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Advance Sustainable Science, Engineering and Technology (ASSET) is a peer-reviewed open-access international scientific journal dedicated to the latest advancements in sciences, applied sciences and engineering, as well as relating sustainable technology. This journal aims to provide a platform for scientists and academicians all over the world to promote, share, and discuss various new issues and developments in different areas of sciences, engineering, and technology.

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Editorial Preface

Advance Sustainable Science, Engineering and Technology (ASSET)
Volume 5 Number 2 July 2023

We are thrilled to introduce the diverse and insightful research contributions featured in Volume 5 Number 2 of Advance Sustainable Science, Engineering and Technology (ASSET), published in July 2023. This edition comprises studies that delve into various facets of science, engineering, and technology, showcasing the innovative work of 57 authors from esteemed institutions.

Commencing with "Fast and Accurate Indonesian QnA Chatbot Using Bag-of-Words and Deep-Learning for Car Repair Shop Customer Service" by Muchamad Taufiq Anwar et al., this research explores the application of bag-of-words and deep learning in developing a proficient Indonesian QnA chatbot tailored for car repair shop customer service. Following this, "Quality Assurance Plan on a Linear Accelerator (LINAC) Plane on Nasopharynx Cancer (NFC) by using Prowess Panther 5.10 at Radiotherapy Installation Ken Saras Hospital" by Pandu Kurnianto et al. presents a comprehensive quality assurance plan for a linear accelerator in treating nasopharynx cancer, using the Prowess Panther 5.10 system at Ken Saras Hospital. "Optimizing Project Performance by Applying the Crashing Method to Road Construction Project" by Pramudya Febryanti Dewi et al. explores the application of the crashing method to enhance project performance in road construction. The study titled "Single Sign On Using Keycloak Integrated Public Key Infrastructure for User Authentication in Indonesia's Electronic Based Government System" by Wawan Hermawan discusses the implementation of a secure single sign-on system using Keycloak integrated with public key infrastructure for user authentication in Indonesia's electronic-based government system. Moving on to "Increasing Maternal Knowledge in Preventing Stunting through Community-based Nutrition Education" by Ade Emaniar Emaniar et al., this research addresses the crucial issue of maternal knowledge in preventing stunting through community-based nutrition education. "Design of Android and iOS Applications for Mobile Health Monitoring Devices" by Ade Silvia Handayani et al. introduces innovative applications designed for mobile health monitoring devices, emphasizing the integration of technology in healthcare. The study "Design Optimization of DR3AM Vapor Polishing Device for ABS 3D-Printed Parts" by Rosa Mae D. Baluyut et al. focuses on optimizing the design of a vapor polishing device for ABS 3D-printed parts. Additionally, "Spatial Analysis of Water Infiltration Potential in the Miu Watershed of Sigi Regency" by Amati Eltriman Hulu et al. presents a spatial analysis of water infiltration potential, offering insights into environmental dynamics.

We extend our gratitude to the authors for their dedication and the universities involved, including Politeknik STMI Jakarta, Universitas Kristen Satya Wacana, Universitas Stikubank, Ken Saras Hospital, Universitas Pembangunan Nasional "Veteran" East Java, Bandung Institute of Technology, Universitas Dian Nuswantoro, Politeknik Negeri Sriwijaya, Universitas Indonesia, Tadulako University, and Bataan Peninsula State University, Philippines.

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Congratulations to ASSET for initiating a quarterly publication schedule, and we look forward to the continued dissemination of impactful research in the upcoming issues.

July 2023
Assoc. Prof. Mega Novita
Asst. Prof. Rizky Muliani Dwi Ujianti

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Fast and Accurate Indonesian QnA Chatbot Using Bag-of-Words and Deep-Learning for Car Repair Shop Customer Service

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Abstract. A chatbot is a software that simulates human conversation through a text chat. Chatbot is a complex task and recent approaches to Indonesian chatbot have low accuracy and are slow because it needs high resources. Chatbots are expected to be fast and accurate especially in business settings so that they can increase customer satisfaction. However, the currently available approach for Indonesian chatbots only has low to medium accuracy and high response time. This research aims to build a fast and accurate chatbot by using Bag-of-Words and Deep-Learning approach applied to a car repair shop customer service. Sixteen different intents with a set of their possible queries were used as the training dataset. The approach for this chatbot is by using a text classification task where intents will be the target classes and the queries are the text to classify. The chatbot response then is based on the recognized intent. The deep learning model for the text classification was built by using Keras and the chatbot application was built using the Flask framework in Python. Results showed that the model is capable of giving 100% accuracy in predicting users' intents so that the chatbot can give the appropriate responses and the response time is near zero milliseconds. This result implies that developers who aim to build fast and accurate chatbot software can use the combination of bag-of-words and deep-learning approaches. Several suggestions are presented to increase the probability of the chatbot's success when released to the general public.

Keywords: Indonesian chatbot, car repair shop customer service, fast, accurate, deep learning, bag of words

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1. Introduction

A chatbot is a software that simulates human conversation through a text chat. It is one of the tasks in Natural Language Processing (NLP) in the field of Artificial Intelligence. Chatbots are expected to be fast and accurate [1] and chatbot performance is important to increase customer experience and therefore improve customer satisfaction [2]. However, the currently available approach for Indonesian chatbots only has low to medium accuracy and high response time. The accuracy of the chatbot is a measure of how likely the chatbot is to give the correct (matching) answer to the question asked by the user [3]. Whereas response time is defined as the time required by the chatbot to give a response based on the user's query [4]. Research [5] has an accuracy of 26-78% using pre-built platforms namely Artificial Intelligence Markup Language (AIML) and Pandorabots. Another research has an accuracy of up to 93.75% [6] and another research using RNN for intent classification has an accuracy of 81% [7]. Another research using the GloVe model and CNN produces the best accuracy of 95.84% [8]. Only one research reports the chatbot's response time and it has a low response time with an average response time of 3.4 seconds [4]. Chatbot in Bahasa Indonesia had been used for FAQ in a university library during a pandemic situation [9], virtual assistant for banking service [10], [11], hotel [12], [13], software requirements elicitation [14], legal information service [15], digital historian [16], maternal and child health [17], and e-commerce [5].

The approach to building a chatbot varies from traditional methods such as pattern matching [11] and cosine similarity [18], to the more modern, neural-network-based approaches such as sequence-to-sequence model [19] and Transformers[20]. However, it has been proved that the development of a pattern-matching or rule-based approach is very difficult [21]. The later approaches will also allow the users to use free text as their queries, rather than a fixed pattern [22]. Some authors may use the pre-build platform such as RASA [23], Dialogflow [9], and AIML [5], [12]–[14]. This research aims to build a deep-learning-based chatbot from scratch using TensorFlow/Keras.

A deep neural network is a type of neural network that has more than one hidden layer. The higher complexity of the deep neural network will allow the model to do a more complex task including language modeling and Question-and-Answering task such as chatbot. For a computer to be able to process text, the text needs to be pre-processed and undergo feature extraction steps before being fed into the model. The text pre-processing tasks include tokenization, lemmatization, stemming, stop-word removal, etc. There are some text feature extraction techniques such as (Term Frequency–Inverse Document Frequency) TF-IDF [24], Term Document Matrix (TDM) [25], Bag of Words (BoW) [26], Word Embeddings [27], etc. Research showed that when using BoW, the text conversion of uppercase letters into lowercase letters gave a significant improvement in text classification accuracy [26]. Whereas stop word removal may improve the accuracy but the result is dependent on the dataset used [26]. The result from text feature extraction is a matrix that later is used for text classification. The text classification part may use some "traditional" Data Mining techniques such as Random Forest and Gradient Boosting [24] or a more modern, neural-network-based approach, such as Transformers. The text classification task may use Transformers' zero-shot learning approach but it is slow / resource-intensive [28].

Customer Service (CS) is one of the important parts of every business, including a car repair shop. Traditionally, CS tasks are held by human CS. However, when so many customers only ask about basic information, this can burden the utilization of human CS where the precious resource of human CS are wasted on answering very basic questions from the customers. The use of a chatbot can help CS [1] to alleviate this burden and reduce human resource costs for CS [29]. Furthermore, the use of chatbots can also avoid human error [29] and provide the latest information about the business [1]. Regardless of being a non-human CS, chatbots are proven to increase business agility [30], form positive customer relationships [31], and increase customer satisfaction [2], [32], [33]. This research will apply the chatbot to help a car repair shop CS. If the customers need further questions, the chatbot will direct the customer to a human CS.

2. Methods

The research methods are shown in Figure 1 which shows that the methods are separated into two phases: the training phase and the implementation phase. In the training phase, a set of preset queries and their corresponding intent is prepared as the training dataset in the JSON file format. The queries consist of questions such as “What is the opening hour?” and “How long will the repair take time?”. There are a total of 16 intents with each intent having several possible queries. There is one special intent to handle the case when the user inputs an invalid or blank query or queries that the chatbot can not understand. This special intent will be responded to by the chatbot asking the user to type a valid / better query. The approach for this chatbot is by using a text classification task where intents will be the target classes and the queries are the text to classify. The chatbot response then is based on the recognized intent. An example of the training data is shown in Figure 2.

The preset queries will undergo text preprocessing and feature extraction steps which includes tokenization, lemmatization / stemming, and bag-of-words creation. Tokenization will list all words in the query. Lemmatization and stemming will change the words into their root form. Bag of Words will create a corpus that lists all unique words and count the word frequency for each word. These steps will result in a matrix that is ready to be used for model training. The model consists of one input layer, two hidden layers, and one output layer. The details of the model architecture are shown in Table 2. The model is trained using SGD optimizer with Learning Rate = 0.1. The trained model will be saved as an H5 file to be further used in the chatbot application development.

In the deployment phase, the user will input queries in the app which will then be replied to by the chatbot. The query will undergo the same text preprocessing and feature extraction as in the training phase before being fed into the model. The model will then output the predicted intent and the app will give the appropriate response based on the predicted intent. The confidence threshold for the intent prediction is set to 0.25 and the model will give a response based on the class with the highest confidence score. If there is more than one preset response, the app will give a random preset response for that intent. In case of a low confidence prediction score, the app will respond with a statement that the chatbot does not understand the user query. And for special or further queries, the chatbot will direct the customer to human customer service. Both the training and deployment phases are done in the Python environment by using several libraries such as NLTK [34] for tokenization and lemmatization, Sastrawi for Indonesian stopword removal and stemming, Tensorflow [35] and Keras [36] for the deep learning model, Pickle for saving the model, and Flask [37] as the framework to develop the web-based chatbot app.

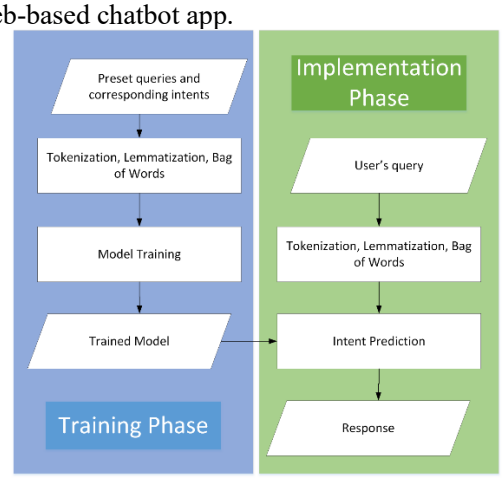

Figure 1. Research Methods

```
{"tag": "1",
 "patterns": ["Jam Operasional","Jam operasional
 bengkel?","Apakah bengkel buka?","Buka jam berapa?",
 "Tutup jam berapa?","Jam Buka"],
 "responses": ["Bengkelin melayani servis mobil
 setiap hari, kecuali hari libur. Kami buka mulai
 pukul 08.00 - 20.00 WIB. Silahkan berkunjung
 \uD83D\uDE0A",
                "Halo kak, jam operasional kami
                dimulai dari pukul 08.00 - 20.00 WIB
                ya",
                "Silahkan datang ke bengkel kami pada
                pukul 08.00 - 20.00 WIB"],
 "context": [""]
},
```

Figure 2. A sample of intent, its preset queries, and its preset response in the JSON format

Table 1. Model architecture

Layer	Details
Input layer	Input shape equals the number of BoW elements
Hidden layer 1	128 neurons, dropout rate = 0.5, ReLu AF
Hidden layer 2	64 neurons, dropout rate = 0.5, ReLu AF
Output layer	Neuron units = number of intents, Softmax AF

3. Results and Discussion

By using 200 epochs, the training phase resulted in a model with 100% accuracy as shown in Figure 3. The training time was two minutes. The trained model is saved and then deployed in a web-based Python app. The result of the app is shown in Figure 4 and Figure 5. User will input their queries in the text field and hit the "Send" button and the chatbot will respond to it. For example, when the user asked about facilities, the chatbot will respond with information regarding the available facilities in the car repair shop. The timestamp of each message is displayed in each of the bubble chats. Figure 5 shows that when users' queries contain abbreviated words and/or typos (writing errors), the chatbot can still understand them and give the appropriate response (as long as another/other important keywords are present). When the words in the query are all abbreviated and/or typos, the chatbot will return a response saying that it can not understand the query, as shown in Figure 6. Figure 7 shows the Python console showing the difference between the user's query time and chatbot response time. The difference is near zero milliseconds. This shows that our results is better in both accuracy and speed than previous research mentioned in the Introduction section. The use of this Chatbot will certainly help the car repair shop CS to serve their customers who want to ask questions about their services. CS will only focus on serving customers who need further information about its services.

```
Epoch 190/200
21/21 [==============================] - 0s 877us/step - loss: 0.0732 - accuracy: 0.9756
Epoch 191/200
21/21 [==============================] - 0s 929us/step - loss: 0.0501 - accuracy: 1.0000
Epoch 192/200
21/21 [==============================] - 0s 1ms/step - loss: 0.0568 - accuracy: 0.9756
Epoch 193/200
21/21 [==============================] - 0s 2ms/step - loss: 0.0411 - accuracy: 1.0000
Epoch 194/200
21/21 [==============================] - 0s 2ms/step - loss: 0.0638 - accuracy: 0.9878
Epoch 195/200
21/21 [==============================] - 0s 1ms/step - loss: 0.0406 - accuracy: 0.9878
Epoch 196/200
21/21 [==============================] - 0s 997us/step - loss: 0.0586 - accuracy: 0.9756
Epoch 197/200
21/21 [==============================] - 0s 937us/step - loss: 0.0531 - accuracy: 0.9756
Epoch 198/200
21/21 [==============================] - 0s 849us/step - loss: 0.0675 - accuracy: 0.9634
Epoch 199/200
21/21 [==============================] - 0s 851us/step - loss: 0.0298 - accuracy: 0.9878
Epoch 200/200
21/21 [==============================] - 0s 855us/step - loss: 0.0168 - accuracy: 1.0000
model created

Process finished with exit code 0
```

Figure 3. The trained model has 100% accuracy

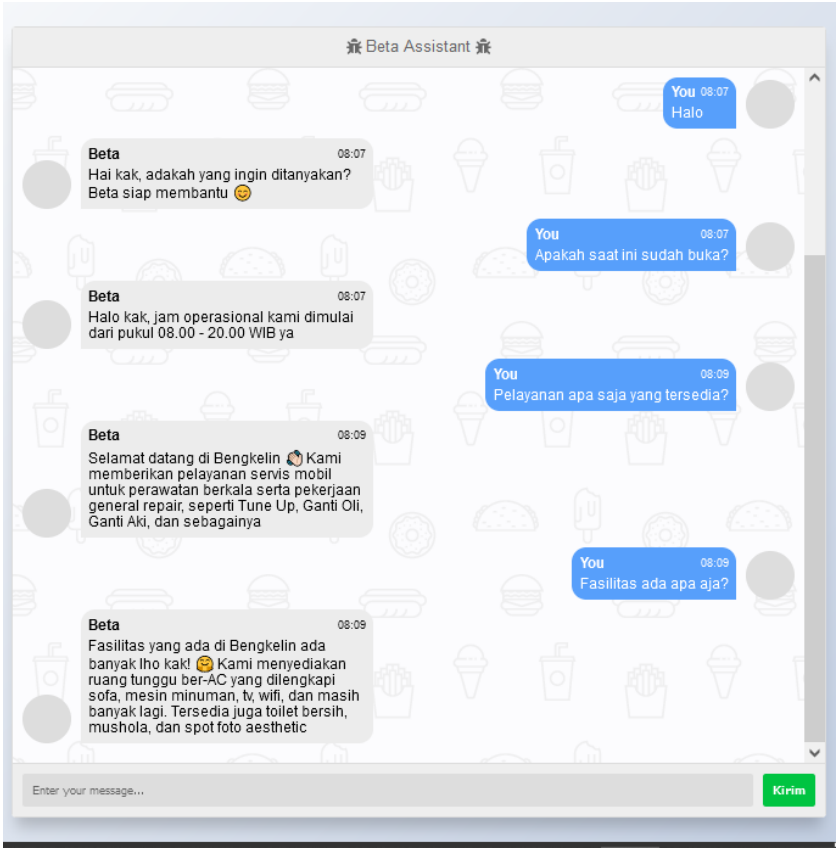

Figure 4. The result of the chatbot app

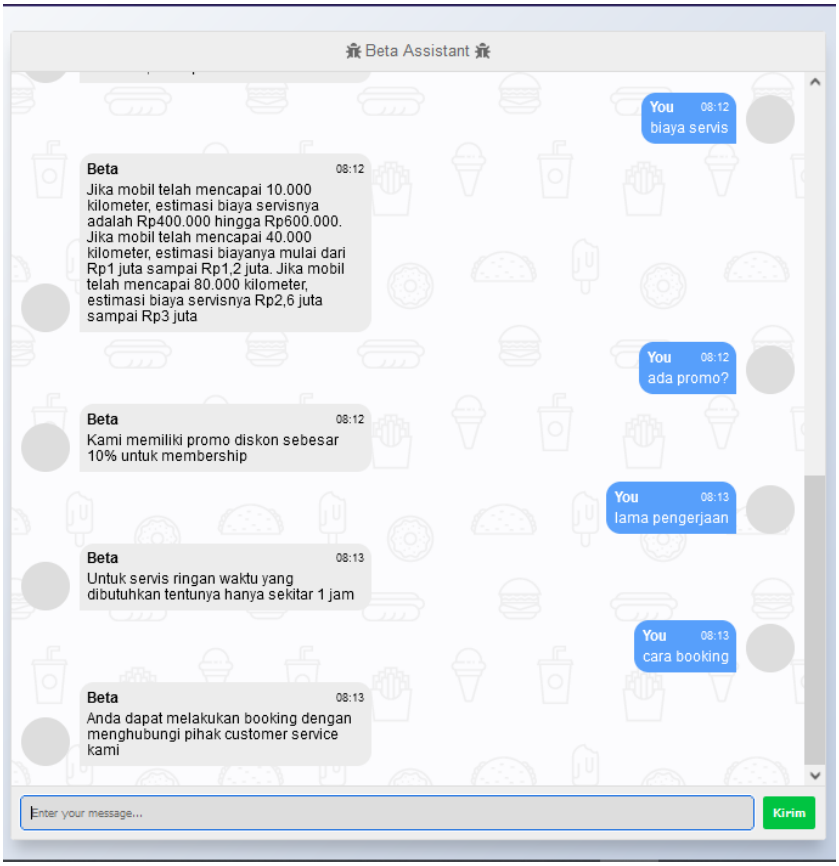

Figure 5. A screenshot of the chatbot app showing its capability to respond to incomplete/short sentences

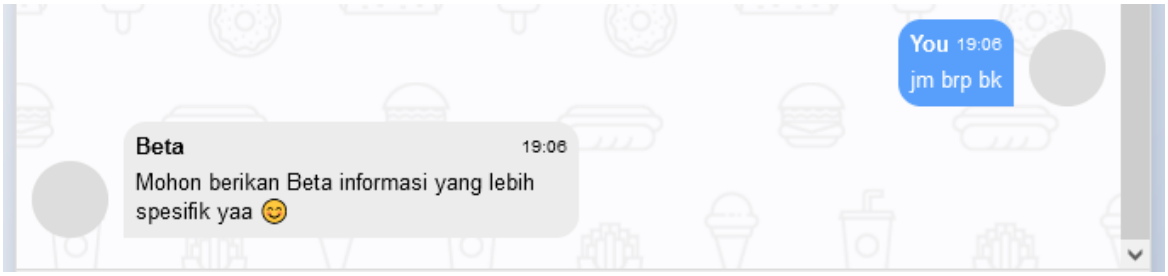

Figure 6. A screenshot of the chatbot app showing a respond to a sentence containing all abbreviated words and typos. The chatbot will respond by asking the user to input a more detailed / better-typed query

Despite its great accuracy and speed, when released to the public, research showed that a successful chatbot needs to be useful and easy to use [38], [39]. Research also showed that user satisfaction in using a chatbot is influenced by System Quality, Information Quality, and Service Quality [40]. Whereas the intention to use a chatbot is influenced by Information Quality and Personal factors (such as age and occupation) [40]. Further research may address and implement those insights to guarantee a successful chatbot implementation that is well-received by the public. Further research may also use a more sophisticated out-of-scope intent detection [20] rather than by providing one extra intent class as used in this research. Latent Dirichlet Allocation (LDA), a text clustering technique [41], might be explored to be used as an approach to / to assist the text classification task [42], [43]. Future research may also add Typographical Error correction to make the chatbot more robust in handling Typographical Errors using a method such as Schema Matching Technique [44]. Future research may add more datasets for both preset queries and their corresponding intents to further expand the functionality of the chatbot. The chatbot can be further improved by integrating the chatbot into the car repair shop information system so that it can handle service orders, provide real-time information about the current service queue, provide real-time information on the estimated time to complete service, etc. But such system may require a referee policy so that it will not be abused by irresponsible users.

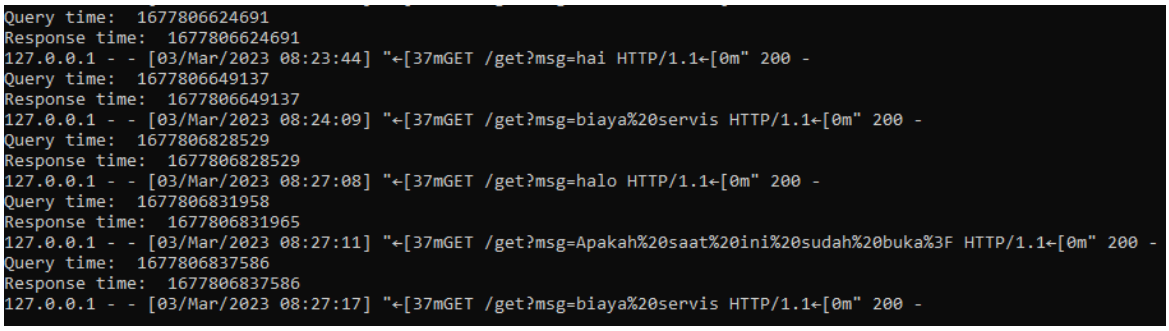

Figure 7. The Python console showing the difference between the user's query time and chatbot response time. The difference is near zero milliseconds

4. Conclusion

This research aims to build a fast and accurate Indonesian QnA chatbot using bag-of-words and deep-learning approach applied to a car repair shop. The training phase resulted in a 100% accurate model. Results showed that the chatbot app can provide a fast (near-zero milliseconds response time) and highly accurate response based on users' queries. This chatbot can help to reduce the cost use of hiring human CS and reduce human errors. Despite from its already great performance, there are several suggestions to increase its chance of success when released to the general public.

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Quality Assurance Plan for Linear Accelerator (LINAC) on Nasopharynx Cancer (NPC) Treatment at Radiotherapy Installation Ken Saras Hospital

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Abstract. Radiotherapy is the treatment of cancer by using electromagnetic and particle radiation. Nasopharyngeal Cancer (NPC) is one of the difficult case to be treated in radiotherapy because its anatomical location. Precision of radiation dose is part of Quality Assurance Program as the key factor in this treatment. Thus, it is very important to ensure that the output dose of Linear Accelerator (LINAC) matched with result of Treatment Planning System (TPS). This study used Siemens LINAC Type Primus MACH Series 5633 and a set of detectors for Nasopharynx Cancer analysis with 8 field. The total dose of 5,000 cGy divided into 25 fractions with 200 cGy dose per fraction. The 8 fields are irradiated with a target on a detector device. It is then accumulated with PTW-Verisoft software by plotting the results obtained from the detector tool with PTW (phantom) which we have CT Scanned first in PTW-Verisoft. From the total detectors exposed to the radiation, the detector corresponding to PTW is 372 detectors (100%) with unsuitable detector of 0 detectors (0.00%). It is proved that the planning is 100% match for NPC with 8 fields of radiation. Thus, this method is recomended to be implemented for NPC treatment.

Keywords: Quality Assurance, Treatment Planning System, NPC, Radiotherapy

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1. Introduction

Radiotherapy is the treatment of diseases, especially tumors or malignant cancer by using electromagnetic radiation (X-ray and gamma) and particle radiation (electrons, protons, neutrons). This technique was first discovered in the late 19th century after the discovery of X-rays by W.C. Rontgen, the radioactivity properties by Becquerel, and the discovery of radium by Pierre and Marie Curie. With the rapid advancement of technology, radiation therapy continues to improve and is increasingly popular and commonly used, particularly for cancer treatment[1]. The presence of vital organs affected in this radiation will greatly limit the maximum dose that can be given, especially if the vital organs have a high sensitivity to radiation. In general, external radiation is done by a linear accelerator (LINAC)[2].

The nasopharynx is located near several anatomical structures that are highly sensitive to radiation, including the spinal cord, medulla oblongata, eyes, middle and internal ear, parotid gland, temporal lobes, and hypothalamus-pituitary axis. The nasopharyngeal wall is covered by mucosa with many folds. Histologically, the nasopharyngeal mucosa formed by the pseudostratified ciliated columnar epithelium (pseudostratified ciliated columnar epithelium) toward the oropharynx will be transformed into a stratified squamous epithelium. Between them there is a transitional epithelium primarily obtained on the lateral wall in the Rosenmüller fossa region [3-4].

Nasopharyngeal carcinoma (NPC) is characterized by its rapid infiltration into nearby tissues, resulting in irregular radiation volumes and multiple toxicities to the structures affected by the tumor[4]. It differs in terms of its epidemiology, histology, natural progression, and treatment response. NPC also shows a clear connection to specific races and geographic regions, which indicates that its development is influenced by multiple factors. While NPC is rare in Europe, it is endemic in Southeast Asia[5]. It is a common cancer in Indonesia and is ranked fourth after cervical cancer, breast cancer, skin cancer and is the most common cancer in the head of the neck. This disease is 100% associated with Epstein Bar Virus (EBV), especially undifferentiated carcinoma type. Nearly 60% of malignant head and neck tumors are NFC, followed by nasal and paranasal sinus tumors (18%), larynx (16%), malignant oral tumors, tonsils, thyroid and hypopharynx in lower percentages[6].

Treatment Planning System (TPS) is a radiotherapy plan to determine accurately, selectively, the type of energy and direction of the ray. This system aims to obtain a homogeneous dose of radiation on tumor mass or to avoid critical organs. There are 3 areas in radioteraphy around the target: 1) Gross Tumor Volume (GTV) is part of a palpable tumor, visible to the naked eye, with the help of endoscopy or imaging of plain and contrast radiographs, CT Scan, MRI; 2) Clinical Tumor Volume (CTV) is a GTV plus an area potentially infected by a subclinical tumor; 3) Planning Target Volume (PTV) is a geometric concept defined by clinical and physics (computers, simulators and radiation equipment used). These targets are designed on the basis of data in software to ensure CTV is adequately radiated. Examples of pulmonary heart, breathing or swallowing; 4) The Organ at Risk (OAR) is an organ within the radiation field and can cause treatment and dosing planning changes and as a healthy organ that needs to be protected from radiation exposure[7].

Quality Assurance (QA) is a program designed to control and maintain the quality set for the program. The QA program in general in radiotherapy is important and fundamental. The goal ensures that the results of a software can be predicted correctly, and that every hardware device is used with the correct system function and ensures that quality control procedures are adequate, and applied to individualized therapy planning systems[8]. Several QA studies have been conducted to obtain quality radiotherapy devices, Ehsan has compared 3D Radiotherapy and Intensity Modulated Radiation Therapy (IMRT) techniques in nasopharyngeal cancer patients. Al Hayat's has also compared the distribution of doses to the target and for normal tissue in brain tumors with IMRT and 3D the 3D conclusions can be applied but if PTV is close to OAR then IMRT is preferred [9-10]. Sahoo did research using Linac tools with 6MV photon energy and 10 MeV electrons in a water phantom. The study measured a complete set of data according to Linac's performance and made a comparison of the data used 13 years earlier [11]. Iskandar in his study analyzed the use of wedge in cases of nasopharyngeal cancer. The wedge used varies from 15^0, 30^0, 45^0, 60^0. The method used is to compare the location of the DVH curve for a

particular volume with different wedge usage. The results obtained that the use of wedge 60^0 contribute the largest dose distribution to PTV and a minimum on OAR[12]. Narsakha has also evaluated the stability of the Linac Medic plane by using two Linacs. Mevatron 20 and 12 have been evaluated for month-long stability using the RMI daily constancy tool. The% stability is less than 3% for the electron beam of 7,10,12,15,18 MeV and photon files 15 MV and Vevatron 20[13].

In newly treated nasopharyngeal carcinoma (NPC) patients, stereotactic radiotherapy is used to deliver increased doses to residual lesions after three-dimensional conformal intensity modulated radiotherapy, resulting in better local control and survival rates. However, during the treatment, it is important to protect the carotid sheath to reduce long-term damage to nerves and blood vessels, which can help decrease the likelihood of severe nasopharyngeal hemorrhage [14]. A crucial aspect of radiation therapy treatment clinics is designing a radiation treatment plan with precise and trustworthy dose calculations, which serves as a crucial assessment tool. The accuracy and reliability of the plan depend on the type of dose calculation algorithm utilized by the treatment planning system (TPS). Despite the dose calculation algorithm used, the delivered dose remains consistent; thus, the predicted dose must be precise and reliable across various TPSs[15]. To achieve effective control of the disease in the area being treated and ensure long-term recovery, it is essential to have a precise, careful, and logical approach to defining the treatment target. Additionally, it is important to take proactive measures to protect healthy structures in order to minimize the likelihood and seriousness of complications associated with radiation therapy[16]. To keep up with the constantly evolving complexity of technology and radiotherapy techniques, including IMRT, small fields, 4D applications, etc., it is essential to have practical, accurate, and precise dosimeters and dosimetry systems[17].

Based on the previous studies and the importance of radiation dose analysis in NPC case, thus we need to determine the suitability of radiation dose from TPS with the doses produced by LINAC that will be used for irradiation on NPC by considering around PTV and OARs.

2. Methods

Data collection begins with the manufacture of Treatment Planning on NFC cases with standard planning (8 Fields) taking into account the anatomical aspects: a)The superior limit covers the entire base of the crani including the spenoid sinus; b)The anterior margin is in the middle of the durum palate, including khoanae or 1/3 posterior maxillary sinus; c)The posterior limit should include the posterior lymph node of cervical and all of the soft tissue cervicalis or include the cervical spinosus process.;d)The inferior limit covers all mandibles approximately as high as C2 and C3; e)The dose is given 180-200 cGy per fraction given 5 times a week a week so the dose reaches 66-70 Gy with regard to the radiation field.; f)When the dose reaches 40 Gy, the spinal cord must be removed from the radiation field, meaning the posterior border is advancing anteriorly or anterior to the Meatus Acusticus Externus (MAE). At the same time the superior boundary can be lowered so that the base crani is outside the radiation field. When the dose reaches 50 Gy the inferior border is raised to as high as C2 and the anterior border retreats until it reaches khoanae.; g)Furthermore, radiation in the neck and clavicula Lymph node is done from the anterior direction, the superior limit of 0.5 cm caudad from the nasopharyngeal border.; h)The inferior and lateral limits include the entire fossa of the left and the dextra clavicula, and closure or blocking the middle of the neck to protect the thyroid gland, trachea and spinal cord.;i) The two inferior angles of this field are closed to protect the apex pulmo dextra and sinistra.;

With these aspects, 8 radiations fields were designed for nasopharyngeal cancer irradiation: Supraclavicula (SPCLV), Anteroposterior (AP), 40^0,140^0,320^0,220^0 and lateral 90^0 and 270^0. For supraclavicula lymph node section made SPCLV field with gantry angle 0^0 with block at Trachea area, lung apex and spinal cord. For colli lymph node are made 5 fields is AP angle 0^0 with Trachea block and spinal cord, then 40^0, 140^0, 320^0, 220^0 without block. For the Gross Tumor Volume (GTV) area or primary tumor, the 2^{nd} lateral direction is 90^0 and 270^0. Then the dose distribution can be calculated and viewed at Dose Volume Histogram (DVH) up to the maximum dose on Planning Target Volume (PTV) and minimum on Organ At Risk (OAR).

TPS can be made appropriate with the needs, for example: the direction of gantry angle, field width (Jaws), collimator, radiation weights, blocks, and isodic curves to see the distribution of doses in certain areas. Then with the same data we apply to phantom as thick as 10 cm that has been in the previous CT Scan. Before the patient performed radiation, first done Quality Assurance Plan against Planning that has been made to know the suitability of radiation dose output tool with planning that has been made. Quality Assurance Plan is done by phantom previously in CT Scan placed on the table of LINAC with the same phantom thickness, and adjusted to laser on LINAC plane. Then carried out irradiation against the phantom. After completion of the process of irradiation against the phantom, done checking (plotting) by using PTW-Verisoft software.

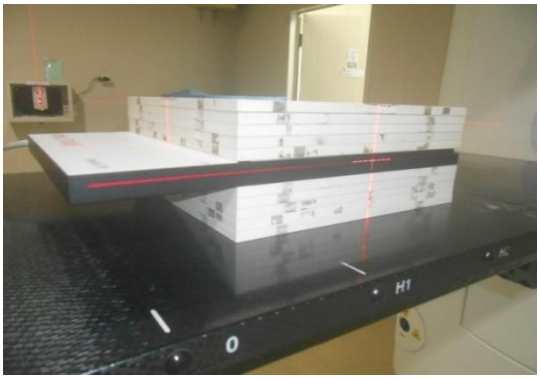

Figure 1. Positioning of Solid Water Phantom and laser marker

Calculating the number of detectors used using equation (1):

$$x(\%) = \frac{x}{TD} \times 100 \qquad (1)$$

X is the number of detectors used and TD is Total Detector. Calculation of the corresponding dose detector using equation (2):

$$y(\%) = \frac{y}{x} \times 100 \qquad (2)$$

Where y is the number of detectors according to the dose. Calculation of non-appropriate dose detector using (3):

$$z(\%) = 100\% - y \qquad (3)$$

Where z is an unsuitable detector dose. The result calculation is obtained by equation (4):

$$result(\%) = \frac{y}{x} \times 100 \qquad (4)$$

3. Results and Discussion

Planning creation is done in TPS room using Prowess Panther 5.10 software. On planning creation is important to check on the PTV and OAR first for determine the radiation dose in each field. This can be seen in the Dose Volume Histogram (DVH). Figure 2 is the relationship or influence of total dose with total volume of target organs (PTV) and OAR. For example target organs (PTV) in light blue graph (target 1), the above picture uses a total dose of 7000 cGy (X axis) and total target volume (Y axis). The conclusion of the figure is on the target organ (PTV) at a total dose of 7000 cGy obtained dose curve close to 1 or 100% of the target volume (PTV). Like previous exposure, the maximum dose on target organs and minimum in healthy organs. For healthy organ around the nasopharynx can be seen in figure 4 as an example is chiasma nerve, mandible, brainstem, orbita, etc as in the graph in different colours to

facilitate the reading. For PTV organs, the maximum limit for over exposure of 2% in the curve indicates a PTV curve that exceeds the line above 7000 cGy.

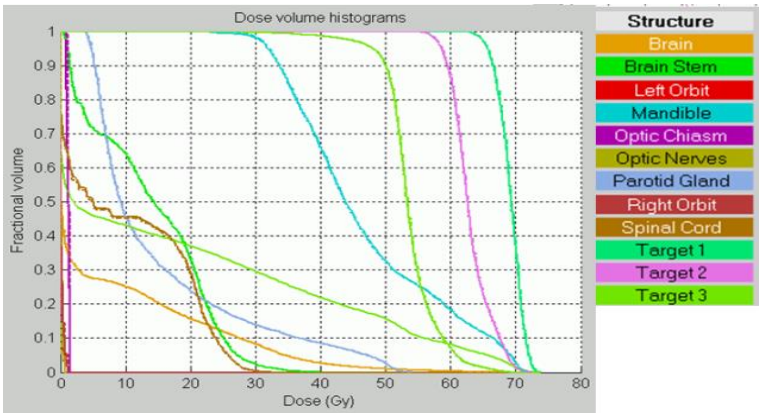

Figure 2. Dose Volume Histogram (DVH) (Primary data)

Matching treatment results with phantom-based simulations to demonstrate the success rate of the QA protocols were performed on each field. For irradiation dose in SPCLV field that is 19.7 cm X 13.6 cm shown in Figure 3a and Figure 3b.

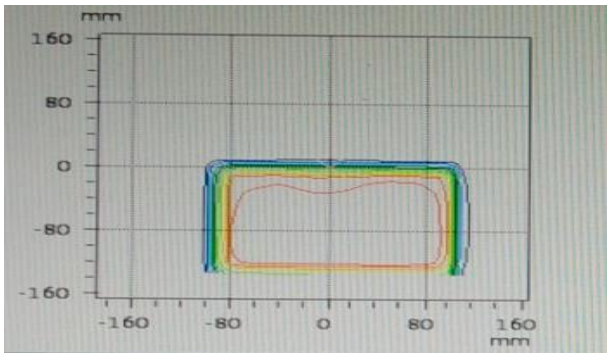

Figure 3a. Result of SPCLV irradiation on detector (Primary data)

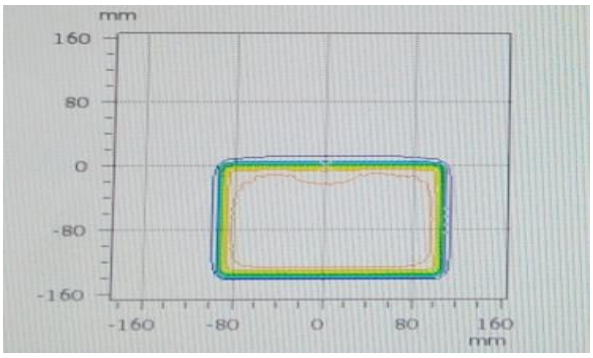

Figure 3b. SPCLV field on phantom (Primary data)

In SPCLV field this is done for irradiation of upper Lymph Node region of clavicle bone where the area is CTV from nasopharyngeal cancer. In that area shows the total detector that is exposed to radiation of 280 detectors, in other words the results corresponding to planning in the SPCLV area are 100% of the total detector that is exposed to radiation.

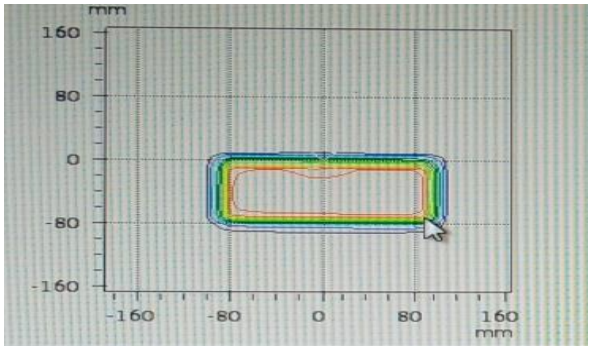

Figure 4a. AP field on detector (Primary data)

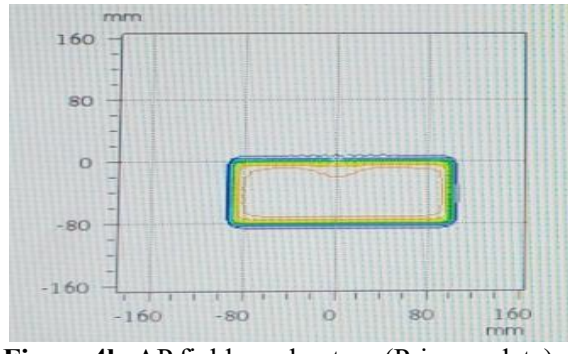

Figure 4b. AP field on phantom (Primary data)

Figure 4a and 4b represent an anteroposterior (AP) irradiation area with the area shined as Coli lymph node. In Coli lymph node, the area is irradiated with 5 fields is AP, 40^0, 140^0,320^0,220^0. Especially for AP field, radiation-exposed detector of 176 detectors. Of the 176 detectors, the detector in accordance with the planning is as many as 176 detectors with an AP field of 19 cm X 8 cm. With these data showing the result of dose conformity on the AP field is 100% of the radiation exposed detector. Irradiation in coli region continued and shown the data as follows:

[1] With data on the number of detectors exposed to radiation of 96 detectors. All 96 detectors are in accordance with the planning results. In other words, on the 140^0 field the corresponding detector is 100% with a field area of 10.5 cm X 8 cm;
[2] With the total number of detectors exposed to radiation of 92 detectors. All 92 detectors are in accordance with the results of planning. In other words, on the field of 40^0 detectors corresponding to is 100% with a field size of 10 cm X 8 cm.
[3] With the data the number of detectors that are exposed to radiation as much as 72 detectors. All 72 detectors are in accordance with the results of planning. In other words, on the field 320^0 the corresponding detector is 100% with an area of 8 cm X 8 cm.
[4] With data on the number of detectors exposed to radiation of 68 detectors. All 68 detectors are in accordance with the results of planning. In other words, on the field of 220^0 detectors corresponding is 100% with a field width of 7.4 cm X 8 cm.

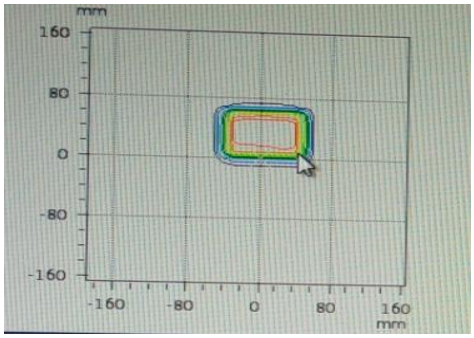

Figure 5a. 270^0 field on detector (Primary data)

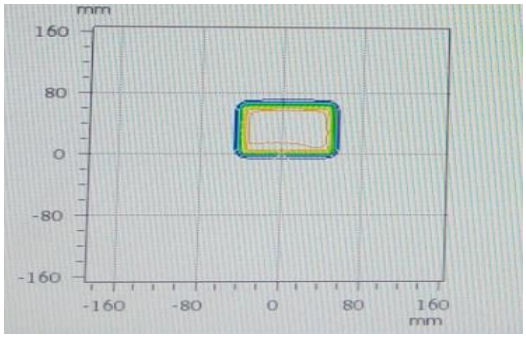

Figure 5b. 270^0 field on phantom (Primary data)

Figure 5a and 5b show the area of exposure to the GTV area or primary cancer. With data on the number of detectors exposed to radiation of 68 detectors. Of the 68 detectors, 67 detectors are in accordance with the planning results, in other words the corresponding 270^0 detector field is 98.5% and the unsuitable one is 1 detector of 68 detectors or 1.5% with the field area of 9.2 cm X 6.4 cm.

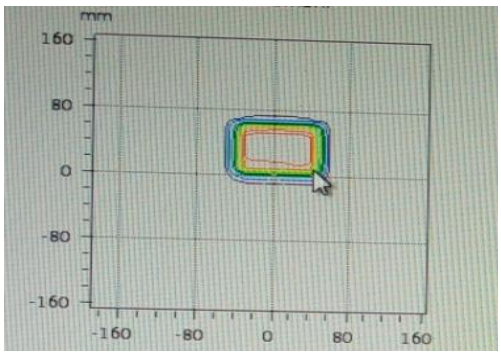

Figure 6a. 90^0 field on detector (Primary data)

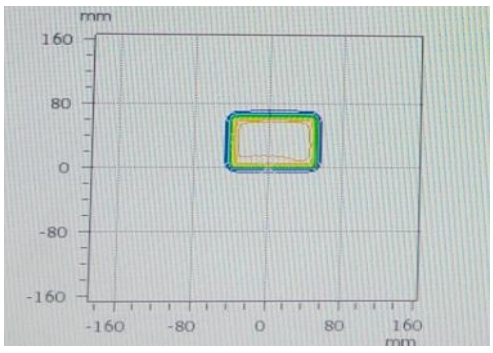

Figure 6b. 90^0 field on phantom (Primary data)

In figure 6a and 6b show the area of irradiation is GTV from nasopharyngeal cancer. With the total number of detectors exposed to radiation of 78 detectors. Of the 78 detectors, 78 detectors are in accordance with the results of planning, in other words on the field the corresponding 90^0 detectors are 100% with a field area of 9.5 cm X 6.8 cm.

The color of the lines on the isodic curve indicates that the area is exposed or has a different dose value. Here is the dose value based on the color ranging from the highest is red with dose distribution 1.1 Gy, yellow 1 Gy, green 0.5 Gy, dark green 0.1 Gy, purple 0.05 Gy. This dose distribution is only used in dosage distribution per field. The incorporation of 8 radiation fields was accumulated into 1 treatment to obtain a complete picture of NFC as shown in Figure 7a and Figure 7b.

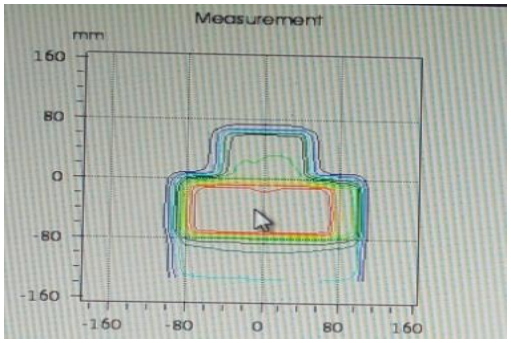

Figure 7a. 8 fields on detector (Primary data)

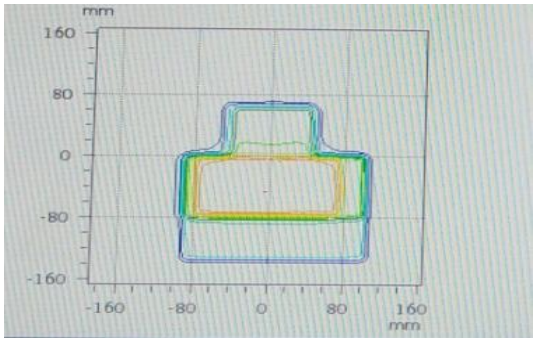

Figure 7b. 8 fields on phantom (Primary data)

By using the PTW-Verisoft software, it was found that 372 detected radiation detectors from a total of 729 detectors (51% of the total detectors). 372 of these 372 detectors obtained 372 detectors according to CT Scan calculations (100% of the number of detectors exposed to radiation) and as many as 0 non-matching detectors (0.00%). With the data obtained the conformity of the results 100%. The dark blue color indicates that the detector is not exposed to radiation, light blue indicates the detector is exposed to radiation smaller than the yellow and red green. The colour does not indicate the dose value, but shows the level of distribution of doses to the surrounding area in the lowest order is purple with dose distribution 0.5 Gy, light blue colour with dose distribution 1.5 Gy, green colour with dose distribution 2.3 Gy, yellow colour with dose distribution 3.3 Gy and orange colour with 4 Gy dose distribution. The shape of the image indicates a dilated field area based on the area of the nasopharyngeal field. The dosage distribution is only used in 8 field treatments. The results of the calculation per field and the 8 field are shown in Table 1.

Table 1. Result of irradiation detector per field

Field	Detector used		Dose appropriate Detector		Incorrect Detector	Result
	in number	in percent	in number	in percent		
SPCLV	280	38.4%	280	100%	0(0%)	100%
AP	176	24.1%	176	100%	0(0%)	100%
140	96	13.2%	96	100%	0(0%)	100%
40	92	12.6%	92	100%	0(0%)	100%
320	72	9.9%	72	100%	0(0%)	100%
220	68	9.3%	68	100%	0(0%)	100%
270	68	9.3%	67	98.5%	1(1.5%)	98.5%
90	78	10.7%	78	100%	0(0%)	100%
8 Fields	372	51%	372	100%	0(0%)	100%

From Table 1 above, it appears that the only radiation field whose success rate <100% is at irradiation of 270^0, but at the merging of 8 field success rates to 100%. This is because between the field with each other mutual superposition so it can close the lack on the edge of the field.

4. Conclusions

Comparison between TPS data and direct measurement of irradiation dose has been done using Siemens LINAC Type Primus MACH Series 5633 and a set of detectors for Nasopharynx Cancer analysis with 8 fields radiation plan. All 372 detectors were successfully exposed to radiation source. For per-field plotting results based on data obtained from 8 irradiation fields only one field is found < 100%, at 270^0 field gantry angle (98.5%). The final conclusion of this research is the conformity between planning made and LINAC tool is 100%. It is proved that 8 fields irradiation technique is suitable for NPC treatment in radioteraphy. The future research might include more than 8 fields as the location of Nasopharynx close to many OARs so that we can calculate the accuracy and more precise possibility of dose distribution and treatment.

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Optimizing Project Performance by Applying the Crashing Method to Road Construction Project

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Abstract. In the implementation of projects, various obstacles are often encountered which cause delays which have an impact not only on the duration of implementation but also on the costs incurred. These constraints can be in the form of a lack of resources, weather factors to social factors. Thus, it is necessary to accelerate and optimize what can be done to overcome the delay. As well as efficient resource management. One of the acceleration methods that can be used is the Crashing method. One of them is the application of the crashing method to the Ringinrejo - BTS road construction project. Regency. Malang STA 2+350 – 6+300 which experienced delays in its implementation. After analyzing the remaining work, the duration of the remaining work was 273 days or completed on December 31, 2022. In the initial planning, the project was scheduled for completion on October 3, 2022, so based on this, the project experienced a delay of 89 days. The total minimum fee that must be incurred is IDR 1,524,960.00 with an additional fee of IDR 21,180,000.00 per day. Daily productivity for ordinary excavation works, which was originally 303.20 m³/hour, increased to 909.59 m³/hour. For daily productivity on ordinary embankment work which was originally 371.92 m³/hour to 743.84 m³/hour and productivity on road construction work which was originally 330.91 m³/hour to 661.81 m³/hour. After the acceleration using the crashing analyzing method on existing critical paths, it is known that the duration of project implementation which was originally 273 days became 184 days by adding the number of heavy equipment. with an additional fee of IDR 1,524,960,000.

Keywords: Project Delay, Crashing Method, ASSET, Project Management

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1. Introduction

Research for this final project is located at the Ringinrejo Road Development Project - Bts.Kab. Malang is located in Ringinrejo Village, Wates District, Blitar Regency, East Java. In this study used

quantitative methods. This method has been used for a long time, so it is often called the traditional method. This type of research, starting from the beginning to making the research design, is carried out in a systematic, planned and structured manner. Project management refers to how resources are available to managers so that they can be properly applied to a construction project. The resources used in development projects include labour, equipment, materials, methods and money[1]. The process of setting goals and objectives that require the preparation of resources to achieve them is known as planning activities[1].

There are three factors to consider when planning activities. These three factors are known as the three constraints (triple constraint). To make the best scheduling decisions, the use of resources during implementation requires effective and efficient planning. The definition of scheduling is determining the time and sequence of work in project implementation to produce the overall time duration[2].

Project management is an important component for the sustainability of a project. One of them is the road construction project which is an infrastructure project that has been developed by the government. This is because roads play an important role in increasing the economic and social activities of the people in the region. Likewise in the implementation of the Ringinrejo - BTS road construction project. regency. Malang STA 2+350 – 6+300. With the various obstacles that occurred including weather factors to social factors, the project experienced delays so that efforts were needed to accelerate to catch up with the delay so that it was in accordance with the planned schedule. So the purpose of this research is to find out the amount of time needed to complete the project after adding the number of heavy equipment used.

1.1. Problem Formulation

1.What is the total duration of the project after the acceleration analysis is carried out using the crashing method?
2.What is the minimum cost that must be incurred after the acceleration analysis is carried out using the crashing method?
3.What are the results of increasing the performance productivity of the heavy equipment used?

1.2. Project Management

The definition of management basically includes methods, techniques, or procedures to achieve certain goals in a systematic and effective manner through planning, organizing, actuating, and controlling tasks by utilizing existing resources effectively. effective[1]. Project management consists of three stages, namely:

1. Planning

Planning is identifying many options for action and choosing the best one.

2. Scheduling

Scheduling is determining the time and sequence of work in project implementation to produce the overall time duration (Mubarak, 2010).

3. Controlling

Control is the process of ensuring what has been achieved, assessing performance, and if necessary taking corrective action (Ervianto I, 2005).

1.3. Scheculing Method

Scheduling methods used in a project include:

1. Bars (gantt)Charts
2. Curve – S
3. Network Planning Diagrams:

a. Activities on Arrow
b. Activity on Node
c. Critical Path Method(CPM)

1.4. Activity om Node

Activity on Node(AON) has a representation that is closely related to what is called the Precendence Diagram Method (PDM)[5]. In this method there are several time relationships, namely:

1. Early Start(ICE) =The earliest time an activity can start after the previous activity has finished.
2. Late Start(LS) =The latest time an activity can be completed without slowing down the completion of the project schedule.
3. Early Finish(EF) =The earliest time an activity can be completed if it starts at the earliest time and is completed according to the duration.
4. Late Finish(LF) =The latest time an activity can be started without causing delays in project completion.

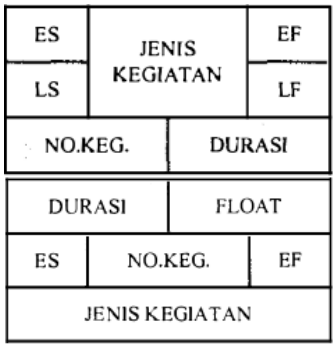

Figure 1. Activity Type in Activity on Node

1.5. Project Duration Acceleration

Project acceleration means shortening the normal duration of project work (or it can also be called schedule compression).[2]. The basic function of project management is to manage matters relating to the three constraints (triple constraint)[6]. The idea is that projects are generally limited to selecting two of the three elements and sacrificing the others to get the two selected[7]. So that it can be said in terms of the triple constraint, one of them is good – fast, good – cheap, or fast – cheap, but you cannot choose all three.

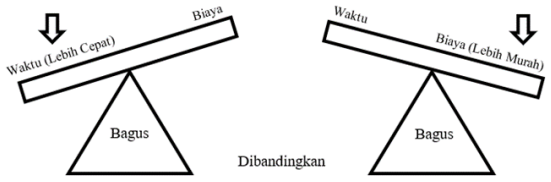

Figure 2. Acceleration On Project

1.6. Critical Path

The critical path is the work path where the execution time of the activity cannot be delayed[8]. The critical path is the path that most determines the overall project completion time[9]. Accelerating every activity, especially those that are on a crucial trajectory and with the lowest acceleration costs, are things that need to be taken into account in accelerating project completion[8].

2. Methods

The data used is secondary data. Where at this stage the data - the data needed is RAB, HSPK, S – Curve, daily reports and supporting data. In this study there are several stages of data analysis, namely Identification of Activities on the Critical Path, Determining Crashing Scenarios, Determining Crash Duration and Crash Costs, Calculating Cost Slope, Reviewing Time Cost Trade Off (TCTO) Analysis Results, Identifying Heavy Equipment Productivity, and Calculating Increased Productivity of Heavy Equipment.

2.1. Crash Method

Examining all project operations with a focus on activities that are on the critical path is known as crashing", and is a deliberate, methodical, and analytical procedure. The shortest time required to complete an activity that is technically still achievable, assuming resources are not an obstacle[10]. To speed up the process, there are four variables that can be improved: the number of workers, overtime scheduling, use of heavy equipment, and construction techniques in the field[11]. To further analyze the relationship between time and cost of an activity, the following definition is used[4]:

a. The normal timeframe is the amount of time required to complete the job efficiently, without neglecting overtime and other additional efforts such as renting more complex equipment
b. Normal costs are the direct costs required to complete an activity in an ordinary amount of time.
c. Shortened Time Frame (crash time) accelerated time required to perform a technically feasible task. Resources are not seen as a limitation in this situation.
d. Cost for Shortened Time (crash cost) is the total direct expenditure to complete the job in the smallest amount of time known as the crash cost.
e. The cost for the duration of the acceleration each day (cost slope) is the increase in costs for each reduction in the duration of the project. By accelerating the duration of work on certain activities, there will be additional costs due to the acceleration of the duration carried out.
   Or the relationship between time and cost can be seen in the following figure:

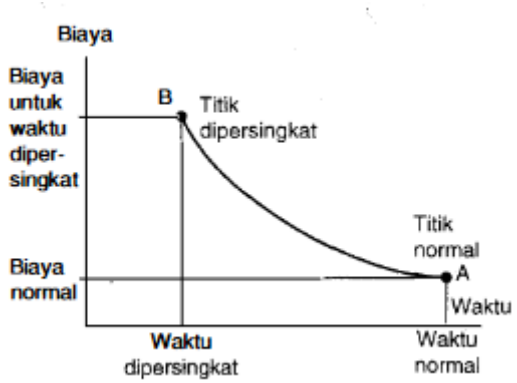

Figure 3. Relationship between time andcost in normal and accelerated circumstances

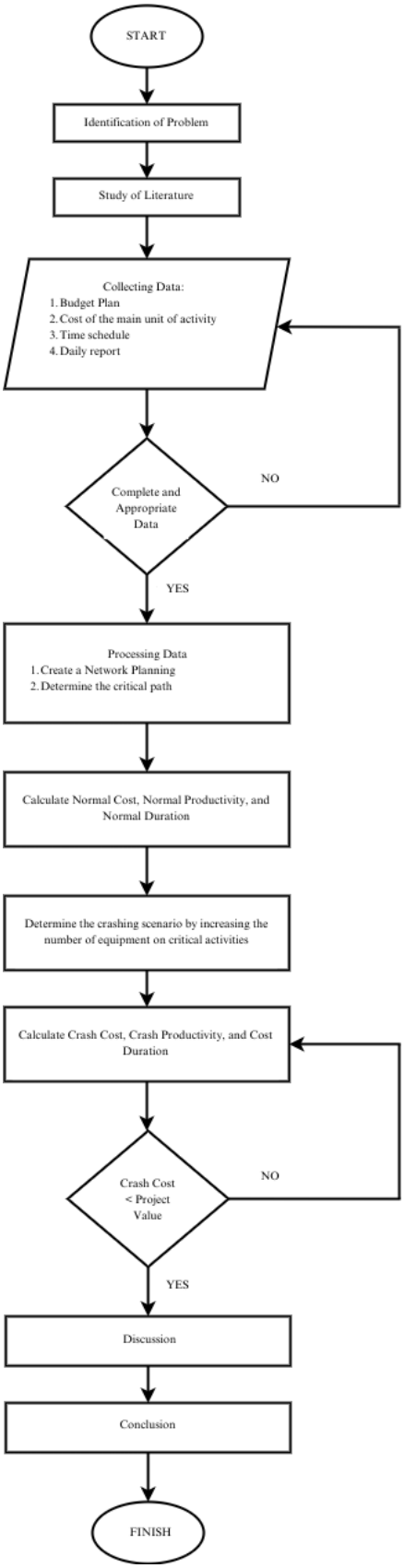

Figure 4. Research Methodology

3. Results and Discussion

For the work on this Final Project general data was obtained from PT. Ridlatama Bahtera Construction. PT. Ridlatama Bahtera Construction as a contractor on the Ringinrejo – Bts Road Construction project. Regency. Malang STA 2+350 – 6+300. The data to be processed is as follows:

3.1. Project General Data

Ringinrejo – BTS road construction project. Regency. Malang STA 2+350 – 6+300 starts on 10 May 2021 with a duration of 670 days. In this study, activities that were accelerated were only activities that were on the critical path at week 47 to completion.

The following is the Road Construction Project data,

Project name : Ringinrejo Road Development Project – BTS. Malang Regency STA 2+350 – 6+300
Execution time : 670 days
Contract value : IDR 46,004,000,000,-

3.2. Critical

After knowing the duration of each work on the project at the scheduling stage, or you can also refer to the project plan schedule. After the duration of each job is known, then determine the relationship of each work which will then be included in the 2016 Microsoft Project. Thus, it will be known that several work activities are on the critical path. Where in the 2016 Microsoft Project for bar charts or network diagrams of work that are included in the critical path will be red as shown in Figure 3. It is the work that is on this critical path that will be accelerated (crashing).

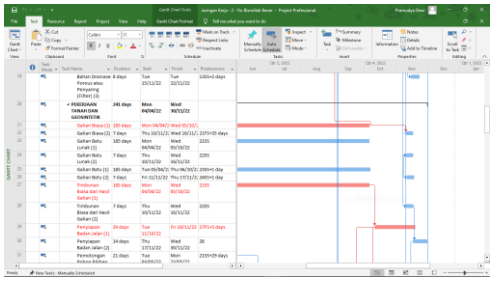

Figure 5. Critical Path Determination

Table 1. Work on Critical Path

No.	Work on the Critical Path	Volume	units	Normal Duration (Days)
1.	Common Digs (1)	109,446.96	m3	110
2.	Ordinary Stockpiles from Excavations	15,241.58	m3	112
3.	Road Agency Preparation (1)	47,400.00	m3	54

3.3. Calculating Normal Cost

Normal costs (normal costs) in the project consist of direct costs (direct costs) and indirect costs (indirect costs). Direct costs are obtained from the multiplication of the residual volume and the unit price of each job.

Normal Cost = Work Volume × Material Unit Price (1)

Table 2. Normal Cost of Work Activity

No.	Work	Volume	units	Normal Fee (Rp)
1.	Common Digs (1)	109,446.96	m3	1,094,469,620.00
2.	Ordinary Stockpiles from Excavations	15,241.58	m3	303,612,353.28
3.	Road Agency Preparation (1)	47,400.00	m3	85,320,000.00

In this study, the total value of normal cost was IDR. 43,325,708,137 with direct costs of IDR. 40,755,208,137 and indirect costs of IDR. 2,570,500,000. This indirect cost includes housing. , water needs, electricity needs and workers' wages.

3.4. Calculating Heavy Equipment

Machine productivity per hour is needed to find out the amount of machine productivity needed for each job. Machine productivity is calculated using the formula;

$$\text{Productivity} = (2)\frac{Volume\ Pekerjaan}{Durasi\ Pekerjaan}$$

For productivity on each job on the critical path will be described in the table

Table 3. Actual and Planned Productivity

No.	Work	Daily Productivity	Plan Productivity	Unit
1.	Common Dig (1)	303,20	994.97	m3/hour
2.	Ordinary Stockpiles from Excavations	371.92	136.09	m3/hour
3.	Road Agency Preparation (1)	330.91	574,27	m3/hour

3.5. Crash Method

In this study, the acceleration process (crashing) will be applied by increasing the number of heavy equipment. Then, some of these scenarios are compared in terms of costs in order to get the optimal acceleration scenario. The acceleration scenario is as follows,

1. Acceleration Scenario 1

This scenario is carried out by crashing the usual excavation work, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa			
		Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian			
		Excavator	1	1
		Dump Truck	2	2
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan			
		Motor Grader	1	1
		Vibrator Roller	1	1
4	Lapis Pondasi Agregat Kelas A			

Figure 6. Acceleration Scenario 1

2. Acceleration Scenario 2

This scenario is carried out by crashing the usual excavation works and ordinary embankments from the excavation, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa			
		Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian			
		Excavator	1	2
		Dump Truck	2	6
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan			

Figure 7. Acceleration Scenario 2

3. Acceleration Scenario 3
This scenario is carried out by crashing the usual excavation work and preparing the road body, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa			
		Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian			
		Excavator	1	2
		Dump Truck	2	6
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan			
		Motor Grader	1	2
		Vibrator Roller	1	1
4	Lapis Pondasi Agregat Kelas A			

Figure 8. Acceleration Scenario 3

4. Acceleration Scenario 4
This scenario is carried out by crashing on ordinary excavation work, ordinary piles of excavation results and preparation of road bodies, namely,

No.	Pekerjaan Lintasan Kritis	Jenis Alat Berat	Jumlah	
			Normal	Crashing
1	Galian Biasa			
		Excavator	2	6
		Dump Truck	8	15
2	Timbunan Biasa dari Hasil Galian			
		Excavator	1	2
		Dump Truck	2	6
		Motor Grader	1	1
		Vibrator Roller	1	1
		Water Tank Truck	1	1
3	Penyiapan Badan Jalan			
		Motor Grader	1	2
		Vibrator Roller	1	1
4	Lapis Pondasi Agregat Kelas A			

Figure 9. Acceleration Scenario 4

Then calculate crashing productivity for each of the above scenarios by adding the number of heavy equipment to obtain the following calculation,

Table 4. Crashing Productivity

No.	Description	Daily Productivity	Crashing Productivity	Unit
1.	Crash Scenario 1	303,20	909.59	m3/hour
2.	Crash Scenario 2	675,12	1350.24	m3/hour
3.	Crash Scenario 3	634,10	1571,40	m3/hour
4.	Crash Scenario 4	1006.02	2315,24	m3/hour

After obtaining acceleration scenarios, crashing duration calculations are performed for each acceleration scenario using the formula;

Crashing duration = (3)$\frac{Volume\ Pekerjaan}{Produktivitas\ Crashing}$

Table 5. Normal Duration and Crashin Duration

No.	Description	Normal Duration (Days)	Crashing Duration (Days)
1.	Crash Scenario 1	192	72
2.	Crash Scenario 2	304	164
3.	Crash Scenario 3	245	80
4.	Crash Scenario 4	357	171

After calculating the productivity and duration of crashing. The next step is to calculate the acceleration costs for each acceleration scenario, which is calculated by,

Crash costs = Duration*crashing*× Total price of crashes (4)

Total cost of crashes = Cost*crashing*+ normal fees (5)

Cost Slopes $=\frac{Biaya\ crashing - biaya\ normal}{Durasi\ crashing}$(6)

Table 6. Normal Fee and Crashin Fee

No	Crash Scenarios	Normal Fee (Rp)	Crashing Cost (Rp)	Total Cost of Crashing (Rp)	*Cost Slopes*(/day)
1	Crash Scenario 1	IDR 1,094,469,620	IDR 1,524,960,000	IDR 2,619,429,620	IDR 21,180,000.00
2	Crash Scenario 2	IDR 1,398,081,973	IDR 1,885,600,000	IDR 3,283,681,973	**IDR 25,100,000.00**
3	Crash Scenario 3	IDR 1,179,789,620	IDR 1,588,774,865	IDR 2,917,699,350	IDR 29,280,000.00
4	Crash Scenario 4	**IDR 1,483,401,973**	**IDR 1,949,414,865**	**IDR 3,432,816,838**	IDR 33,200,000.00

From the calculation results above, it is found that the acceleration scenario 1 is the acceleration scenario with the lowest cost slope. For this reason, the acceleration scenario 1 will be used in the Time Cost – Trade Off analysis.

3.6. Analysis of Time Cost – Trade Off

After determining the scenario to be used, a time cost – trade off analysis is carried out on that scenario in order to obtain the optimum acceleration that can be carried out on the project. The acceleration scenario must not exceed the remaining value of the project contract that can be used to accelerate the amount of Rp. 2,678,291,863 for scenario 1, the percentage of the remaining loss is

Table 6. Normal Fee and Crashin Fee

No.	Crash Scenarios	Crashing Cost (Rp)	Remaining Cost after Crashing (Rp)	Percentage Loss of Residual Costs
1.	Crash scenario 1	IDR 1,524,960,000	IDR 58,862,243	85.50%

Thus, an alternative scenario of acceleration 1 can be used on this road project so that it can be completed on time and has the lowest cost slope. With a residual value that was originally IDR. 2,678,291,863 to IDR. 58,862,243. Or it can be explained in the following graph,

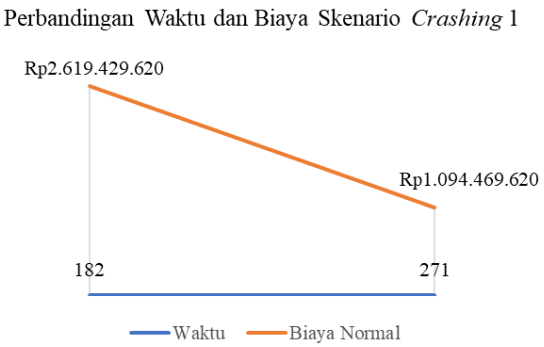

Figure 10. Comparison of Normal Time, Cost, Expedited Time and Cost

4. Conclusion

After processing the data, analyzing the data and discussing the results of this study, conclusions have been obtained to answer the research objectives. The description is as follows

1. After analyzing the remaining work, the duration of the remaining work was 273 days or completed on December 31, 2022. In the initial planning, the project was scheduled for completion on October 3, 2022, so based on this, the project experienced a delay of 89 days.
2. The total minimum fee that must be incurred is IDR 1,524,960.00 with an additional fee of IDR 21,180,000.00 per day
3. Daily productivity for ordinary excavation works, which was originally 303.20 m^3/hour, increased to 909.59 m^3/hour. For daily productivity on ordinary embankment work which was originally 371.92 m^3/hour to 743.84 m^3/hour and productivity on road construction work which was originally 330.91 m^3/hour to 661.81 m^3/hour.

In the case of this road project, the acceleration scenario that is more effective to carry out is the acceleration 1 scenario, namely by increasing productivity in ordinary excavation work. With normal work costs of IDR 1,094,469,620.00 and crashing costs of IDR 1,524,960.00 or an increase in costs of 1.40% of normal costs with remaining costs of IDR 58,862,243.00.

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Single Sign On Using Keycloak Integrated Public Key Infrastructure for User Authentication In Indonesia's Electronic Based Government System

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Abstract. *The government in carrying out its function as a public administration servant is regulated in law of the Republic of Indonesia number 25/2009 on public services. In this regulated about electronic government (e-government), many individuals use various web applications that require users to authenticate themselves to access each application. Many entities require various web- based applications for operational activities. This makes centralized access management for web-based applications very much needed. Currently, access management is often implemented using Single Sign On (SSO) with password authentication method. Security considerations arise against the use of passwords. This is because passwords have a vulnerability to brute forcing using a password list, and human nature often uses repeated or uncomplicated passwords. There is an alternative authentication method,* namely *Mutual TLS which utilizes Public Key Infrastructure (PKI). Users authenticate with X.509 digital certificates, so the authentication factor becomes something you have. This research aims to implement an integrated PKI SSO system and RBAC access automation. The approach of this project is research, design, implementation, and testing. The entire system is built with open-source software and implemented on a cloud infrastructure. The system has three subsystems, namely registration, login and RBAC access automation. All subsystems are tested according to the specified flow. The test results show that the registration subsystem has been successfully carried out as evidenced by the success of filling in personal data, approval flow, and downloading of certificates. The login subsystem was also successfully implemented, as evidenced by the existence of mTLS authentication with certificate validation. In testing the RBAC access automation subsystem, it is shown that the script created can perform access checks and access remediation if needed.*

Keywords: Digital government, E-government, SSO, PKI, RBAC

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1. Introduction

Nowadays Information Technology (IT) has been evolving significantly in many fields not only for which closely related to Information Technology or Information System, but it also penetrated into different fields including government's policies and businesses [1]. Electronic government (e-government) is the administration of government that uses information and communication technology to provide services to e-government users. Through the ministry of communication and information technology, the Indonesian government currently has a roadmap related to the Indonesia Digital Nation 2021-2024, which touches on four strategic sectors: digital infrastructure, digital government, digital economy, and digital society [2].

The first Digital Indonesia Roadmap is accelerating infrastructure to expand public access to the internet. Second, encourage technology adoption. Third, increasing digital talent and finally finalizing supporting regulations to prepare a digital society. In addition, the Ministry of Communications and Information Technology has prepared the construction of data centers that will be placed in four locations to realize One Indonesia Data. With the massive development of digital infrastructure and the provision of government data centers for digital government services, it is hoped that this can be utilized to develop Indonesia's digital economy. The digital roadmap is also expected to encourage further the success of digital transformation in Indonesia, which is more focused and can accelerate the digital transformation process in the government environment so that later it can change how the government provides public services for the community.

Figure 1. Indonesia Digital Nation Roadmap 2021-2024

Specifically for the digital government sector, the government has issued Presidential Regulation No. 95 of 2018 concerning the Electronic-Based Government System (SPBE). The presidential regulation regulates the governance of electronic-based government systems, management of electronic-based government systems, auditing of information and communication technology, administration of electronic-based government systems, acceleration of electronic-based government systems, and monitoring and evaluation of electronic-based government systems. The implementation of SPBE itself departs from the problems that have occurred so far, such as the occurrence of waste of ICT spending due to each ministry building its government applications. With such conditions, there is also the disintegration of government information systems, so the validity of government data is not fully believed.

Figure 2. Presidential Regulation No. 95 of 2018 concerning SPBE

Estonia is one country that has successfully implemented E-Government or an electronic-based government system. In the context of E-Government, Estonia is an example of extraordinary success and attracts international attention, especially in developing countries [3], [4]. The main factor for Estonia's success that influenced and contributed to the evolution of E-Government was its information systems research.

The security vulnerability of electronic systems is currently one of the things that must be a concern, including electronic-based government systems. We must understand that in the security of electronic systems, we are all attractive targets for cybercriminals. Some threats may include data theft, such as usernames, passwords, documents, and emails. Most cyberattacks are common and can happen to anyone, although personalized attacks can happen. One of the primary and common triggers of cyberattacks is human error.

According to [5], every online user leaves a digital imprint of his data and identity on the internet. Some of the activities carried out by online users are often unsafe, and many cyber criminals commit fraud and are always looking for new ways to get hold of someone's data. Identity plays a significant role in our daily activities because identity is a complex subject. Building an identity usually requires several supporting components such as a verification process, what you know (e.g., username, password, or PIN), and what you have (e.g., cellphone number or token generator) to allow individuals to complete the process whether the transaction is rejected or accepted.

With the current advancement in information system applications, access control is one of the crucial aspects within an organization to protect information [3]. One of the most popular methods of authentication is password-based access,which is vulnerable to attacks. A Secure Sockets Layer (SSL) based on Public Key Infrastructure (PKI), now popularly known as Mutual TLS Authentication (mTLS), provides a safer solution as an authentication method [4]. Recently, mTLS is gaining traction again caused by the Ease of Use increasing usage of security-critical activities online such as banking and healthcare, thus escalating the needs for mutual authentication [5].

Role Based Access Control (RBAC) is one of the access control models that is suitable for organizational structure [6]. It enables authorization within an application with the role asa reference of a user's permissions. PKI based RBAC can beachieved by embedding the role information within a user's certificate. Previous studies [4], [7], [8] have explored ways to use PKI for RBAC, mostly by adding an external database forRBAC and integrating it with LDAP. The use of RBAC within an organization is often related to the use of SSO, since it is now the common standard of managing access.

There are also similar platforms that use SSO as a single-sign-on app access feature. One of them is the OKTA platform. OKTA is an identity and access platform that provides authentication, authorization, and identity management services for cloud and internal applications. With OKTA, organizations can manage user identities, control access to applications and data, and provide a secure authentication experience for their users. Okta also uses RBAC as well as PKI and features X.509 certificates. However, OKTA also has some disadvantages compared to using keycloak, including cost, OKTA is a paid platform, costs can increase with the number of users and features used, so it needs to be considered in budget planning. OKTA's learning curve requires a fairly complicated and complex technical understanding and skills, OKTA is a cloud platform, so it relies on a reliable internet connection to be able to use it. Customization is limited. For this reason, researchers conducted validity and usability tests to compare the quality of the platform to be used with other similar platforms.

PKI is the basis of a security infrastructure whose services are implemented using the concept of public key cryptography [9]. PKI is an embedded technology that underlies the provision of security for Secure Sockets Layer (SSL)/ Transport Layer Security (TLS) thereby enabling a user to securely access public networks such as the internet [10]. PKI provides digital certificates that can identify individuals or companies and provides a directory service that can store them and revoke them. Public-key cryptography is based on a key pair from a trusted authority. These key pairs (private key and public key) are stored separately and both keys are required for communication to take place [11].

Single sign-on (SSO) is a mechanism that uses a single authentication action to allow authorized users access to all associated software systems or applications without being asked to log back in on

each system during a specific session. In PKI-based SSO, the server and user authenticate each other by using their respective key pairs. Users can authenticate the server by challenging the server to decrypt the messages they send encrypted by the server's public key. In the same way, servers can authenticate users by challenging them to decrypt messages they send encrypted by the user's public key. Since only the true owner of the private key can decrypt it. User and server certification authorities can differ and if they differ there should be trust between certification authorities [12]. This approach utilizes public key cryptography for user authentication. This system relies on the role of the Certificate Authority (CA) for the issuance and management of digital certificates and users' digital identities [6].

RBAC is based on the given authority of the role the entity has assigned. Each user has a specific role that must be matched with the operating executive. RBAC can perform access control based on user roles in the organization. Access management based on the RBAC concept can be implemented by utilizing PKI. PKI binds access rights to entities provided by authorities through digitally signed data structures. This model can ensure protected system authorization and maximize user management flexibility [8].

This paper proposes an SSO integrated with PKI and RBAC automation system. The authentication method of SSO will be mTLS. This paper heavily focuses on the RBAC automation system that will help administrators to remediate access according to a desired configuration. All of the software components are fully open-sourced, thus making it cheaper and easier for installations and deployments.

2. Methods

2.1. Cloud Infrastructure

The overall cloud infrastructure has 5 GCE instances. Access to the GCP infrastructure using a VPN while in development, this is implemented to mitigate the threat of attacks via public IP which often occurs with automated scanners. The illustration of the cloud infrastructure is shown in Fig. 3.

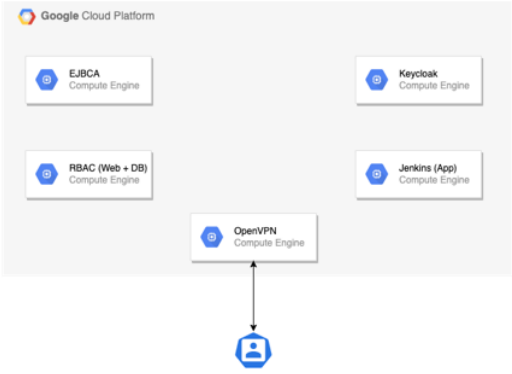

Figure 3. Cloud infrastructure of proposed system

The EJBCA instance is used for managing the PKI configuration and as a host to run the access automation script. Keycloak instance contains the software for the SSO login. The RBAC instance is used for configuring the RBAC and acts as a web application connected to SSO. Jenkins instance is also a web application connected to SSO. Meanwhile the OpenVPN instance is a VPN server to connect external traffics to the network.

2.2. Registration Flow

The registration flow of the proposed system is shown in Figure 4.

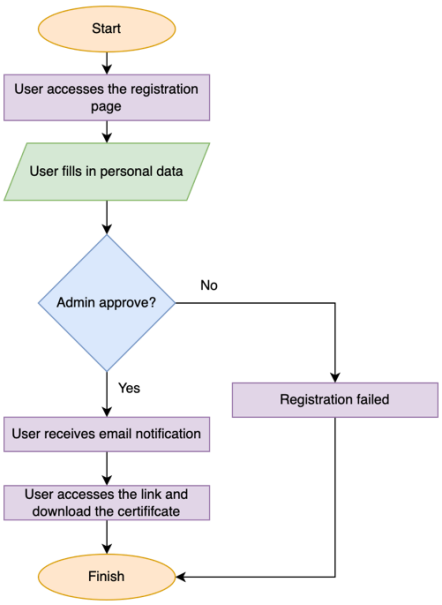

Figure 4. Registration flow

The registration process is held completely in the web. New users can access the registration page and fill in their data. The data will be read by an administrator and then the request can be approved or denied. If the request were denied, the registration process will fail. Meanwhile, if the request were approved, then the user will receive an email notification with a link to get download the certificate. The user can then access the link and provide the credential set when filling data to prove that the user is indeed the one who files the request.

2.3. Login Flow

The login flow of the proposed system is shown in Figure 5 below:

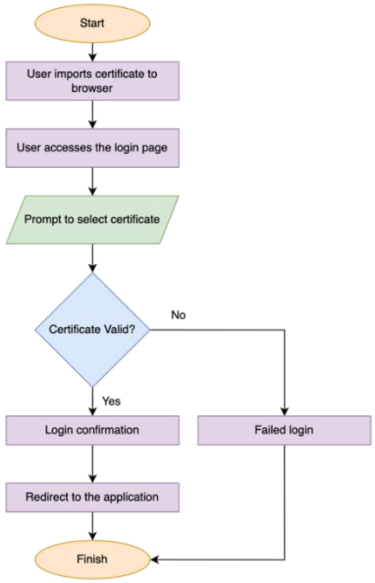

Figure 5. Login flow

The login process can be held after the user has completed the registration process. The downloaded certificate needs to be imported to the preferred browser. A user can then access an application or the SSO page to authenticate. The web prompts a selection of certificate to be used as the identity.

The SSO then checks whether the certificate is valid or not. If the certificate is invalid, then the login process is failed. Meanwhile if the certificate is valid, then the SSO shows a login confirmation and redirects to the application. The validation is done by checking the certificate issuer, user (email), expiry, and Certificate Revocation List.

2.4. RBAC Automation Flow

The RBAC automation flow of the proposed system is illustrated in Figure 6.

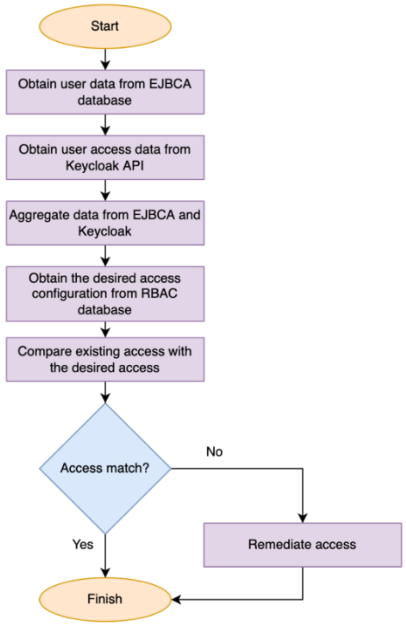

Figure 6. RBAC automation flow

The RBAC automation subsystem works by comparing the existing access and the desired access. Data regarding the current access is obtained by gathering all user information from EJBCA and Keycloak. Meanwhile data regarding the desired access is obtained from the RBAC database. If the automation subsystem finds any difference between the existing and desired access, then the subsystem will remediate the access accordingly.

3. Results and Discussion

3.1. Registration Subsystem

The PKI management system used is EJBCA [13] with the open-source version. EJBCA itself has a built in RA Web that can be used as the registration page. The user certificate that is generated will have the following properties:

- E : Email
- CN : Common Name
- OU : Organization Unit
- O : Organization

The CA structure of the proposed system contains a root CA and an intermediate CA. This is done to match the Keycloak mTLS requirement for CRL checking. There will be two roles that is implemented within EJBCA. One of them is a user role, which is only capable of requesting a user certificate. The other one is a super admin role, which can practically do anything as it is the default admin user. The privileges configured for the user role are as follows:

- /ca_functionality/create_certificate/
- /ra_functionality/view_end_entity/
- /ra_functionality/create_end_entity/
- /ra_functionality/delete_end_entity/
- /ca/[CA Name]/
- /endentityprofilesrules/[ProfileName]/view_end_entity/
- /endentityprofilesrules/[ProfileName]/create_end_entity/
- /endentityprofilesrules/[ProfileName]/delete_end_entity/

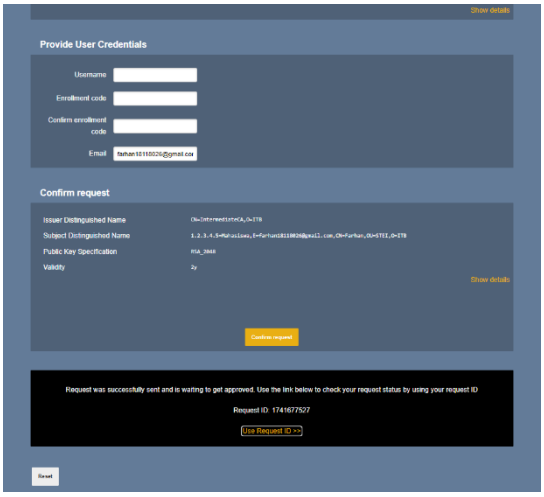

Figure 7. Registration request in EJBCA

The sample registration request in EJBCA is shown in Figure 7. The user can provide details about their identity and createa credential that acts as a passphrase of its private key and a password for downloading the certificate. After the request issent, it will have to be approved by the administrator.

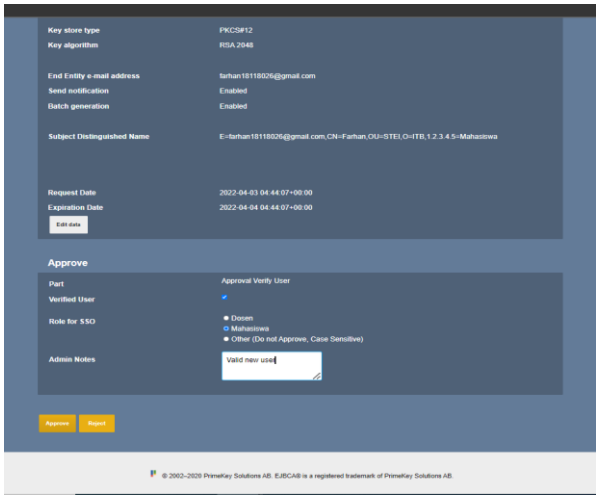

Figure 8. Registration approval in EJBCA

The registration approval page is shown in Figure 8. An administrator can review the details of the user's request. The page has a form for administrator to fill as a note. The form is highly customizable so that it can conform to any use cases.

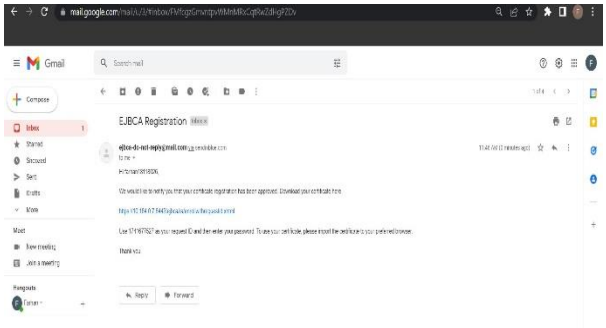

Figure 9. Email notification

If a request is approved by the administrator, the user will receive a notification email as shown in Figure 9. The email contains a link and a request ID to obtain the certificate.

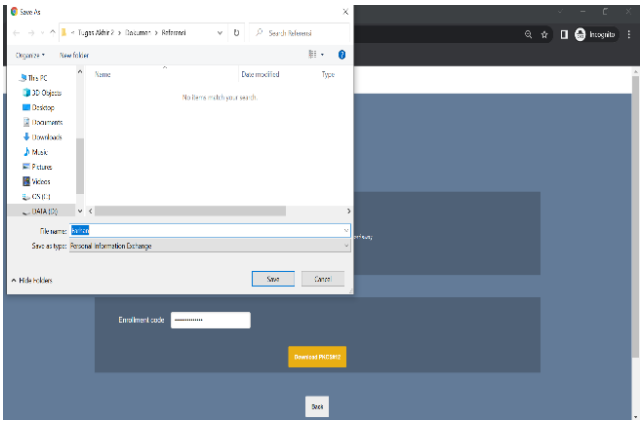

Figure 10. User certificate download

Downloading the certificate is shown in Figure 10. The user can access the link and enter the request ID to check whether the certificate is ready to be downloaded. To download the file, the user must enter the credential that was made during the making of registration request.

3.2. Login Subsystem

The proposed system uses Keycloak [14] as its SSO software, as it is an open-source software. To make it easy to install, keycloak is installed via docker. The container is defined by a dockerfile shown below.

```
1.  services:
2.    keycloak:
3.    image: quay.io/keycloak/keycloak:14.0.0
4.    command: -c standalone.xml
5.    environment:
6.      DB_VENDOR: h2
7.      KEYCLOAK_USER: admin
8.      KEYCLOAK_PASSWORD: admin
9.      X509_CA_BUNDLE:
    /etc/x509/https/rootCA.crt
10.   ports:
11.     - 8080:8080
12.     - 8443:8443
13.   volumes:
14.     -
    ./x509/localhost.crt:/etc/x509/https/tls.crt
15.     -
    ./x509/localhost.key:/etc/x509/https/tls.key
16.     -
    ./x509/rootCA.crt:/etc/x509/https/rootCA.crt
```

Before creating the container, Keycloak is registered a certificate for HTTPS and mTLS purposes. The issuer CA and Keycloak server certificates is imported to the container. The issuer CA certificate is used as a reference to validate mTLS authentication.

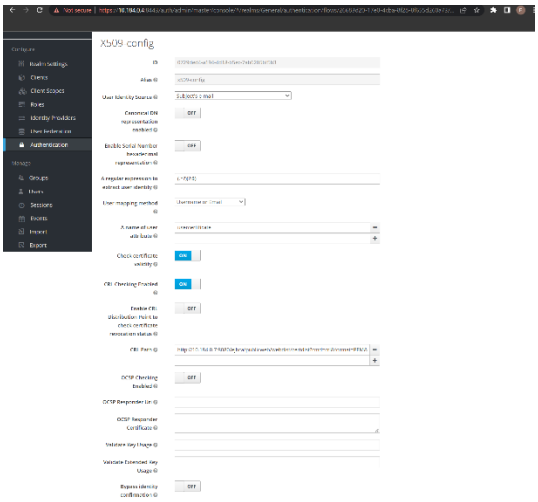

Figure 11. Keycloak mTLS configuration

The configuration of mTLS is presented in Figure 11. Keycloak maps a user by the email field provided in the certificate. Certificate validity checking is enabled to deny any expired certificates. The system checks for revocation status by accessing the issuer's CRL by URL.

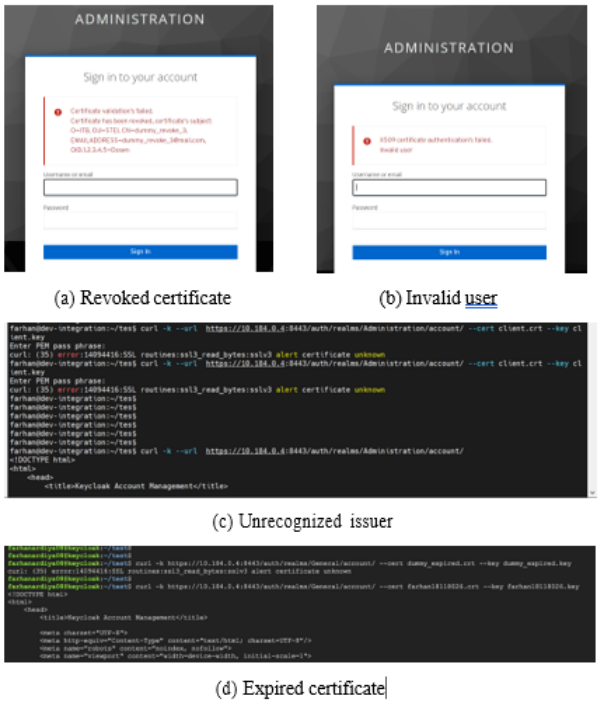

Figure 12. Invalid certificate errors

Figure 12 displays errors when trying to login using invalid certificates. The SSO can recognize whether a certificate is invalid because it has been revoked, thus giving a specific error. If the user is not in the SSO realm, but everything elsechecks out, the SSO gives an invalid user error. Meanwhile if the certificate is not issued by the trusted CA or it has expired, the errors will be similar (SSL errors).

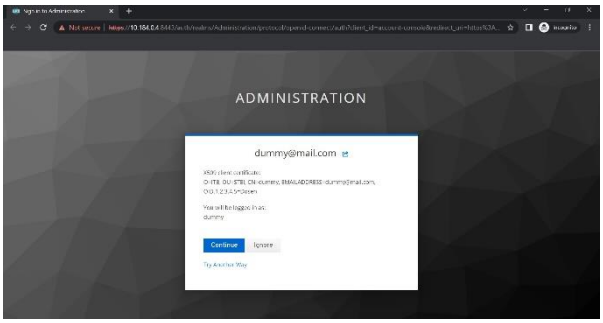

Figure 13. Valid certificate response

Figure 13 displays the response when logging in with a valid certificate. The page confirms that the user wants to continue as the presented username. It also shows the certificate information. When clicked continue, the user will be authenticated within the SSO realm.

3.3. RBAC Automation Subsystem

The RBAC automation uses a database as a reference of how the access should be provided. Then, a script can be run to check whether there is a remediation needed and take action accordingly. The script is capable of creating, deleting, and assigning groups for user access.

RBAC works by restricting access levels based on each user's role. Access levels, of course, govern what users can and cannot do. Admin is usually the highest access level. Admin users

have full control over the network or service at hand. But you can create other access levels with fewer privileges. The principle behind RBAC is that users should have access levels based on their roles.

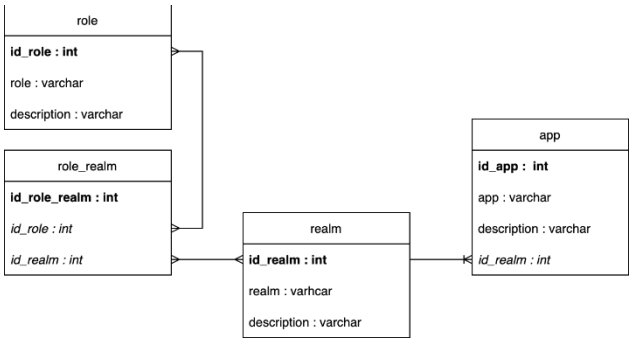

Figure 14. RBAC database entity relationship diagram

Figure 14 is an entity relationship diagram of the database used for RBAC management. There are four tables used, which are role, realm, app, and role_realm. The role table contains information about all of the roles in a system. The realm table contains information about all of the realms used in a system. The role_realm table is a junction table that stores the access mapping of each role. The app table is used to store information about apps and which realm it sits within the SSO.

The RBAC automation subsystem is a python script that will compare and remediate access. It is configured to be runperiodically so that the SSO is in sync with the desiredconfiguration. The subsystem consists of a main script, a toolscript, a configuration script, and a configuration file. The main script is the one that will be run, it executes the main functions defined in the tool script. Meanwhile, the configuration script reads the configuration file so that other files can call configuration variables easily.

```
1.  #__main__.py
2.  from tools import *
3.
4.  def main():
5.    ejbcaUsers = getUserEJBCA()
6.    keycloakUsers = getUserKeycloak()
7.
8.    currentAccess =
    getCurrentAccess(ejbcaUsers, keycloakUsers)
9.
10.   accessRole = getDBAdminMapping()
11.
12.   checkGroups()
13.
14.   add_access, delete_access =
    compareAccess(currentAccess, accessRole)
15.
16.   createUser(add_access)
17.   deleteUser(delete_access)
18.
19. if__name   == '__main__':
20.   main()
21.
```

The main script works by gathering data from EJBCA database and Keycloak API, then comparing it with the data in the RBAC database. Before comparing access, the script checks for groups within all of the realms and remediate access by adding or removing groups within realms. The compare Access function returns two outputs, which is list of access that needs to be added and a list of access that needs to be deleted. The actuator of access remediation is creating User and delete User function.

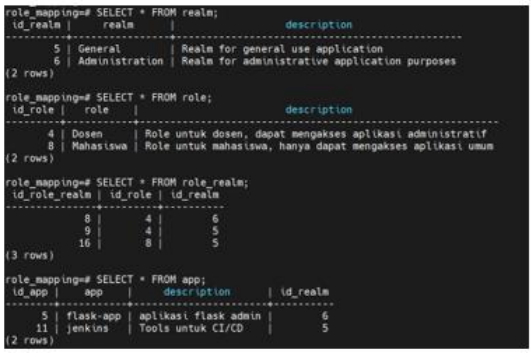

Figure 15. RBAC database configuration

Figure 15 illustrates the desired configuration for RBAC. The database will act as a reference for the automation script. Thescript will try to remediate access to reach the desired state configured.

Table 1. Access Before Remediation

Realm	Group	User
Administration	Alumni	-
	Dosen	**dummy_revoke_3**
		farhan18118026
		test_rbac_2
General	Dosen	**dummy_revoke_3**
		test_rbac_2
	Mahasiswa	**18118002**
		dummy_expired
		farisansafrialnafis
		test_rbac

Table 1 describes the state of access before the script is executed. As can be seen that there is a group that does not exist within the configuration. The script will be expected to remediate that group.

Table 2. Desired Access Configuration

User	Role	Desired Realm Access
18118002	Mahasiswa	**General**
dummy	Dosen	**General and Administration**
dummy_expired	Mahasiswa	**General**
dummy_revoke_3	Dosen	**General and Administration**
farhan18118026	Mahasiswa	**General**
farisansafrialnafis	Mahasiswa	**General**
test_rbac	Mahasiswa	**General**

test_rbac_2	Dosen	**General and Administration**
18118002	Mahasiswa	**General**
dummy	**Dosen**	**General and Administration**

Table 2 describes the access that is supposed to be implemented. There are two users that require access remediation which is farhan18118026 and dummy. The userfarhan18118026 is placed at the wrong realm and the user dummy has not been added to both realms.

Table 3. Access After Remediation

Realm	Group	User
Administration	Mahasiswa	-
	Dosen	dummy_revoke_3
		dummy
		test_rbac_2
General	Dosen	dummy_revoke_3
		test_rbac_2
		dummy
	Mahasiswa	18118002
		dummy_expired
		farisansafrialnafis
		test_rbac
		farhan18118026

Table 3 describes the state of access after the script is executed. The access configuration is the same as the desired access configuration described in Table II. There are three main remediations, which are the group change from Alumni to Mahasiswa, the user farhan18118026 is moved from Administration realm to General realm, and the user dummy is added to both realms.

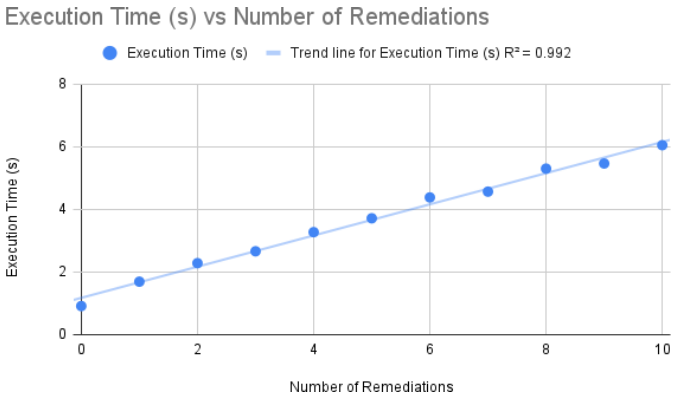

Figure 16. Automation execution time

Figure 16 illustrates the execution time needed against the number of remediations. The value of R square disapproaching 1, thus the linear trend line is a valid fit. The average increment of execution time is 0.5136 seconds. The increment of each data point is similar, since the script makesan API call to

Keycloak for each remediation action taken. With the performance of the script mentioned, it is wise for the script to be executed with a schedule that fits the behavior of access granting within an entity. The more frequent the access change, then the script needs to be performed more frequently.

Based on the research that has been conducted by Chatterjee et al (2022) showed that the SSK implementation and configuration in the eCoach prototype system has effectively secured its microservice APIs from an attack in all the considered scenarios with 100% accuracy [15].

4. Conclusion

The PKI integrated SSO with RBAC automation system has been successfully implemented using EJBCA as PKI management, Keycloak as SSO software, and python as the script for RBAC automation. Main functionalities of the system include certificate registration, web based SSO login, and access granting automation. Registration subsystem is implemented using the RA Web functionality of EJBCA. Meanwhile the SSO login uses mTLS authentication method which validates user's digital certificate. The RBAC automation works by comparing the desired state stored in a database with the current state by querying information through EJBCA database and Keycloak API.

The benefits to using RBAC are the first, improved operational efficiency, with RBAC, companies can decrease the need for paperwork and password changes when they hire new employees or switch the roles of existing employees. Second, Enhanced compliance, companies generally prefer to implement RBAC systems to meet the regulatory and statutory requirements for confidentiality and privacy, as executives and IT departments can more effectively manage how the data is accessed and used. Third, increased visibility, RBAC gives network administrators and managers more visibility and oversight into the business. Fourth, reduced costs and the fifth, decreased risk of breaches and data leakage.

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INCREASING MATERNAL KNOWLEDGE IN PREVENTING STUNTING THROUGH COMMUNITY-BASED NUTRITION EDUCATION

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Abstract. Stunting is a disorder of growth and development of children due to chronic malnutrition and recurrent infections, which is characterized by their length or height being below the r mark set by the minister who organizes government affairs in the health sector. The respondents in this activity were mothers and toddlers in RW 02, RT 01, 02, and 03. The sample in this activity was 42 toddlers. The purpose of this activity is to increase mothers' knowledge about feeding, especially fruits and vegetables with balanced nutritional content for toddlers. The method used is the Wilcoxon Test with a confidence level of 95% and $\alpha = 0.05$. The results and discussion using the Wilcoxon test showed an increase in maternal knowledge related to stunting. There are 5 toddlers affected by stunting. There are efforts to change behavior for the better and increase maternal knowledge in stunting prevention, namely by socialization about the importance of preventing stunting, nutritious food demos, posters of processed fruit and vegetable creations, and distribution of PMT (Supplementary Feeding). After community-based nutrition education, there can be an increase in maternal knowledge in stunting prevention.

Keywords: stunting, maternal knowledge, toddler nutrition.

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1. INTRODUCTION

According to Presidential Regulation of the Republic of Indonesia Number 72 of 2021, stunting is a disorder of growth and development of children due to chronic malnutrition and recurrent infections, which is characterized by their length or height below the standards set by the minister who organizes government affairs in the health sector. Meanwhile, based on the Ministry of Health, stunting is children under five with a z-score of less than -2.00 SD / standard deviation (stunted) and less than -3.00 SD (severely stunted). Stunting is associated with birth weight, diarrhea, maternal knowledge and education level, family income, and sanitation (Herlina *et al.*, 2021).

Risk factors for stunting children are nutritional status and birth weight <2,500 grams, maternal education factors, low household income factors, poor sanitation factors.(Sutio, 2017). In addition, stunting risk factors tend to be more men than women, healthy and clean living habits that can affect the incidence of diarrhea as well.(Anwar, Winarti and Sunardi, 2022). Risk factors that can occur in

rob areas, caused by protein intake, iron intake, incidence of diaera, ISP, history of exclusive breastfeeding, sanitary hygiene and economic status.(Yuniarti, Margawati and Nuryanto, 2019).

Kelurahan Bandarharjo is a kelurahan located in JL. South Bandarharjo No.17, Bandarharjo, North Semarang, Semarang City, Central Java 50175. Which consists of 12 RW and 103 RT. Based on stunting data from the Semarang city government in 2023, there are 61 stunting cases. With 33 male children, and 28 female children. Integration activities were carried out in RW 02 RT 01, 02, and 03. The number of toddlers is 42, Rt 01 is 17 toddlers, Rt 02 is 15 toddlers, and Rt 03 is 10 toddlers. There is a problem of stunting cases as many as 9 toddlers, the most cases are in Rt 01 with 4 toddlers, Rt 2 with 2 toddlers, and Rt 3 with 3 toddlers.

Increasing maternal knowledge about child nutrition can be done through nutrition education. Nutrition education activity is an activity for nutrition-related information with the aim of increasing knowledge and changing behavior for the better (Muzarofatus, 2021). Knowledge about the health and nutrition of mothers will greatly affect the nutritional status of children under five (Sahanggamu, Purnomosari and Dillon, 2017) Good maternal nutrition behavior can have a positive impact on toddler nutrition. The ability of mothers to provide the right food ingredients and menus supported by their knowledge about nutrition can prevent nutritional problems in toddlers (Dwi Pratiwi, Masrul and Yerizel, 2016).

One of the efforts to prevent and overcome stunting is to implement balanced nutrition. Balanced nutrition is the fulfillment of food needs that are consumed daily and contain nutrients with the type and amount needed by the body (Fajriani, Aritonang and Nasution, 2020) UNICEF framework explains the factors that cause malnutrition. Two direct causes of stunting are disease factors and nutrient intake. Both of these factors are related to parenting factors, access to food, access to health services and environmental sanitation.

The impact that can be caused by stunting in the short term disrupts brain development, intelligence, impaired physical growth, and metabolic disorders in the body. The adverse effects in the long term are decreased cognitive ability and learning achievement, decreased immunity so that it is easy to get sick, and a high risk for the emergence of diabetes, obesity, heart and blood vessel disease, cancer, stroke, and disability in old age, as well as uncompetitive work quality which results in low economic productivity (Mother, 2012). Several studies show the risks caused by stunting are decreased academic achievement, increased risk of obesity, more susceptible to non-communicable diseases and increased risk of degenerative diseases according to United Children's Fund Indonesia (Mother, 2012). The purpose of this study is to find out whether there is an increase in maternal knowledge through nutrition education.

2. METHODS

The type of research carried out isQuasi-Experimental research with the design of the research carried out, namely One Group Pre-Post Test Design, which means that this test is carried out before and after the intervention of knowledge extension of mothers to prevent stunting. This activity began with filling out the pre-test and then continued with community-based nutrition education counseling intervention activities, cooking demos, discussions and questions and answers, at the end of filling out the post test. The duration of this intervention is carried out for 4 hours. The media used are posters, questionnaires about knowledge to prevent stunting, and the Si Gembul application. The population of this study was all children under five in Bandaharjo RW 2 sub-district. Samples were taken as many as 42 toddlers. Pprocesses this sampling with confirmation to RT 01,02, 03 to show parents who have toddlers. The technical data analysis used is using the *Wilcoxon* Test with a confidence level of 95% and $\alpha = 0.05$. The Wilcoxon test is performed as an alternative dependent paired t-test because the pre-test and post-test data are not normally distributed. (Alfedo *et al.*, 2023). This data analysis was performed using SPSS software version 26.

3. RESULTS AND DISCUSSION

1. Characteristics of Mother and Toddler Respondents

The maternal characteristics of the study subjects included the mother's age, and the mother's height. For toddler characteristics of the study subjects include the sex of toddlers, the age of toddlers (months), and the length of birth of toddlers.

Table 1. Characteristics of Mother and Toddler Respondents

Characteristics of Maternal Respondents	**F**	**%**
Mother's Age		
23 – 33	11	44
34 – 37	9	36
38 – 52	5	20
Mother's height		
130 – 150	7	28
155 – 159	13	52
160 – 168	5	20
Characteristics of Toddler Respondents	**F**	**%**
Gender of Toddler		
Male	10	40
Woman	15	60
Toddler Age (Months)		
10 – 30 months	9	36
31 – 43 months	7	28
43 – 56 months	9	36
Toddler Birth Length		
42 – 47	9	36
48 – 51	15	60

Based on Table 1. The age characteristics of IBU are grouped into 3, namely 22-33 years as many as 11 people, 34-37 years as many as 9 people and 38-52 as many as 5 people. Based on the characteristics of the mother's height, the average height of the mother is 155 cm as many as 10 people. While the mother's height is more than 130 cm as many as 24 people. Mothers with a height below 150 cm are at risk of having stunted children.

Based on the sex characteristics of respondents, it was found that the survey results of respondents were more women, which was as much as 60% compared to men as much as 40%. Based on the age characteristics of toddlers, they are divided into 3 categories, namely the age of 10-30 months as many as 9 toddlers (36%), the age of 31-42 months as many as 7 toddlers (28%) and the age of 43-56 months as many as 9 toddlers (36%). Based on the characteristics of the birth length of toddlers, the average toddler has a length of 49 cm as many as 7 people.

2. Overview of nutritional status conditions according to Z Score PB/U

The condition of nutritional status according to Z Score according to PB/U in 25 toddlers in RW 02 RT 01, 02, 03 in Bandarharjo Village. The Z Score is managed from the "The Gembul" application.

Table 2. Overview of nutritional status conditions according to Z Score PB/U

Nutritional Status According to Z Score	f	%
Normal -2SD+3SD	19	76
Short -3SD	3	12
Very Short <-3SD	2	8
Tall >+3SD	1	4

Based on the results of the description of stunting conditions according to PB / U with 25 toddlers, it can be known the nutritional status of toddlers who are stunted as many as 5 toddlers, 19 toddlers who have normal nutritional status, and 1 toddler has high nutritional status. The average Z Score for toddlers is -0.86, with a minimum value of -3.68 and a maximum of 5.27, so the category of z score is good (>= -0.86).

3. Normality Test Results and Wilcoxon Test

Table 3. Data Normality Test Results & Wilcoxon Test

Normality Test Results	**P - *value***
Mother's Knowledge in Preventing Stunting	
Pre Test	0.000
Post Test	0.004
Test Results- *Wilcoxon*	**Asymp. Sig.(2 – Tailed)**
Post Test – Pre Test	0.000

Based on the results of the normality test, the data above was foundthat maternal knowledge in preventing stunting before and after the intervention was not normally distributed (p – *value* < 0.005).

The following is data processing using nonparametrics because the results of the normality test are not normally distributed. So it uses the *Wilcoxon* test to find out if there is a difference after counseling. Based on the results of *the Wilcoxon* test, it produces with α (0.05) obtained a value of p = 0.000. Because the value of 0.000 < 0.05 so that there is a difference between knowledge to prevent stunting for pre-test and post-test scores. There are differences in knowledge before and after counselingso that the community pays attention to the material that has been delivered.

These results are in line with James Kevin's research which states that the Wilcoxon test results of pre-test and post-test data are < 0.05 =, these results show that there is a difference between pretest results before counseling and post-test results after counseling experienced effective results (Alfedo *et al.*, 2023). This result is also in line with Ravi Masitah's research which states that nutrition education in mothers can have a positive impact on increasing maternal knowledge related to stunting with the results of data analysis (p-value < 0.005) (Masitah, 2022).

This is also supported by Ansori's statement, namely research that can be concluded that nutrition counseling has an effect on changing knowledge about stunting in Kelampaian Village, Pontang District, Serang Regency. (Village, District and Regency, 2022).

4. Community-Based Education Methods

The following methods of community-based education that can be done, namely:

- Data collection using interview techniques using Google Form.
- Application "Si Gembul" as a medium to calculate the nutritional status of toddlers.
- Intervention activities were carried out by socializing stunting prevention using book guidelines from BKKBN with the themes "Skata Demi Keluarga Understand Important Steps to Prevent Stunting" and "Cook Delicious According to My Plate".
- Division of Pre Test and Post Test as a medium to measure maternal knowledge.
- Nutritious food demo as a medium to increase mothers' creativity in food processing for toddlers.
- The distribution of posters with the theme "Various Healthy Preparations to Prevent Stunting" as a medium to add ideas for processed food creations.
- The distribution of PMT (Supplementary Feeding) aims to improve nutritional status and meet the nutritional needs of toddlers.

4. CONCLUSION

Stunting cases in RW 02 RT 01, 02, and 03 in Bandarharjo there are 5 toddlers. The occurrence of stunting cases can be triggered by risk factors that can affect stunted toddler growth and development. In an effort to handle stunting cases in RW 02, RT 01, 02, and 03 in Bandarharjo, counseling activities were carried out on the importance of preventing stunting attended by mothers and toddlers, conducting nutritious food demonstrations, distributing posters of processed fruit creations to toddlers, and distributing PMT (Supplementary Feeding). Based on the results of the Pre Test and Post Test using *the Wilcoxon* Test to find out if there is a difference after counseling and show an increase in maternal knowledge about stunting.

5. THANK YOU SPEECH

The students expressed their gratitude for the cooperation and support during the implementation of Integration activities to Bandarharjo Village, North Semarang District, which has allowed and helped all activities carried out by students so that they can run smoothly, All RW 02 communities who have actively participated in the implementation of integration activities, Posyandu Minasari 1 which has helped increase public awareness, especially in terms of maintaining maternal and child health, as well as BKKBN of Central Java Province which has supported Integration, Monitoring, Evaluation activities in the field of population control and family planning.

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Design of Android and IoS Applications for Mobile Health Monitoring Devices

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Abstract. This research proposes a multifunctional wireless health monitoring tool with a display for Android and iOS devices. This research aims to develop a realistic solution for real-time and conveniently accessible health monitoring via mobile devices. The device allows users to test and track health factors such as heart rate, blood pressure, blood oxygen levels, body temperature, and blood glucose. It collects data properly by using wireless technology and sensors. The data is subsequently supplied to the appropriate apps on Android and iOS devices. The data is presented visually in the program, making it instructive and user-friendly. The device's development technique involved extensive testing and validation against established comparators to assure accuracy. The results of this study show that this digital, multi-purpose health monitoring device works well and reliably to give real-time health information. This innovation promotes health monitoring and digital health information access.

Keywords: Android, Application Health, iOS, ISO/EIC 9126 , WBAN

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1. Introduction

In this era of technological advancement, health, and wellness is a significant concern for many people. At the same time, the popularity of smartphones and mobile devices is on the rise. These devices have

become an integral part of people's daily lives. Medical software is an essential part of modern, integrated healthcare. Physicians, patients, and healthcare organizations increasingly use it to influence treatment decisions [1]. Therefore, wireless technology integration into the healthcare industry is an excellent opportunity. This technology is a practical and efficient solution for users to monitor their health conditions. In this study, an application is designed that can record and monitor patient data efficiently and accurately. The design of this application uses the principle of IOT (Internet Of Things), which is a principle that aims to expand the benefits of Internet connectivity that is continuously connected [2]. The power of IOT (Internet of Things) is now widely used and has made tremendous contributions to healthcare [3].

WBAN (Wireless Body Area Network) technology obtains the patient's body health data. Wireless Body Area Network (WBAN) provides continuous patient health monitoring without interfering with normal daily activities [4]. The technology is a multi-functional wireless health monitoring device consisting of multiple sensors. The patient's body health data include body temperature, heart rate, blood pressure, oxygen level, and blood sugar. This application design will display various functions of the patient's body health data, such as real-time data display, diagnosis results, diagnosis results graph, health status, clinical data display, and history display.This application is available on Android or iOS-based user smartphones. Smartphones are cell phones based on an operating system with computing capabilities and more advanced connections than telephones. Android and Ios are the most common or dominating operating systems today [5]. Android is a Linux-based operating system. It is based on open-source principles [6]. The iOS operating system is based on UNIX, now widely recognized as an operating system that makes it easy for users to develop applications [5].

Previous research on wireless health monitoring tools has used four parameters : heart rate, body temperature, blood oxygen, and blood pressure. This research adds one more parameter, which is blood glucose level. With the parameter of blood glucose level, patients are expected to know more about their health and can live a healthier life. Thus, the current monitoring tool has five parameters: body temperature, heart rate, blood oxygen, blood pressure, and blood glucose. The application display has been designed to be more efficient and easy to understand by users. It displays several functions such as user login, user register, user profile, health status, results from each sensor graph, real-time data, and user history display. Therefore, this research designs an Android and iOS-based mobile application to get a user-friendly display. The application can make it easier for users to receive data on body health conditions and accurately record patient data.

2. Methods

The design of a multifunctional wireless health monitoring device depicts a brief system block diagram. This aims to find out the general form of the system to be designed to facilitate the hardware design process.

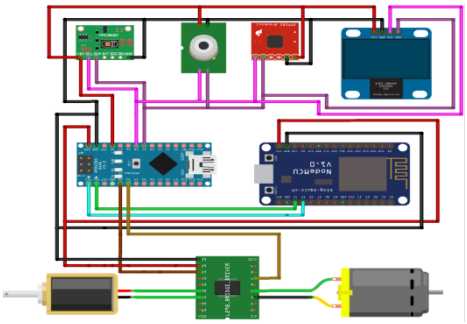


Figure 1. Hardware Schematic Diagram

Figure 1 is the overall circuit design scheme that has been designed. They are using the components of the hardware. The part consists of several sensors, such as the MAX 3105 sensor for blood and blood sugar oxygen levels. MLX 90615 sensor as a body temperature sensor. AP3 models a blood pressure sensor as a blood pressure and heart rate sensor. a Mini DC motor as an air pressure

pump. The Selenoid is a place that regulates the entry and exit of force. As well as essential components such as ESP8266 mini as a wifi module, OLED as a display, and Arduino nano as a program controller.

Figure 2 is a block diagram, a step-by-step wireless health monitoring application that will be designed. They start with the input of clinical data by the patient and begin the sensor detection on the device. After that, the patient's health data is sent to the server to be processed to produce a healthy or unhealthy health status. Android and iOS applications are designed using Flutter software. Flutter is an open-source framework or SDK developed by Google. Flutter helps build interface applications that have high performance and can be published on the Android and iOS platforms. Flutter uses the Dart programming language, developed by Google for general needs (general-purpose programming language). Android and iOS applications use Firebase, a database stored in the Cloud in real-time and supports multi-platforms such as Android and iOS [7].

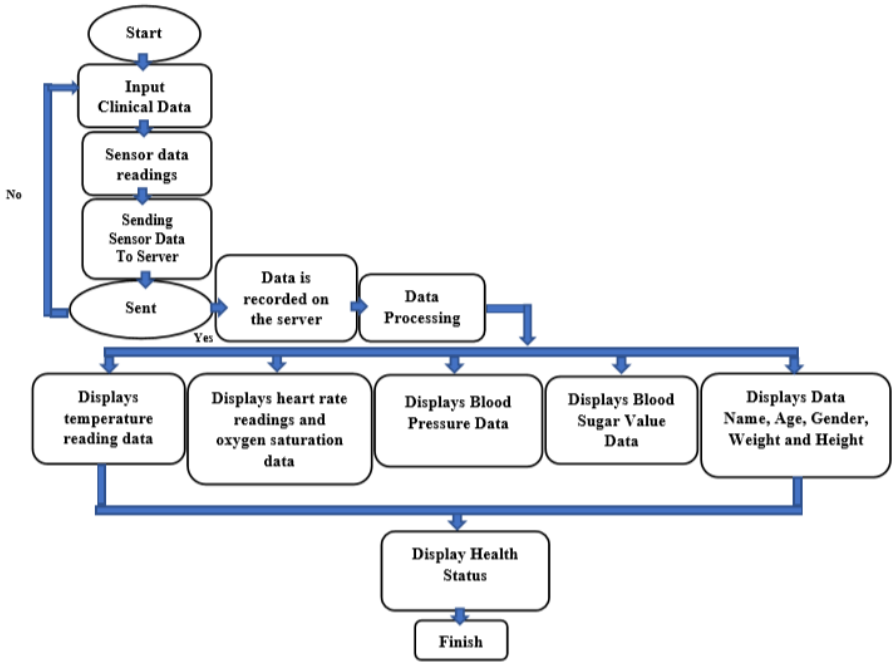
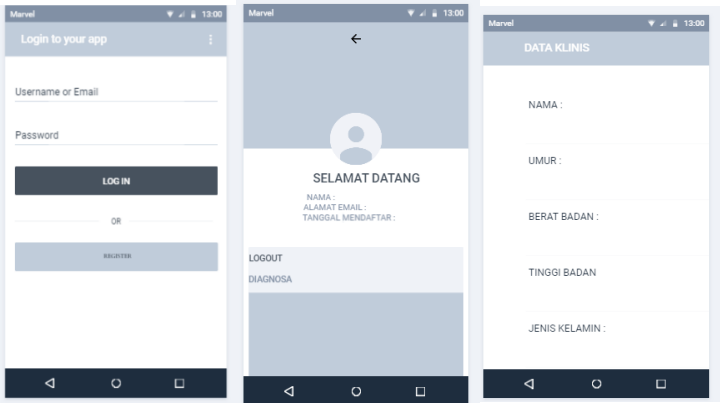
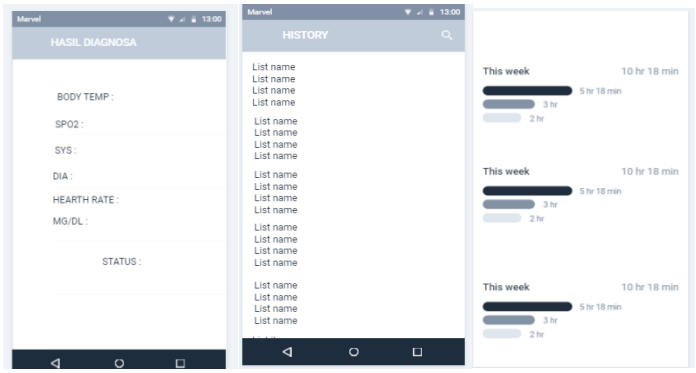


Figure 2. Flowchart System Software



(a) (b) (c)



(d) (e) (f)

Figure 3. Application Display Design (a) User Login (b) User Profile (c) Clinical Data Input (d) Diagnostic Results (e) User History (f) Graph

Figure 3 is a plan for designing an app to be used as a guide for making apps. Figure 3(a) shows how the Login view looks on Android and iOS apps. Users and admins can put their email address and password in the picture. Figure 3(b) shows that a user and user biography will appear when the Login button is clicked. Figure 3(c) shows a menu for entering clinical data that the user or manager will fill out. Figure 3(d) shows the results of tests or measurements for each element. Figure 3(e) shows the page for the past detection history, and Figure 3(f) shows the page for the graph. This page will show a line graph of the data from each sensor's parameters.

Software testing plays a vital role in the development process because it adopts reliability and ensures the quality of the developed product/project. The main features of software testing are verification and validation. In this stage, the mobile application that has been created will be tested in detail and thoroughly. In this study, application testing uses a world-recognized standard, namely ISO / IEC 9126. ISO/EIC 9126 is one of the international standard frameworks used to test software quality. ISO 9126 was created by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (EIC). This international standard can define the quality of software products [8]. The ISO/EIC features combine several existing quality standards. These standards were developed to identify various aspects of an application to determine compliance with software quality rules. With these measurements, the resulting application can be considered a quality application [9]. This test includes functional testing, suitability testing, and efficiency testing.

This study selectively selected respondents who met certain criteria. Inclusion criteria included ages between 18 and 50 years. A total of 150 respondents participated in this study. This number was selected based on statistical considerations to produce significant and relevant results. The selected respondents represented a wide range of ethnic and geographic backgrounds. The average age of the respondents was 20 years old, and there was an equal number of males and females. All respondents had a high level of smartphone experience. This study focuses on using an application that stores and records patient data. The application is expected to be useful in monitoring the health status of the patient's body. Respondents were given a thorough explanation of the purpose of the study, and the researcher adhered to all ethical standards.

3. Results and Discussion

Results of Multifunctional Wireless Health Monitoring Device

The hardware design of the multifunctional wireless medical device is applied to a red protective box. The system hardware has been successfully made based on the sketch design of the device. Figure 4 shows the hardware of the multifunctional wireless health monitoring device. The sensors are placed inside the protective box with the aim that they can be protected, and the sensors work properly.

Figure 4. Multifunctional Wireless Health Monitoring Device

In Figure 4 above, there are sensors used in this multifunctional wireless medical device. These sensors include the MAX 3105 blood oxygen and blood sugar sensor. MLX 90615 sensor as a body temperature sensor. AP3 models blood pressure sensors as blood pressure and heart rate sensors. Essential components such as mini DC motors and air pressure pumpers. The Selenoid is a place that regulates the entry and exit of pressure. As well as the use of ESP8266 mini as a wifi module, OLED as a display, and Arduino nano as a program controller.

After the sensor nodes send the body health detection readings to the central server, the reading data will be processed and displayed on the user's smartphone. Smartphones that have Android and iOS operating systems. The goal is to be accessed efficiently and quickly to get information on the patient's body health.

Multifunction Wireless Health Monitoring App

The software has been successfully created based on the design of the display sketches that have been designed. The software obtained is a multifunctional wireless health monitoring application. Applications that have been integrated with smartphones are made using Flutter SDK software. Android and iOS-based applications to record the health of the patient's body using this sensor are named "I-Health."

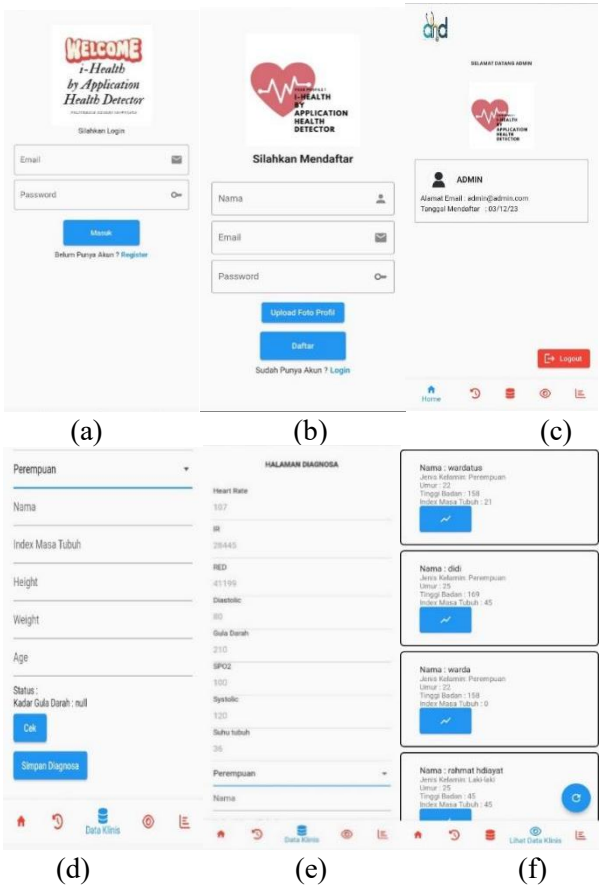


Figure 5. Display result of multifunctional wireless health monitoring application (a) Login (b) register (c) User profile (d) clinical data (e) diagnosis results (f) user history

The user login page consists of filling in the email and password. If the user does not have an account, they are required to register. Figure 5(b) shows the register page, which consists of filling in the desired name, email, and password; the user can return to the login page after registering. Figure 5(c) is the user's profile page, and the button to select another menu is displayed in real-time. Figure 5(d) is the clinical data input page filled in by the user, which consists of gender, name, BMI, weight, height, and age. Meanwhile, Figure 5(e) shows the diagnosis results, which contain data the sensor detects on the device and the user's health status, which will appear when the "check" button is clicked. Furthermore, the data sent to the application displays real-time data. The next page shows the user's previous measurement history, as shown in Figure 5(f).

Application Testing Using ISO/EIC 9126

Respondents in the implementation of this system test our users. The characteristics of respondents are categorized based on the type of user, age, and smartphone operating system of the user. Respondent characteristics based on user

Table 1. Total Respondent

Number of Respondent	150 Respondent
Operation System	Android : 80
	iOS : 70
Age	<20
	>20

Next is to analyze the data for calculation. The analysis uses the percentage value (%) of the success of the i-health application and the percentage value (%) of errors in the i-health application. These formulas are in the following equation.

Percentage of success of i-health app testing

$$= \frac{Skor\ Aktual}{Skor\ Ideal} \text{ X } 100\% \quad (1)$$

Percentage of i-health app testing errors

$$= \frac{Skor\ ideal - Skor\ Aktual}{Skor\ Ideal} \text{ X } 100\% \quad (2)$$

Description:

a. Actual score is the answer of all respondents
b. The ideal score is the highest score or value, or all respondents are assumed to choose the answer with the highest score.

Furthermore, these results are processed and calculated with the criteria set out in the study design.

Table 2. Percentage of success

% Total score	Criteria
20% - 36%	Not good
37% - 52%	Less good
53% - 68%	Enough
69% - 83%	Good
84% - 100%	Excellent

a. Characteristics of Funcitonality

The ability of the Software to provide the functionality required by the user, when

used under certain conditions.
Functionality Characteristic Testing Results:

Table 3.Functionality Testing Results

No	Indicator	Skor Aktual	Skor Ideal
1	Suitability	9814	2250
2	Accuracy	8995	2250
3	Security	8311	2250
	Jumlah	27120	33750

For Success percentage :
Skor Aktual :27120
Skor Ideal : 33750

$$= \frac{27120}{33750} \text{ X } 100\%$$
$$= 80{,}355\ \%$$

For Error Value (error) using the formula :

$$= \frac{33750-27120}{33750} \text{ X } 100\ \%$$
$$= 19{,}65\ \%$$

Analyze the quality of functionality characteristics obtained a total value of 80.355%. Comparing the results of the respondents with the Likert scale, the value of 80.355% is included in the Good classification. This means that the I-Health application can be used in providing appropriate function facilities and displaying the results needed and can prevent unwanted access, such as avoiding data manipulation from other parties, After calculating the functionality for the percentage of errors in the I-Health application, it gets a value of 19.65%, which has a low error rate and good accuracy seeing the success rate at 80.335%. Avoiding errors when running the application is expected to affect the percentage of error values.

Figure 6. Functionality percentage chart

b. Usability Characteristics
The ability of the Software to understand, learn, use, and appeal to users when used under certain conditions.

Table 4. Usability Testing Results

No	Indicator	Skor Aktual	Skor Ideal
1	Understandibility	619	750

2	Learnability	600	750
3	Operability	607	750
4	Attractiveness	616	750
Total		2442	3000

For Success Percentage
Skor Actual : 2442
Skor Ideal : 3000

$$= \frac{2442}{3000} \text{ X } 100\%$$
$$= 81{,}44\ \%$$

The percentage of success obtained for all usability sub-characteristics. A total value of 81.44% was obtained. Comparing the results of respondents with a Likert scale, 81.44% is included in the Good classification. This means that the I-Health application has an effortless display for users to understand and operate. With this level of success, users can run the application without taking a long time to learn the I-Health application. Next, calculate the error in the usability test for the I-Health application as follows.For the error value (error) using the formula :

$$= \frac{3000-2442}{3000} \text{ X } 100\ \%$$
$$= 18{,}6\ \%$$

After calculating usability for the percentage of errors in the I-Health application, it gets a value of 18.6%, with a low error rate. The i-health application provides ease of understanding and has its appeal. Make it easy for patients to operate the application and understand what is in it.

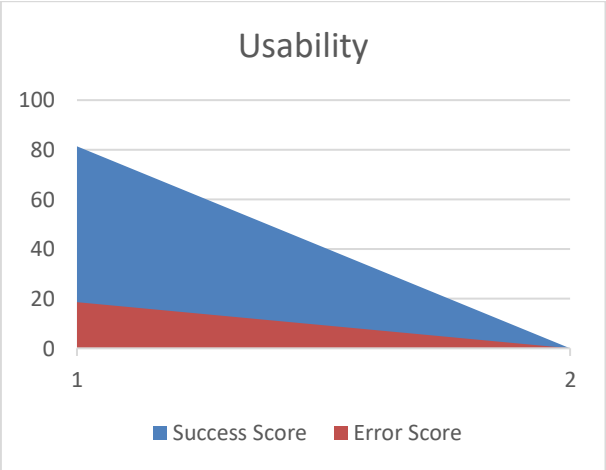


Figure 7. Usability Percentage Chart

c. Characteristics of efficiency

The Software can deliver appropriate performance relative to the resources used under the circumstances.In the Performance Efficiency aspect, testing is done by calculating the average response time of each task run. Testing the performance efficiency aspect is done at least five times by considering the response time when the application retrieves data from the server and then displays it in the system. The results are then compared with Table 1 about user satisfaction with response time.

Table 5. Average response time

Response Time (second)	Predicate

<3	Very Good
3-9	Satisfied
9-12	Satisfied Enough
>12	Dissatisfied

Effciency Characteristic Testing Results:
Response Time Result

$$= \frac{Average\ Time}{Total\ Respondent}$$

Response Time = 55,51
Number of respondent = 50

$$= \frac{55,51}{50}$$

$$= 1,1102 \text{ s}$$

The I-Health application scored 1.11 seconds in efficiency testing, which is very good. Quality analysis of efficiency aspects is done by calculating the system's average response time to retrieve and display data. The result of testing the performance efficiency of the response time required by the system in performing specific tasks is 1.11 seconds. The user satisfaction table includes these results in the very satisfying category because it is less than 3 seconds.

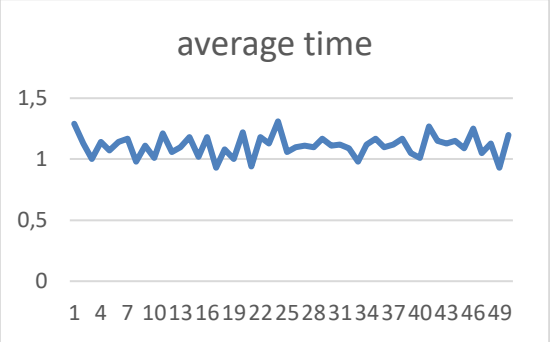


Figure 8. Average Efficiency Time Chart

4. Conclusion

I-Health is an application used in this study to display patient information and health status through device health monitoring. The I-Health application is available for Android and iOS. The mobile health app was evaluated according to ISO/EIC 9126 using functionality, suitability, and efficiency. The results were an 80% success rate in functionality testing, an 81% success rate in usability testing, and an average time to complete the specified tasks of 1.11 seconds. Multifunctional wireless health monitoring devices with displays on Android and iOS have great potential to improve individual health monitoring. Implications include changes in health behaviors, management of chronic diseases, and expanding the understanding of overall health. Future research should focus on developing functionality, integration, better user interface, data security, and privacy compliance.

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Design Optimization of DR3AM Vapor Polishing Device for ABS 3D-Printed Parts

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Abstract. 3D printing is an additive manufacturing method that turns digital design into an actual product. A 3D-printed part sometimes requires post-processing to enhance its physical and mechanical properties. Acetone vapor polishing is one of those techniques which is highly beneficial in smoothing 3D-printed parts made of acrylonitrile butadiene styrene (ABS). Previously, an acetone vapor polishing device using a mist maker was developed at the Bataan Peninsula State University. However, for a more efficient polishing method, an optimized vapor polishing device using heat has been developed in this study. Using a heating device, which is an insulated nichrome coil, shows a more gradual and fine vaporization of acetone unlike the mist maker. To further assess the efficiency of the optimized device, the researchers tested the dimensional accuracy, surface roughness, tensile strength, and impact strength of polished and unpolished ABS 3D-printed specimens. The findings showed that the change in surface roughness of the polished cube specimens did not significantly alter their physical geometry. The tensile test reveals that the overall elasticity of the polished tensile specimens has increased noticeably. The impact test also shows that the polished specimen can absorb more impact from a swinging pendulum compared with unpolished specimen. Thus, all testing procedures indicated that post-processing using the optimized vapor polishing device improved the overall physical and mechanical properties of the polished ABS 3D-printed specimens.

Keywords: 3D printing, acrylonitrile butadiene styrene, dimensional accuracy, surface roughness, tensile properties, impact strength

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1. Introduction

3D printing is becoming known globally, and one of the types of this technology is the Fused Filament Fabrication (FFF). FFF is analogous in using a computer-controlled hot glue gun in its most basic form.

In contrast to traditional hot glue guns, 3D printers have a nozzle that is about 0.1 mm to 2.0 mm in diameter. Nowadays, FFF technology is one of the most popular 3D printing techniques [1]–[6]. However, post-processing is sometimes required for this type of technology to improve the layer adhesion strength and surface finish of 3D-printed parts [2].

One of the most commonly-used filaments for FFF 3D printers is the Acrylonitrile Butadiene Styrene (ABS). It is a thermoplastic polymer that has made a significant contribution in high-performance engineering applications [3]–[6]. However, poor layer bond strength and rough surface consistency are common characteristics of FFF 3D-printed ABS materials that sometimes require post-processing techniques [6]. Heat treatment and vapor-polishing are some examples designed to address these issues. Heat treatment is a post-processing procedure that enhances the mechanical properties of 3D-printed polymers and improves surface finish [7]. On the other hand, acetone vapor polishing is another way to smoothen the surface without altering the object's features and improve the mechanical properties of a 3D-printed ABS part through acetone vapor [2], [3], [8]. Furthermore, employing acetone vapor to ABS 3D-printed parts also ensures a high degree of process stability [9]. The application of heat treatment and acetone vapor polishing procedures are proven to be effective in improving both the mechanical and physical properties of 3D-printed materials [2], [3], [7].

Previously, an acetone vapor polishing device was developed by researchers of Bataan Peninsula State University (BPSU) which uses a mist maker [3]. However, for a more efficient vapor polishing method, an optimized vapor polishing device using heat has been fabricated in this study. This study was focused on developing an acetone vapor polishing device that utilizes the heat produced from an insulated nichrome coil. The insulated nichrome coil is a core heating element commonly used in various industrial and scientific applications. This type of metal is highly resistive, with a voltage current applied to the coil, which produces heat [10]. Additionally, this study used a new cover for the vapor polishing device using T6 6061 aluminum as it is one of the strongest alloys on the market. It is a highly corrosion-resistant and strong material used to make lightweight products and components, making it ideal for various structural components and industrial goods applications [11].

2. Methods

2.1. Design Optimization of DR3AM Vapor Polishing Device

2.1.1 Materials.

This optimized the existing vapor polishing device for ABS 3D-printed parts at BPSU's DR3AM Center. According to the recommendation from the paper of Gache et al. (2022), the device's design should be optimized. For instance, it was observed that the wooden cover of the device can expand and be affected by the chemical reagent acetone. Additionally, the mist maker of the vapor polishing device is of poor quality [3]. With this, the researchers considered various criteria in proposing a new method of optimizing the existing vapor polishing device. The availability of materials and components has a significant factor in improving the design and functionality of the device.

Before achieving the ideal function of the optimized device, the researchers conducted several testing and experiments to obtain the appropriate type of vaporizer (the part that creates vapor) to use for the acetone vaporization. Considering the advantages and disadvantages of different vaporizers, an insulated nichrome coil indicates its edge over other vaporizers as shown in Table 1.

Table 1. Advantages and Disadvantages of Different Vaporizers

	Vaporizers	**Advantages**	**Disadvantages**
Initial Design	Mist Maker	Easier to use. Focuses on a specific area, preventing acetone wastage.	Perfect for water-based but not effective for acetone solvent. It makes too much pressure which makes the acetone evaporation uncontrolled.

			Acetone mist directs at the top of the glass dome, making the polishing time longer
Improved Design	Peltier Module	Smaller in size. Gradual acetone evaporation.	One side of the Peltier module gets cold, which makes it incompatible with the device since its cold side might affect the electronic components inside the base. Dependent on the Arduino system to operate utterly.
Final Design	Insulated Nichrome Coil	Good conductor of heat. Gradual and fine acetone evaporation.	Electrical wires are sensitive.

The vapor polishing device was initially optimized and designed using computer-aided design software. The 3D-printed base made of PLA and glass cover of the device are similar from the existing device. The wooden cover of the existing device was replaced with aluminum to prevent deformation. The researchers used an insulated nichrome coil instead of a mist maker to make the acetone evaporation process more effective and for a longer lifespan of the device. In addition, the researchers decided to install a digital thermostat temperature alarm and time relay module for a better system function. This component aids in determining the average temperature of insulated nichrome coil to achieve smooth acetone evaporation, the standard amount of acetone, and the time required for vapor polishing of 3D-printed parts. The following figures show the comparison between the existing and optimized design of the vapor polishing device. Figure 1 shows the CAD model of the existing vapor polishing device using a mist maker. Figure 2 shows the CAD model of the optimized vapor polishing device using the insulated nichrome coil. To set up the insulated nichrome coil, the researchers made a customized aluminum cover using T6 6061, which has three layers to make it more durable. These are the measurements: 8.10 x 4.1 inches, 8.10 x 7.5 inches, and 7.45 x 4.25 inches, respectively. Since the base of the device contains circuits, the acetone was designed to have its own container so that it could be stored properly. This container was placed at the center of the device which is covered with a 5 x 5 inches receptacle as support, and placed under it is the insulated nichrome coil.

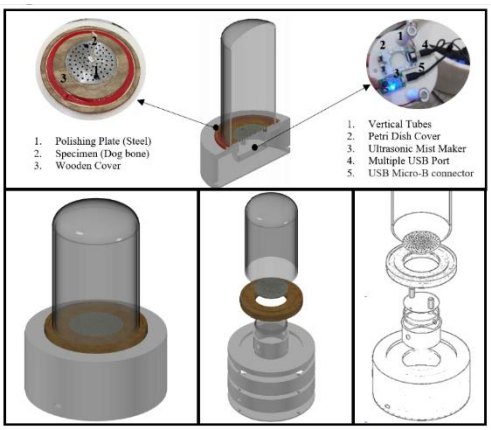


Figure 1. CAD Model of the Existing Vapor Polishing Device Using Mist Maker [3]

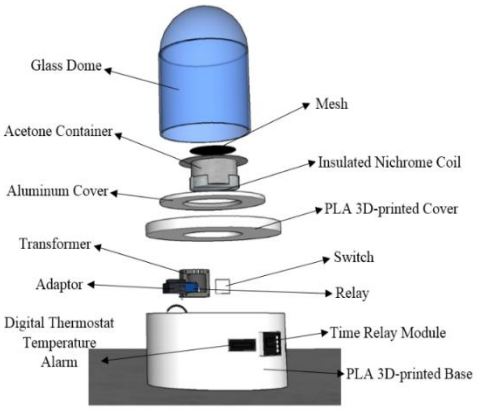


Figure 2. CAD Model of the Optimized Vapor Polishing Device Using Insulated Nichrome Coil

2.2. Experimental Design and Procedures

2.2.1. Material

Acrylonitrile Butadiene Styrene (ABS) material is known for its flexibility, durability, adaptability, and

high heat tolerance; although it has interface lines between layers, there are ways how it can be polished. The commonly-used post-processing technique for ABS material is acetone vapor smoothing, as the acetone can polish or reduce the visible raster layer on the surfaces of the 3D-printed parts [3], [4], [6]. This study used Polymaker PolyLite ABS filament which has a much lower volatile component compared with standard ABS polymers. Thus, providing an outstanding print quality and excellent post-processing capabilities [12]. All test specimens in this study were 3D-printed using Zortrax M200 FFF 3D printer with a printing temperature of 275 °C.

2.2.2. Dimensional Accuracy

Five (5) cube specimens were 3D-printed with 90% infill density and 0.19 mm layer thickness with different dimensions starting from $(10\ mm)^3$, $(15\ mm)^3$, $(20\ mm)^3$, $(25\ mm)^3$, and up to $(30\ mm)^3$. The dimensions of each specimen were measured and recorded using the Mitutoyo Digimatic Vernier Caliper, following the study of Robles et al. [13], [14]. Accordingly, the cubes were polished to the optimized vapor polishing device. Figure 3 shows the procedure for obtaining the measurements of dimensions of the unpolished and polished cube specimens.

2.2.3. Surface Roughness.

Mixing hot chemical vapors with heated air accelerates the vapor polishing technique and produces an excellent surface finish [15]. The changes in surface roughness after the polishing process was measured using the cube specimens. The specimen's surface was captured and analyzed with an AMScope MU503 T-720-Q and Mountains Topography software. The researchers measured the 3D-printed sample before being subjected to the optimized vapor polishing device with an acetone of 20 mL for 30 minutes and a curing time of another one hour. Figure 4 shows the use of AMScope trinocular microscope to capture a digital image of the surface of a 3D-printed specimen.

Figure 3. Cube Specimen Measurement

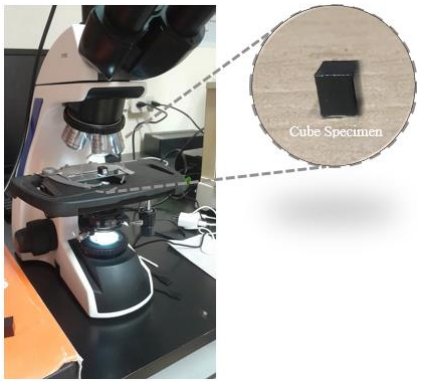


Figure 4. Actual Setup to capture the Digital Topography of 10mm cube

2.2.4. Tensile Test

In determining the effect of the vapor polishing device on the tensile properties of the ABS 3D-printed parts, the study tested two (2) sets of samples: unpolished and acetone vapor polished. Five (5) specimens were printed and manufactured for each sample in accordance with ASTM D638 Type IV [16]. Each tensile test specimen was 3D-printed with a honeycomb infill pattern, 90% infill density, 0° raster angle, and edgewise orientation. Acetone vapor polished specimens were subjected to the optimized vapor polishing device using 40 mL of acetone. The acetone vapor polishing process was estimated to be 30 minutes followed by a curing time of 30 minutes. Tensile test was conducted using the Shimadzu AGS-X Series Universal Testing Machine (UTM) with 10kN capacity. Figure 5 displays the tensile test setup and the specimen’s dimension.

2.2.5. Impact Test

The researchers used ASTM D256 test method E to obtain the difference in impact resistance of unpolished and acetone vapor-polished 3D-printed specimens, using a pendulum-dial Izod testing machine. This ASTM standard test method is a single-point assessment of the resistance of material from breaking using a swinging pendulum [17]. For preciseness, the equipment was thoroughly tested and calibrated in line with ASTM D256 before conducting the experiment. The Izod Type E test specimens have a layer thickness of 190 microns and an infill density of 70%. Figure 6 depicts the actual impact test set-up. Table 2 summarizes the amount of acetone used, vapor polishing time, and curing time of the specimen from the dimensional accuracy, surface roughness, tensile strength, and impact test. As observed by the researchers, these are the data needed to smoothen each ABS 3D-printed parts.

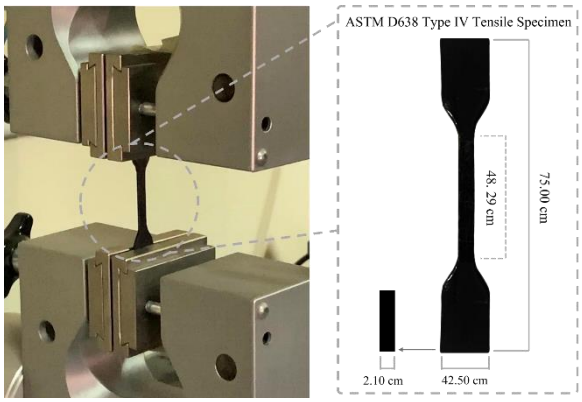


Figure 5. Tensile Test Set-up and Tensile Specimen's Dimension

Figure 6. Actual Impact Test Set-up

Table 2. Summary of Amount of Acetone Used, Vapor Polishing Time, and Curing Time

Type of Test	Specimen	Amount of Acetone Used (mL)	Vapor polishing time (sec)	Curing time (hour)
Dimensional Accuracy and Surface Roughness Test	10mm cube	20	14.28	1
	15mm cube	20	14.28	1
	20mm cube	30	24.95	1
	25mm cube	40	30.15	1
	30mm cube	40	30.15	1
Impact Test	ASTM Izod Type E	30	24.95	1
Tensile Test	ASTM Tensile Type IV	40	30.15	1

3. Results and Discussion

3.1. Effectiveness of the Optimized DR3AM Vapor Polishing Device

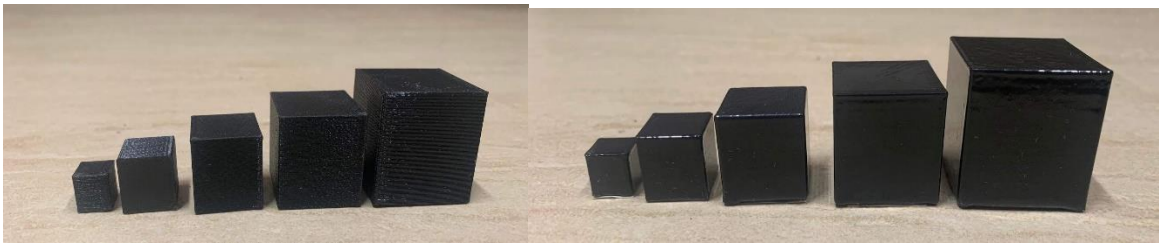
The optimized vapor polishing device has proven its effectiveness based on various testing procedures done. As mentioned in the previous section, the effectiveness of the optimized vapor polishing device was assessed by having a comparative test between the dimensional accuracy, surface roughness, tensile strength, and impact resistance of unpolished and polished specimens. The vaporization mechanism of

the optimized vapor polishing device clearly shows the possibility of effectiveness using other heating methods which was crucial to the improvement of the vapor polishing device. Figure 7 shows the final CAD design and actual photo of the device used for vapor polishing. Since the focus of this study was to develop an acetone vapor polishing device which optimizes the vapor polishing device previously done by Gache et al., its effectiveness was measured by comparing the test results of both studies. However, this study used ABS PolyLite filament from the Polymaker brand. This material is different in terms of melting point and composition (blend), to the material used by Gache et al., the Z-Ultrat ABS filament from Zortrax brand. Hence, the result and mechanical response to various tests of these materials were expected to be different. This difference in result was initially observed through visual inspection. ABS PolyLite already has a smoother surface after 3D printing compared to ABS Z-Ultrat even though both filaments underwent the same printing parameter. This is because ABS PolyLite specimen was printed at temperature 10 ^{o}C higher than its maximum melting temperature. Unlike the ABS Z-Ultrat which was printed within its required melting temperature range.

Figure 7. Final CAD Design (a) and (b) Actual Photo of Optimized Vapor Polishing Device

3.1.1. Dimensional Accuracy

Various cube sizes were used to examine the dimensional accuracy of the 3D-printed cube specimen after being subjected to vapor polishing. Figure 8 shows the unpolished and polished ABS 3D-printed cube specimen using the optimized acetone vapor polishing device. Results showed an insignificant change in the dimension of cube specimens in any directions, such as top to bottom, front to back, and left to right, before and after acetone vapor polishing. Table 3 shows the summary of dimensional changes in unpolished and polished specimens. It shows that each of the specimen's dimensions has retained or decreased by about ±1 mm. Equation 1 shows the formula used in determining the volume reduction in the dimensional accuracy test.



(a) (b)

Figure 8. Images of (a) Unpolished Cube Specimens and (b) Polished Cube Specimens

$$Volume\ Reduction\ (\%) = \frac{Volume_{unpolished} - Volume_{polished}}{Volume_{unpolished}} \times 100\% \quad (1)$$

Table 3. Summary of dimensional changes for the Unpolished and Polished cube sample

Cube Size $(mm)^3$	Top to Bottom (mm)		Front to Back (mm)		Left to Right (mm)		Volume Reduction (%)
	Unpolished	Polished	Unpolished	Polished	Unpolished	Polished	
10	10.25	10.20	10.13	10.10	10.12	10.07	**1.29**
15	15.15	15.15	15.05	15.03	15.07	15.05	**0.26**
20	20.21	20.18	20.07	20.05	20.15	20.08	**0.60**
25	25.15	25.02	25.12	25.06	25.14	25.07	**1.03**
30	30.10	30.10	30.20	30.16	30.10	30.05	**0.30**

3.1.2. Surface Roughness

For the surface roughness assessment, the researchers captured a digital image of the topography of unpolished and polished 3D-printed cube using the AMscope trinocular microscope and analyzed them using Mountains9 software to measure their surface roughness. The results show a significant difference in the surface roughness of the unpolished and polished 3D-printed sample. Figure 9 shows the image of an unpolished 3D-printed sample compared to a polished one after the vapor polishing procedure using the optimized vapor polishing device. Tabulated results of Maximum Peak Height (Sp), Maximum Pit Height (Sv), and Maximum Height (Sz) gathered from the roughness analysis of unpolished and polished specimens using the Mountains9 Software was shown in Table 4. It can be observed that based on the roughness analysis, a difference of 2.416 µm in maximum peak height and 2.68 µm for maximum pit height were obtained between unpolished and polished specimens. This data implies that the optimized vapor polishing device reduces the maximum peak height with 65.87%, maximum pit height with 65.24%, and maximum height with 65.52% of the surface of 3D-printed specimens. As reported by Gache et. al, this reduction is due to the flowing of melted surface peaks of ABS 3D-printed specimen to the surface pit during the acetone polishing procedure, resulting in the reduction of the specimen surface's maximum height, Sz [3]. Therefore, improvements in the surface roughness of the specimen prove the effectiveness of the optimized vapor polishing procedure.

(a) (b)

Figure 9. Digital Image of (a) Unpolished and (b) Polished Surface of 10 mm Cube Specimen

Table 4. Results obtained by Mountains9 Topography Software

Sample	Maximum Peak Height, Sp	Maximum Pit Height, Sv	Maximum Height, Sp + Sv = Sz
Unpolished	3.668 µm	4.108 µm	7.775 µm
Polished	1.252 µm	1.428 µm	2.681 µm

3.1.3. Tensile Test

The obtained results in tensile strength and Young's Modulus for unpolished and polished specimens are shown in Table 5. The Young's modulus (E) of a material determines how it responds to external stress in terms of reversible elastic deformation and irreversible plastic deformation. Tensile strength was proportional to E, but the relationship varied with material [18].

Table 5. Tensile Strength and Young's Modulus of Unpolished and Polished Specimens

Test Samples	Tensile Specimen No.	Tensile Strength (MPa)	Average Tensile Strength (MPa)	Young's Modulus (MPa)	Average Young's Modulus (MPa)
Unpolished	1	44.520	**46.354**	17.002	**17.486**
	2	45.219		17.612	
	3	45.722		17.570	
	4	48.153		17.758	
	5	48.155		17.486	
Polished	1	36.908	**40.713**	13.496	**14.446**
	2	37.307		14.659	
	3	41.616		13.996	
	4	43.138		14.888	
	5	44.596		15.191	

After polishing the tensile specimen, it was subjected to tension using the UTM to investigate the effects of vapor polishing on the tensile strength and elasticity of the polished specimens compared to the unpolished specimens. Figure 10 and 11 show the test specimens after testing and the summary of stress-strain curves and Young's Moduli of unpolished and polished specimens, respectively. Based on the tensile test results of both the unpolished and polished specimens, polishing using the optimized vapor polishing device affected the Young's modulus and tensile strength of the ABS 3D-printed specimens. It was observed that the stress-strain curve of polished specimen has a smoother curve compared to unpolished specimen. Specifically, the unpolished specimens showed a peak value between 2.5%-3.0% strain. This can be related to the observed higher Young's modulus (stiffness) of unpolished specimen compared to polished specimen. And as a result of the change in Young's modulus, the polished specimen became less resistant to elastic deformation compared to unpolished specimen. In addition, the polished specimen yielded a lower tensile strength compared to unpolished specimen. However, this was not the case observed in the obtained data by Gache et al, wherein the Young's modulus and tensile strength of the vapor polished specimen both improved [3]. It could be due to the melting temperature of materials used, as mentioned in the previous section. Since PolyLite was printed with temperature higher than its melting point, it produced a smoother surface than Z-Ultrat even before it was vapor polished. Therefore, once vapor polished, it produced a smoother surface which means that each raster layer was bonded better to its adjacent layer. This resulted in a lower Young's modulus and lower tensile strength, compared to Z-Ultrat when vapor polished. In addition, this could also be related to the difference in polymer blend of PolyLite and Z-Ultrat, which may be the reason for its higher susceptibility to melting during vapor polishing.

Figure 10. (a) Unpolished and (b) Polished Type IV Tensile Specimen

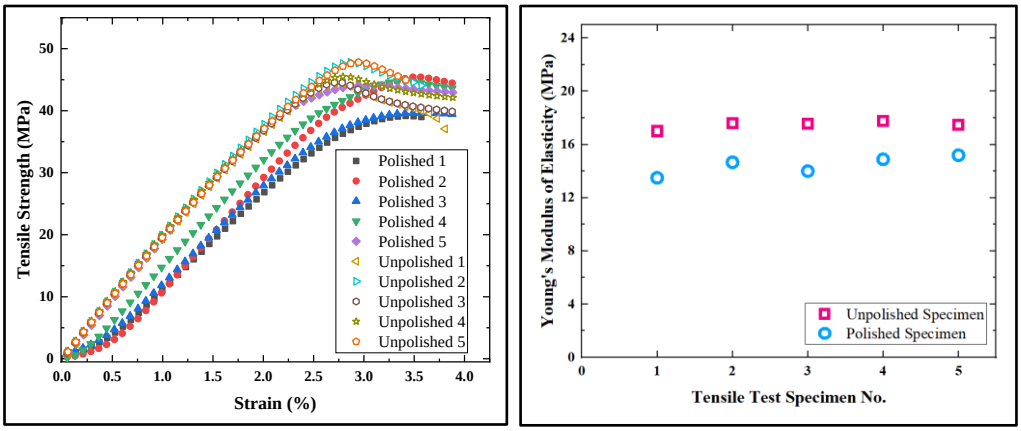


Figure 11. Summary of (a) Stress–Strain Curve and (b) Young's Moduli of Unpolished and Polished Type IV Test Specimens

3.1.4. Impact Test

Using the Izod impact test, the researchers were able to investigate the fracture behavior of unpolished and polished 3D-printed specimen using the optimized vapor polishing device. Using Equation 2 and 3, the researchers calculated the impact resistance and impact energy that can be absorbed by the specimen from a swinging pendulum before fracture. Table 6 and Figure 12 show the tabulated and graphical representation of the calculated impact resistance and impact energy, comparing the result of polished and unpolished specimens. Generally, vapor polished specimen obtained a higher impact resistance and higher impact energy compared to those unpolished specimens. This improvement can also be related to the bonding of raster layers caused by melting of ABS plastic during acetone vapor polishing. However, some data obtained from unpolished and polished specimen were almost equal, this can be due to the defect, such as void or crack, produced during its printing which is common printing problem in FFF 3D printers. The effect of such defect cannot be out done by the effectiveness of bonding of raster layers alone during the vapor polishing process.

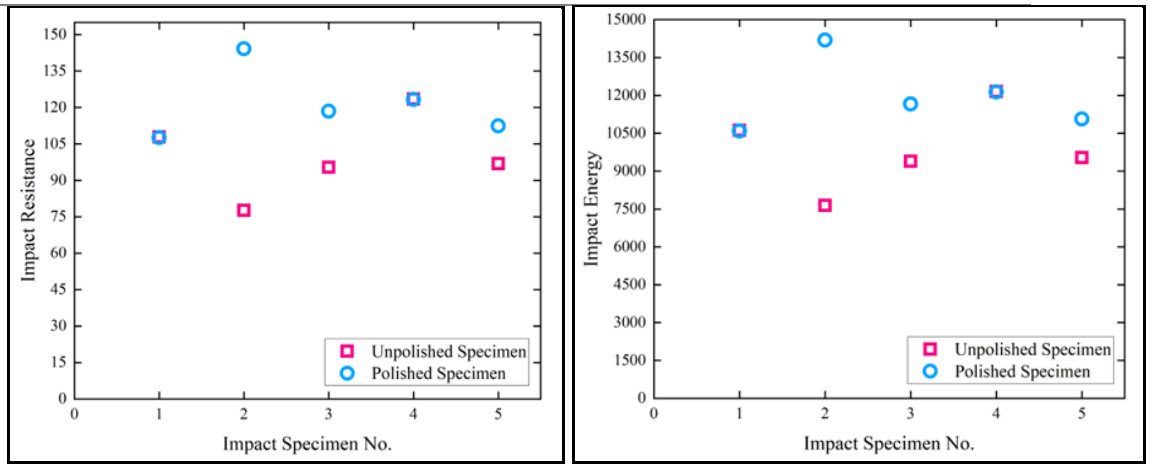
$$\text{Impact Resistance,} \quad I_R = \frac{E_S}{\mathrm{w}} \tag{2}$$

$$\text{Impact Energy,} \quad I_R = \frac{E_S}{\mathrm{dw}} \tag{3}$$

Table 6. Summary of Mean Experimental Results of Impact Test

Post-processing	Impact Resistance $(\mathbf{J/m})$	Impact Energy $(\mathbf{J/m^2})$

	107.81	10611.47
	77.61	7638.97
Unpolished	95.38	9388.25
	123.44	12149.36
	96.88	9534.94
	107.58	10588.17
	144.16	14188.76
Polished	118.44	11657.56
	123.29	12134.61
	112.46	11069.10



(a) (b)

Figure 12. Summary of (a) Impact Resistance and (b) Impact Energy of Unpolished and Polished Izod Type E Specimen

4. Conclusion and Recommendation

The existing acetone vapor polishing device was optimized by incorporating an insulated nichrome coil and using a volume-based ratio to polish the different ABS 3D-printed parts. Compared to the mist-maker used in previous iterations of the device, which have more pressure in releasing the acetone vapor, the nichrome coil has they could gradually evaporate the acetone which is advantageous in terms of vapor polishing. The efficiency of the optimized DR3AM vapor polishing device was assessed using dimensional accuracy, surface roughness, tensile strength, and impact strength of polished and unpolished ABS 3D-printed specimens. The optimized DR3AM vapor polishing device significantly smoothens the surface of 3D-printed parts without completely altering the dimensional accuracy. The tensile test reveals that the overall elasticity of the polished tensile specimen has increased significantly while the impact test also shows that the polished specimens can absorb more impact from a swinging pendulum compared with unpolished specimen.

ABS 3D-printed parts might have different results depending on the amount of acetone used, the time allotted to polish each 3D-printed part, and the brand of filament used (filament brands sometimes differ in polymer blend and melting temperature). It was also observed that some parts of the polished specimen are not evenly smoothened. Thus, the researchers recommend the following:

- identify the right amount of acetone and set a standard vapor polishing time in order to determine if the polishing of the surface of a 3D-printed specimen is already enough;
- investigate the optimal curing time for the acetone vapor polished to be absorbed by the 3D-printed part.
- utilize advanced mechanisms like Arduino, to monitor the temperature of the nichrome coil after it attains the set temperature and time.

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Spatial Analysis of Water Infiltration Potential in the Miu Watershed of Sigi Regency

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Abstract. The Miu Watershed is essential in supplying clean water for the community's needs and as a source of irrigation water for agricultural land in the Sigi Regency. Despite having an important role, the Miu Watershed is frequently hit by floods and landslides, resulting in economic, social and environmental losses. Low water absorption capacity will affect surface water runoff resulting in flooding. This study aims to identify the potential for water absorption in the Miu watershed based on four spatial parameters, namely land use, rainfall, soil type, and slope, as determining factors for the condition of water catchment areas. The method used in this study is the scoring and overlay method to obtain the condition of the water catchment area based on current conditions. Spatial data analysis uses a Geographic Information System (GIS) by adding up the results by multiplying the scores and weights of each different parameter. The analysis results produce four conditions of the water catchment area: good, naturally normal, critical start, and critical conditions. The condition of the Miu watershed catchment with the most significant area is 53,727.64 ha (81.98%) of the total area of the study area with normal natural conditions.

Keywords: MIU watershed, watershed potential, geographic information system (GIS)

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1. Introduction

Watersheds in Indonesia are currently experiencing damage due to changes in land use and human activities; this impacts the environment and society, such as landslides, erosion, drought and floods [1]–[3]. Changes in land use affect the function of the watershed, one of which is the impact of reducing water absorption [4], [5].

A water catchment area is an area that has a water catchment function through the process of seeping surface water into the ground [6]. Water catchment areas have a significant role in maintaining the stability of the hydrological cycle, including water catchment areas, water storage and water distribution

[7]. Some things that affect the water absorption process are soil type, land use, slope and rainfall.

Research on water absorption has been carried out in the Unda River Basin, Bali Province, regarding the identification of water catchment areas; the results of the study show that the Unda River Basin has good, normal, rather critical and very critical conditions based on the overlay results of the four parameters used [8]. Saputra, Ridwan and Nurlina [9] analyzed the Water Infiltration Rate Using a Geographic Information System in the Tabunio Basin; the results of the analysis were divided into five criteria, namely natural, normal criteria, starting critical, moderately critical, critical and very critical.

The Miu River Basin is one of the watersheds in Central Sulawesi Province, Sigi Regency, which has an area of 65,535.20 ha (Figure 1); the Miu River Basin is located in 5 Districts namely Lindu District, Palolo District, Kulawi District, Gumbasa District and South Dolo District. The Miu Watershed has an essential role for the community as a fulfilment of household needs and a provider of water for irrigation of agricultural land [10]. However, there are frequent floods [11] due to overflowing water in the Miu watershed and landslides [12] which result in economic, social and environmental losses.

Research on the analysis of water infiltration in the Miu watershed is a significant study for managing watersheds and preventing adverse effects such as floods and landslides. Information about water catchment areas in the Miu watershed still needs to be improved, so it is necessary to analyze the potential of water catchment areas. Based on the background described, this study aims to map the condition distribution of water catchment areas in the Miu watershed by utilizing a Geographic Information System (GIS) [13].

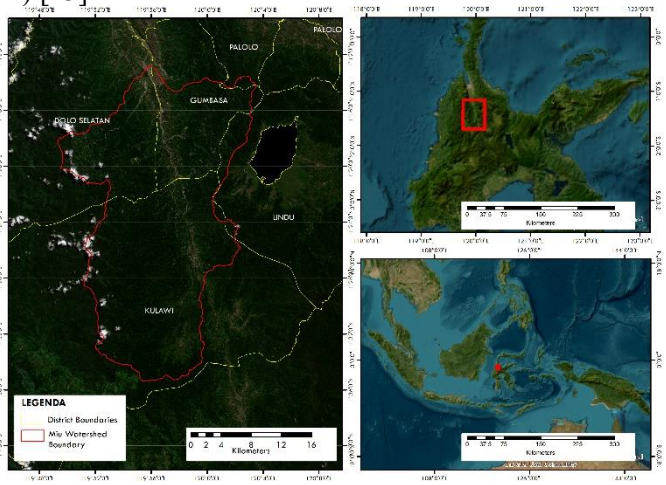

Figure 1. Map of Research Locations

2. Methods

The method used in this study is the scoring method based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 10 of 2022 concerning the Preparation of a General Plan for Forest and Land Rehabilitation of Watersheds and Annual Plans for Forest and Land Rehabilitation [14]. The materials used by the researchers are: (1) Sentinel 2A Image sourced from the Copernicus Open Access Hub web; (2) Rainfall data for the Indonesian region, sourced from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS); (3) Digital Elevation Model (DEM) data, sourced from the National Digital Elevation Model (DEMNAS); (4) Soil type data for Sigi Regency; (5) Miu watershed boundary shapefile. While the tools used are: (1) ArcMap 10.8 software is used to analyze sentinel 2A images and is used when overlaying each parameter; (2) Microsoft Office software is used to process data and write articles.

The parameters used in this study were land use, rainfall, soil type, and slope, with different scores and weights for each parameter (Table 1-4).

2.1 Water Infiltration Parameters Scoring

1. Soil type

Soil type affects the process of water absorption; sandy soil texture can absorb water faster than clay [15]

due to the small particle size, which inhibits water movement. Scores and weights of soil types can be seen in Table 1.

Table 1. Score and weight of each soil type

No	Soli Type	Infiltration	Score	Weight
1	Regosol	Large	5	5
2	Aluvial dan Andosol	Rather Large	4	5
3	Latosol	Medium	3	5
4	Litosol	Rather Small,	2	5
5	Grumosol	Small	1	5

2. Slope

The slope of the slope has a significant effect on the ability of water absorption; steep slopes will drain water quickly without going through the infiltration process [16]. Conversely, a gentle slope will hinder the movement of runoff water. Scores and slope weights can be seen in Table 2.

Table 2. Score and weight of each slope

No	Slope (%)	Infiltration	Score	Weight
1	0-8	Large	5	2
2	8-15	Rather Large	4	2
3	15-25	Medium	3	2
4	25-40	Rather Small,	2	2
5	>40	Small	1	2

3. Rainfall

Rainfall affects the amount of water that falls to the ground surface; the high rain intensity will result in runoff of surface water that is higher than the water absorption capacity [17]. Scores and weights of rainfall can be seen in Table 3.

Table 3. Score and weight of each rainfall

No	Rainfall (mm/tahun)	Infiltration	Score	Weight
1	>5000	Large	5	4
2	4,500-5,000	Rather Large	4	4
3	3,500-4,500	Medium	3	4
4	2,500-3,500	Rather Small,	2	4
5	<2,500	Small	1	4

4. Land use

Land use is a parameter closely related to water absorption; land cover vegetation will increase water absorption to prevent surface water flow from increasing [18]. Land use scores and weights can be seen in Table 4.

Table 4. Scores and weights for each land use

No	Land Use	Infiltration	Score	Weight
1	Primary Dryland Forest, Secondary Dryland Forest	Large	5	4
2	Plantation	Rather Large	4	4
3	Bush	Medium	3	4
4	Dryland Agriculture, Mixed Dryland Agriculture, Fields, Drylands	Rather Small,	2	4
5	Water bodies, settlements, rice fields	Small	1	4

Data for each parameter is converted using ArcMap 10.8 software to produce vectorized data (.shp) which is then used as a map.

2.2 Classification of Water Catchment Area Conditions

Parameter vector data for each parameter is scored with an assessment of the score with the weight of each parameter; the assessment results are added to a new field in the attribute table. To determine the condition of the water catchment area, spatial vectorization results are overlayed using union analysis by combining the vector layers for each parameter into one vector layer. The overlay results are classified based on the criteria for the condition of the water catchment area.

$$Potensi\ Daerah\ Resapan = Kb.Kp + Pb.Pp + Sb.Sp + Lb.Lp \quad (1)$$

K = Soil type
P = Average rainfall
S = Land use
L = Slope
B = Weight value
p = Parameter class score

The water catchment interval value uses the Sturgess formula by dividing the most considerable and smallest data values.

$$Kelas\ Interval = \frac{(Xt-Xr)}{k} \quad (2)$$

Xt = Largest data
Xr = Smallest data
k = Number of classes

3. Results and Discussion

3.1. Spatial Parameters Determining Water Infiltration Potential

a. Type of soil

Various types of soil have different water absorption capacities. There are two types of soil in the Miu watershed, namely, alluvial and red-yellow podzolic. The Miu watershed is dominated by red-yellow podzolic soils covering an area of 60,327.17 ha with a rather large infiltration capability. Research by Amar, Muyassir and Hifnalisa [19] states that red-yellow podzolic soil types have a sandy texture to absorb water well. The alluvial soil type in the Miu watershed has a fine texture consisting of sand and clay, so this type of soil has a hollow soil structure that can absorb water quite well [20]. The following is the classification of soil types and infiltration rates in the Miu watershed (Table 5).

Table 5. Soil Type Classification and Miu Watershed Infiltration

No	Type of soil	Infiltration	Area (ha)	Percentage (%)
1	Red-Yellow Podzolik	Rather Large	60,327.17	92.05%
2	Alluvial	Medium	5,208.03	7.95%
	Total		65,535.20	100 %

b. Slope

The results of the analysis of the slope of the Miu watershed are pretty varied; as many as five classes of slope are known. Slope class, area, infiltration rate and percentage can be seen in table 6.

Table 6. Miu watershed slope

No	Slope	Information	Infiltration	Area (ha)	Percentage (%)
1	0-8	Flat	Large	2,169.09	3%
2	8-15	Sloping	Rather Large	2,869.99	4%
3	15-25	Wavy	Medium	5,182.21	8%

4	25-40	Steep	Rather Small,	11,288.01	17%
5	>40	Very Steep	Small	44,025.89	67%
		Total		65.535,20	100 %

able 6 shows that the topographical conditions of the Miu watershed are generally in steep and very steep conditions; this condition causes a lack of water seeping into the ground; this is in accordance with the research of Tamod, Aryanto and Purwiyono [21], which states that the steeper the slope will accelerate the flow of water surface area decreases as water is absorbed into the ground. Flat, sloping and undulating areas can absorb water well. The research results by Qur'ani, Harisuseno and Fidari [22] state that the lower the slope, the higher the infiltration rate.

c. Rainfall

Miu Watershed infiltration rainfall from 2014 - 2023 belongs to the small category, <2,500 mm. Based on Table 7, the average infiltration rain is 1,886.40 mm/year. According to Yunagardasari, Paloloang and Monde [23], low rainfall will minimize runoff so that the soil can absorb water. The following is Table 7 of Miu watershed rainfall data.

Table 7. Annual Rainfall from 2014-2023

No	Year	Rainfall	Average Rainfall (mm/year)	Infiltration
1	2014	1,726.32	1,886.40	small
2	2015	1,290.23		
3	2016	2,200.27		
4	2017	2,359.27		
5	2018	1,682.68		
6	2019	1,506.09		
7	2020	2,216.91		
8	2021	2,468.27		
9	2022	2,196.09		
10	2023	1,217.86		

d. Land Use

Land use is determined by several factors, including humans who use and cultivate land; excessive land use without regard to environmental and ecosystem aspects will cause problems such as floods and landslides. There are eight types of land use in the Miu watershed: primary dryland forest, secondary dryland forest, dryland agriculture, mixed dryland agriculture, settlements, paddy fields, shrubs and bodies of water. The land use of the Miu Watershed is dominated by primary dryland forest covering an area of 46,806.60 ha, which has dense vegetation in the form of trees; Anggun D stated [24] that land conditions with dense vegetation can absorb water well. The following is a data table for land use classification in the Miu watershed (table 8).

Table 8. Classification of Land Use Data

No	Land use	Infiltration	Area (ha)	Percentage (%)
1	Primary Dryland Forest, Secondary Dryland Forest	Large	51,930.51	79%
2	Bush	Medium	4,953.14	8%
3	Dryland Agriculture, Mixed Dryland Agriculture, Fields, Drylands	Rather Small,	6,604.16	10
4	Water bodies, settlements, rice fields	Small	2,047.39	3
	Total		65,535.20	100 %

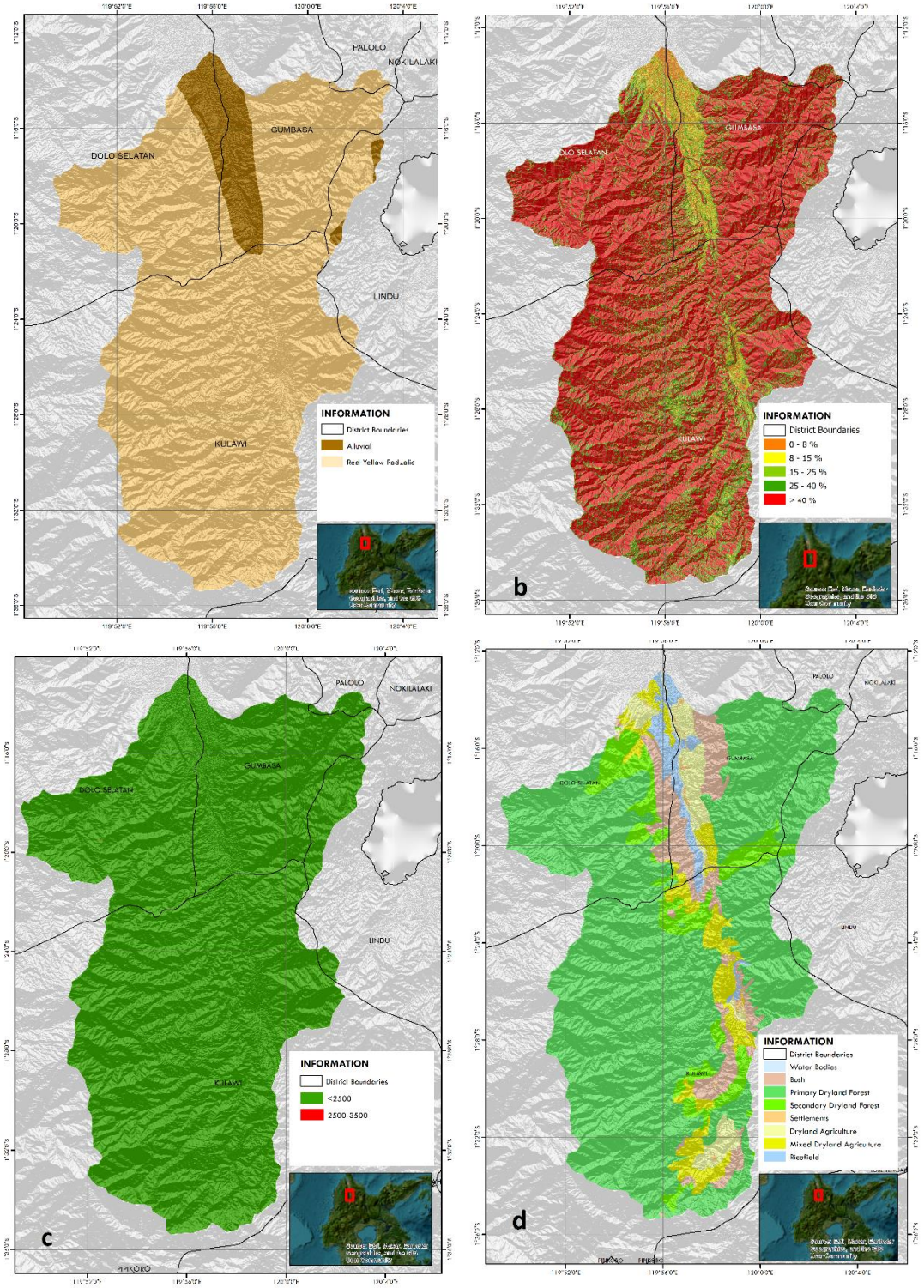

Figure 2. Map of special parameters for soil type (a), slope (b), rainfall (c), and land use (d)

3.2. Conditions of Water Infiltration

The overlay results of the four parameters used, namely soil type, rainfall, slope, and land use, produce a map of the conditions of the Miu water catchment area, which can be seen in Figure 3.

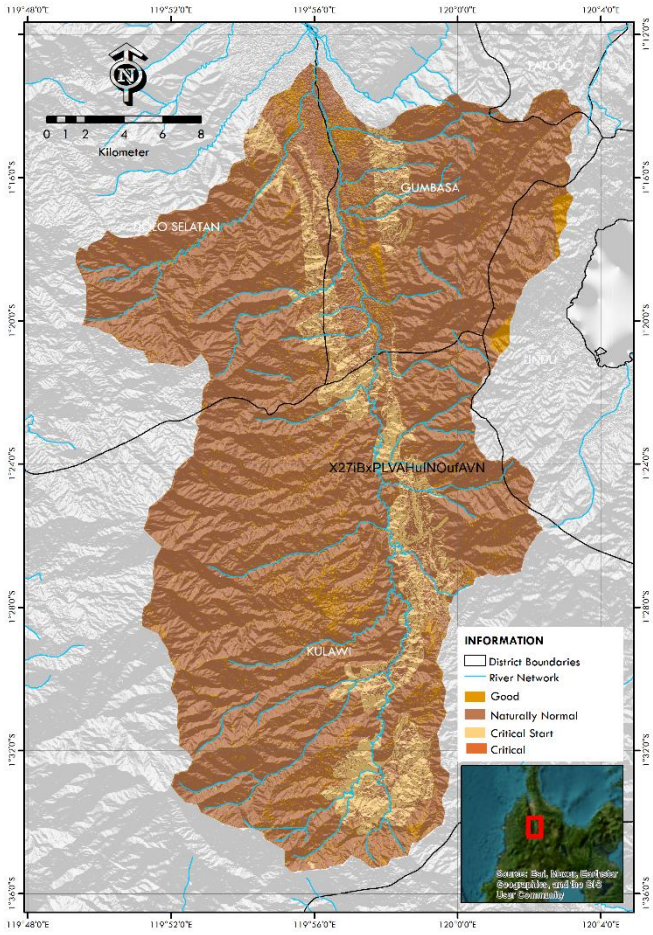

Figure 3. Spatial Distribution of Miu Watershed Conditions

Figure 3 shows that naturally normal conditions dominate the water catchment area of the Miu watershed. The calculation of the area and percentage of water absorption in the Miu watershed can be seen in Table 9.

Table 9. Area of Water Absorption Conditions in the Miu Watershed Basin

No	Conditions of Water Infiltration	Area (ha)	Percentage (%)
1	Good	5,706.33	8.71%
2	Naturally normal	53,727.64	81.98%
3	Critical start	6,101.03	9.31%
4	Critical	0.20	0.00%
	Total	65,535.20	100 %

Based on the results of the spatial analysis, it is known that the condition of the naturally normal catchment area dominates the Miu watershed with an area of 53,727.64 ha. This data informs that the Miu Watershed has natural characteristics as a water catchment area.

The condition of the Miu watershed catchment area is influenced by soil type, rainfall, slope and land use. The following describes the condition of the Miu water catchment area based on these four factors.

1. The condition of the catchment area is good

The condition of the catchment area is good; the Miu Watershed has an area of 5,706.33 ha (8.71%); this area is dominated by forests with high density, sloping slope class, and a relatively fast level of permeability. The intensity of rainfall in this area is very low. Meanwhile, land use is in the form of

primary dryland forest, secondary dryland forest, dryland agriculture, mixed dryland agriculture and bush.

2. Naturally normal Infiltration Area Conditions

The condition of the Naturally normal catchment area of the Miu Watershed is 53,727.64 (81.98%); this area is dominated by primary dryland forest with a moderate permeability level. This catchment area occupies the undulating slope class with very low rainfall intensity.

3. The condition of the catchment area is Critical start

The critical condition of the area is 6,101.03 ha (9.31%); this area has steep slopes, and land use is dominated by dryland farming and mixed dryland farming. Medium permeability level and very low rainfall intensity.

4. Conditions of Critical Infiltration Areas

The condition of the critical area is 0.20 ha (0.00%); this area has a steep topography with a red-yellow podzolic soil type. Land use includes water bodies, rice fields and settlements, and deficient rainfall.

3.3. Miu Watershed Management Recommendations

Based on the category of water catchment areas of the Miu watershed, several recommendations for the management of the Miu watershed are (1) good catchment areas are focused on maintaining and maintaining the current conditions; (2) in Naturally normal catchment areas, conservation of natural vegetation is carried out and involving the community in preserving the watershed; (3) in areas with critical conditions, it is necessary to carry out soil rehabilitation and conduct training involving the community to improve watershed conditions; (4) in critical condition areas, it is necessary to rehabilitate the watershed by increasing vegetation in open land and making infiltration wells in residential areas.

4. Conclusion

In general, the water catchment conditions of the Miu watershed are divided into four conditions, good, naturally normal, critical start, and critical conditions. The condition of the water catchment area, with the largest area in the Miu watershed, which is 53,727.64 ha (81.98%) of the total area of the study, is in the normal natural category. The reasonable infiltration rate of each parameter will affect the excellent water absorption potential. In general, forest-vegetated areas will have sound absorption.

In areas with critical conditions, it is necessary to improve land management, such as planting vegetation and using organic matter, and involve the community, stakeholders and the government in managing the Miu watershed.

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