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Application of IOT for Barangay Document Acquisition with Face Recognition Security

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Abstract: In today's digital age, the traditional method in acquiring the documents in government offices often involve lengthy queues, paperwork, and time-consuming processes. This manual approach can be inefficient, prone to errors, and frustrating for both residents and government workers. To address this challenge and enhance the overall efficiency of the barangay services, the development and implementation of an automated document acquisition system provided a promising solution. This developed design utilized the internet and databases to request for a specific type of document with the face recognition security as the only way for getting the request in the absence of the barangay official or personnel. It also featured an email notification to alert the user should their document request be approved or disapproved. The developed system was tested based on its performance with an average turnaround time of 73.55 seconds from the time the user was able to login up to the printing of document resulting to significant improvement on the processing time. As to the user experience it was found out that the system is easy to navigate with an acceptable user interface response time within 2-6.3 seconds making it a user-friendly device.

Keywords: Document Acquisition System, Barangay Documents Acquisition, IOT, Raspberry Pi

I. INTRODUCTION

Leveraging the use of technology in government unit can streamline the operations by reducing the processing time. By adopting digital tools and automated processes, public sector organizations can move beyond traditional, often cumbersome, manual workflows. The remarks of Buonocore [1] stated that the shift from manual processes to digital technologies not only enhances the efficiency of internal operations but also significantly decreases the time needed for handling administrative tasks and service requests. Moreover, In the study of Smith [2] he mentioned that the resulting improvements in processing speed and accuracy contribute to greater transparency, accountability and a more responsive and effective government that better serves its constituents. Despite the positive outcomes of digital technology in government Angala et al., [3] stated that even with the increasing trend toward digitalization, many businesses and agencies still rely heavily on paper documents. The said agencies include local government unit especially in barangays that is still using manual processing for their information and data. This can cause delays and data loss when residents need to retrieve their information. In addition, fraud paper clearances and certificates can be falsified, leading to problems such as improper accounting of person living in a certain community.

The rapid advancement of the Internet of Things (IoT) has significantly transformed data management across various industries, including document acquisition. Marakam et al., [4] define IoT as a network of interconnected devices capable of collecting, transmitting, and processing data without human intervention. In the context of document acquisition, IoT technologies facilitate real-time data capture from physical sources, automate the digitization process, and ensure seamless integration with cloud-based document management systems as applied on the study of Ray[5]. Additionally, these capabilities enhance accuracy, efficiency, and security in document handling workflows, especially in sectors like logistics, healthcare, and government services as mentioned by Al-Fuqaha et al.,[6]. By adopting sensors, smart scanners, and RFID-enabled devices, IoT can automate the identification, classification, and storage of documents, thereby reducing manual errors and operational delays. As organizations strive toward digital transformation, the application of IoT in document acquisition emerges as a pivotal strategy for improving information governance and process automation.

Implementing a document acquisition is a critical process for Local Government Units (LGUs). While digital document acquisition offers numerous benefits such as improved efficiency, transparency, and accessibility there is a challenge underlying the authenticity and security of the information. As documents transition from physical to digital formats, the risk of tampering, forgery, or unauthorized modification increases, especially if proper digital authentication mechanisms are not in place. The reliance on digital formats also necessitates trust in the technologies and platforms used. If these systems are not certified or compliant with national standards for digital records management, the legal admissibility and authenticity of digital documents may be questioned as highlighted by Khoo [7]. Moreover, the

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conventional method in the access and acquiring of documents had significant drawbacks and are insufficient to ensure security which were presented by the study of Mushtaq et al, [8].

The absence of clear protocols for validating digital documents carries a risk of misidentifying unofficial or falsified records as legitimate, which can affect government decision-making and service delivery. Several techniques were established to answer the falsified data in the web. Ahmad et al., [9] created a protocol using printed domain document with image hashing and public-Key cryptography that prevent forgery from occurring by manipulating credible data imprinted on the document. The algorithm is accessible on the web that he created. Furthermore, on the study of Senthil et al., [10] QR code and stenography were implemented for document authentication. It carried pros and cons in the quality of the image captured. It implemented online signature verification as added signature authentication which can be accessed through Adobe reader. It was suggested on the mentioned study that signature verification is a more dependable alternative for enhancing security measures beyond traditional means. It was also reveled by Liao and Liu [11] that document security based on PDF document signature is a safe and more secure option as it can be said to use signature online as an identity which can be verified by authorities. Given that the usage of online document signature verification was slowly being disseminated and were now taught to the government's relevant personnel. Those studies established a strong evidence that the issue with authenticity and falsification can be resolved if it is embedded in a system. The security and efficiency handling of authentication processes, from identity verification to document retrieval, stands to be revolutionized by IoT's capabilities for real-time data exchange. Zhong and Liang [12] noted that integration of internet of things (IOT) by using raspberry Pi is the best and effective vehicle in developing IOT in data management with security as presented in the study of microcontroller application in the emerging technologies.

Numerous studies have aimed to tackle the problem of storing and organizing data online. However, none of them have emphasized enhancing the infrastructure of barangay adopting automation in handling data. To address these issues, authors opted to create and application of IOT for Barangay Document Acquisition with Face Recognition Security, which aims to digitize the document acquiring process. This system can help residents acquire their documents conveniently and minimize person-to-person contact. Moreover, it can prevent the falsification of papers and add a modern technological twist to the Barangay Institution.

The goal of this research is to develop a standalone system which allows users to request digital documents even away from the government office through online transactions and public kiosk. The other objective of this research is to evaluate the performance of the system through its usability and latency. An analysis on system functionality was carried out based on the user experience performance evaluation

II. METHODOLOGY

This section is divided into two parts: the hardware and software components of the system.
The system development followed an iterative approach, involving requirements analysis, system design, and implementation and testing. User experience test was applied to ensure the system's usability and accessibility.

A. Hardware Part

The system was powered by Raspberry Pi 4, which served as the central processing unit and controller of the entire system design. With built-in features such as WIFI, printer port, Raspberry Pi camera port, and LCD port, it can function as a minicomputer to control all system components. The printer and LCD served as the system's output, while WIFI connectivity enabled access to the internet and database needed for the documents template and information of the resident/user.

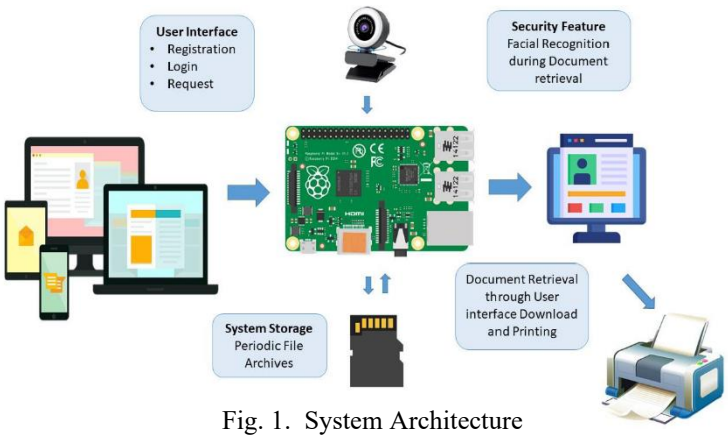

Fig. 1. System Architecture

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Figure 1 presented the architecture of the developed system. The components needed to operate the system were shown in the system architecture. The pi camera was inserted to its tailored port in the microcontroller. The Raspberry Pi Camera Module typically consumes approximately 250–300 mA at 5V, equating to about 1.25–1.5 watts during active use remarks by Upton et al., [13]. Based on the said standard there is no external power supply required to run the component. Additionally, the 7-inch LCD display operated at approximately 550 mA at 5V and was connected via both the USB and HDMI ports concurrently. Input to the system is facilitated by any device capable of opening a URL, allowing users to initiate registration or login processes. Document request queries are processed by the system through a validation mechanism that cross-checks the resident's profile information stored in the database adopted from the notes of Elmasri et al. [14]. To enable document printing in Raspberry Pi-based kiosk, Dalal et al., [15] integrated an embedded system for printer server that uses a printer compatible with CUPS (Common UNIX Printing System) allowing the system to handle user print requests effectively through standard UNIX-based printing protocols. This method will be used to operate the design. For increased storage capacity, an SD card was attached to the microcontroller.

B. Software Part

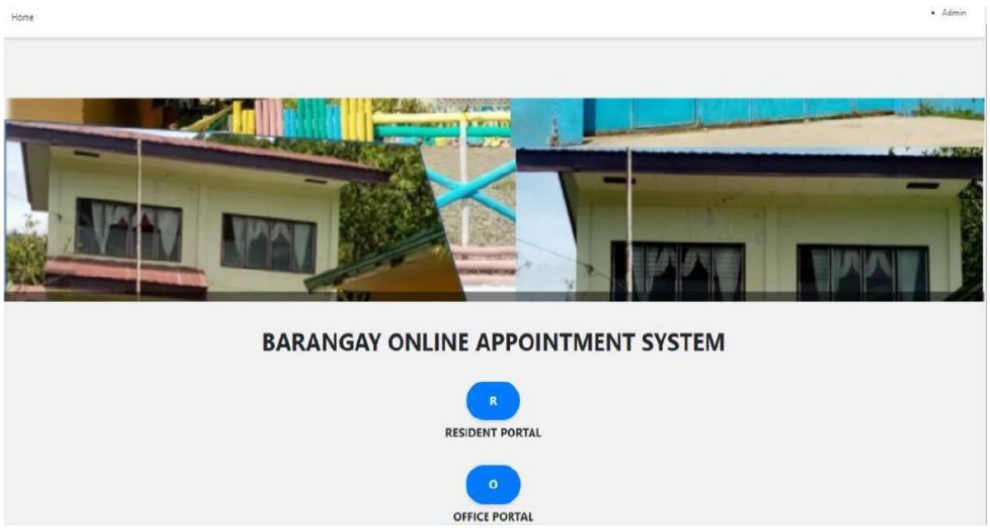

Fig. 2. System's User Interface

The system's user interface, as shown in figure 2, features two user access options. This dashboard becomes accessible after a successful user registration. It provides two distinct portals: one for residents, which allows users to request barangay documents, and another for barangay personnel, designated for those responsible for monitoring and managing the system's operations.

A. Indigency B. Clearance C. Residency

Fig. 3. Output Document Template

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Figure 3 displays a sample output document generated by the developed system, which users can request through the interface. The system supports three commonly requested barangay documents: Certificate of Indigency, Barangay

Clearance, and Certificate of Residency. These documents can be printed directly from the kiosk without requiring the physical presence of barangay officials. To ensure authenticity, each printed document includes a QR code that links to an online verification system, allowing users or authorities to confirm that the document originated from the official barangay database.

1) Flowchart of the System

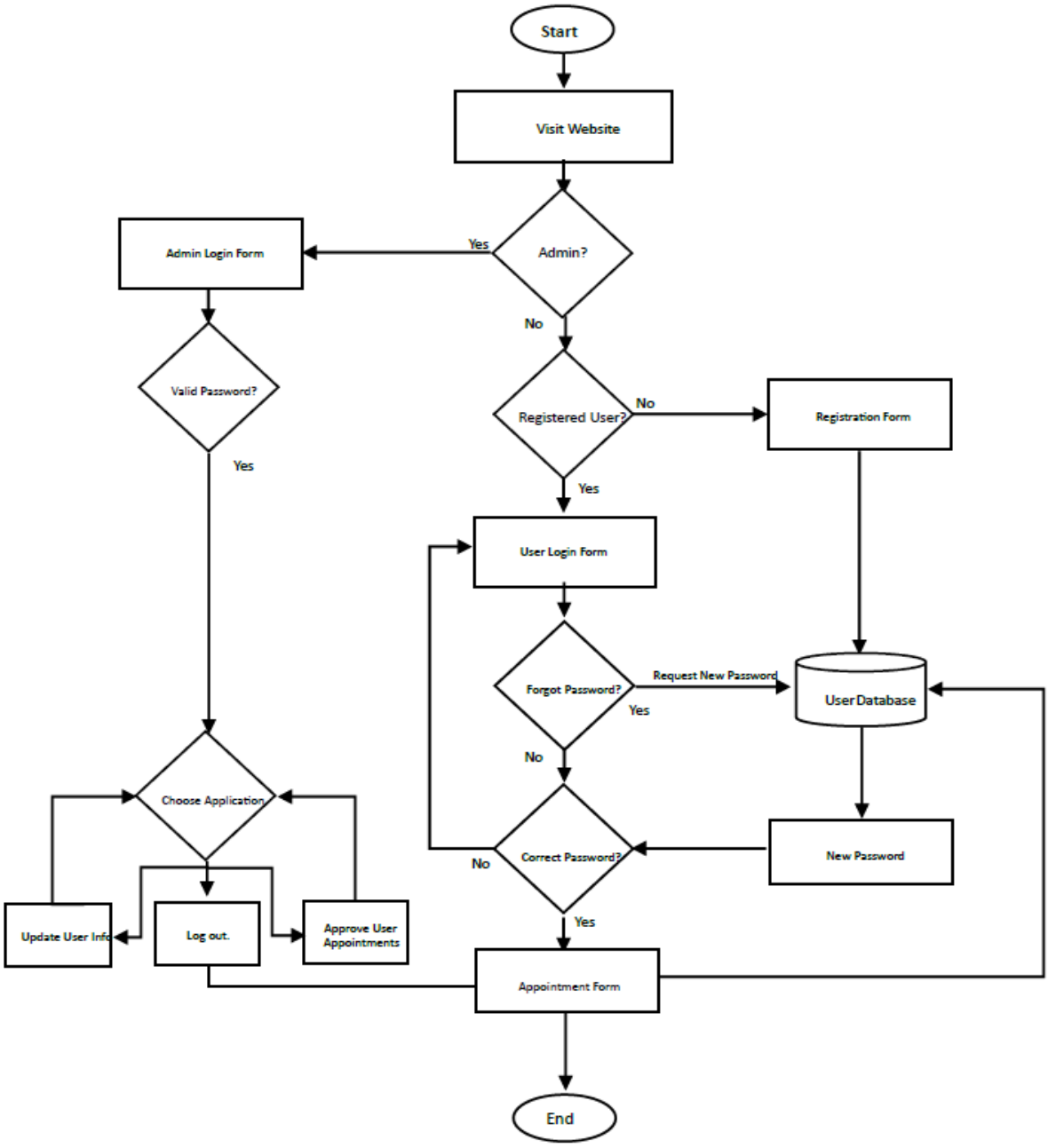

Fig. 4. Requesting Document Flowchart

There are two main protocols for acquiring online documents. The first involves requesting a document through the online registration process, as illustrated in Figure 4. This process begins with the user visiting the designated URL and entering the required information. The submitted data is stored in the database and undergoes verification through the

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system's data confirmation and monitoring procedures. Once the data is confirmed, the user can proceed to the next step. The second protocol pertains to the acquisition and printing of the document, which is detailed in Figure 4.

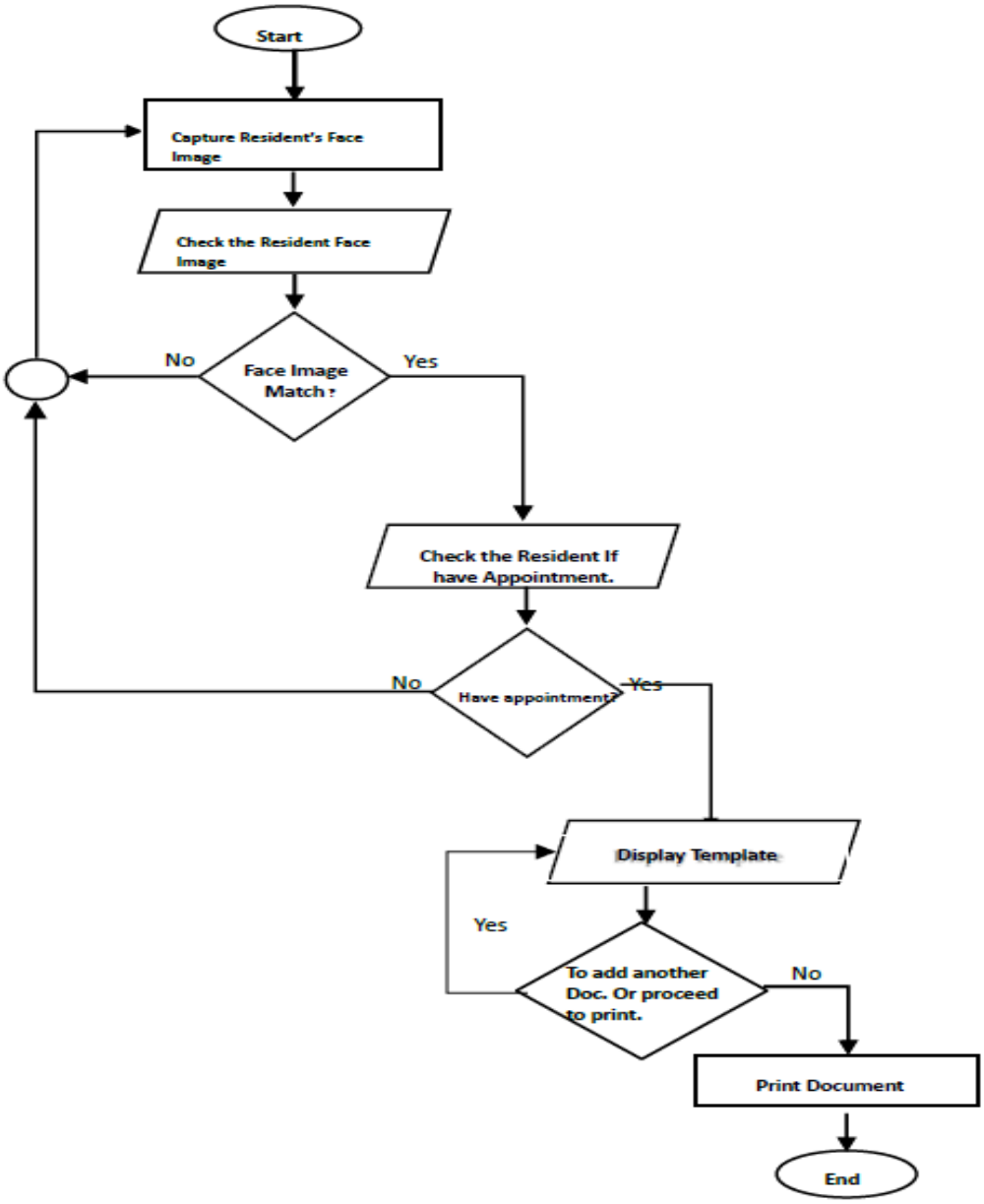

Fig. 5. Document Acquisition Flowchart

Figure 5 above illustrates the process of acquiring the document, which begins with accessing the URL secured by login data. When a print request is submitted, the device scans the user's image to verify if it matches a registered entry. Once a match is found, the system proceeds to check the user's appointment details. If confirmed, the document template is displayed on the LCD screen. The user can then review the document for accuracy, after which the option to print is presented for confirmation.

III. RESULTS AND DISCUSSION

A. Document Acquisition System

Table 1 below presents the response times of three different devices accessing the system's URL-based user interface. A compatibility test was conducted to evaluate the accessibility of the developed interface across three commonly used devices: a laptop running Windows 11, an Android smartphone, and an iPhone 11 Plus. Each device was

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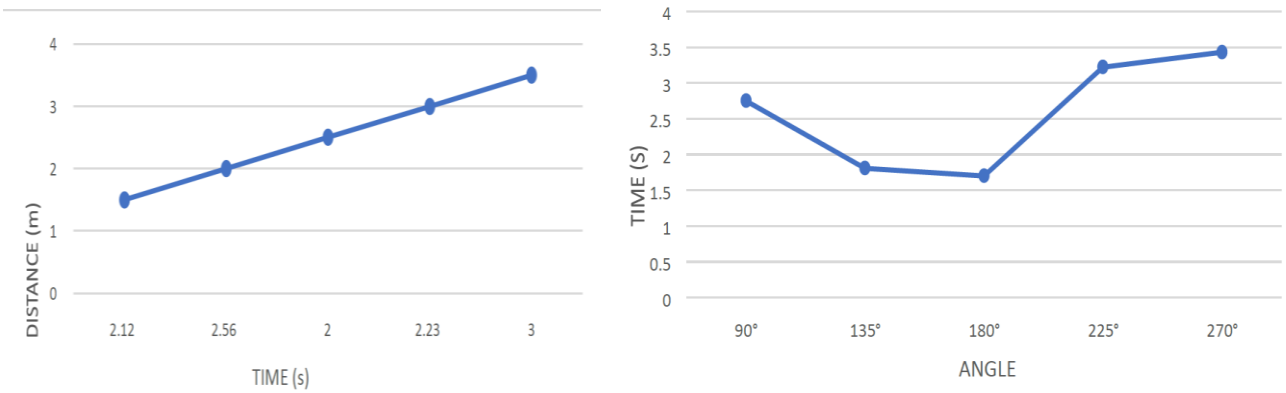
tested ten times at 2-minute intervals. The Windows 11 laptop recorded the shortest average response time at 1.2 seconds, with a maximum time of 1.6 seconds. The Android phone showed an average of 1.5 seconds, while the iPhone 11 Plus had the slowest average response time at 1.62 seconds. The fastest individual response, 0.8 seconds, was achieved on the Windows 11 laptop, whereas the longest response time, approximately 2.2 seconds, was recorded on the iPhone 11 Plus. All tests were carried out under stable internet conditions, with speeds ranging from 2.3 to 4.2 Mbps.

TABLE 1 SYSTEM INTERFACE ACCESSIBILITY

Trials	Windows-Laptop Access Time (s)	Andriod Phone Access Time (s)	iPhone Access Time (s)
1	1.2	1.5	1.4
2	0.8	1.2	1.5
3	0.9	1.3	1.1
4	1.2	1.3	1.8
5	1.3	1.9	2.2
6	1.3	1.4	1.8
7	1.6	1.8	2
8	1.2	1.4	1.4
9	1.2	1.8	1.5
10	1.3	1.4	1.5
Ave	1.2	1.5	1.62

B. System Performance

Smith et al [16] indicated that the distance and angle of the Raspberry Pi camera significantly influence acceptable system response time performance, as optimal proximity and alignment ensure clearer image capture and faster processing, while increased distance or improper angles lead to degraded accuracy and longer response delays. The Raspberry Pi Foundation [17] stablished a set of acceptable response time for a Raspberry Pi camera depending on application. In less time-sensitive applications like security monitoring or periodic image capture, response times can be longer - up to 1 second or more without significant impact.



(a) (b)

Fig.6. Pi Camera Performance (a) camera distance (b) camera angle

After a resident requests a barangay document, it can be printed through a self-service kiosk located within the barangay premises. Access to this document is secured via facial recognition, using a camera to verify the identity of the requesting resident. As shown in Figure 6.a, the system was tested for detection time relative to the user's distance from the camera. The results indicated that the accuracy of facial recognition was influenced by the user's distance, particularly

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after a 3-second focusing period. The system performed optimally at a distance of 2.5 meters, provided that both the angle and lighting conditions were ideal for face detection. For the camera angle placement, five angular positions—from 90° to 270° in 45° increments—were evaluated. The results indicate that the optimal mounting orientation is 180°, at which the system achieved the shortest detection response time of below 2 seconds. On the study of Ahn et al. [18] camera placement should minimize the angle of incidence—ideally within 0–15° of the subject's line of sight—to preserve facial detail and maximize recognition performance which aligns to the mounting orientation of 180°.

C. User Experience

The system undergone with user experience (UX) test to determine the functionality and overall user satisfaction. There were 43 participants randomly selected consisting of Computer Engineering and Computer Science students and professionals, barangay officials and personnel, and barangay residents. The test was composed of key factors that could affect the user satisfaction specifically the ease of navigation and robust interface. The test is adopted based on the applicable response time in the book of Nilsen [19] regarding usability engineering. It was stated that there were 3 limits in response time that were acceptable and tolerable by the user. The first limit was 0.1 second about the limit for having the user feel that the system was reacting instantaneously, meaning that no special feedback was necessary except to display the result. The second limit was 1.0 second was about the limit for the user's flow of thought to stay uninterrupted, even though the user will notice the delay. The third limit was 10 seconds was about the limit for keeping the user's attention focused on the dialogue. These three indicators were used in testing the user interface for the interface functionality.

The results collected from the user experience in table 1 were all within the acceptable response time of the adopted indicators having the slowest response time of 6.3 seconds, navigating the search bar, which was tolerable for keeping the user's attention. It was found out that clear and concise menu options, along with the prominent calls to action, guided users through the document acquisition process. The system's interface layout, label and tooltips enhance the understanding of system functionalities. The system's ability to recover from errors contributed to a positive response gaining a high levels of satisfaction with the Document Acquisition System. The majority perceived the developed system as a significant improvement over previous methods of document acquisition.

TABLE 2 SYSTEM INTERFACE FUNCTIONALITY

User Task	**User Access Average Time (s)**	**Remarks**
Locating Menu and Tabs	2.85	Acceptable
Comprehending menu and tab labels	3.1	Acceptable
Navigating Scroll bar and buttons	5.4	Acceptable
Search bar navigation	6.3	Acceptable
Notification pop-up for more than the maximum input character	3.9	Acceptable
Notification pop-up during multiple(continuous) input of buttons	3.4	Acceptable
Cancellation of error page	2.7	Acceptable

D. Comparison on traditional and developed IOT

In Philippine barangays, NewstoGov [20] clarified that standardized frontline services such as residency or good-moral certificates are typically released within the same day within 15 to 60 minutes using the traditional-manual document processing. Additionally, Under the Ease of Doing Business Act as posted by FOI.Phil [21], barangay-issued certificates of "no objection" must be completed within 3 working days for simple requests, or up to 7 days for those requiring additional verification. This information was supported by a case study of Dela Cruz et al.,[22] examining Barangay Sauyo, Quezon City and it was found that manual, single-window processing of multiple document types such as barangay clearances, IDs, residency, indigency, business permits, and cedulas led to frequent delays and bottlenecks reaching to several days due to both disorganized procedures and understaffing .

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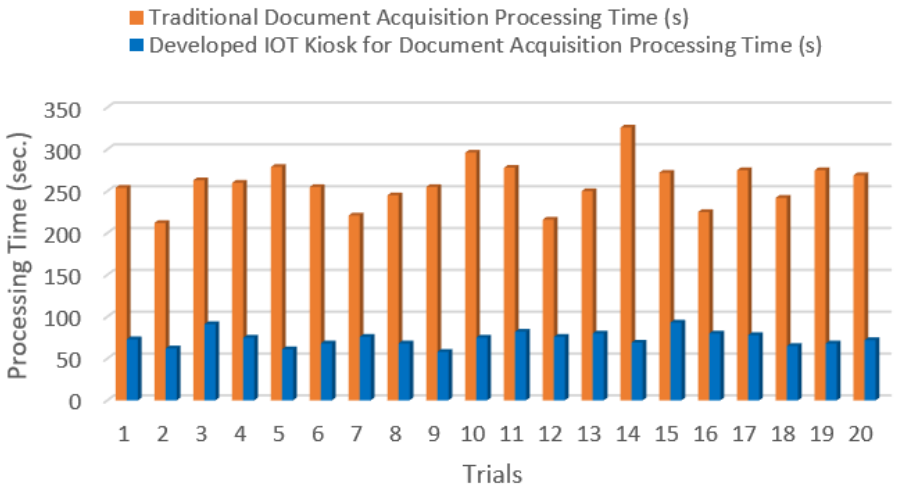

Fig.7. Comparison of Document Processing Time

Figure 7 illustrates the comparison between the traditional manual document acquisition process and the implementation of the developed IoT-based kiosk system for requesting barangay documents. The experimental trials measured the turnaround time starting from the user's login to the system up to the successful acquisition of a single document. In the traditional method, it was assumed that all necessary barangay personnel were available during the transaction. This method recorded an average processing time of 258.4 seconds (approximately 4.3 minutes), with the maximum time reaching 326 seconds. In contrast, the IoT kiosk significantly reduced processing times, with an average of 73.5 seconds (approximately 1.3 minutes) and a maximum of 82 seconds.

To assess the statistical significance of the observed difference in performance, a paired t-test was conducted. As shown in Table 3, the analysis revealed a p-value of less than 0.0001, indicating a statistically significant improvement. The standard error of the difference was calculated at 6.409, further supporting the system's efficiency. These results highlight the potential of digital transformation tools, such as IoT-integrated kiosks, to streamline local government services and reduce administrative delays [22].

TABLE 3 COMPARISON ON TURNAROUND TIME

Group	**Traditional Document Acquisition Processing Time (s)**	**Developed IOT Kiosk for Document Acquisition Processing Time (s)**	**p value**	**t**	**df**	**standard error of difference**
Mean	258.4	73.55	<0.0001	28.8405	19	6.409
SD	27.81	9.16				
SEM	6.22	2.05				
N	20	20				

IV CONCLUSION

This research has successfully demonstrated the application of IoT in streamlining document acquisition processes by developing a standalone system that enables users to request digital documents remotely through online platforms and public kiosks. The integration of IoT technologies facilitated seamless communication between users and government systems, reducing the need for physical presence and improving accessibility. Performance evaluation, focusing on usability and latency, showed that the system offers a user-friendly experience with efficient response times. Overall, the analysis of user experience validated the system's functionality and effectiveness, indicating that IoT can significantly enhance public service delivery in document management and acquisition.

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