw X7.

Testing

Testing is done to ensure that the results of making multimedia applications are following the plan. Stages of the black box testing carry out the tests by the application maker. Then they will be given to be tested by the end-user.

Distribution

This stage is the last step in the development cycle of this method. Distribution can be done after the application is declared feasible to use. The application will be stored on a storage device such as a CD or mobile device at this stage. The cube markers can be stored in the form that has been made or still in the raw form that still needs to be printed.

Use Case Diagram

Use Case diagram describes the relationships that occur between actors with activities that occur in a system. Actors in the system are users, while the system is an augmented reality application. The design of the use case diagram is shown in Figure 1. Use Case Diagram.

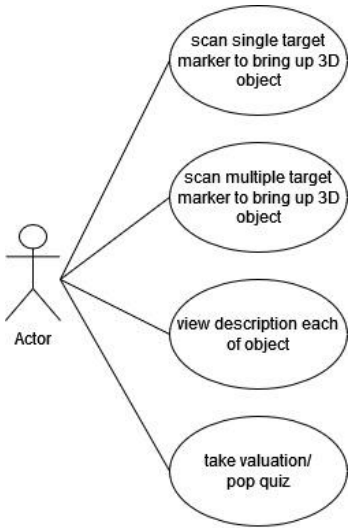

Figure 1. Use case diagram

From the use-case diagram, we can find out the definition of system functional and operational requirements. The definition of each use case is:

a. Scan Object marker to bring up the 3D object
   The system detects a marker, and if the marker is suitable it will issue objects in the form of 3 dimensions.
b. Scan 2 Object (Combine Object)
   The system detects 2 or more markers, and if the marker matches the rule-based method applied, a new object will appear.
c. View Description of each object
   The system will display a description of an object that has been scanned marker. The description can be a brief explanation of a planet.
d. Take Evaluation / Pop Quiz
   The system will display the quiz feature, where the user is required to answer a short question that is randomized to the order so that one user with another user will get a different question.

Flow Chart

The overall system flow for the Solar System Learning Media in the form of flowcharts is as to Figure 2 Flow Chart.

a. Learn Menu
   If the user selects the Learn menu, the application will direct the user to a camera display interface, where the user can scan the marker prepared. If the marker scanned is only 1 piece, the system will check whether the object is in accordance with the database. Otherwise, the system will not respond until the object is the same as the database.
b. Quiz Menu
   After the user plays and learns in the learn menu, the user will be directed to a test Evaluating the understanding of the Solar System that has been explained in the Scan Menu. The system will scramble the questions that have been provided by the author using the Linear Congruential Generator method, then it will be displayed to the user.
c. Menu Description
   In the description menu, the system will display a popup description of the selected planet, in that popup, there is an explanation of the planet.
d. Exit Menu
   The exit button is used to end the application.

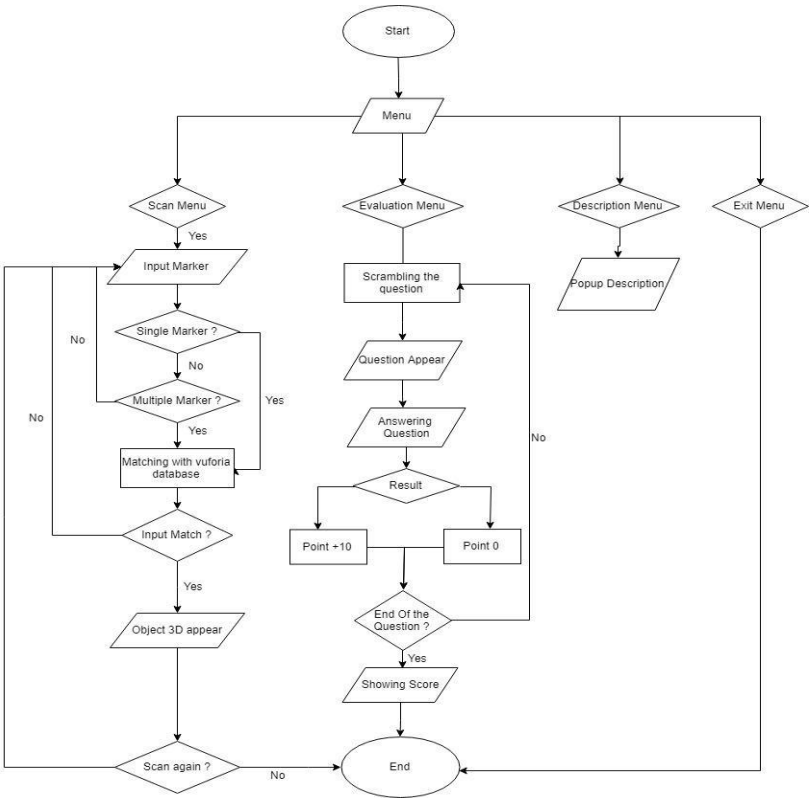

Figure 2. Flow chart

Marker Design

The function of the marker is to bring up a three-dimensional object if the marker is scanned by the camera. Markers are made in Corel draw X4. Figure 3 shows the marker design that has been made. The design marker shows a picture and the name of the planet (Nama Planet in Bahasa Indonesia).

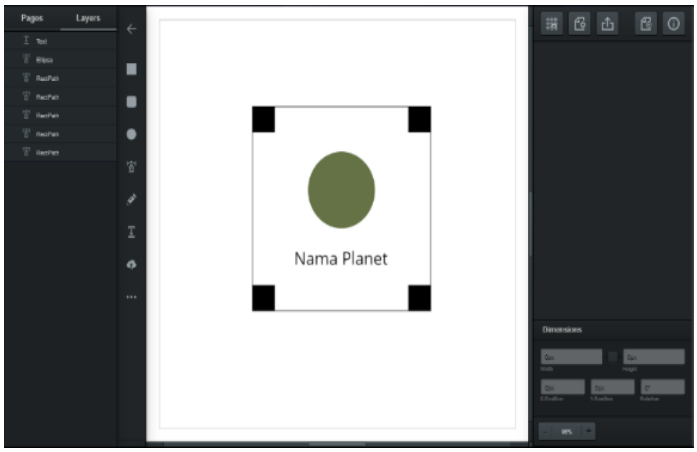

Figure 3. Design marker

Designing Interface

Designing User-Interface will be built using unity, and will also be a compiler so that project unity can be run in android in the form of an extension (.apk). The programming language used is C Sharp (C #). In the design, there are several User Interface pages, Figure 4 shows the main

menu design, Figure 5 shows the AR design, Figure 6 shows the description of the planet, and Figure 7 shows the quiz page.

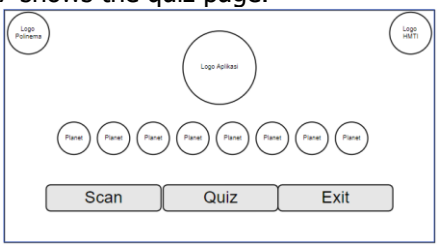

Figure 4. Main menu design

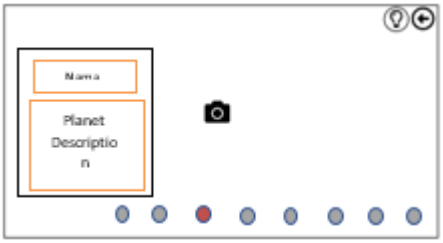

Figure 5. Augmented reality design

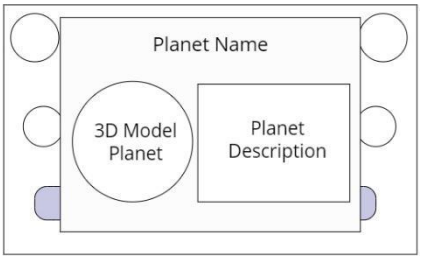

Figure 6. Design description of the planet

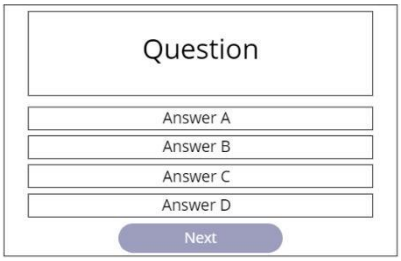

Figure 7. Quiz page

3D Planet Model Design

The process of making three-dimensional models of this application uses the Autodesk 3Ds Max version 2015. Figure 8 shows the process of developing the three-dimensional planet models.

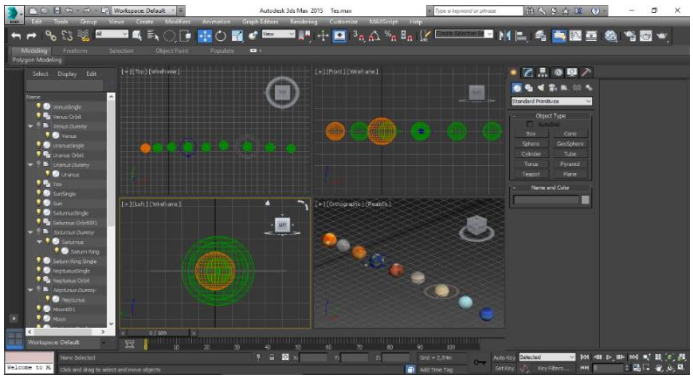

Figure 8. 3D planet models

Designing a Rule-Based System

The rule "if" translated literally has rules. Around us, there are so many rules that exist. The function of these rules is to limit what is done. Examples of rules that exist in life are laws, traffic rules, and rules for using objects. In IT terms, Rule-Based Systems will provide a tool that is useful in the development of specific applications. According to a reference to a book[8], the basic form of a rule-based system is as follows.

rule: (preconditions) -> (conclusions) (1)

Where conditions (preconditions) are a formula that defines when the rule or rule is applied, and the results (conclusions) are the effects of the application of the rule or rule [9]. Table 1 describes the rules in the solar system application.

Table 1. Rules in rule-based systems

Information	Condition (Rule)	Results (Conclusions)
Solar markers	Detected by camera	Display descriptions of the moon in the form of text & audio, and the position of the sun.
Moon Marker	Detected by camera	Displays a description of the moon in the form of text & audio, and the position of the moon.
Mercury Marker	Detected camera	Display descriptions of planets in the form of text & audio, and Mercury's position in the solar system.
Venus Marker	Detected by camera	Displays a description of the planet in the form of text & audio, and the position of Venus in the solar system.
Earth Markers	Detected by camera	Display descriptions of planets in the form of text & audio, and the position of the earth in the solar system.
Mars Markers	Detected camera	Display descriptions of planets in the form of text & audio, and the position of Mars in the solar system.
Jupiter Marker	Detected by camera	Displays descriptions of planets in the form of text & audio, and Jupiter positions in the solar system.
Saturn Markers	Detected by camera	Display descriptions of planets in the form of text & audio, and Saturn's position in the solar system.
Uranus Markers	Detected by camera	Display descriptions of planets in the form of text & audio, and Saturn's position in the solar system.
Neptune marker	Detected by camera	Displays descriptions of planets in the form of text & audio, and the position of Neptune in the solar system.
Earth & Moon Markers	Detected by camera	The condition if the marker of earth and moon caught by the camera device is to eliminate the 3-dimensional model of the two markers, then the new 3-dimensional model will emerge along with the available animations.

Results and Discussions

Marker Implementation

The application used the markers of planets in the solar system. Markers are created using Corel draw X4 software with an extension file.jpg. Markers that have been created will be entered into the Vuforia database. Figure 9 shows the sun, earth, and moon markers.

Figure 9. Marker

Interface Implementation

The interface implementation appears on the application. The following are the interfaces contained in the application according to the design that was built in the previous chapter. Figure 10 shows the home menu interface of the application. Figure 11 shows the scan marker window. Figure 12 shows the scene description Interface, the description of the planet written in Bahasa Indonesia. Figure 13 shows the quiz page. Each question is written in Bahasa Indonesia.

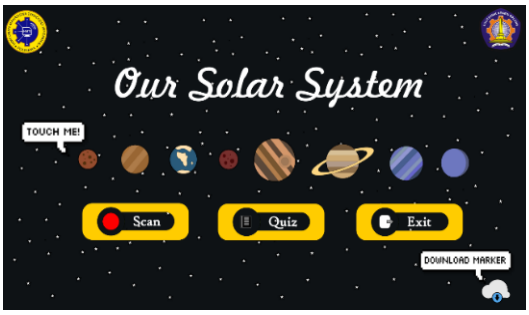

Figure 10. Scene menu interface

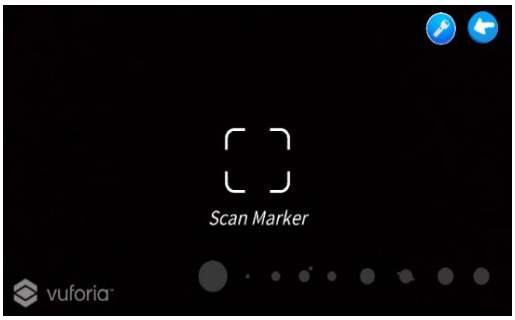

Figure 11. Scene scan marker

Figure 12. Scene description interface

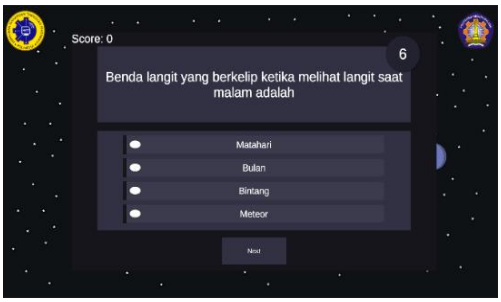

Figure 13. Quiz page

Augmented Reality Testing

Augmented RealityTesting is testing a system to test all the components that have already been designed and implemented into the system. The purpose of this test is to test whether markers that have been entered into the Vuforia database are running and can display object 3 in the application. Figure 14 shows the augmented reality content of the marker.

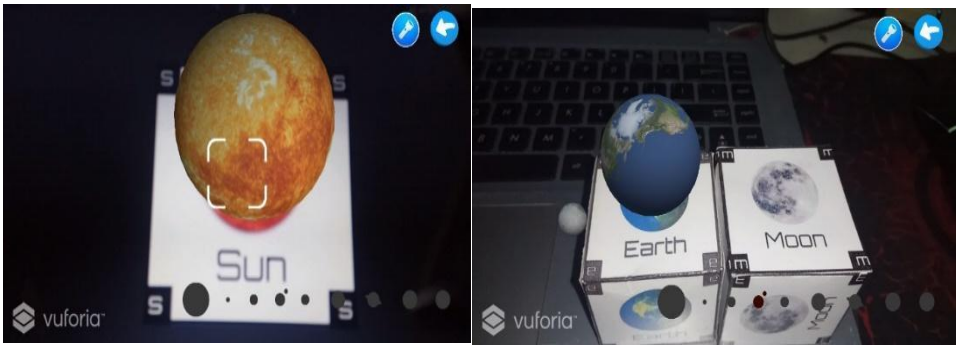

Figure 14. Augmented reality result

Marker Efficiency Testing

The process of identifying markers was carried out to determine the marker pattern by searching for the marker pattern captured by the camera recorded by reference comparison on the stored marker pattern file and integrated into the program [10]. Table 2 describes the results of the test markers. The distance column shows the distance between the camera and the target marker. The degree of angle column shows the camera angle with the target marker. The lightning column describes the conditions of the environment used at the time of testing. For example, dark light indicates the condition of a dark room. The results column shows the testing process results, whether the content can appear properly or not.

Table 2. Test markers

Distance	Degree of angle	Lighting	Results
5 cm	0	Dark light assisted flashlight	• The tracking process does not find a target
5 cm	15	Dark light	• The tracking process does not find the target
5 cm	25	Dark light, assisted by flash-light	• Tracking does not find the target
10 cm	0	Dark light	• The tracking process does not find the target
10 cm	0	light is dark, assisted by flashlight	• The tracking process is easy to find the tar-get
			• 3D objects are only partially visible Anima-tion runs
10 cm	0	Light is sufficient	• The tracking process is easy to find the tar-get
			• 3D objects only appear partially Animation runs
15 cm	0	Dark light	• The tracking process does not find the target
15 cm	0	Dark light, assisted by flash-light	• The tracking process is easy to find the tar-get
			• 3D objects are only partially visible Anima-tion runs
15 cm	0	Light is sufficient	• The tracking process is easy to find targets
			• 3D objects only partially visible Animation runs
20 cm	0	Dark light	• The tracking process does not find a target of
20 cm	0	Dark light, assisted by flash-light	• The tracking process is easy to find the tar-get
			• 3D objects only appear partially Animation runs
20 cm	0	Enough light	• The tracking process is easy to find the tar-get
			• 3D objects only appear partially Running ani-mations

The test results in Table 2 show that the test results indicate the conditions under which the solar system application can run well. The ideal conditions for solar system applications are between 10-20 cm with sufficient lighting conditions.

Testing

Applications trial to users taken place at SD Purwantoro, Kelurahan Purwantoro, Blimbing, Malang, East Java. The author conducted a user acceptance test, "Solar System Learning Media Based on Augmented Reality Using Cube Object Marker" to grade 6 students, with total respond-ents of 18 students. The test activities are shown in Figure 15.

Figure 15. User acceptance test

The author distributes questionnaires to students to assess applications of Solar System Simulation. There are 7 questions developed in the questionnaire. The first question is regarding the ease of use of the application. The second question is about content design. The third question is regarding the clarity of the appearance of 3D objects. The fourth question is regarding the clarity of content description. The fifth question is regarding content animation. The sixth question is regarding the interest in AR in general. The seventh question regarding the intention to use the AR solar system application. The results obtained from the testing process of 18 respondents shown in table 3 are as follows, one respondent answered that the solar system simulation application was not attractive, two respondents stated that the 3D objects made were unclear and unattractive. Three respondents had difficulty understanding the description of the solar system simulation. The results of the questionnaire that have been distributed to students are shown in Table 3.

Table 3. Student questionnaire result

Question Number (Q)	Result (%)	
	Yes	No.
Q1	100%	0%
Q2	100%	0%
Q3	100%	0%
Q4	94%	6%
Q5	88%	12%
Q6	83%	17%
Q7	100%	0%

The percentage of results obtained from student questionnaires is calculated by summing all the percentage results obtained in each question category.

$$total\ percentage = \frac{Q1\%+Q2\%+Q3\%+Q4\%+Q5\%+Q6\%+Q7\%}{Total\ number\ of\ Question} \quad (2)$$

The total results obtained are ± 95% so it can be stated that this application is helpful to elementary students in 6th grade in learning the Solar System.

Conclusion

Augmented Reality Solar System applications have been successfully applied to the education sector by bringing up 3D objects and descriptions in the solar system. From the test on the subject of the use of AR for solar system simulations, the result shows that 95% of respondents gave a positive response. Augmented Reality technology makes it easier to simulate the planets in the solar system more realistically and interactively to arouse students' enthusiasm to learn about the solar system. The rule-based method used in this application can run well and according to system requirements. The application can detect both one marker and multiple markers.

Acknowledgments

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Implementation of human-centered design methods in designing application interfaces for nursing home service

Stefanus Setyo Wibagso [1]*, Ivana Celesta [2]

[1,2] *Universitas Katolik Musi Charitas, Indonesia*

*****Corresponding Author: *setyo.wibagso@ukmc.ac.id*

Abstract: In a nursing home, the elderly gets health services to support their daily life. These services are documented and reported periodically to elderly families. In addition to managing information about nursing services, there is other information that must also be managed properly to help the smooth operation of the nursing home. To support the information management process, reliable software is needed to have the functions and benefits that are in accordance with the needs. One of the supporting components that contribute to building good software is interface design. This study will discuss the design of nursing home service application interfaces that have fields, characteristics, and functions that are different from other fields, especially the field of special health services for the elderly. The purpose of this study is to provide an overview and insight to desktop, mobile, and web application developers regarding aspects of designing an interface that is acceptable to system users in nursing homes. This will certainly make it easier for developers to produce good and acceptable software. The design of the interface is carried out using the Human-Centered Design (HCD) method which applies a user-focused design approach so that it makes it easy to understand what their needs are. There are several stages in HCD, namely the stage of identifying and determining the context of the user (Understand and specifying the context of use), the stage of identifying user requirements (Specifying the user requirements), the stage of producing design solutions (Producing design solutions) and the stage of evaluating the design (Evaluating the design). This research produces an interactive and easy-to-use interface design because the testing process uses a prototype as a demonstration tool. The test results using the End User Computing Satisfaction (EUCS) method show that 88.25% of users are satisfied with the design made and in line with the needs of users in a nursing home.

Keywords: nursing home, HCD, interface, EUCS

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Introduction

As a place that provides health care services to the elderly [1], a nursing home does not only focus on health services. But further, it seeks to improve the information services that can be provided to the patient's family related to the care for each elderly. There is a variety of information in the orphanage including elderly data, elderly care, elderly mutations, visits, contributions, donations from donors in the form of goods and money, staff data, to donor data [2]. Data documentation activities have an important role in managing an organization, including a nursing home. Integration of data or information serves to assist services and provide comprehensive health information to patients, nurses, and families [3]. The better the management, the easier it will be for managers to provide information on elderly care to families.

To assist the operations of the orphanage in managing information, technology can be used as a reliable tool. The use of technology in the form of software or software can provide its advantages for users, one of which is to transform manual methods of documenting and managing data. With the use of software, information can be generated more effectively. The outcome of managing information is obtained in a faster and cheaper way.

In the last few years, the world of software is growing very rapidly starting from desktop applications, web to mobile. These developments have had a huge impact on changing the perspective of developers in designing and building software. The big thing that is a concern in the

development process is to build an interface or commonly referred to as a user interface (UI). UI is an important and key component of interactive software applications [4]. The interface is a design display that refers to software functions and interactions between users through commands, inputting data, and using content [5]. One of the productivity successes of a software application can be seen from the good or bad interface created. This is a very important factor because most of the operations on software applications are carried out by the user using the interface. Inter-face design support for applications makes the final software product more leverage in improving usability so that it can provide several benefits including increased productivity, increased user well-being, stress avoidance, increased accessibility, and reduced risk of harm [6].

Many bad designs are produced as a result of ignoring the people for whom the design is intended [7]. For this reason, therefore the interface design that is built can run and function properly, an appropriate design method is needed. One method that can be used in designing the interface is the Human-Centered Design (HCD) method. HCD is an approach in the design process that involves users and stakeholders. This approach is very useful in producing a usable and interactive system between humans and the system because of its focus on the user [8]. By maintaining a focus on the needs and requirements of users it will result in increased satisfaction and acceptance of the system [9]. The ISO 9241-210 standard describes the potential benefits of following a design approach that improves usability and the human factor [6].

Putting the user at the heart of the design process means making him or her the guiding principle of the philosophy associated with HCD, namely universal design. The goal of universal design is to create products, environments, and services for all users regardless of their physical or cognitive abilities [10]. Through HCD, the interface design that is designed can be in line with the expected usability of the software that will be built. User-centered interface design is developed to address poor software product design and aims to emphasize user needs and capabilities to improve understanding and use of the software.

Based on the above background, the authors are interested in conducting research on designing web-based nursing home software application interfaces with an HCD approach that adapts to user needs. Web-based software is the choice because it is dynamic and has the convenience of managing changes in data display [11]. The result to be achieved in this research is an interface design in the form of a prototype which can later be used as a design display recommendation in developing nursing home service applications.

Methodology

The definition of Human-Centered Design (HCD) according to the ISO 9241-210 standard is a human-centered design through a systems design and development approach that aims to make the system interactive, more useful, usable, and productive [12] by focusing on the use of the system and human application, ergonomic factors, and knowledge and skills usability technique [6]. The HCD method helps in the research process to understand the needs of users and stakeholders in meeting the requirements of the design [13].

HCD is a system design-oriented process that can be applied early in the design process, even before a system exists that can allow user feedback [12]. HCD is a mandatory upstream process that allows the design team to incorporate human requirements into the system design which is usually scenario and prototype-based. Information amassing for HCD is regularly blended methods, depending closely on qualitative investigations to recognize contextual and user needs, in addition to quantitative information to evaluate opportunity designs or answers thru a couple of iterations [14]. The HCD process consists of gathering human factors issues from the appropriate user community, or general-ly actors anticipated to act on the designed system. Actors can be end-users who also act as managers who have to fix the system in case of failure. This allows users to play a role in producing designs for usability but also for designs that are easy to maintain [15].

In the research to design the nursing home service application interface, several stages were carried out [16] by adopting the Human-Centered Design (HCD) method. These stages can be seen in Figure 1.

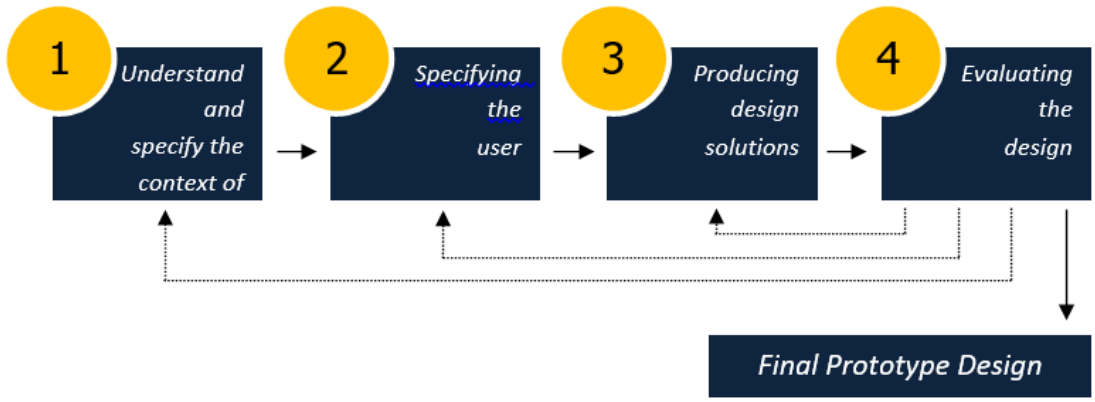

Figure 1. Interface design using HCD method

1. Understand and specify the context of use: At this stage, identification and determination of the context of use from the user's side of the nursing home are carried out to produce identification in the form of group division, characteristics and user roles in the application environment to be built.

2. Specifying the user: At this stage, the detailed requirements of the nursing home are carried out by looking specifically at the expected functional and non-functional needs. This phase will produce detailed requirements, a list defining user tasks, and use case diagrams that are used to describe the workflow and scenarios of the application.

3. Producing design solutions: At this stage, a design solution is carried out by designing an application interface by drawing a sitemap and using a prototype with a high degree of accuracy (high-fidelity prototyping).

4. Evaluating the design: At this stage, evaluation of the design and validation of user needs is carried out through usability testing to measure aspects of effectiveness, efficiency, and user satisfaction. This phase is carried out interactively if the results are not in accordance with the needs. After the evaluation stage, the accepted design will be used as the final prototype design of the application interface.

Results and Discussions

Based on the design flow that adopts the Human-Centered Design method, this chapter will explain the results of each stage starting from determining the context of application usage, describing detailed specifications of user needs, and implementing interface design solutions. Furthermore, an evaluation of the design that has been made through interface testing in the form of a prototype will be carried out and evaluate the test through a questionnaire that refers to the EUCS (End User Computing Satisfaction) method.

Results

From the identification and determination of the context of use through interviews at a nursing home, the results of the group division, characteristics, and roles of users are shown in Table 1.

After taking a deeper look at the specifications of the expected functional requirements, the detailed specifications of user requirements are obtained. Table 2 shows examples of elderly nursing services performed by nurses and Table 3 shows examples of financial and donation management by finance staff.

Table 1. Group division, user characteristics, and roles

Group	Characteristic	Roles
Nurse	Provide health care services to the elderly.	As a nurse who uses a system to record nursing action data for the elderly and reports periodically to the elderly family.
Administrative staff	Carry out administrative activities that occur in a nursing home.	As an administrative staff who uses the system to record and manage data related to the elderly, elderly mutations, staff, donors, elderly family visits, and elderly food intake menus.
Financial staff	Carry out recording and documentation activities related to finances in a nursing home.	As a financial staff who uses the system to record and manage data related to the receipt of payment for the elderly, donations of money, and goods from donors.
System Admin	Manage the system and management system users in a nursing home.	As an admin who uses the system to add and subtract users according to the roles and needs of the nursing home. In addition, the system admin has a role to fully control the running of the system.

Table 2. The detailed specification of user requirements for elderly nursing services

No.	Function Detail Name	Description
1.	System login	Enter username and password.
2.	Dashboard and Main Menu	Information summary of elderly data, nursing services, and navigation menus.
3.	Elderly data	Search for elderly data information.
4.	Elderly nursing action data	Management of nursing action data for the elderly.
5.	Logout	Log out of the system.

Table 3. The detailed specification of user requirements for donations and financial management

No.	Function Detail Name	Description
1.	System login	Enter username and password.
2.	Dashboard and Main Menu	Information summary of elderly data, donors, donations of money, donations of goods, and navigation menu.
3.	Money donation data	Data management of monetary donations from donors.
4.	Item donation data	Management of data on donations of goods from donors.
5.	Elderly contribution data	Management of data on payment of elderly contributions.
6.	Logout	Log out of the system.

The detailed list of task definitions for each user can be seen in example table 4 which shows a list of user task definitions for elderly nursing services and table 5 which shows a list of user tasks for donations and financial management.

Table 4. User duties defined list for elderly nursing services

No.	Task	Objective
1.	Open dashboard and main menu	Looking at the summary, looking for elderly data, and looking for nursing action data for the elderly.
2.	Adding data on nursing actions for the elderly.	Manage data on nursing actions for the elderly.
3.	Print reports on nursing actions for the elderly periodically.	Produce nursing action documents for the elderly that will be sent to the family.

Table 5. User task defined list for donations and financial management

No.	Task	Objective
1.	Open dashboard and main menu.	View summaries, look for elderly data, look for data on donations of money and goods.
2.	Add money donation data.	Manage data on donations of money from donors.
3.	Add item donation data.	Manage data on donations of goods from donors.
4.	Adding data on elderly contributions.	Manage data on payment of elderly contributions.

To explain in more detail, the interactions between users (actors) and systems, use case diagrams are needed that can be used to visually explain the context of interaction between users and the system [17], workflows, and scenarios of each user. The use of the use case diagram itself aims to analyze the design of a system [18]. Figure 3 shows an example of a use case diagram for nursing services for the elderly and Figure 4 for the management of donations and finances.

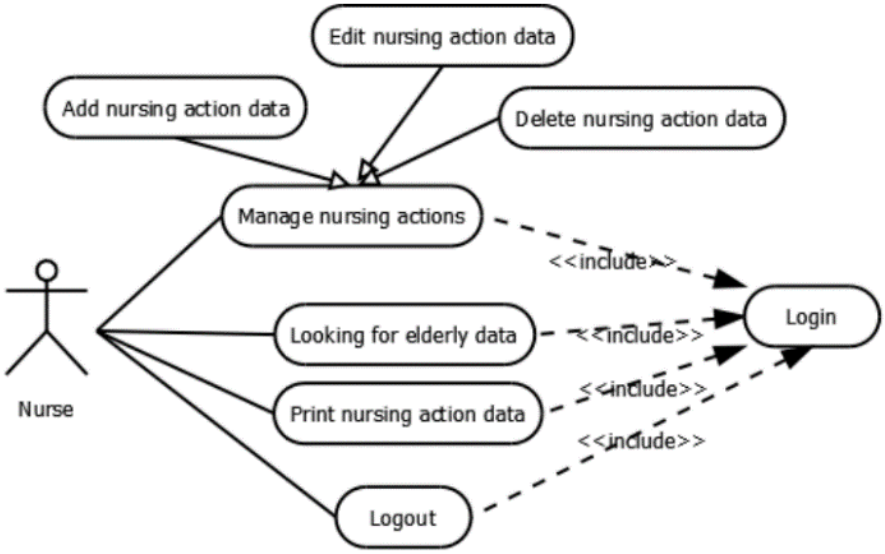

Figure 3. Use case diagram of elderly nursing services

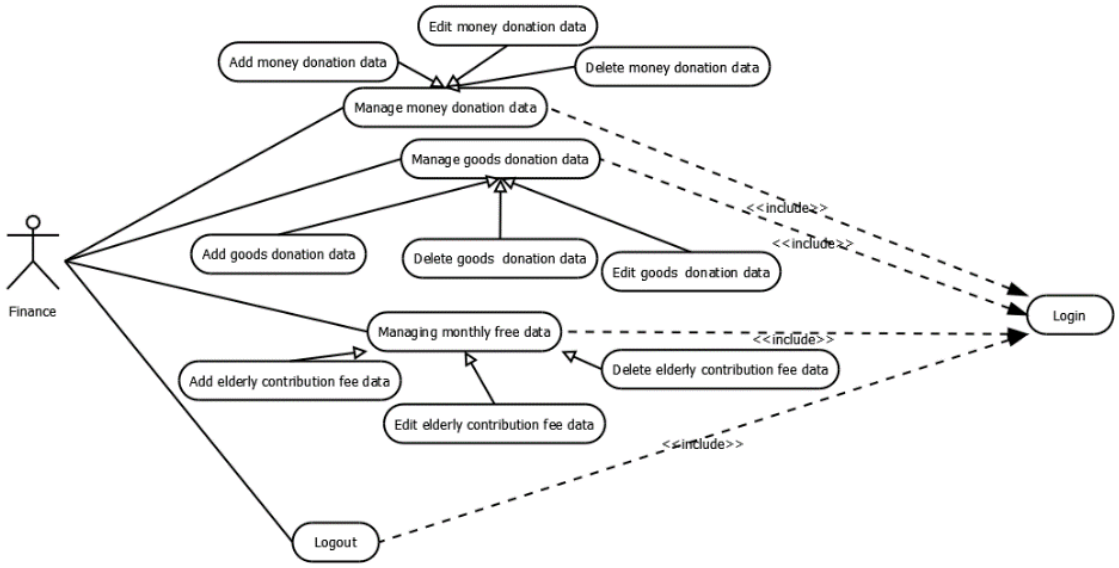

Figure 4. Use case diagram of donations and financial management

The next stage is the stage of making a solution whose design is carried out through 2 stages, namely sitemap design and application interface using prototypes. The sitemap is useful as mapping information for all content contained in the application [19] and also can be used to ease or arrange code dan its file [20]. The results of the sitemap are shown in Figure 5, the sitemap for a nursing home service application below.

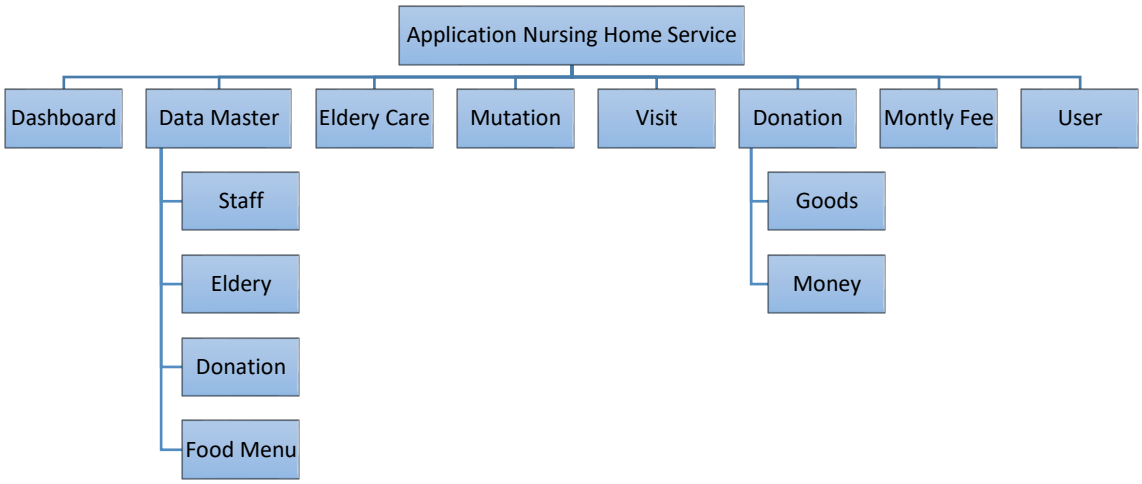

Figure 5. Nursing home service application sitemap

Based on the workflow of each user in the use case diagram, a prototype for a nursing home service application can be designed based on 4 access rights, namely:

1. Interface for nursing services accessed by nurses.

Interface design for nurses is only limited to access to nursing care for the elderly. Figure 6 shows an example of an interface design to add data for elderly nursing actions and Figure 7 shows an interface to view and search for elderly nursing data.

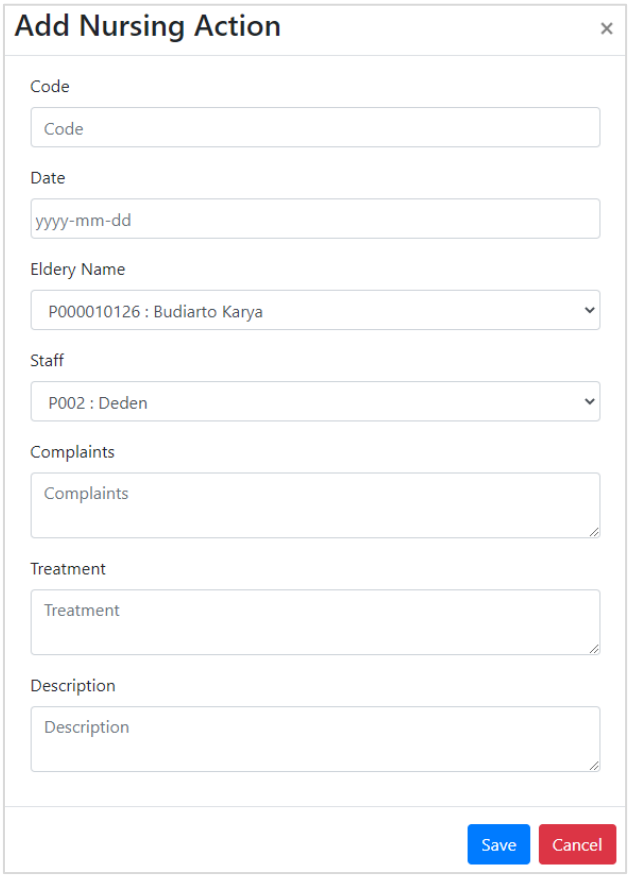

Figure 6. Display addition of elderly nursing data

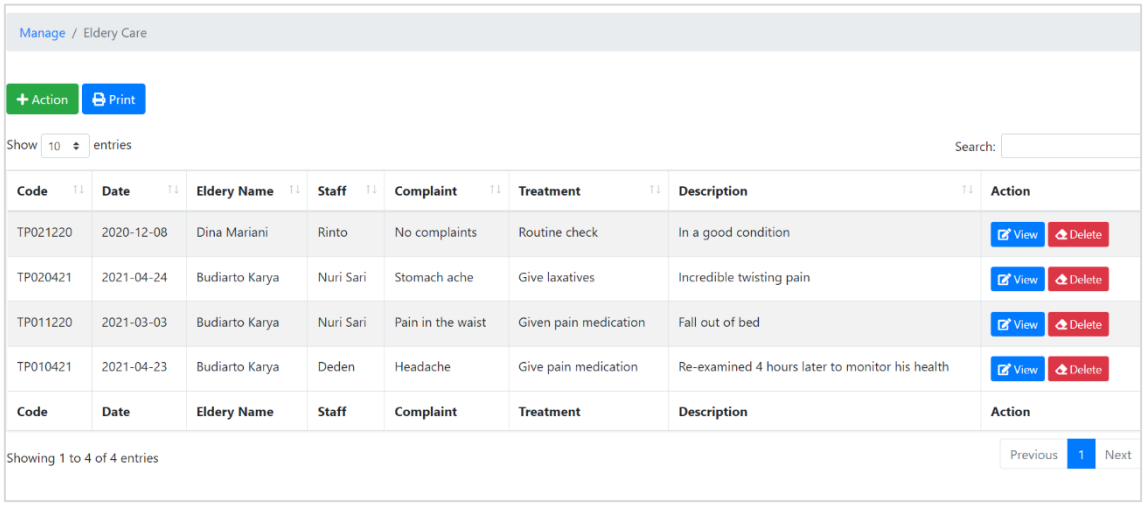

Figure 7. Display of elderly nursing data search

2. Interface for administrative services accessed by administrative staff.

The interface design for administrative staff is only limited to access to staff data, the elderly, donors, food menus, transfers, and visits. Figure 8 shows an example of an interface design for viewing and searching for elderly data and Figure 9 shows an interface for searching for nursing history data for each elderly.

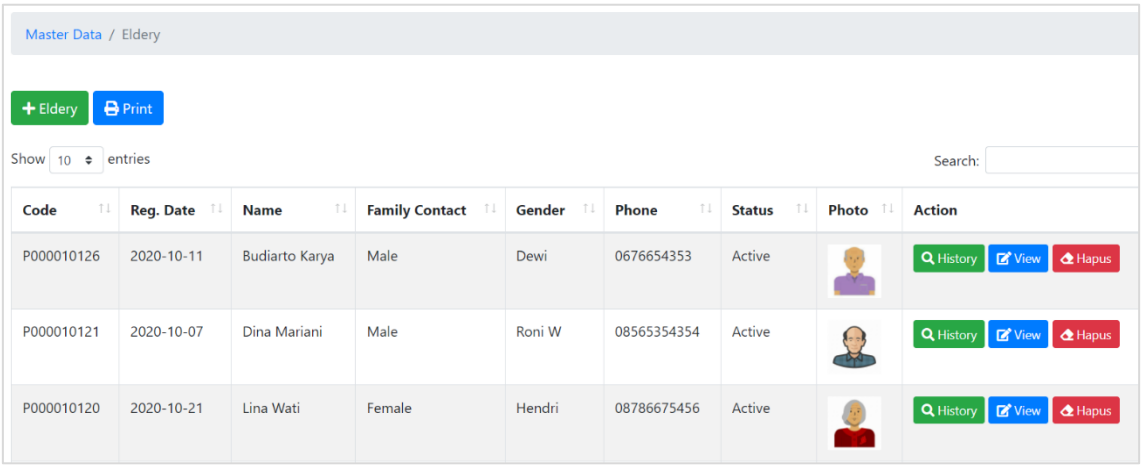

Figure 8. Elderly data search display

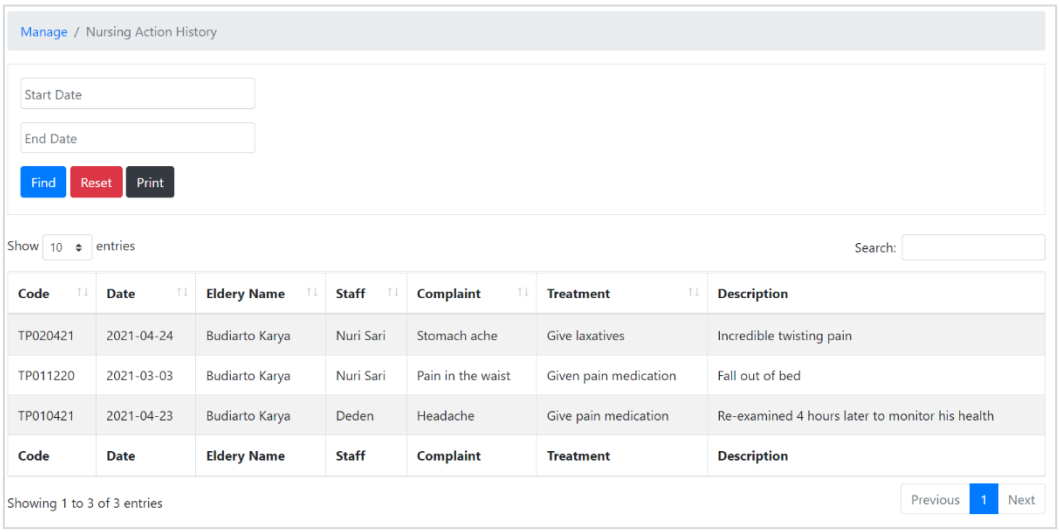

Figure 9. Display of elderly nursing history data search

3. Interface for financial management and donation services accessed by finance staff. Figure 10 shows an example of an interface design for adding item donation details.

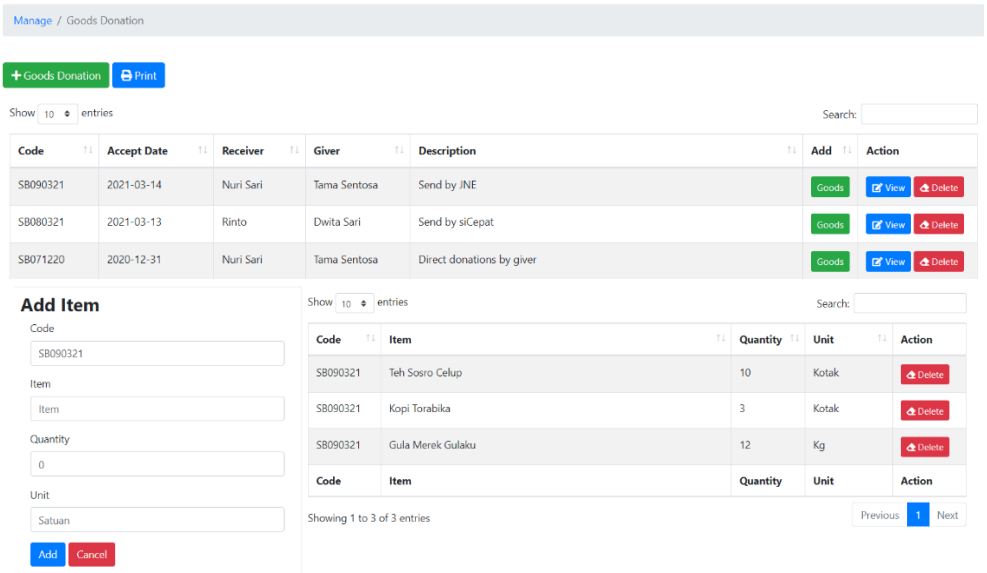

Figure 10. Display addition of goods donation details

4. Interface for all services accessed by system admin.

The admin system interface design includes all the access that nurses, administrative staff, financial staff have plus the system user management interface. Figure 11 shows the design of the navigation menu interface and the system admin dashboard.

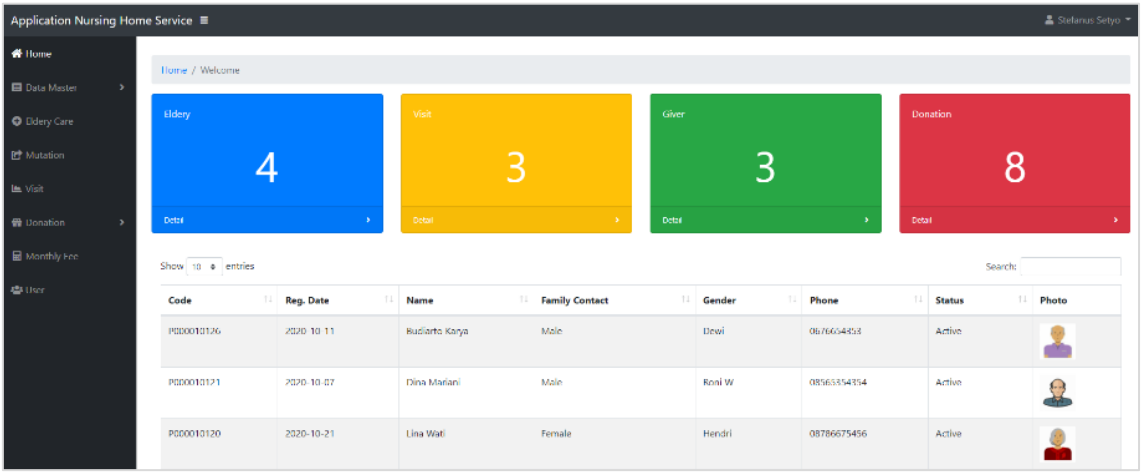

Figure 11. Display navigation menu and system admin dashboard

Discussions

There are two steps taken in conducting usability testing to measure the effectiveness, efficiency, and user satisfaction aspects of the interface design, namely by testing the application based on its access and followed by filling out a questionnaire. A list of questionnaire question items based on the EUCS (End User Computing Satisfaction) method where the question instruments include con-tent, accuracy, format, ease of use, and timeliness in obtaining information [21]. EUCS is an important determinant that affects the user's intention to use the system [22], which in this case is represented in the user interface. Table 6 below shows a list of questions that will be asked to the user after completing the trial use of the application.

Table 6. List of questionnaire

EUCS Dimensions	Question Code	Question
Content	C1	The featured content of the nursing home service application prototype is in accordance with the needs.
	C2	The featured content of the nursing home service application prototype is clear and easy to understand.
	C3	The featured content of the nursing home service application prototype can help the performance of the staff concerned.
	C4	The data displayed on the prototype of the nursing home service application is accurate or in accordance with the data entered.
Accuracy	A1	The data displayed on the prototype of the nursing home service application is accurate or in accordance with the data entered.
	A2	Each link in the application prototype menu that is clicked always matches the page in question.
Format	F1	The interface design created has a menu structure and links that are easy to understand.
	F2	The interface design made makes it easy for users to use the application prototype.
	F3	The display interface design for text types, icons, and colors has an attractive arrangement.
Ease of Use	E1	The prototype of the nursing home service application can be accessed easily using a mobile phone, tablet, laptop, or computer.
	E2	The nursing home service application prototype is very easy to use.
Timeliness	T1	Information about nursing home services can be obtained quickly through this application prototype.
	T2	Data search results can be done quickly and precisely.

Table 7. Test results using EUCS method

Respondent	Question Score													Total	Score
	C1	C2	C3	C4	A1	A2	F1	F2	F3	E1	E2	T1	T2		
1	3	3	4	3	4	4	4	3	4	4	4	4	4	48	92.31
2	3	3	3	3	4	3	3	4	4	4	4	4	4	46	88.46
3	4	4	4	3	3	4	4	4	4	3	4	3	4	48	92.31
4	3	3	3	4	4	4	3	3	3	3	3	3	4	43	82.69
5	3	3	3	3	3	3	3	3	3	3	3	3	3	39	75.00
6	4	4	4	4	4	4	3	3	4	3	3	3	4	47	90.38
7	4	3	3	4	4	4	3	4	3	4	3	3	3	45	86.54
8	3	3	3	4	3	4	4	4	3	3	4	4	4	46	88.46
9	4	4	4	4	4	4	4	4	4	3	4	4	4	51	98.08
Score Total															794.23
Average															88.25

The total average result of testing using the EUCS method is 88.25%. The percentage figure is greater than 70% which means that the interface design of the application that is built is considered valid [23] and meets user needs with an easy-to-reach, accurate and fast display in managing information related to services in a nursing home.

Conclusion

This study resulted in an application interface design for a nursing home service based on the needs of nurses, administrative staff, finance staff, and leaders with a satisfaction level of 88.25%. The Human-Centered Design (HCD) method provides very clear guidance in the interface design stages therefore it can produce interactive and easy-to-use designs for users. The next researchers need to carry out further research on the characteristics of the information needed in another nursing home. The more and richer the information obtained, the more complete the reference for the development of the information system for the nursing home. This interface design needs to be developed into a nursing home information system application that can be used to simplify and speed up the information processing process at the home and improve the quality of information to elderly families and related agencies.

Acknowledgments

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Komodo National Park fiber optic network design and analysis by considering earthquake epicenter

Muhammad Riza Darmawan [1]*, Nurul Aini [2], Awangga Febian Surya Admaja [3], Catur Apriono [4]

[1,2,3,4] *Universitas Indonesia, Indonesia*

*****Corresponding Author: *muhammad.riza93@ui.ac.id*

Abstract: Labuan Bajo and Komodo National Park (KNP) are the government's agendas in the tourism sector by making the area a premium tourist destination. On that basis, the tourism potential of the region requires infrastructure development to support this plan. One of the critical infrastructures is telecommunications, where the region does not have a direct fiber-optic line. In this paper, the authors propose two scenarios design of fiber-optic networks that also consider the potential for an upward fault earthquake in the northern waters of Labuan Bajo and KNP. The design is analyzed using calculation results of the power link budget, rise time, bit error rate (BER), and Signal to Noise Ratio. The BER value obtained is 5.63×10^{-13}, which is still below the parameter threshold of 10^{-12} with a design that avoids the epicenter of the disaster and a longer route. The SNR value on the longest route (route 7) is 34.69 dB. The SNR value has met the SNR standard, which is 21.5 dB.

Keywords: bit error rate, power link budget, rise time analysis, signal to noise ratio

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Introduction

Komodo Island and Rinca Island have been designated as National Parks since 1980 to protect the ancient endemic Komodo in East Nusa Tenggara Province. One area that has experienced a significant design change is the Rinca Island part of Komodo National Park (KNP) in the West Manggarai Regency. This island will be converted into a premium tourist destination with a geopark concept approach [1]. This development is expected to help the management of Komodo Island, which currently reaches Rp 129 billion and only gets Rp 33 billion allocations from the government [2]. The development of KNP is expected to increase government revenue from the tourism sector and increase the income of the surrounding population. Based on data in 2019, the economic potential of tourism value in Labuan Bajo and KNP could reach Rp 2.3 trillion [3].

Developing the area's infrastructure is necessary with the planned development of the Labuan Bajo and KNP areas into premium tourist destinations. One of the crucial infrastructures is a telecommunications infrastructure network. It also supports the government's program to improve telecommunication access in tourist destination areas to increase tourist arrivals [4]. One way is to build a fiber-optic network that has direct access to the area.

The change of the area into a premium tourist destination is expected to require a larger data connection for both the conservation and tourism sectors. Meanwhile, the current condition of the submarine cable shows that no one goes to KNP directly. One thing that needs to be considered in the deployment of submarine cables is the potential for damage to underwater cables caused by underwater earthquakes. Based on BNPB data, the sea area of NTT is an earthquake alert area [5].

The current optical cable network connects Sumbawa Island to NTT with MKCS Cable (Mataram Kupang Cable System) along 1851 Km with 1,041 Km of sea cable and 810 Km of land cable connecting six-station points, namely Mataram, Sumbawa Besar, Raba, Waingapu, and Kupang [6], [7]. However, this MKCS cable had an experience of breaking in 2018 due to the Lombok Earthquake [8]. Repairing the cable requires a lot of money and a long time because the

damage occurs under the sea [9]. Several studies have been carried out in designing fiber optic networks in an area such as in [10], which proposed a backbone network for North Sumatra. In [11], a proposed optical network design aims to support 4G technology in Sleman.

Based on the disaster map issued by BNPB in 2020, the KNP and Labuan Bajo location is surrounded by Megathrust and faults. The Rising Back Fault, which is located in the north, is the Alert Zone with a track record of earthquakes and tsunamis occurring in 1992 – 2018, while in the south, there is the Bali – Nusa Tenggara Megathrust which was last recorded by an earthquake in 1977 and is included in the Alert Zone [5]. In 2018-2019 the Labuan Bajo and KNP areas experienced several underwater echoes in the northern part of the waters of Labuan Bajo and West Manggarai [12]–[15].

This paper proposes two scenarios for deploying fiber optic networks in the tourist areas of Labuan Bajo and KNP. The deployment scenario without considering potential underwater earthquake disaster points and deployment scenarios by considering potential aspects of underwater disaster points. The calculation results of the two scenarios will then be compared with the technicalities, impacts, and costs required. This research considers planning flowcharts, location determination and network planning, technical specifications, the power link budget calculation, rise time analysis calculation, signal to noise ratio (SNR), and Bit Error Rate (BER) calculations. Results and Discussions contain power link budget analysis, rise time analysis, SNR and BER analysis, technical analysis, potential risks, and impact estimates, and estimates of cost requirements.

Methodology

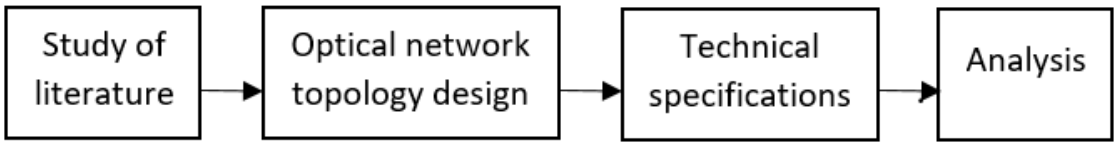

Figure 1. Planning flowchart

Planning Flowchart

The planning flowchart is shown in Figure 1. The planning design of this optical cable deployment will begin with a literature study of the existing Palapa Ring cable system in Sumbawa and East Nusa Tenggara. Its deployment scenario without considering potential underwater earthquake disaster points and deployment scenarios considering potential aspects of underwater earthquake disaster points. Then, we design an optical network topology design to determine the deployment location to determine the necessary cable requirements and deployment scenario without considering aspects of potential underwater earthquake disaster points and deployment scenarios by considering potential aspects of underwater earthquake disaster points. Some researchers consider the need for additional cables with a backup cable of 5% of the distance between points [16]–[18]. After that, we search technical specifications to ensure the devices' specifications used to deploy fiber optic networks, power link budget calculation, rise time analysis calculation, signal to noise ratio (SNR), and Bit Error Rate (BER) calculations. And the last, we analyze:

1. Power link budget analysis (Power link budget analysis is used to determine whether the power sent along with the information from the transmitter can be received by the receiver or not after passing through the optical cable media at a certain distance)
2. Rise time analysis (Rise time analysis is used to determine the total time required for the system from the initial state to reach a stable state)
3. SNR and BER analysis (BER analysis is a parameter to determine the number of bit errors at the receiver end for each number of data bits sent in a certain time interval. The smaller the BER value in a system, the better the system performance will be. BER can be obtained by using the Q-factor derived from the Signal to Noise Ratio (SNR). SNR is one of the parameters used to determine the performance of a receiver. The higher the SNR, the better the communication quality. SNR is used to determine the ratio of the received signal to noise in the system)

4. Technical analysis (Technical analysis is used to show results of power link budget analysis, rise time analysis, SNR, and BER analysis)
5. Potential risks and impact estimates (Potential risks and impact estimates is used to show technical and non-technical risks)
6. Cost requirements (Cost requirements is used to show parameters, quantity, and price to build KNP fiber-optic network)

Location Determination and Network Planning

1. Scenario 1

The location determination in scenario 1 is based on the current location of the MKCS cable [19] and palapa ring [20] as the starting and ending points of the proposed route. Location determination in scenario 1 is a deployment scenario without considering aspects of potential underwater earthquake disaster points. Deployment scenario without considering aspects of potential underwater earthquake disaster points as shown in Figure 2.

Figure 2. Scenario route 1

The calculation of the distance and total cable length for scenario 1 is shown in Table 1. The total cable length is the sum of the distances with a cable reserve of 5% on each route. Total cable from Soro to Kelapa to Komodo to Pasir Panjang to Labuan Bajo is 162.76 km, where location determination deployment scenario without considering aspects of potential underwater earthquake disaster points.

Table 1. Scenario route 1

No	Route	Distance (km)	Cable Length (km)	Description
1	Sondo to Bima	47.5	49.88	Land cable
2	Bima to Soro	48.3	50.72	Land cable
3	Soro to Kelapa	35.6	37.38	Submarine cable
4	Kelapa to Komodo	55.5	58.28	The longest in submarine cable
5	Komodo to Pasir Panjang	43.8	45.99	Submarine cable
6	Pasir Panjang to Labuan Bajo	20.1	21.11	The shortest in submarine cable
7	Labuan Bajo to Lembor	63.9	67.10	The longest inland cable
8	Lembor to Ruteng	62.1	65.21	Land cable
9	Ruteng to Wangkung	61.2	64.26	Land cable
10	Ruteng to Borong	55.9	58.70	Land cable
11	Borong to Ngada	41.2	43.26	The shortest land cable
12	Ngada to Nagekeo	62.9	66.05	Land cable
13	Nagekeo to Nangaroro	56.2	59.01	Land cable
14	Nangaroro to Ende	43.0	45.15	Land cable
	Total	697.2	732.06	

2. Scenario 2

In scenario 2, the location determination is almost the same as scenario 1. It is based on the location of the MKCS cable [19] and the palapa ring [20] as the starting and ending points of the proposed route. However, there are differences in the deployment of the route on routes 4 and 5; namely, the proposed route is a submarine cable with the deployment avoiding the waters in the northern part of KNP and Labuan Bajo. Deployment scenarios by considering potential aspects of underwater earthquake disaster points as shown in Figure 3.

Figure 3. Scenario route 2

The calculation of the distance and the total cable length for scenario 2 is shown in Table 2. The total cable length is the sum of the distance with a cable reserve of 5% on each route. Total cable from Soro to Kelapa to Komodo to Pasir Panjang to Labuan Bajo is 171.79 km, where location determination scenarios by considering potential aspects of the underwater earthquake disaster.

Table 2. Scenario route 2

No	Route	Distance (km)	Cable Length (km)	Description
1	Sondo to Bima	47.5	49.88	Land cable
2	Bima to Soro	48.3	50.72	Land cable
3	Soro to Kelapa	35.6	37.38	Submarine cable
4	Kelapa to Komodo	57.2	60.06	The longest in submarine cable
5	Komodo to Pasir Panjang	50.7	53.24	Submarine cable
6	Pasir Panjang to Labuan Bajo	20.1	21.11	The shortest in submarine cable
7	Labuan Bajo to Lembor	63.9	67.10	The longest land cable
8	Lembor to Ruteng	62.1	65.21	Land cable
9	Ruteng to Wangkung	61.2	64.26	Land cable
10	Ruteng to Borong	55.9	58.70	Land cable
11	Borong to Ngada	41.2	43.26	The shortest land cable
12	Ngada to Nagekeo	62.9	66.05	Land cable
13	Nagekeo to Nangaroro	56.2	59.01	Land cable
14	Nangaroro to Ende	43.0	45.15	Land cable
	Total	705.8	741.09	

Technical Specification

Bandwidth requirements are calculated in advance to determine the parameters that will be used in network planning. The bandwidth requirement is calculated from the number of

residents of the tourist areas of Labuan Bajo and Komodo National Park by the assumption of bandwidth requirements per person (4 Mbps) [21]. The number of people who have the potential to use the internet is in Table 3. From [21], Age 13 to > 60 has potential to use the internet. Region Labuan Bajo has a larger potential to use the internet than Komodo and Pasir Panjang. Region Gorontalo has the largest potential to use the internet. Region Pasir Panjang has the smallest potential to use the internet.

Table 3. Number of people who have the potential to use the internet

No	Region	Age 13 to >60
1	Komodo	1528
2	Pasir Panjang	1393
3	Gorontalo	5900
4	Wae Kelambu	5392
5	Batu Cermin	4649
6	Labuan Bajo	5742

From Table 3, the total number of people who can use the internet is 24,604 from the age range of 13 to more than 60 years [21], so the total bandwidth requirement is 24,604 x 4 Mbps = 98,416 Mbps = 98.4 Gbps. Table 4 shows the technical parameters. BER, signal encoding, and wavelength are 10^{-12}, NRZ, and 1550 nm, respectively. System Margin is 4 dB. From [22] explained that attenuation (α_f) is used 0.16 dB/km, and chromatic dispersion is used 3 ps/nm.km. From [23] explained that attenuation (α_f) is used 0.16 dB/km, and chromatic dispersion is used 3 ps/nm.km. From [24] explained that transmit power is used 4 dBm, Receiver Sensitivity is used -24 dBm. Transceiver Rise Time has used 28 ps, Spectral Width ($\sigma\lambda$) is used 0.3 nm, Maximum Acceptable Loss is used 28 dB. In Additional loss, Connector Attenuation is used 2 dB/connector. From [25] explained that Dark Current is used 40 nA, M of APD is used 20 dBm, T_eff used 25˚C, excess noise figure is used 0.7 nm, FM (Noise Figure) is used 8.14 dB, and Receiver Efficiency is used 85 %.

Table 4. Technical parameters

No	Parameter	Value	Unit
1	Bandwidth	98.4	Gbps
2	BER	10^{-12}	
3	Signal Encoding	NRZ	
4	Wavelength	1550	nm
5	System Margin	4	dB
	Land Optical Fiber Cable (ITU-T G.654.B) [22]		
1	Attenuation (α_f)	0.16	dB/km
2	Chromatic Dispersion (D)	3	ps/nm.km
	Submarine Optical Fiber Cable (ITU-T G.973) [23]		
1	Attenuation (α_f)	0.16	dB/km
2	Chromatic Dispersion (D)	3	ps/nm.km
	Huawei Optix OSN 8800 – TN55TTX [24]		
1	Transmit Power	4	dBm
2	Receiver Sensitivity	-24	dBm
3	Transceiver Rise Time	28	ps
4	Spectral Width ($\sigma\lambda$)	0.3	nm
5	Maximum Acceptable Loss	28	dB
	Additional Loss		
1	Connector Attenuation	2	dB/connector
	Hamamatsu InGaAs APD G8931-04 [25]		
1	Dark Current	40	nA
2	M of APD	20	dBm

3	T_eff	25˚	C
4	excess noise figure	0.7	nm
5	FM (Noise Figure)	8.14	dB
6	Receiver Efficiency	85	%

Calculation of Power Link Budget

Power Link Budget analysis is used to determine whether the power sent along with the information from the transmitter can be received by the receiver or not after passing through the optical cable media at a certain distance. Equations (1) and (2) are used to obtain the network's Total Loss value, which will be compared with the maximum allowable loss in the system. Equation (1) is used to calculate Power Link Budget $(\mathrm{P_t})$ which is a power source (P_S) and power receiver (P_r). Equation (2) is used to calculate Power Link Budget $(\mathrm{P_t})$ which the source of power loss comes from cable attenuation $(\alpha_f L)$, connector loss (L_c), loss splices (L_s), and system margins (assuming 4 dB) [26]–[28].

$$P_T = P_S - P_R \tag{1}$$

$$P_T = \alpha_f L + L_c + L_s + margin\ sistem \tag{2}$$

Calculation of the Rise Time Analysis

Rise time analysis is used to determine the total time required for the system from the initial state to reach a stable state. Equation (3) is used to calculate the time described in equation (4). Equation (4) is used to calculate the total rise time (t_{sys}) which is the sum of the rise time of the transmitter (t_{tx}), the rise time of the receiver (t_{rx}), and the rise time of the velocity dispersion group (t_{GVD}). Where the value of t_{GVD} is obtained through equation (5) which is the product of the dispersion time of the cable (D), cable length (L), and wavelength width. Equation (6) is used to calculate the maximum rise time dispersion ($t_{max\ sys}$) [26]–[28].

$$t_{sys} = (\textstyle\sum_{i=1}^{N} {t_i}^2)^{1/2} \tag{3}$$

$$t_{sys} = ({t_{tx}}^2 + {t_{GVD}}^2 + {t_{rx}}^2)^{1/2} \tag{4}$$

$$t_{GVD} = D.L.\sigma_\lambda \tag{5}$$

$$t_{max\ sys} = 70\% \times \frac{1}{Data\ Rate} = 259.259 \tag{6}$$

Calculation of Signal to Noise Ratio (SNR) and Bit Error Rate (BER)

BER analysis is a parameter to determine the number of bit errors at the receiver end for each number of data bits sent in a certain time interval. The smaller the BER value in a system, the better the system performance will be. BER can be obtained by using the Q-factor derived from the Signal to Noise Ratio (SNR) which is calculated by Equation (13). Like BER, SNR is one of the parameters used to determine the performance of a receiver. The higher the SNR, the better the communication quality. SNR is used to determine the ratio of the received signal to noise in the system [26]–[28].

$$SNR = \frac{Signal\ Power}{Noise\ Power} \tag{7}$$

Signal Power is the amount of signal power received at the receiver. Equation (7) is the equation for calculating the amount of SNR. Equation (8) is the SNR variables are P_R (power at receiver (W)), η (receiver efficiency (%)), q (electron charge (1.6 x 10^{-19} C)), h (Plank's constant (6.626 x 10^{-34} Js))), ν (frequency (Hz)), and M (gain of Avalanche Photodiode (APD)).

$$Signal\ Power = \left(P_R M \left(\frac{\eta q \lambda}{hC}\right)\right)^2 (M)^2 \quad (8)$$

Noise power is the amount of noise in the system, namely thermal noise ($N_{thermal}$), dark current noise (N_{dc}), and shot noise (N_{shot}). Equation (9) is an equation to calculate the amount of noise power in the system.

$$Noise\ Power = N_{thermal} + N_{dc} + N_{shot} \quad (9)$$

The following equations (10), (11), and (12) are used to calculate the amount of thermal noise, dark current noise, and shot noise in the system. T_{eff} is the effective noise temperature (K), k is the Boltzman constant (1.38 x 10^{-23} Joule/k), B is the bandwidth, R is the equivalent resistance (ohms), I_D is the dark current (A), and $F(M)$ is noise figure.

$$N_{thermal} = \frac{4kT_{eff}B}{R} \quad (10)$$

$$N_{dc} = 2qI_D B \quad (11)$$

$$N_{shot} = 2q(P_R \frac{\eta q \lambda}{hC})BM^2F(M) \quad (12)$$

The Q-factor can be used to indicate the minimum SNR ratio required to obtain BER. The Q-factor is a function of OSNR (Optical SNR). Equations (13) and (14) represent the relationship between SNR, Q-factor, and BER. Q is the magnitude of the Q-factor, Pe is the probability of error.

$$SNR = 20\ log\ 2Q \quad (13)$$

$$BER = Pe(Q) = \frac{1}{\sqrt{2\pi}} \frac{e^{-\frac{Q^2}{2}}}{Q} \quad (14)$$

Results and Discussions

Results and discussions contain the Power link budget analysis, rise time analysis, SNR and BER analysis, technical analysis, potential risks and impact estimates, and cost estimates.

Power Link Budget Analysis

Power link budget analysis is the first consideration parameter carried out by calculating the total optical power loss using equations (1) and (2). Table 5. shows the results of calculating the total optical power loss in scenario 1 and scenario 2.
Calculating power link budget use formula from equations (2). Example of calculating power link budget route 1 (Sondo to Bima) in scenario 1 and scenario 2 as below:
Equation (2) is used to calculate Power Link Budget (P_t) which the source of power loss comes from cable attenuation ($\alpha_f L$), connector loss (L_c), loss splices (L_s), and system margins (assuming 4 dB).

$$P_T = \alpha_f L + L_c + L_s + margin\ sistem$$
$$P_T = 0.16\ \text{dB/km} * 49.88\ \text{km} + 2 * 2\ \text{dB} + 0\ \text{dB} + 4\ \text{dB}$$
$$P_T = 15.98\ \text{dB}$$

Table 5 shows the power link budget calculation for each route for both scenario 1 and scenario 2. Because the difference between scenario 1 and scenario 2 only lies in the deployment of route 4 and route 5, the difference in the calculation value is only on that route. All the power link budget calculation for each route are still below the maximum allowable loss based on the parameters in the proposed design, which is 28 dB.

Table 5. Calculation of power link budget

No	Route	Scenario 1			Scenario 2		
		Cable Loss (dB)	Total Power Loss (dB)	Maximum Allowable Loss (28 dB)	Cable Loss (dB)	Total Power Loss (dB)	Maximum Allowable Loss (28 dB)
1	Sondo to Bima	7.98	15.98	Yes	7.98	15.98	Yes
2	Bima to Soro	8.1144	16.1144	Yes	8.1144	16.1144	Yes
3	Soro to Kelapa	5.9808	13.9808	Yes	5.9808	13.9808	Yes
4	Kelapa to Komodo	9.324	17.324	Yes	9.6096	17.6096	Yes
5	Komodo to Pasir Panjang	7.3584	15.3584	Yes	8.5176	16.5176	Yes
6	Pasir Panjang to Labuan Bajo	3.3768	11.3768	Yes	3.3768	11.3768	Yes
7	Labuan Bajo to Lembor	10.7352	18.7352	Yes	10.7352	18.7352	Yes
8	Lembor to Ruteng	10.4328	18.4328	Yes	10.4328	18.4328	Yes
9	Ruteng to Wangkung	10.2816	18.2816	Yes	10.2816	18.2816	Yes
10	Ruteng to Borong	9.3912	17.3912	Yes	9.3912	17.3912	Yes
11	Borong to Ngada	6.9216	14.9216	Yes	6.9216	14.9216	Yes
12	Ngada to Nagekeo	10.5672	18.5672	Yes	10.5672	18.5672	Yes
13	Nagekeo to Nangaroro	9.4416	17.4416	Yes	9.4416	17.4416	Yes
14	Nangaroro to Ende	7.224	15.224	Yes	7.224	15.224	Yes

Rise Time Analysis

Rise time analysis determines the total time required for the system from the initial conditions to reach a stable condition.

Calculating rise time use formula from equations (4) & (5). Example of calculating rise time route 1 (Sondo to Bima) in scenario 1 and scenario 2 as below:

Equation (4) is used to calculate the total rise time (t_{sys}) which is the sum of the rise time of the transmitter (t_{tx}), the rise time of the receiver (t_{rx}), and the rise time of the velocity dispersion group (t_{GVD}).

$$t_{sys} = ({t_{tx}}^2 + {t_{GVD}}^2 + {t_{rx}}^2)^{1/2}$$
$$t_{sys} = (28^2\ \text{ps} + 44.89^2\ \text{ps} + \left(\frac{350}{28}\right)^2\ \text{ps})^{1/2}$$
$$t_{sys} = 54.36\ \text{ps}$$

Value of t_{GVD} is obtained through equation (5) which is the product of the dispersion time of the cable (D), cable length (L), and wavelength width.

$$t_{GVD} = D.L.\sigma_{\lambda}$$
$$t_{GVD} = 3\ \text{ps/nm.km} * 49.88\ \text{km} * 0.3\ \text{nm}$$

$t_{GVD} = 44.89$ ps

Table 6 shows the calculation of the rise time analysis for routes 1 to 14 with a direct comparison between scenario 1 and scenario 2. Similar to power budget analysis, the difference in values is on routes 4 and 5. The total rise time value in the system is greater in scenario 2 for both paths because it has a longer route.

Table 6. Calculation of the rise time

No	Route	Scenario 1		Scenario 2	
		T_{gvd} (ps)	T_{sys} (ps)	T_{gvd} (ps)	T_{sys} (ps)
1	Sondo to Bima	44.89	54.36	44.89	54.36
2	Bima to Soro	45.64	54.99	45.64	54.99
3	Soro to Kelapa	33.64	45.52	33.64	45.52
4	Kelapa to Komodo	52.45	60.75	54.05	62.15
5	Komodo to Pasir Panjang	41.39	51.51	47.91	56.88
6	Pasir Panjang to Labuan Bajo	18.99	36.07	18.99	36.07
7	Labuan Bajo to Lembor	60.39	67.72	60.39	67.72
8	Lembor to Ruteng	58.68	66.21	58.68	66.21
9	Ruteng to Wangkung	57.83	65.46	57.83	65.46
10	Ruteng to Borong	52.83	61.08	52.83	61.08
11	Borong to Ngada	38.93	49.56	38.93	49.56
12	Ngada to Nagekeo	59.44	66.88	59.44	66.88
13	Nagekeo to Nangaroro	28.32	28.16	28.32	28.16
14	Nangaroro to Ende	21.67	24.63	21.67	24.63

SNR and BER Analysis

SNR and BER are parameters to analyze the number of broken bits during signal transmission on optical fiber.

Calculating SNR & BER use formula from equations (1), (7), (8), (9), (10), (11), (12), (13), & (14). Example of calculating SNR & BER route 1 (Sondo to Bima) in scenario 1 and scenario 2 as below:

Equation (1) is used to calculate Power Link Budget $(\mathrm{P_t})$ which is a power source (P_S) and power receiver (P_r). In this calculation, using equation (1) to get power receiver (P_r).

$$P_T = P_S - P_r$$
$$P_r = P_S - P_T$$
$$P_r = 4\ \mathrm{dB} - 15.98\ \mathrm{dB}$$
$$P_r = -11.98\ \mathrm{dBm}$$

Signal Power is the amount of signal power received at the receiver. Equation (7) is the equation for calculating the amount of SNR. Equation (8) is the SNR variables are P_R (power at receiver (W)), η (receiver efficiency (%)), q (electron charge (1.6 x 10^{-19} C)), h (Plank's constant (6.626 x 10^{-34} Js))), ν (frequency (Hz)), and M (gain of Avalanche Photodiode (APD)).

$$Signal\ Power = \left(P_R M \left(\frac{\eta q \lambda}{hC}\right)\right)^2 (M)^2$$
$$Signal\ Power = \left(6.34 * (10)^{-5}\ \mathrm{W} * 20 * \left(\frac{0.85 * 1.6 * (10)^{-19}\ \mathrm{C} * 1.55 * (10)^{-6}\ \mathrm{m}}{6.26 * (10)^{-34}\ \mathrm{Js} * 3 * (10)^{8}\ m/s}\right)\right)^2 * (20)^2$$
$$Signal\ Power = 8.1 * (10)^{-4}$$

The following equations (10), (11), and (12) are used to calculate the amount of thermal noise, dark current noise, and shot noise in the system. T_{eff} is the effective noise temperature (K), k is the Boltzman constant (1.38 x 10^{-23} Joule/k), B is the bandwidth, R is the equivalent resistance (ohms), $\mathrm{I_D}$ is the dark current (A), and $F(M)$ is noise figure.

$$N_{thermal} = \frac{4kT_{eff}B}{R}$$
$$N_{thermal} = \frac{4 * 1.39 * (10)^{-23}\text{J/K} * 298.15\text{ K} * 9.84 * (10)^{10}\text{ Hz}}{50\text{ Ohm}}$$

$$N_{thermal} = 3.2547 * (10)^{-11}$$

$$N_{dc} = 2qI_DB$$
$$N_{dc} = 2 * 1.6 * (10)^{-19}\text{ C} * 4 * (10)^{-8}\text{A} * (20)^2 * 9.84 * (10)^{10}\text{Hz} * 20^{0.7}$$

$$N_{dc} = 4.1026 * (10)^{-12}$$

$$N_{shot} = 2q(P_R \frac{\eta q \lambda}{hC})BM^2F(M)$$
$$N_{shot} = 2 * 1.6 * (10)^{-19}\text{C} * \left(6.34 * (10)^{-5}\text{W} * \left(\frac{0.85 * 1.6 * (10)^{-19}\text{ C} * 1.55 * (10)^{-6}\text{ m}}{6.26 * (10)^{-34}\text{ Js} * 3 * (10)^{8}\text{ m/s}}\right)\right) * 9.84 * 10^{10}\text{ Hz} * 20^2 * 20^{0.7}$$
$$N_{shot} = 1.46 * (10)^{-7}$$

Noise power is the amount of noise in the system, namely thermal noise ($N_{thermal}$), dark current noise (N_{dc}), and shot noise (N_{shot}). Equation (9) is an equation to calculate the amount of noise power in the system.

$$Noise\ Power = N_{thermal} + N_{dc} + N_{shot}$$
$$Noise\ Power = 3.2547 * (10)^{-11} + 4.1026 * (10)^{-12} + 1.46 * (10)^{-7}$$
$$Noise\ Power = 1.46 * (10)^{-7}$$

Signal Power is the amount of signal power received at the receiver. Equation (7) is the equation for calculating the amount of SNR. Equation (8) is the SNR variables are P_R (power at receiver (W)), η (receiver efficiency (%)), q (electron charge (1.6 x 10^{-19} C)), h (Plank's constant (6.626 x 10^{-34} Js))), ν (frequency (Hz)), and M (gain of Avalanche Photodiode (APD)). Noise power is the amount of noise in the system, namely thermal noise ($N_{thermal}$), dark current noise (N_{dc}), and shot noise (N_{shot}). Equation (9) is an equation to calculate the amount of noise power in the system.

$$SNR = \frac{Signal\ Power}{Noise\ Power}$$
$$SNR = 10 * \log \frac{Signal\ Power}{Noise\ Power}$$
$$SNR = 10 * \log \frac{8.1 * (10)^{-4}}{1.46 * (10)^{-7}}$$
$$SNR = 37.44$$

The Q-factor can be used to indicate the minimum SNR ratio required to obtain BER. The Q-factor is a function of OSNR (Optical SNR). Equations (13) and (14) represent the relationship between SNR, Q-factor, and BER. Q is the magnitude of the Q-factor, Pe is the probability of error.

$$SNR = 20\ log\ 2Q$$
$$Q = (10)^{\frac{(\frac{SNR}{20})}{2}}$$
$$Q = (10)^{\frac{(\frac{37.44}{20})}{2}}$$
$$Q = 8.63$$
$$BER = Pe(Q) = \frac{1}{\sqrt{2\pi}} \frac{e^{-\frac{Q^2}{2}}}{Q}$$

$$BER = Pe(Q) = \frac{1}{\sqrt{2\pi}} \frac{e^{-\frac{8.63^2}{2}}}{8.63}$$

$$\text{BER} = 1.94 * (10)^{-17}$$

Tables 7 and 8 show the calculation of SNR and BER for routes 1 to 14 in scenario 1 and scenario 2. Similar to power budget analysis and rise time analysis, the difference in values is on routes 4 and 5. BER values in the longest route (route 7) are 5.69 x 10^{-13}. The BER value has met the proposed BER standard, which is 10^{-12}. The SNR value on the longest route (route 7) is 34.69 dB. The SNR value has met the SNR standard, which is 21.5 dB [28].

Table 7. SNR and BER for scenario 1

No	Route	Scenario 1				
		Pr (dBm)	Q	SNR	BER	BER standard (10^{-12})
1	Sondo to Bima	-11.98	8.63	37.44	1.94 x 10^{-17}	Yes
2	Bima to Soro	-12.11	8.56	37.31	3.47 x 10^{-17}	Yes
3	Soro to Kelapa	-9.98	9.68	39.44	1.13 x 10^{-21}	Yes
4	Kelapa to Komodo	-13.32	7.99	36.10	4.38 x 10^{-15}	Yes
5	Komodo to Pasir Panjang	-11.36	8.95	38.06	1.18 x 10^{-18}	Yes
6	Pasir Panjang to Labuan Bajo	-7.38	11.25	42.05	7.36 x 10^{-29}	Yes
7	Labuan Bajo to Lembor	-14.74	7.36	34.69	5.69 x 10^{-13}	Yes
8	Lembor to Ruteng	-14.43	7.49	34.99	2.14 x 10^{-13}	Yes
9	Ruteng to Wangkung	-14.28	7.56	35.14	1.29 x 10^{-13}	Yes
10	Ruteng to Borong	-13.39	7.96	36.03	5.62 x 10^{-15}	Yes
11	Borong to Ngada	-10.92	9.17	38.50	1.46 x 10^{-19}	Yes
12	Ngada to Nagekeo	-14.57	7.44	34.85	3.32 x 10^{-13}	Yes
13	Nagekeo to Nangaroro	-13.44	7.93	35.98	6.77 x 10^{-15}	Yes
14	Nangaroro to Ende	-11.22	9.01	38.20	6.28 x 10^{-19}	Yes

Table 8. SNR and BER for scenario 2

No	Route	Scenario 2				
		Pr (dBm)	Q	SNR	BER	BER standard (10^{-12})
1	Sondo to Bima	-11.98	8.63	37.44	1.94 x 10^{-17}	Yes
2	Bima to Soro	-12.11	8.56	37.31	3.47 x 10^{-17}	Yes
3	Soro to Kelapa	-9.98	9.68	39.44	1.13 x 10^{-21}	Yes
4	Kelapa to Komodo	-13.61	7.86	35.81	1.25 x 10^{-14}	Yes
5	Komodo to Pasir Panjang	-12.52	8.37	36.90	1.87 x 10^{-16}	Yes
6	Pasir Panjang to Labuan Bajo	-7.38	11.25	42.05	7.36 x 10^{-29}	Yes
7	Labuan Bajo to Lembor	-14.74	7.36	34.69	5.69 x 10^{-13}	Yes
8	Lembor to Ruteng	-14.43	7.49	34.99	2.14 x 10^{-13}	Yes
9	Ruteng to Wangkung	-14.28	7.56	35.14	1.29 x 10^{-13}	Yes
10	Ruteng to Borong	-13.39	7.96	36.03	5.62 x 10^{-15}	Yes
11	Borong to Ngada	-10.92	9.17	38.50	1.46 x 10^{-19}	Yes
12	Ngada to Nagekeo	-14.57	7.44	34.85	3.32 x 10^{-13}	Yes
13	Nagekeo to Nangaroro	-13.44	7.93	35.98	6.77 x 10^{-15}	Yes
14	Nangaroro to Ende	-11.22	9.01	38.20	6.28 x 10^{-19}	Yes

Technical Analysis

The total power loss in both scenarios ranges from 11.38 to 18.74 dB, and the power received in both scenarios has a range of -7.38 to -14.74 dBm. The power loss value is still below the maximum value of the total power loss allowed by the parameters specified in the system. Based on the power link budget calculation, both scenarios are in line with expectations.

In Rise Time analysis, the Maximum Rise Time allowed is 259.29 ps. In both scenarios, no route exceeds the maximum allowed value. The total rise time value in the system is greater in scenario 2 for both paths because it has a longer route.

SNR is calculated on each route. It is to show the smallest SNR value against other routes. The smallest SNR value is on route 7 from Labuan Bajo to Lembor, with a value of 34.69 dB for both scenario 1 and scenario 2. This value is still above the SNR value that meets the SNR standard of 21.5 dB [28] so based on the SNR calculation in both scenarios according to the author's expectations.

BER System is calculated on each route. This parameter aims to show the smallest BER value for other routes. The largest BER value is on route 7 from Labuan Bajo to Lembor with a value of 5.69×10^{-13} for both scenario 1 and scenario 2. This value is still below the BER value specified in the system parameters, 10^{-12}, based on the BER calculation for both scenarios according to expectations.

Potential Risks and Estimated Impacts

In planning this network, it is estimated that the potential risks, such as a fiber cut due to construction work on land or anchors in submarine cables, can be overcome by splicing but increasing processing time costs. In addition, it should be noted that the presence of splices will increase the loss that needs to be recalculated. In addition, there are non-technical risks related to administration such as material costs, taxes, user fees, and human resources that need to be considered in the deployment plan.

Estimated Cost

Table 9. and Table 10. show the results of calculating the estimated cost in scenario 1 and scenario 2. The list of items needed in both scenarios includes rack server, sfp module, patch cord, 48 core fiber optic cable, 48 joint port closure, installation cable pulling, and OSN of each node (Huawei). In scenario 1, the required cost is around Rp 675,559,025,000 while in scenario 2, the cost is around Rp 683,884,685,000.

Table 9. Estimated cost in scenario 1

No	Parameter	Quantity	Unit Price (Rp)	Total (Rp)
Data Center Device				
1	Rack Servers (units)	15	8,650,000	129,750,000
Fiber Optic Network Device				
1	SFP Modules (units)	45	5,335,000	240,075,000
2	Patch cord (unit)	100	35,000	3,500,000
Fiber Optic Material				
1	Fiber optic cable 48 Cores (meters)	732,060	18,000	13,177,080,000
2	Joint Closure 48 port	6	230,000	1,380,000
3	Cable pulling installation (meters)	732,060	904,000	661,782,240,000
4	OSN each node - Huawei Price (unit)	15	$ 1,000	225,000,000
Total (Rp)				675,559,025,000

Table 10. Estimated cost in scenario 2

No	Parameter	Quantity	Unit Price (Rp)	Total (Rp)
Data Center Device				
1	Rack Servers (units)	15	8,650,000	129,750,000
Fiber Optic Network Device				
1	SFP Modules (units)	45	5,335,000	240,075,000
2	Patch cord (unit)	100	35,000	3,500,000
Fiber Optic Material				
1	Fiber optic cable 48 Cores (meters)	741,090	18,000	13,339,620,000
2	Joint Closure 48 port	6	230,000	1,380,000
3	Cable pulling installation (meters)	741,090	904,000	669,945,360,000
4	OSN each node - Huawei Price (unit)	15	$ 1,000	225,000,000
Total (Rp)				683,884,685,000

Conclusion

Both scenarios have total power loss and power received with the same value range. The difference in values is only on routes 4 and 5. The total cable deployment in scenario 2 is longer than scenario 1 because the planned deployment route avoids earthquake-prone areas. Scenario 2 is expected to be more disaster-resistant based on the selected deployment location. So it is expected to minimize the cost of restoration. The value of the Rise Time analysis in both scenarios is that no route exceeds the allowed value So that both scenarios can be applied. By considering technical aspects and risks, it is expected that the construction of fiber optic networks in the Labuan Bajo and KNP areas can provide increased bandwidth needs for residents and travelers. The BER value on the longest path is 5.69×10^{-13}. The BER value has met the proposed BER standard, which is 10^{-12}. Based on the calculation of the system's feasibility, the proposed route in scenario 1 and scenario 2 has the feasibility for deployment. But what needs to be considered is the deployment location where scenario 2 has a deployment route that avoids disaster-prone areas even though it impacts higher initial deployment costs. This condition will reduce the risk of catastrophic cable breakage resulting in higher repair costs.

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The object detection system of balinese script on traditional Balinese manuscript with findcontours method

Ida Bagus Putra Manuaba*[1]*, *Komang Ayu Triana Indah [2]

[1,2] *Politeknik Negeri Bali, Indonesia*

*Corresponding Author: *manuabaputra@pnb.ac.id*

Abstract: *Lontar* is a traditional Balinese manuscript with a Balinese script in it. Balinese traditional manuscripts can be more than 100 years old. The age factor of the Balinese manuscript has an impact on the Balinese script in it. Balinese script that has been written more than 10 years tends to be darker, this makes Balinese script not visible well, and this affects the image quality of the manuscript. This thing becomes the main issue in this research, Balinese script detection on Balinese manuscript images. the first of all is image processing using edge detection, canny and Sobel becomes the main algorithm of this process. After image processing, the Balinese manuscript will be processed with the findcontour method to detect an object that contains in it. The final process of this detection system is to separate detected objects into three main groups namely noise object, Balinese script object, and hole object. Application (Balinese script object detection system) is more accurate in detecting Balinese script objects in Balinese script under 1 year (new script), it tends to be more likely to find noise/dirt, this is because the writing of the *lontar* using a pencil first before using the knife media, this adds to the noise or dirt detected by the application The findcontour method can detect Balinese script objects with a detection result of 30% - 70% Balinese script objects.

Keywords: object detection, Balinese manuscript, edge detection, findcontour

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Introduction

Lontar is a traditional Balinese manuscript with a Balinese script in it. a few years ago, a Balinese manuscript has been used to record the historical knowledge. Currently, *lontar* is a Balinese cultural product that has been recognized as a world cultural heritage [1], and Balinese scriptwriting has been cultural preservation. Digitalization of Balinese script from the manuscript to image is one of the cultural preservation. Digitalization of Balinese script is not easy to do, the first of all is Collecting Balinese manuscript and making it into an image is one of the digitalization of Balinese manuscript.

The object detection system of Balinese script on traditional Balinese manuscript is one of the digitalization of Balinese script. To detect, the Balinese script object on the traditional Balinese manuscript becomes the main issue of this research. The detection system for Balinese script objects in traditional Balinese script is one of the efforts to digitize Balinese script. Detecting Balinese script objects in traditional Balinese script is the main problem in this research. There are several processes to detect Balinese script object on Balinese manuscripts, like preprocessing, object detection with findcontour, and object filtering process.

The process of detecting of Balinese script on Balinese manuscript image is carried out in several stages such as preprocessing, contour segmentation, and object filtering processes. is an effort to improve the image, the reason or basis for this stage is that the input image is not good, such as the amount of noise that appears in the image preprocessing input, this is caused by the age and condition of the Balinese manuscript. Several edge detection algorithms are applied to perform preprocessing such as Sobel Operator and Canny.

The next process of this research is contour segmentation, in this process, the input image will be mapped into segments. The input image will be grouped into two parts, namely the segment which is the object on the palm leaf, and not the segment, namely the palm leaf media itself. After this process, the objects that have been segmented will be processed again in the object filtering process. The object being segmented can be in the form of a Balinese script or noise detected in the input image, so it is necessary to carry out an object filtering process. The process of filtering or filtering objects uses several parameters, such as size, shape, and distance. Objects that are filtered using the above parameters are Balinese script objects, while objects that are not filtered or do not match the above parameters are categorized as noise objects.

Methodology

System Overview

In general, the process in research is grouped into 3 three main processes. The first step of the group is image enhancement using edge detection with Sobel operator and prewitt. The purpose of this process is to improve the image, and clearly show the difference between the object and the background. The process takes input as an image and then apply efficient algorithms, and the results may be image, data, or features associated with that image [2].

The second step of the object detection system is to detect the object in the image. Object detection is a basic research direction in the fields of computer vision, deep learning, artificial intelligence, etc [3]. In this research, object detection will detect all of the objects in the Balinese manuscript image. In the process, objects are divided into three main groups, the first is noise objects, Balinese script objects, and holes objects. A Balinese script object is a single object that will be stored by the system. While noise and hole objects will be considered as non-literal objects.

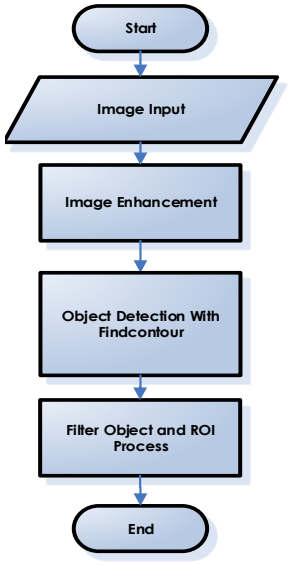

Figure 1. System overview

Data

The data that will be used in this study is in the form of Balinese script images. The size of the documented Balinese *lontar* script is 30 cm (centimeter). There are 2 groups of Balinese script image data used in the research

1. New manuscript, a new manuscript is a manuscript that has just been written and is less than one year old (figure 2 a. New Balinese manuscript).
2. Old manuscripts, Old manuscripts are *lontar* manuscripts that have been previously written and are more than 1 year old (figure 2 b. Old Balinese manuscript).

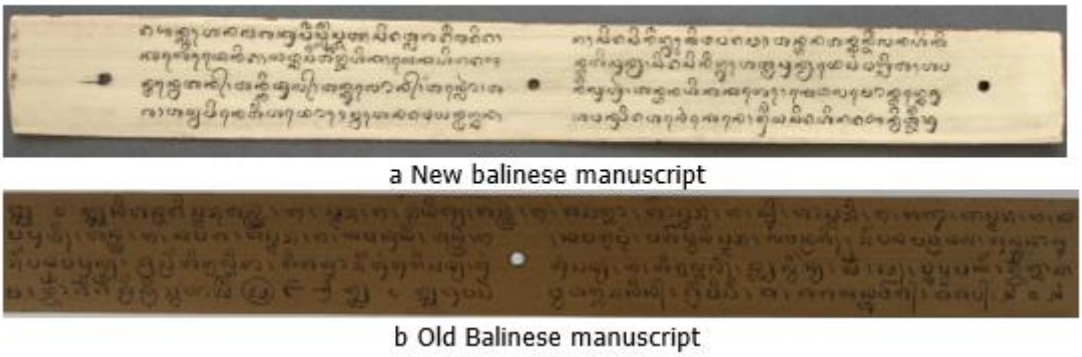

Figure 2. New Balinese manuscript and old Balinese manuscript

Pre-processing

Pre-processing is a part of image processing, it has different Computer Vision on basic techniques, and some authors use both terms interchangeably [4], [5]. Pre-processing is a process that is carried out before the main process is executed, namely the process of contour detection and object filtering. This process has an important role for the next process, in this process image improvement is carried out. The image improvement process is an effort made to improve the input image, one form of image improvement is edge detection. Edge detection is becoming an important part of problems based on computer graphics and image processing. After understanding the steps for preparing an image, the first structure you will find is the edges, or outlines, of each object in an image [6].

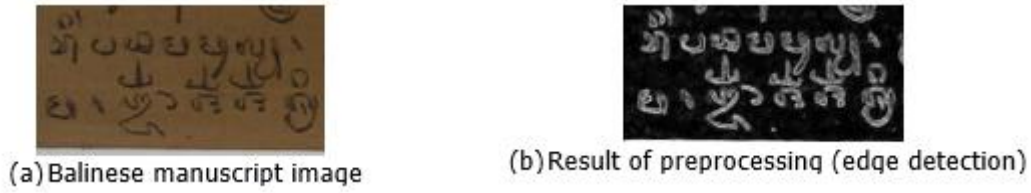

Figure 3. Balinese manuscript image and result of pre-processing (edge detection)

Edge detection is the primary step in identifying an image object, it is very essential to know the advantages and disadvantages of each edge detection filter. Figure 3 a is an example of an image source used for pre-processing, and figure 3 b result of pre-processing was the result of pre-processing used canny edge detection. Canny's edge detection algorithm is costlier in comparison to Sobel, Prewitt, and Robert's operator. Even though, Canny's edge detection algorithm has a better performance [7]. The Canny edge detection algorithm is found to be better in noise and blur conditions but the results are highly dependent on the adjustable parameters [8]. The canny edge detector gives better outcomes related to others with some optimistic points. The recognition is less sensitive to noise, adaptive in nature, and recognizes sharper edges when contrasted with others [9].

Object Detection with Findcontour

Findcontour is a method in opencv/emgu cv library. The application of the opencv library in research [10] has worked with a success rate of 80 to 90%. The working system of object detection is to separate the object from the background, then segment the object using the area approach. Segmentation is a process to partition an image into several parts (regions) or a collection of pixels. The segmentation process divides the image into areas that do not overlap or overlap. In general, image segmentation that is often used uses the intensity method using color and shape approaches.

Contours are used to detect and analyze shapes, to perform various types of recognition, and so on [11]. labeling in the segmentation process is important to limit the object being segmented [12]. The Findcontour method was developed by OpenCV (EmguCv) to detect looking for

objects or two-dimensional images. OpenCV is Open Computer Vision Library, it's launched in 1999 by Intel. In simple terms, contours can be interpreted as a curve that connects points continuously as a barrier to objects that have the same intensity or color. A simple technique is adopted to detect the contours of words in a line of text, the contour is traced in a line of text [13].

The contouring process in this study uses the findcontour method to detect all objects that appear in the Balinese manuscript. The concept of findcontour is to find boundaries (boundary) and map it in the form of coordinates (x,y). It only takes two coordinate points to describe a line as a marker of object boundaries. this method only takes four points as the boundary of the object ar-ea. The boundary illustration is shown in Figure 4.

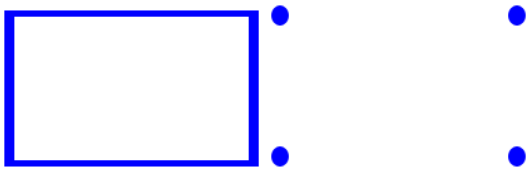

Figure 4. Boundaries object with chain approx none dan chain approx simple

Findcontour provides options on the object area to be constrained, such as cv.CHAIN_AP-PROX_NONE this method will mark the entire object area outside, the entire object area boundary will be saved. While the second picture shows points with cv.CHAIN_APPROX_SIMPLE to find out an object, the object boundaries that are taken are only 4 points as a marker of object boundaries. It only takes two coordinate points to describe a line as an object marker. After the detection process image will be desperate with ROI (region of interest) method. ROI detection has been applied in many fields, for example, medical imaging, security surveillance, databases, and re-mote sensing imaging [14]. ROI on the image is used to mark a part of the input image. ROI placement also plays a significant role in obtaining an effective ROI image retrieval [15].

Results and Discussions

Balinese manuscript image in the Balinese script detection system on Balinese manuscript image has been several image improvements, this process aims to obtain optimal image quality. One of the image improvement techniques to use for this image improvement process is edge detection with Sobel Operator and Canny.

Figure 5. Edge detection with sobel and edge detection with canny

The image improvement process by applying parameters is carried out continuously and automatically on the system until optimal detection results are found. Sobel and Canny are edge detection operators that are applied to the image improvement process for the study of Balinese script contour segmentation in Balinese *lontar* manuscripts. For the applied pre-processing method Canny edge detection show the better result (figure 5 b edge detection with canny) than Sobel edge detection (figure 5 an edge detection with sobel).

The contour detection process is a process to map the entire object that is written and appears on the Balinese papyrus script media. This study divides the objects that appear in the Balinese lontar script into three types, namely circle or hole objects, Balinese script objects, and non-Balinese script objects or dirt objects. Circle objects are common objects that appear in Ba-linese lontar manuscripts. A circle object is a hole object that is used to combine the writing on the Balinese lontar script. The whole object in this study is used as a parameter for marking the begin-ning of writing and marking the end of Balinese script writing. Meanwhile, Balinese script

objects and Balinese script objects are the main objects in this segmentation process The test was carried out with two types of data, the first test using *lontar* manuscript data written in less than one month.

The results of the first test image test showed that the number of objects detected was 5807 objects with the number of Balinese script objects being 63 and non-Balinese objects being 5744 objects. Figure 6 is an image capture of the application of the first image tested process. That figure shows some information like the capture of image detection objects from resource images, image capture of ROI process, and some information of image detection process.

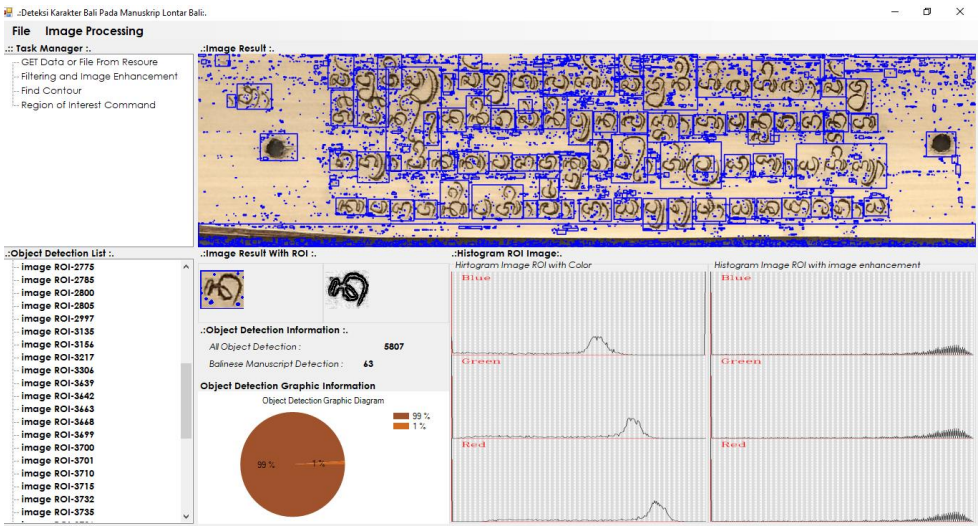

Figure 6. Image result object detection of Balinese script

The first image sample in figure 6 was tested to show that the image has good texture, all object in the *lontar* manuscript was detected as good. As seen in figure 6 at the image result feature, almost all the Balinese object has been detected. For the enhancement process, the application was used edge detection with canny. The blue boundary is the marking of object detection, not only Balinese letter or *aksara*, but the application was detected all object of image resources like noise and hole object. Table 1 shows the data from the Balinese script object detection process.

Table 1. Result of object detection (new manuscript)

No	Description	Total	Percentage
1	All object detected	5807	99%
2	Balinese script object	63	1%
4	Total Balinise script	89	
5	detection result	63/89	70%

The results show that the first stage of testing can detect Balinese script objects up to 70%. The percentage of result detection of the real object, i.e., Balinese letter or *aksara* depends on the object *aksara* has detected. The percentage of result object detection is measured by dividing the real objects with object detection as shown in equation (1).

$$Accuration\ of\ object\ detection = \frac{Balinese\ Scrit\ was\ Detected}{Real\ Balinese\ Script}\ x\ 100 \quad (1)$$

The application has the feature called ROI to extract Balinese object that has been detected and separated from the main image. Object detection list is relust of ROI process, and if data in this feature is chosen, the application will show the object with a detailed histogram report about that object.

The next level of application tested was used with the old manuscript. For this test, the application could detect 897 objects. Figure 7 is the captured image of the old manuscript testing process.

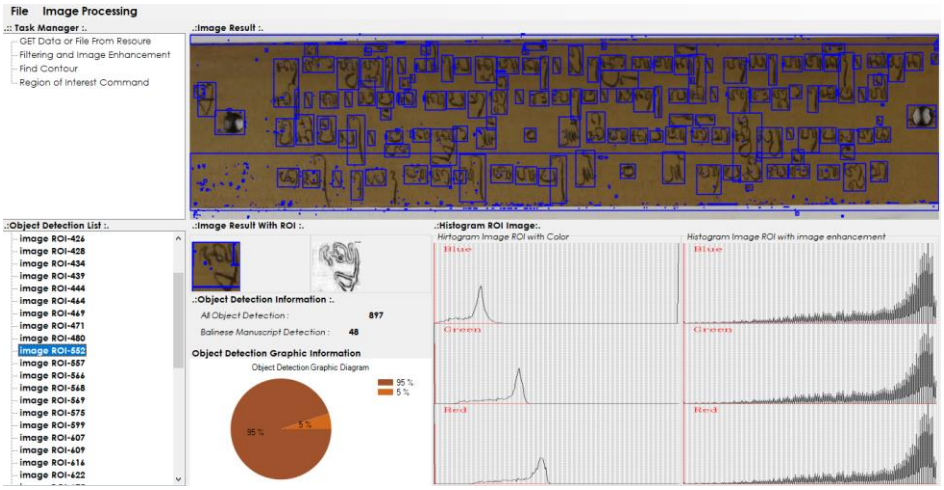

Figure 7. Graphic diagram of the old manuscript test

For this test, the application detects 48 Balinese script objects and 849 non-Balinese script objects. The percentage of detection results for this level reached 30 % for Balinese script objects. The result of this process is shown in Table 2.

Table 2. Result of object detection (old manuscript)

No	Descriptions	Total	Percentage
1	All object detected	897	95%
2	Balinese script object	48	5%
4	Total Balinise script	115	
5	Detection result	48/115	30%

The difference between the two sample kinds of the image has been realized as a result of object detection. The first test has shown 5807 of all object detection and only 63 objects of the Balinese script object. And the second level of testing used the new script. The result of this test has shown 897 objects detected and 115 Balinese script objects. It means the new script has a lot of noise compared to the old script. This is due to the process of lontar making, before using a carving knife to write Balinese script in lontar, lontar was written based on some sketches using pencils.

The new script has a lot of stretch marks compared to the Balinese old script. The Strech mark from the old script is blurry or doesn't have the stretch mark, a lot of noise object was detected in the old script is from the stain or age of the script.

Conclusion

Based on the results of the discussion, it is concluded that the best algorithm in pre-processing is the canny algorithm which is intended to perform image improvements in the form of edge detection on the input image of Balinese script images. The object detection process using findcontour will detect all objects that appear above the Balinese script, whether it is a circle/hole object, a Balinese script object, and an object that is not a Balinese script or a hole object. So to produce Balinese script object segmentation, parameters are needed that are used to separate these objects. With this technique, all Balinese script objects with various shapes and sizes can be detected properly.

Application (Balinese script object detection system) is more accurate in detecting Balinese script objects in Balinese script under 1 year (new script), it tends to be more likely to find

noise/dirt, this is because the writing of the *lontar* using a pencil first before using the knife media, this adds to the noise or dirt detected by the application The findcontour method can detect Balinese script objects with a detection result of 30% - 70% Balinese script objects. Several things that cause the object detection result is not optimal is the grouping of objects that are not optimal is a simple object classification (objects are divided into Balinese script objects, object noise, and hole objects). If there is a Balinese script object that does not have characteristics according to the system, the object is not included as a Balinese script object or noise object. Two Balinese characters can be detected as a single object; this is because the distance between the characters is very close.

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Designing an early flood detection system prototype in riverbank settlements

Dita Dwi Hartanto [1]*, Peby Wahyu Purnawan [2]

[1,2] *Program Studi Teknik Elektro, Universitas Budi Luhur, Indonesia*

*****Corresponding Author: *ditahartanto93@gmail.com*

Abstract: There is still a lot of use of the floodgates in the main hole to drain the residential water into the river is still operated manually by someone in charge of opening and closing the floodgates. It is less efficient and often happens to the operator, so the water overflows and can lead to flooding. In this final task, a prototype of an early flood detection system and the automation of sewerage in a settlement located on the riverbanks. The control of floodgates on the main hole works automatically according to the signal from a sensor that reads the state of the water level. Main hole floodgates will work when the river water enters it at a specific limit that sensors will read and provide information on the level of river water in it to someone via WhatsApp to prevent river water from entering the settlement. When the main hole door is closed automatically, the residential water flow will be directed to a temporary reservoir. When the temporary reservoir is full, the sensor will signal to activate the discharge pump that will be discharged into the river to dispose of the water in the reservoir. The design and testing of flood early detection prototype tools and residential water disposal automation can work well by the design principle.

Keywords: early detection, flooding, settlement, riverside, main hole

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Introduction

Floods are natural disasters that have often occurred. The occurrence of flooding can be caused by natural factors or the condition of a place. One example of a flood-prone place is a settlement close to the river caused by rising river water in the main hole dumping residential water into the river. The main hole is a construction built for sewerage from settlement to the river. When the river water at the main hole increases over the limit, and there is no warning, flooding can occur in the settlement. Therefore, monitoring the floodgates at the main hole needs to be carried out so that the process of discharging water from settlements to rivers runs smoothly. Most of the process of opening the floodgates in the main hole is still done manually by someone. It would be nice if the control of the floodgates on the main hole works automatically and can be monitored because the water level changes are always changing in an uncertain time.

Research has been carried out to solve flood problems, including designing a flood warning and monitoring system to provide early warning to victims in certain flood-prone areas. Implementing Internet of Things technology into the system can help victims get accurate flood status in real-time [1]. Research has also been done to deal with the flooding problem, which impacts the loss of people due to a lack of information and warning. So it is necessary to convey emergency information, monitoring, and warning systems is needed to the public so that they are prepared in case of a flood. The monitoring system can be accessed easily, quickly, anywhere, and anytime by the community. As well as the need for early warning that can inform the public that there is an increase in the water level in the dam, it is hoped that people can prepare themselves for the upcoming floods [2].

Other research to overcome the flooding problem has been conducted by designing a river's water level detection system as an early warning system for floods based on Arduino Nano using the Thingspeak website technology and the Thingsview Android application to provide information for the entire community. With this tool, people who live around the watershed can monitor the

river's water level to find out in advance if a disaster occurs [3]. Furthermore, to solve the problem of flooding in dams that have often occurred due to many factors, research has been conducted to produce a dam floodgate that can adjust the water level automatically at a cost that is not as high as the actual plant using the Fuzzy Method Logic Controller. With the Fuzzy control method, to determine each parameter, a plant identification process is carried out to obtain a rule evaluation used as a guide in setting water levels [4].

In addition, other research was being carried out on a water level control system that has an important role in providing convenience in the drainage system, opening and closing the floodgate based on the level of rainfall using Arduino. This design is expected to be a good contribution to the drainage system. With this automatic floodgate, of course, it will minimize the risk of flooding or other risks [5]. The research was carried out to overcome the flood problem by using Arduino as a microcontroller which will thoroughly control the ultrasonic sensor as a water level detector and the buzzer sensor as a sounder or alarm when the water level has reached a certain limit. The SMS will be directly sent by SIM800L sensor to the citizen's mobile number or contact number that has been adjusted by the system [6].

Furthermore, research conducted based on the problems of opening and closing floodgates on rivers or dams in Indonesia has been carried out. The study stated that the problem occurred because the process was still manually based on the water level, so more workers were needed to guard the floodgates. It is inefficient, so an automatic control system for opening and closing the floodgates is made based on tidal water level using Arduino UNO as a processor [7].

Research has also been conducted due to the lack of information on flooded roads to design a GSM-based flood detection and location information system. A GSM-based wireless flood detector has been designed using the HC-SR04 ultrasonic sensor. This tool works based on the height of the water inundated on the highway. The tool consists of an ultrasonic sensor placed at the height of 150 cm on a highway pole. When the water level reaches 40 cm, the Arduino Uno as a data processor using the C language, will control the SIM800L program to send SMS once with an average delivery time of 12:06 s to the registered number [8].

As one of the developing cities in West Papua Province, Sorong City almost always experiences flooding during the rainy season caused by overflowing river water. This problem was overcome by building a prototype system design for this automatic sluice control device using an information delivery system via a microcontroller-based SMS, the GSM Shield media interface between sending SMS and automatic sluice gates [9].

Vulnerability is a condition that can reduce the ability of the community to prepare themselves to face a hazard or threat of disaster. The purpose of understanding vulnerability is to reduce the likelihood of adverse impacts caused by disasters. The formulation of the problem in this study is how to compare the Fuzzy Mamdani and Fuzzy Sugeno methods to detect flood-prone areas in Pringsewu District. The construction of a prototype to determine flood-prone areas in the Pringsewu District can reduce the risk of flooding through physical development and awareness and increased capacity to face disasters [10].

The problem that often occurs in the community is the difficulty of early detection of impending flooding so that it has an impact on material losses and casualties. For that, we need a system that can detect floods early so that people can immediately find out early warning information quickly and effectively anticipate early by saving themselves or valuables. Therefore, the researcher designed a flood detection system that automatically monitors water levels and sends early warnings. This water level monitoring system uses the NodeMCU ESP8266 with ultrasonic and IOT-based sensors to provide real-time data to determine the water level created at a certain level. In addition, this system is connected online and displays real-time water level data on the Thingspeak platform and integrated with the Telegram application as an early flood warning [11].

Based on that background, this research builds a control system of early flood detection and automation of water disposal in riverside settlements. The system controls the water door on the main hole. The door on the main hole will work automatically according to the signal from the sensor. When the river water rises and enters the main hole at a certain level, the sensor will signal to send information on the river water level at the main hole to someone. At the same time, the water door will close so that the river water does not enter the reservoir. When the water door to the river is closed, water flow from the reservoir will be diverted to temporary reservoirs. It is hoped that this system can overcome the problem of flooding in the reservoir due to the entry of river water through the main hole.

Methodology

System Design

The design is a prototype system on the main hole of community water disposal to the river based on Raspberry Pi 3 with the on/off system method. Discussion of system design starts from the research stage, diagram block system, hardware design, and software design.

Stages of Research

Figure 1 shows the stages of research. The first thing to do is identify the problem to understand the action that needs to be taken. After identifying the problem, the data collection needed in the implementation of tool creation can be processed. After that, the literature study is conducted to determine what control methods would be used in the tool's design. Next, after obtaining data and there is a step called the manufacture of tools. Once the tool is complete, the tool is then evaluated. If the testing results are not following the desired outcome, then another test is conducted. Finally, after the tool runs smoothly and meets the desired results, the final report is written.

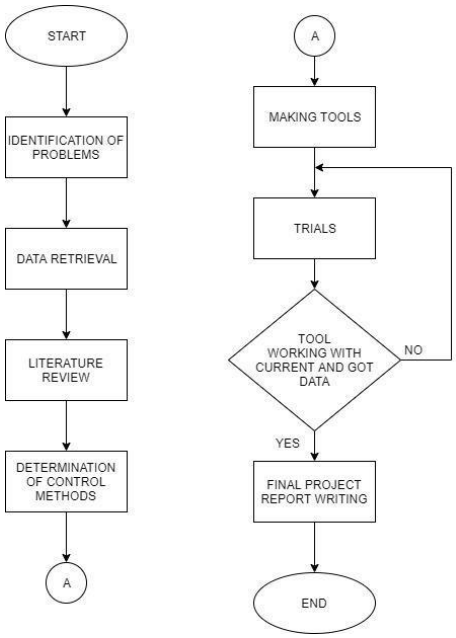

Figure 1. Stages of Research

System Design Diagram

Figure 2 shows the system design diagram. The sensor serves as a river water level detector and provides a signal to the Raspberry Pi 3. The Raspberry Pi 3 serves as a data processor while storing the binary data needed to control the motor drive to open the floodgates, displaying the information on the LCD. The motor drive serves as an automatic floodgate drive that receives it from the sensor to open and close the water doors. LCD serves as a display of circuit activity. The pump serves to discharge water from the settlement if the reservoir is full. The Wi-Fi module connects Raspberry Pi 3 with the internet to access WhatsApp servers and send messages. WhatsApp in this plan serves as a medium to inform the level of river water level.

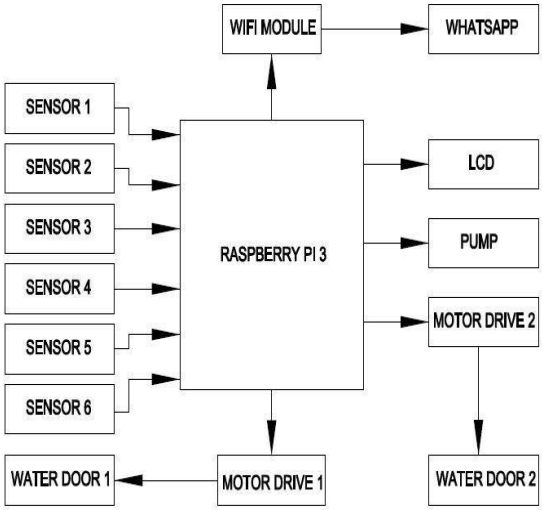

Figure 2. Diagram of system design

System Block Diagram

Figure 3 shows the system block diagram. Raspberry Pi 3 is a component used to process data and feedback from sensors to be passed to motor drives and water doors. A floating water level sensor is a component used to detect water levels. A DC motor drive is a component used to drive the water doors that previously got input from the Raspberry Pi 3. The pump is a component used to drain water in a reservoir. Water doors are components used to set the waterways on the main hole. A water reservoir is a container to hold the wasting water if the river water spills out to the normal limit on the main hole. The main hole is a building that serves to drain water into the river.

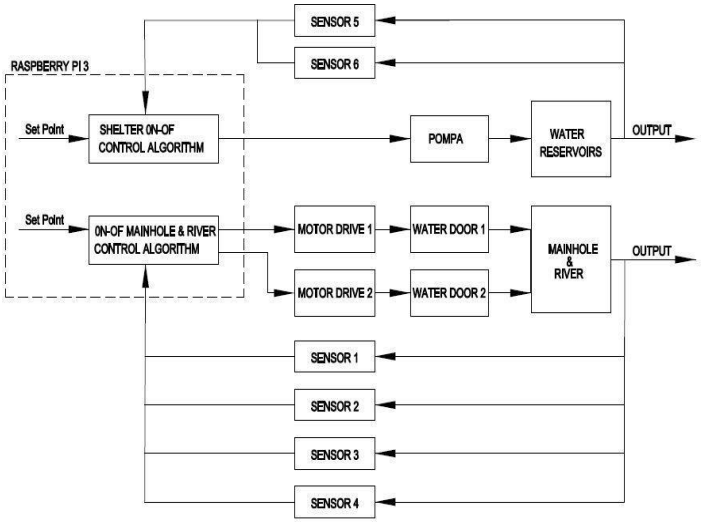

Figure 3. Diagram of system block

Working Principles of the System

This control system is built to control the water doors and exhaust systems automatically. This system works by controlling the water doors in the main hole to be automatically open or

closed based on the height of river water flowing in the main hole. The water doors operate automatically, get a signal from the sensor, and are reprocessed by Raspberry Pi 3. The water doors can be open or closed automatically following the activity level of the river water level. When the river water is high and enters the main hole disposal, the sensor will read the water level and signal the Raspberry Pi 3. It drives motor 1 to close water door 1 and drives motor 2 to open water 2 connected from the disposal of the reservoir to the river. The system will send information on the river water level to the settlement residents via WhatsApp. When water door 1 is closed, the disposal from the settlement will be diverted to the reservoir that passes through water door 2. When the reservoir is full of sensors installed in the reservoir will work and will activate the pump to dispose of the water in the reservoir dumped into the river.

The Design of Mechanical Systems

The mechanical system is designed using PCV plate material. This system is mechanically designed with a material thickness of 3mm and dimensions of 0.6m × 0.6cm. The design of the mechanical system shows in Figure 4.

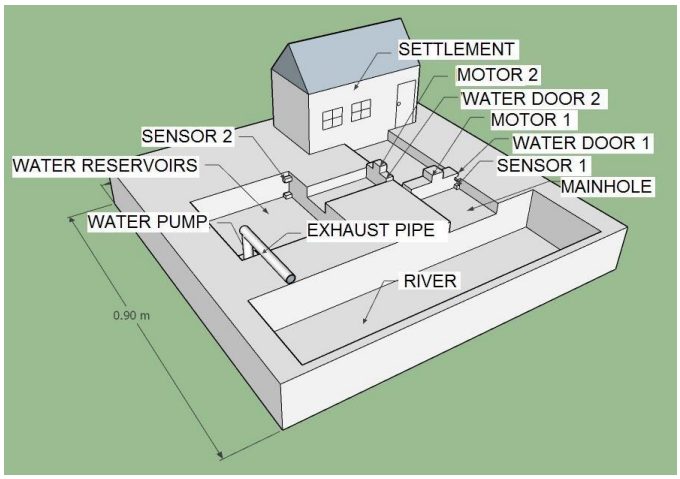

Figure 4. The design of the mechanical system

Software Design

In the software design, early flood detection systems and automation of sewerage systems in riverside settlements use python software to create programs uploaded on Raspberry Pi 3. To facilitate the creation of the program, the main program flowchart and sub-program flowchart are created.

1. Main Program Flowchart

   The flowchart of the program can be seen in Figure 5. When the program works, the program goes through initialization. After that, the program works according to the inputs from the sensor. There are six sensors installed in different places. Four sensors are installed on the main hole and riverbanks to read river water levels, and two sensors are installed in reservoirs to read water levels in the reservoir. After getting input from sensors installed in the main hole and riverbank, the system will automatically send messages via WhatsApp to the residents according to the level changes. After the program runs, the LCD will display the status that the program is completed.

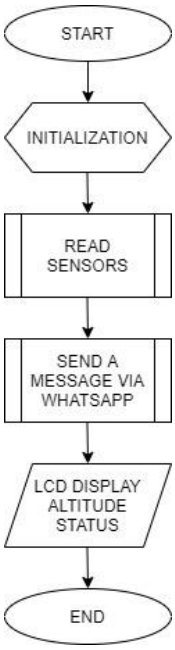

Figure 5. Main program flowchart

2. Flowchart of Sub Program in Reading River's Water Level Sensor
The flowchart for the sub-program in reading the river's water level sensor program shows in Figure 6.

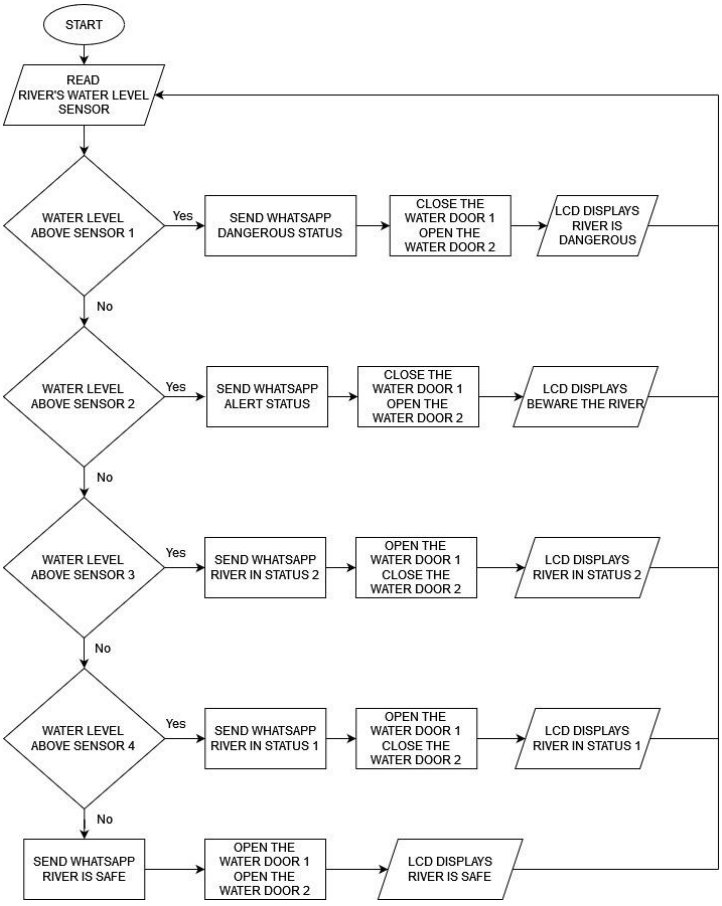

Figure 6. Flowchart of the subprogram in reading river's water level sensor

When the program is working, the sensor will read and provide input on the program. The program works according to inputs from sensor values that have been installed in the main hole and in rivers that serve to detect the level of the river's water level. Once the program receives input from the sensor, it runs according to the values read by the sensor. For example, if the water level is above sensor 1, the system will send a message via WhatsApp dangerous status, and LCD will display the status "river is dangerous". On the other hand, if the water is under sensor 4, the system will send a safe status message, and the LCD will display the "river is safe" status.

3. Flowchart of Sub Program in Reading Reservoir Height Sensor
Figure 7 shows the flowchart of the subprogram in reading the program of the reservoir height sensor.

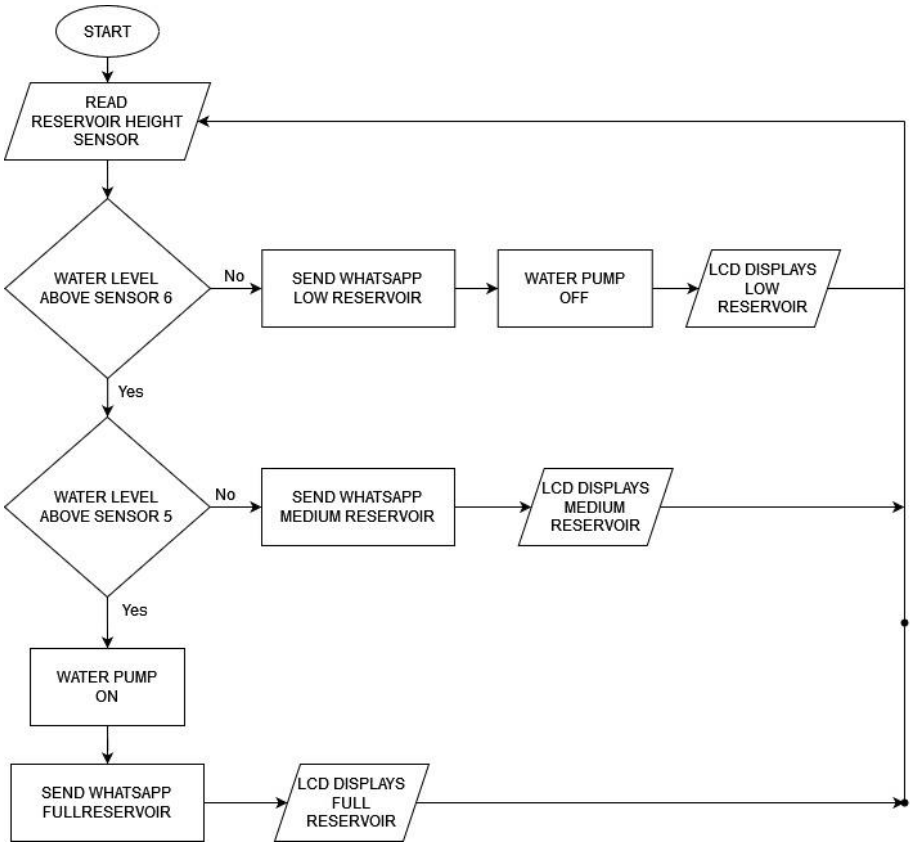

Figure 7. Flowchart of the subprogram in reading reservoir height sensor

When the program starts working, then the sensor will work and provide input on the program. Once the program receives input from the sensor, it runs according to the values read by the sensor. For example, if the reservoir water height is under sensor 6, the pump will not work, and the LCD will display "low reservoir". On the other hand, the pump will work if the water is above sensor 5, and the LCD shows a "high reservoir".

4. Flowchart of sub-program in sending messages via WhatsApp
Figure 8 shows the flowchart of the sub-program in sending messages via WhatsApp. When the program works, sensor 1,2,3,4 will provide input to the Raspberry Pi 3. Once the Raspberry Pi 3 receives input from the sensor, the program works and processes the data. After Raspberry Pi 3 processes the input from the sensor, the raspberry will call the Pywhatkit application to forward the data obtained from the sensor. After the data is loaded in Pywhatkit, the message will be ready to be sent via WhatsApp web with a delay of 30 seconds to 1 minute. After the delay of loading the data and sending the message is

complete, the message is ready to be sent to the WhatsApp number registered, and the program is complete.

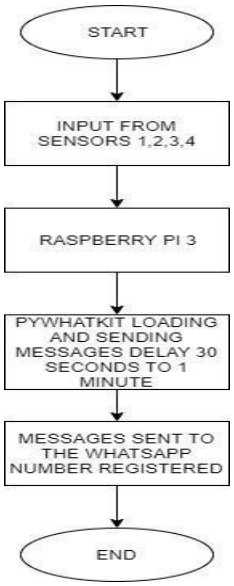

Figure 8. Flowchart of the subprogram in sending messages via WhatsApp

System Testing and Analysis

System testing is divided into testing parts of the system and testing the system as a whole.

Testing System Parts

The tests performed on the system parts of this final task tool aimed to determine each component's performance by comparing the actual measuring instrument with the program's results. So that when running the overall tool design, it can run by the purpose and minimize the occurrence of system performance errors. The parts tested are water-level float sensor circuit, limit switch sensor testing, LCD circuit testing, relay circuit testing, DC motor circuit testing, and pump testing.

Overall Tool Testing

1. Testing the Process of Water Level Check

   Testing the process of water level check aims to determine the level of river water and whether the reservoir is working as expected. The river water level parameter in this prototype is 13 cm and is divided into five height levels for the status of river water level. Figure 9 shows the test using float water level sensors. In Figure 9, four sensors are attached to the device that serves as a river water level sensor. In Figure 9 points (1), it is seen that the river water is still under sensor 4, then the sensor reads the level of river water in the river in a safe state. At point (2), the buoy of sensor 4 has been lifted upwards, and then the sensor reads the river water level in standby state 1. At point (3), it looks like the buoy sensor 3 lifted upwards, then the sensor reads the river water level in alert state 2. At point (4), the buoy of sensor 2 is already lifted, then the sensor will read that the level of river water is in a state of alert. Finally, at point 5, where all the buoys of all sensors have already lifted, the sensor will read the river water level in danger. Table 1 shows the test results of checking the river water level.

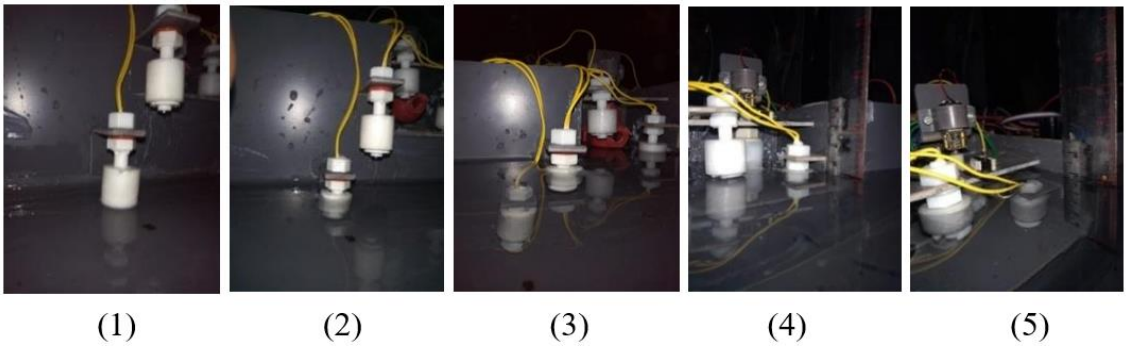

Figure 9. The test using float water level sensors

Table 1. Result of testing river water level

No.	River water level (cm)	Sensor 1	Sensor 2	Sensor 3	Sensor 4	Output
1	1-2	Off	Off	Off	Off	Safe
2	3-5	Off	Off	Off	On	Standby 1
3	6-8	Off	Off	On	On	Standby 2
4	9-11	Off	On	On	On	Alert
5	12-13	On	On	On	On	Danger

Table 1 shows the test results of checking the river water level. In Table 1, it can be seen that the water level will make the sensor work according to the height level that has been set at a certain water level and will produce output according to the height read by the sensor. The process of altitude check testing using a float water level sensor in the reservoir can be seen in Figure 10.

Figure 10. The process of altitude check testing using a float water level sensor

In Figure 10, two sensors are mounted on a tool that serves to sensor the water level in the reservoir. Point (1) shows that the water in the reservoir is still below the lower limit of the sensor, then the sensor reads that the reservoir's water level under normal circumstances. Point (2) indicates that the water is already on the lower limit sensor and lifted. Therefore, the sensor reads that the reservoir water level is in a moderate state. Point (3) indicates that the lower and upper limit sensors have been submerged in water, and the upper and lower limit sensor buoys have been lifted, so the sensor reads that the reservoir's

water level is in a high state. Table 2 shows the results of the sensor testing in the reservoir. In table 2, it can be seen that the water level will make the sensor work under the altitude level that has been fixed at a certain water level and will produce output according to the height read by the sensor.

Table 2. Result of testing river water level

No	Storage water level (cm)	Lower limit sensor	Upper limit sensor	Output
1	<5	Off	Off	Normal water level
2	5-9	On	Off	Medium water level
3	10	On	On	Full water level

2. Testing the Process of Sending Messages via WhatsApp

Testing the delivery process via WhatsApp aims to determine if Raspberry Pi 3 can send messages via WhatsApp. Figure 11 shows a message informing a high river water level warning via WhatsApp in the Indonesian Language. The process of sending WhatsApp messages using the WhatsApp web with the Pywhatkit application requires login. Figure 12 shows that the response speed of sending messages via WhatsApp takes a time lag of about 30 seconds to 1 minute to process data and send messages. It is because the application takes time to process and send the data. If the speed is set quickly, the message will collide with the data, which cannot be sent.

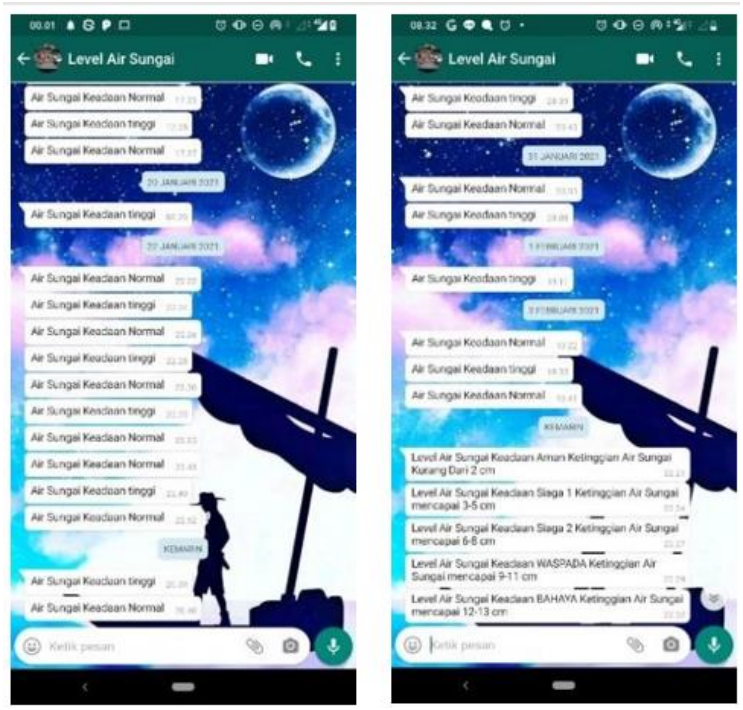

Figure 11. Message informing a high river water level warning via WhatsApp

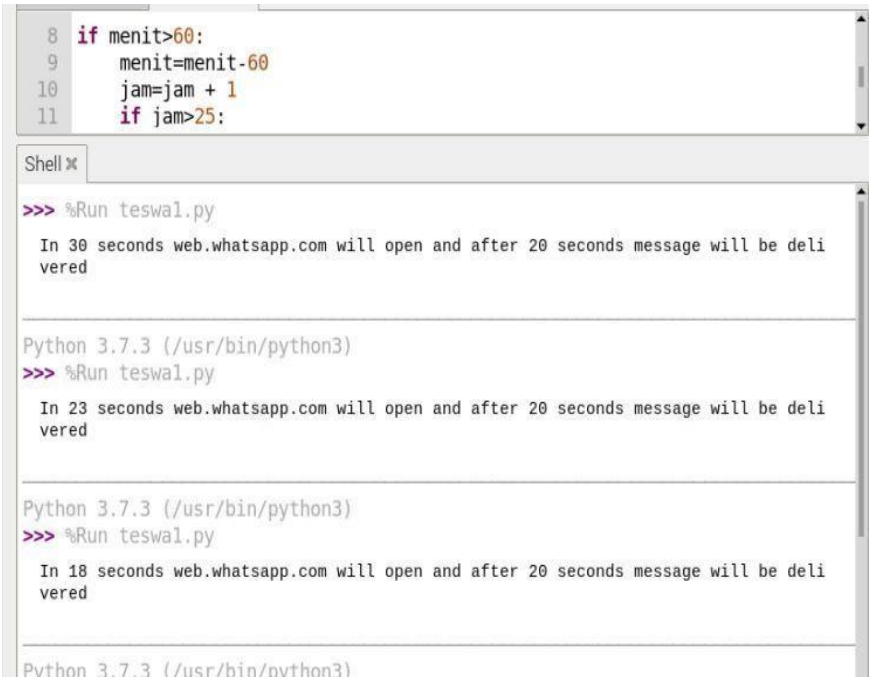

Figure 12. Result of speed response in sending a message via WhatsApp

3. Python Application Testing

Python application testing aims to find out whether the application that has been designed can run as expected.

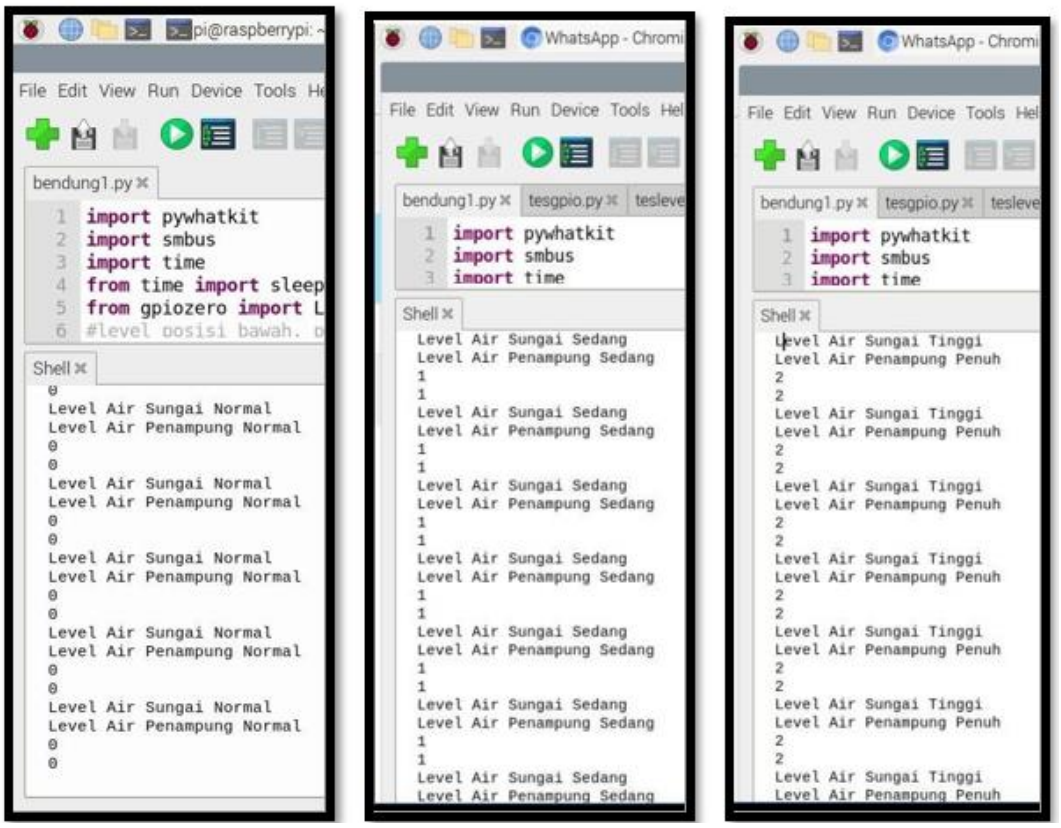

Figure 13. Python Application Testing

Figure 13 illustrates the reading of the float water level sensor installed in the main hole and reservoir in Indonesia Language. The left figure shows that the water level in the main hole and the reservoir are normal. The center figure shows that the water level in the main hole is moderate, and the right figure illustrates that the water level is high and full.

Whole System Analysis

From the steps of testing the parts of the system that have been carried out, it can be analyzed that each component has a different work system. So that the process of testing each component is very necessary to do, aiming to determine the characteristics and work system of each component. After testing and knowing the characteristics of the work system from each component, the components can be placed in the right parts so that the tools created can work as expected.

Testing the whole system covers testing the float water level sensor installed in the main hole and the reservoir. Testing the float water level sensor in the main hole is done by flowing water into the river until it enters the main hole, and the sensor will read the water level and provide input to the raspberry pi 3. Thus, the water level read by the sensor will be processed by the raspberry and displayed on the LCD. When the sensor in a high state reads the river water level in the main hole, the main hole water door closes, and the reservoir water gate opens, and the system sends a high river water message via WhatsApp. Sending messages via WhatsApp requires a time lag because the application used in sending messages via WhatsApp takes time to process data. After the data process is complete, the message is sent via WhatsApp automatically. Testing the automation of the drain pump is done by entering the water into the reservoir with the full water level limit, then it is read by the float water level sensor installed in the reservoir. After the sensor reads the full reservoir water level, the drain pump automatically works. After the water in the reservoir is drained and the sensor reads the normal reservoir water level, the drain pump stops. From the overall system testing that has been done, it can be analyzed that the system can work as expected. Results after testing the whole system can be elaborated as follows:

1. The test results of checking the river's water level with float water level sensor installed in the main hole and the river show that the process can work well, and the sensor can read the water level when the condition is safe, standby 1, standby 2, alert, and danger.
2. The test results of checking the water level in the reservoir with a float water level sensor show that the process can be done well, and the sensor can read the water level at normal, medium, and full time.
3. The process of opening the floodgates can work according to the input of the water level sensor. When the high river water level of the main hole door is closed, the reservoir water door is open.
4. The exhaust of the pump automation system process can work automatically with the input ofthe float water level sensor installed in the reservoir.
5. Raspberry Pi 3 can run an early flood detection system program and exhaust automation system and a message delivery process via WhatsApp with a Python application.
6. The process of sending messages via WhatsApp is still delayed due to the default application that takes time in the process of loading data. In addition, sending WhatsApp is done using the WhatsApp web.

From the Python application testing that has been done, it can be analyzed that the programmed system can run well as expected. Testing the system is done by running the water level float sensor manually so that the Raspberry receives the sensor input, and the results will be displayed on the LCD. The results on the LCD are the same as the input from sensors that have been programmed with Python.

Conclusion

Evaluating the parts of the system is very necessary as it aims to determine the performance of each component and can determine whether the condition of each component is good or damaged so that it can minimize errors and damage to system performance. Thus, system errors can be avoided to work under what has been designed when we run the entire system.

After the whole test is carried out, the tool can work properly according to the design. However, there are still weaknesses in sending WhatsApp messages. The process of sending the message can only be done with one number that has been registered as a recipient, and there is still a delay during the sending process. The application used in this tool cannot send messages simultaneously to different numbers and can only send messages to one number. If the messages are forced to be sent to several numbers, the message to the following number will be sent after sending the message to the first number is completed. It can create delays, and data collisions can occur so that errors will occur on the system. The delay in sending messages happened because it takes time to load data. The message sending process is done via the WhatsApp web, so it requires a WhatsApp number that is always active.

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