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An AI-integrated IoT-based Self-Service Laundry Kiosk with Mobile Application

Kusrini [a,1], Alva Hendi Muhammad [a,2,*], Moch Farid Fauzi [a,3], Jeki Kuswanto [a,4], Bernadhed [a,5], Wiwi Widayani [a,6], Eko Pramono [a,7], Elik Hari Muktafin [a,8], Yossy Ariyanto [b,9]
[a] *Universitas Amikom Yogyakarta, Jl. Ring Road Utara Condongcatur, Sleman, 55281, Indonesia*
[b] *PT. Mataram Karya, Perumnas Condongcatur Depok, Sleman, 55283, Indonesia*
email: [1] kusrini@amikom.ac.id, [2] alva@amikom.com; [3] faridfauzi@amikom.ac.id; [4] jeki@amikom.ac.id; [5] bernadtagger@amikom.ac.id; [6] wiwi.w@amikom.ac.id; [7] eko.p@amikom.ac.id; [8] elixropas@gmail.com, [9] yossyariyanto16@gmail.com
* *Corresponding author*

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Abstract

This paper proposes KILAO, an IoT-based self-service laundry kiosk connected with a mobile application that aims to improve the laundry experience by improving user convenience and operational efficiency. This study aims to streamline the washing process using autonomous payment systems, real-time monitoring, and AI-based queue management, resulting in better resource utilization and higher user satisfaction. The development technique comprises identification and requirement gathering, development of both software and hardware prototypes, and evaluation of the prototype. In the requirement-gathering phase, the design of a kiosk machine that consists of hardware and software is defined by combining regular washing machines with IoT technologies for remote control and monitoring. We also developed a mobile application to engage with the kiosk machine. The kiosk simplifies the choice of laundry bundles and accepts various payment options, including cash, cashless transactions, and card-based purchases. The evaluation procedure of the prototype was conducted by using expert evaluations. They are from academics and industry professionals who verified the system's effectiveness and market potential. The results have shown several unique selling features for KILAO. Extensive payment options and self-service operations were highlighted from the customer's perspective as key benefits. From the seller's perspective, its interoperability with traditional washing machines enables a low-cost shift to intelligent, self-service operations, eliminating the need for pricey coin-operated machines. Also, the automatic monitoring system that detects cycle completion can reduce waiting times and improve energy efficiency. In summary, KILAO presents a significant advancement in laundry automation by integrating IoT and AI. Moreover, the Gradient boosting algorithm forecasts waiting times and gives real-time information on machine availability, removing the need for physical queueing. The research demonstrates that KILAO's capability to provide self-service laundry by providing a user-friendly mobile application can enhance user experience, operational efficiency, and energy utilization.

Keywords: Gradient Boosting; IoT; Laundry Automation; Self-Service Kiosk; Smart Laundry Kiosk.

Introduction

The Internet of Things (IoT) is an innovative technology that originated during the Information Age. The Internet of Things (IoT) has exceptional proficiency in capturing real-time data and facilitating seamless connectivity among various entities, including things and people [1], [2]. This technology enables the improvement of the cognitive ability to perceive, recognize, and handle diverse entities while simultaneously promoting environmental conservation through various methods of network access. The IoT functions as a pervasive digital infrastructure that encompasses and permeates our physical environment, with the primary objective being to establish intelligent services and environments that can be used in many living scenarios [3]. As illustrated in Figure 1, the technology facilitates the integration of various intelligent systems, sensing devices and sensors with the Internet, allowing for data transmission in real-time [4]. Consequently, it enables the implementation of intelligent identification, tracking, locating, and monitoring functionalities for these devices [5]. Furthermore, the Internet of Things includes a variety of sensors that facilitate the collection of dependable data in certain environments [6]. The characteristics of this entity encompass its capacity for adaptability, resilience in the face of errors, heightened level of consciousness, efficiency in terms of cost, strong ability to endure and recover from adverse conditions, and swift implementation [1], [7]. The IoT is utilized in a wide range of sectors, including but not limited to smart homes [5], [8], environmental and healthcare monitoring [3], [7], agriculture [9], smart cities [1], and numerous industries [10].

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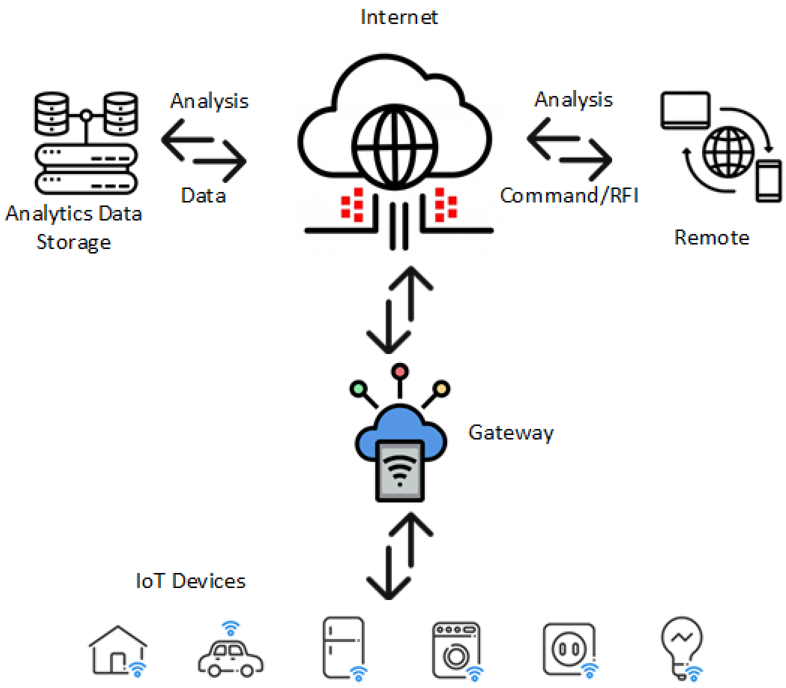


Figure 1. IoT General Architecture

This study investigated how the IoT can be utilized in our daily lives. People with high mobility in today's world often have trouble fitting everything into their schedules, which can lead to their laundry piling up and eventually becoming mildewed. Laundry has always been a significant time- and labor-consuming burden for household chores. Some tasks, such as washing, rinsing, spin-drying, and drying, are now performed by machines rather than humans, which requires resources such as water, energy, laundry soap, fabric softener, and processing time [11], [12]. As a result of the industrialization of laundry work, many businesses that are related to laundry and offer services and capitalize on the qualities of products have emerged as an alternative to doing laundry at home [13]. Laundry services, in particular, are essential in alleviating the stress of domestic tasks in metropolitan settings, which is particularly relevant given the subject matter of laundry. On the other hand, a growing number of people who have mobility issues are finding that they are unable to find the time to make regular trips to a washing service. In the midst of all of this, the laundry service industry is going through a transition that is being defined by ongoing market concentration and a dearth of labor that is reasonably priced [14]. As a direct consequence of this, innovative and effective automated solutions have emerged as a practical and efficient means of addressing these difficulties. In the hectic lives of those who juggle multiple duties, efficiency and practicality are two qualities that are quite essential.

The concept known as the self-laundry kiosk is a disruptive solution that is relevant in this context [15]. The introduction of laundry kiosks has brought about a paradigm shift, particularly for individuals who face challenges in allocating time for personal laundry tasks [16]. These kiosks serve the dual purpose of preventing the accumulation of moldy clothing and provide an intelligent notification system. Moreover, they obviate the necessity for manual sorting. This approach serves the dual purpose of prompting consumers to promptly retrieve their laundered items from the storage section of the kiosk while also obviating the necessity for users to undertake conventional visits to the washing facility. The laundry kiosk exemplifies the potential of the Internet of Things to transform and optimize everyday tasks, leading to enhanced manageability and efficiency in urban living [17], [18].

Self-service laundry machine research is a relatively new study area, particularly those connected with IoT technology. Numerous researchers have made substantial contributions to this topic, with several researchers doing crucial investigations. In [19], they introduced a laundry box equipped with a multifaceted sensor system encompassing three distinct sensor types: a color sensor, a weight sensor, and a humidity sensor. The primary purpose of these sensors is to enhance the efficiency and functionality of the laundry container. The color sensor is designed to detect the color of the garments placed within the laundry box. The humidity sensor serves as a tool for preventing the development of mold on the clothing due to elevated humidity levels. Simultaneously, the weight sensor is employed to gauge the weight of the laundry items within the container, measuring them in grams.

A mobile application for laundry developed by [20] could assist highly mobile customers, particularly those residing in urban areas, who contend with limited time availability for conventional laundry-related tasks. The proposed IoT-based Android application provides customers with notifications and obviates the necessity for manual intervention in the laundry process. Notably, the system employs the Naïve Bayes algorithm to determine the order of processing for garments. This algorithm considers several factors, including the weight, distance, and moisture levels of the clothing items designated for collection by laundry personnel, thereby establishing a prioritization system for laundry processing. The study focuses on the UX development of communal environments, revealing unusual usage models and unique features for multiple laundry users [21]. The study suggests that the computer-supported cooperative work model is not applicable to community products due to differences in user purposes. The author suggested a higher fidelity prototype to reflect users' potential needs. Even though the study aims to improve the UX environment in dormitories and community laundries, the study did not evaluate the system's usability and acceptability.

Another work by [12] introduced an innovative IoT automation system that uses smartphones to send immediate updates to all consumers about the operating state of laundry machines. A mobile phone is securely attached to the rear panel of either a washing machine or a dryer in the experiment, allowing it to record changes in the magnetic field remotely. A customized software program was created to collect and analyze data from the mobile phone's inbuilt sensors. This entailed using computational approaches to determine the device's operating state precisely, notably whether it was switched on or off. The current condition of each particular laundry machine is then uploaded to the cloud, where consumers can access it via specific mobile applications available on both Android and iOS.

Furthermore, we pose the following research questions in this paper:

1. How can we integrate traditional washing machines with IoT technology to enhance user experience and provide a cost-effective alternative to conventional laundry services?
2. How can real-time monitoring and notification systems be designed using IoT technology to reduce waiting times and improve user convenience in self-service laundry services?
3. What role can AI algorithms play in predicting machine availability and managing queues in self-service laundry systems to optimize the laundry process?

This paper aims to answer the above questions. We propose a prototype of a laundry kiosk named KILAO (Kiosk Laundry Self-Service-Based on AI and IoT) that works together with a mobile application. Moreover, the prototype addresses the identified shortcomings by providing a comprehensive solution that includes several payment methods to meet consumer preferences. IoT technology is utilized to monitor machine condition and cycle completion [22]. This will reduce waiting times and increase user convenience using notifications. AI utilization using Autoregressive Integrated Moving Average (ARIMA) can forecast machine availability and queue times, which helps reduce the need for queuing [23]. An evaluation was conducted by inviting experts since the final purpose is to release the final production of the prototype to the market. The evaluation revealed that the proposed approach provided a smart solution for both customers and sellers, especially in an urban setting. The mobile application helped customers with real-time information on machine availability. Thus, enabling instant booking and eliminating the need for physical queuing.

Method

The overall research methodology in this study, as indicated in **Figure 2**, is based on the design science research methodology (DSRM) as introduced in [24], [25]. The research begins with problem identification, defining the problem and its significance by conducting a literature review and understanding the traditional laundry business. Next, we define the objective of a solution through a design problem and the requirements for a solution. Following this, the design and development phase involves creating and refining an artifact, a kiosk laundry that comprises both hardware and software components. Since the primary goal is to forecast the availability of machines and oversee the queues at our self-service laundry, it is necessary to anticipate the duration of the washing cycle for multiple machines. Therefore, we analyze at predetermined intervals in order to dynamically forecast based on the IoT records between periods. Hence, this research utilizes Gradient Boosting to predict the waiting time from several machines.

Demonstration follows, where the artifact is implemented within the stakeholders of a group of laundry business owners in Yogyakarta. The users are interested in the way our solution optimizes and augments user transactions by simplifying and improving the overall user experience. Users are afforded the convenience of interaction through a mobile application or direct engagement with the machine itself. Finally, the evaluation phase uses mix measures to assess the artifact's performance against defined objectives. Since this study is still in its early stages, we have opted not to employ quantitative methods for evaluation. Instead, we will be utilizing qualitative methods and will seek the expertise of professionals for validation purposes. This is due to the study project's scope requirements. For this purpose, we invited experts to identify the prototype limitations and suggest areas for improvement. However, we will carry out the quantitative analysis and data collection in a later stage.

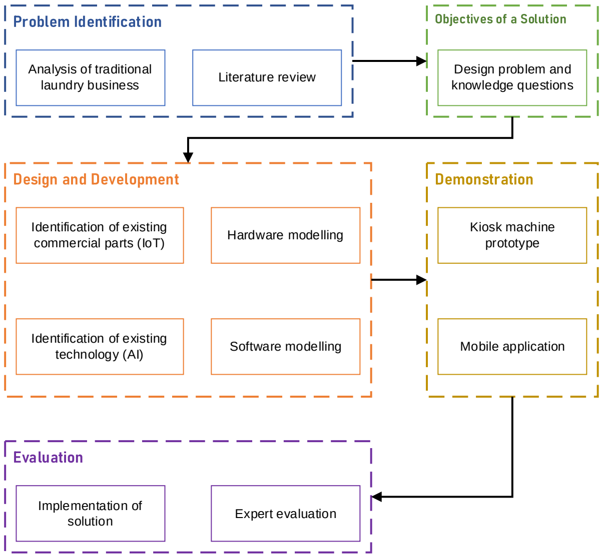


Figure 2. Systematic flowchart of research methodology

A. System Architecture

A system architecture is a schematic representation of a software system that provides a high-level overview of its structure, including the relationships, limitations, and divisions among its components [26]. It is an essential tool as it provides a thorough picture of the physical deployment and development roadmap of the software system [27]. As shown in Figure 3, KILAO represents an integrated system encompassing both hardware components, namely Kiosks and IoT-based Machine Controllers, as well as smart software applications that are developed for both Controllers and Users [8]. The improvement and facilitation of the self-service laundry sector are the fundamental purposes of this organization. There are a variety of unique features and technologies that are offered by the KILAO product. One of them is a Self-Service Machine or kiosk, which is designed to simplify user interactions, payment processing, receipt creation, and independent access to washing machines without the need for physical cashier intervention.

As shown in **Figure 3**, the key features of the proposed system are as follows:

a) ***IoT controller***. Functions to convert standard (non-coin) washing machines on the market into intelligent machines that can be controlled and monitored via the Internet of Things (IoT), allowing integration with the KILAO system.

b) ***Kiosk (Self-Service Machine)***. Allows users to make money transactions and use washing machines independently.

c) ***Hybrid payment***. Supports hybrid payments by cash, cashless (QRIS, E-Wallet, and Balance), and smart card (customer card).

d) ***User application***. Users may see washing machine availability, arrange bookings, and receive AI-based queue waiting time projections.

e) ***Operator/Admin Application***. Controls, monitors, and receives system-generated reports from a laundry business or several branches.

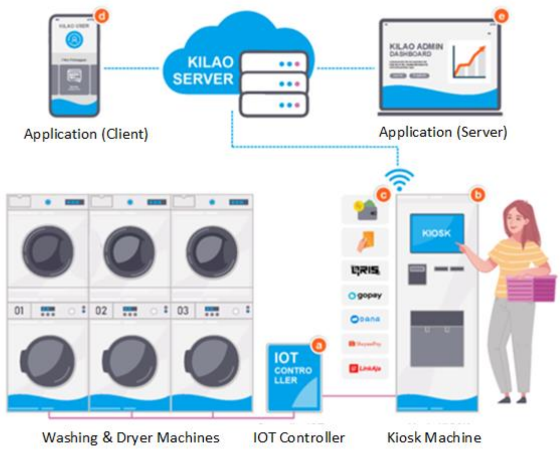


Figure 3. Structure of proposed system architecture

B. System Integration

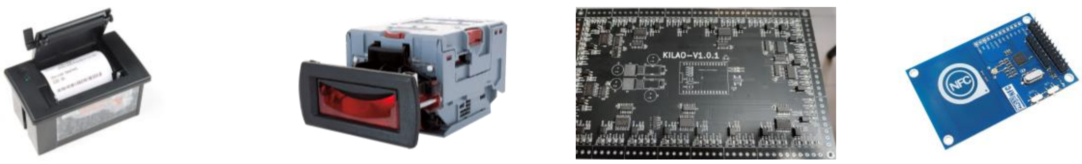
The integration of modern hardware components can change conventional washing machines into KILAO that are intelligent and oriented toward the needs of the user. Tablet Android, Thermal Printer, Bill Acceptor NV10, Microcontroller, and NFC Reader are the individual components that come together to form a KILAO (**Figure 4**). These hardware components are laying the groundwork for the next generation of intelligent washing solutions. KILAO features a Tablet Android, a user-friendly interface with the Android 11 operating system for seamless interactions. Then, a Thermal Printer generates efficient receipts, eliminating the need for ink and ensuring eco-friendliness. The Bill Acceptor NV10 is employed for currency recognition, ensuring the security and accuracy of the bills.

The IoT microcontroller drives the system's intelligence and automation, managing communication between the tablet, Thermal Printer, Bill Acceptor, and other peripherals. It also serves to establish connections between laundry machines and kiosks, thereby enabling remote monitoring and control of the operational status of these machines. Notably, the IoT microcontroller extends the applicability of regular, non-coin-operated washing machines to the domain of self-service laundry, rendering the initial capital expenditure more accessible. Lastly, the NFC Reader facilitates contactless transactions, allowing users to make payments and access machine functionalities by tapping their NFC-enabled devices.

Among the features mentioned above, the bill acceptor considers paramount significance as it serves the crucial purpose of discerning counterfeit currency. The appearance and functionality of each currency worldwide vary due to various factors [28]. Diverse characteristics such as size, color, pattern, and identification marks distinguish each currency. Advancements in scanning and printing imaging technology have facilitated the production of counterfeit banknotes, making the process more accessible and concurrently more challenging to detect. The primary objective of a currency recognition model is to enhance individuals' ability to identify counterfeit currency, thereby streamlining the process and reducing the associated time and effort. Additionally, the kiosk is equipped with a bill acceptor NV10 that can efficiently and accurately discern between counterfeit and authentic currency. The proposed solution effectively addresses the problem at hand.

A User Application is provided to enhance its functionality, offering smartphone-based functionality for end-users. This application empowers users to ascertain machine availability, make reservations, estimate waiting times, and effect cashless payments based on pre-loaded balances. The Owner/Admin Application is strategically designed to afford owners and administrators control and oversight for single laundry establishments or multi-branch laundry enterprises. Moreover, the system incorporates a Cashless Payment method supporting QRIS payments and balance top-ups [29], significantly enhancing the efficiency of transactions, particularly for frequent and returning customers.

The incorporation of AI technology within the application system represents a pioneering advancement, enabling the system to not only store transaction histories but also to discern and comprehend user-specific patterns of behavior. Consequently, the system can predict waiting times and intelligently recommend optimal laundry scheduling. The IoT technology embedded in both the Kiosk and the Washing Machine Controller facilitates automated interaction. Specifically, upon user-initiated self-service payment at the Kiosk, the system promptly activates a designated washing machine. Subsequently, it provides the user with the relevant machine number, thereby initiating the washing and drying process.



Thermal Printer Bill Acceptor NV10 Microcontroller NFC Reader

Figure 4. Main components of KILAO

In terms of payment options, users are presented with three choices: E-banking or E-wallet, utilization of the balance within the application or a customer card, and the option to add to their balance through a cash top-up mechanism. This comprehensive suite of features and technologies collectively positions KILAO as a transformative and technologically advanced solution for the optimization of self-service laundry operations.

C. System Flowchart

We developed a client application that provides a user-friendly interface for accessing laundry services in addition to the kiosk service. With the support of this application, customers can easily handle their laundry thanks to an easy connection between them and the washing machine. Because Android Studio was used to create both user interfaces, a unified and effective user experience across devices was guaranteed. The system flowchart, which shows the entire process flow, is shown in **Figure 5**. First, the user interacts with the kiosk by choosing a package and then moves on to the Payment stage.

Users may choose cash, digital payment methods, credit/debit cards, or other forms of currency to make their payment after selecting an option. The designated washing machine number will be shown to the user during the Display Information phase, initiated when the payment has been verified and properly processed. Afterward comes the Power Activation phase, where the system turns on the power of the chosen washing machine. Using the designated washing machine, the user loads and washes their clothes during the User Operation phase. At the same time, the Automatic Monitoring feature operates to monitor the washing machine's consumption histories and ensure maximum efficiency.

In order to ensure the proper functioning of the machine, a Completion Check is performed to determine when the washing cycle is finished. The system moves on to the next phase if the condition meets the criteria. Otherwise, it will continue to monitor. After a successful completion check, the system turns off the washing machine's power supply during the Power Deactivation phase. In the end, the system notifies the consumer when the washing machine's cycle finishes, thus ensuring a seamless and valuable laundry experience from beginning to end.

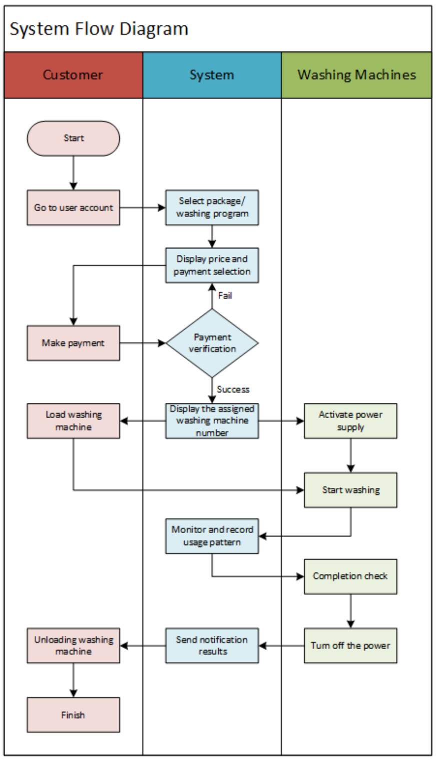


Figure 5. System flowchart

D. Gradient Boosting Model

Before we delve into the models, it is important to reframe the issue: Rather than predicting a continuous value, we predict the waiting time or the moment a machine becomes free. In order to accurately predict the time at which a machine will become available, it is necessary to examine various factors that may affect its availability. This research utilizes the Cycle Mode, Spin, and Completion Time. Cycle modes refer to the various settings available on a washing machine that determine how a load of laundry is washed. Moreover, the spin indicates the rotation in a washing machine in the final phase of the laundry process. Completion time itself shows the total times (in minutes) needed to finish a wash cycle.

Algorithm 1. Gradient boosting algorithm

1). Initialize model with a constant value:
Initialize $F_0(x) = \text{argmin}(\Sigma \text{ loss}(y_i, c))$ for i=1 to n

2). For m = 1 to M (number of boosting rounds):
1. Compute the negative gradient (residuals):
$r_i = -[\partial \text{ loss}(y_i, F(x_i)) / \partial F(x_i)]$ for i=1 to n

2. Fit a weak learner $h_m(x)$ to the residuals r_i:
$h_m(x) = \text{argmin}(\Sigma \text{ loss}(r_i, h(x_i)))$ for i=1 to n

3. Compute the multiplier (learning rate) γ_m:
$\gamma_m = \text{argmin}(\Sigma \text{ loss}(y_i, F_{m-1}(x_i) + \gamma * h_m(x_i)))$ for i=1 to n

4. Update the model:
$F_m(x) = F_{m-1}(x) + \gamma_m * h_m(x)$

3). Final model:
Output $F_m(x)$

Although the problem may be simplified by converting the data to a binary series, this approach may need to be more balanced with the prediction process and overlook critical nuances that could impact machine availability. Since the prediction is a numerical value (completion time), we consider implementing a regression technique. Regression models can analyze the relationship between variables and make predictions based on that relationship. Among many other regression models, this study applies the Gradient Boosting algorithm. Gradient boosting is an ensemble learning technique that builds a model iteratively, starting with an initial model like a decision tree or linear regression [30], [31]. Subsequent models are trained to predict the residuals of the previous model, and the final prediction is formed. The algorithm uses gradient descent optimization to calculate the gradient of the loss function and update model parameters to minimize loss. Decision trees are commonly used as base learners, but other models can also be used. It should be noted that this approach is a heuristic, so it produces an approximation rather than an exact solution to the given problem. The generic gradient boosting method can be described using algorithm 1.

Results and Discussion

A. KILAO Kiosk Deployment

The final prototype of the KILAO kiosk machine is presented in **Figure 6**. The IoT technology integrated into the system facilitates seamless and automatic interactions between various devices. For instance, when a user completes a payment transaction at the Kiosk, the system promptly displays the machine number corresponding to the user's selection and activates the selected washing machine. This feature ensures that users can proceed with a single washing and drying cycle with minimal delays. Furthermore, sensors are in place to detect when a washing machine has completed its cycle and to automatically power it down, optimizing resource usage and overall operational efficiency.

Figure 6. Final Prototype of KILAO Kiosk Machine

The operational sequence for employing the KILAO product entails several key steps. Users initiate the process by engaging with the Kiosk machine, where they have the option to select from a range of available laundry packages (**Figure 7**). Payment can be conducted autonomously using various methods, including cash, cashless transactions, or card-based payments (**Figure 8**). Additionally, the device includes an autonomous monitoring mechanism that continuously observes trends in washing machine usage. It can detect when a washing machine's cycle is complete and deactivate the unit accordingly. This functionality not only improves the user experience by reducing wait times, but it also helps to optimize the use of energy resources inside the self-service laundry system.

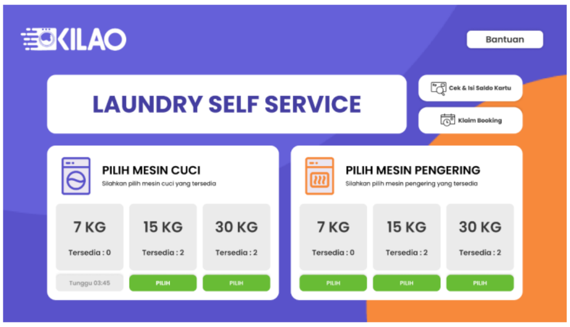


Figure 7. The Selection Process

Figure 8. Payment Selection

B. Mobile System Deployment

The mobile application provides users with essential information related to the availability of washing machines, the ability to schedule bookings, and the utilization of AI-based algorithms for forecasting queue waiting times. This particular application is designated for use by Operators and Administrators and is instrumental in overseeing, monitoring, and receiving comprehensive reports generated by the system. These reports could originate from either a single laundry facility or be aggregated from multiple branches within a network. The integration of AI technology within the system is particularly noteworthy as it empowers the system to archive transaction histories and recognize patterns in user behavior. Consequently, the system is able to forecast waiting durations with a significant level of precision and suggest ideal timetables for user arrivals.

Users can use their respective Android applications to monitor the process, as illustrated in Figure 9. When users have this information at their disposal, they are able to promptly begin the process of doing their laundry by loading their garments into the appropriate washing machine. After a transaction has been completed successfully, the Kiosk device notifies users of the identifying number of the washing machine that has been assigned to them while simultaneously turning on the power supply to the appliance that they have chosen.

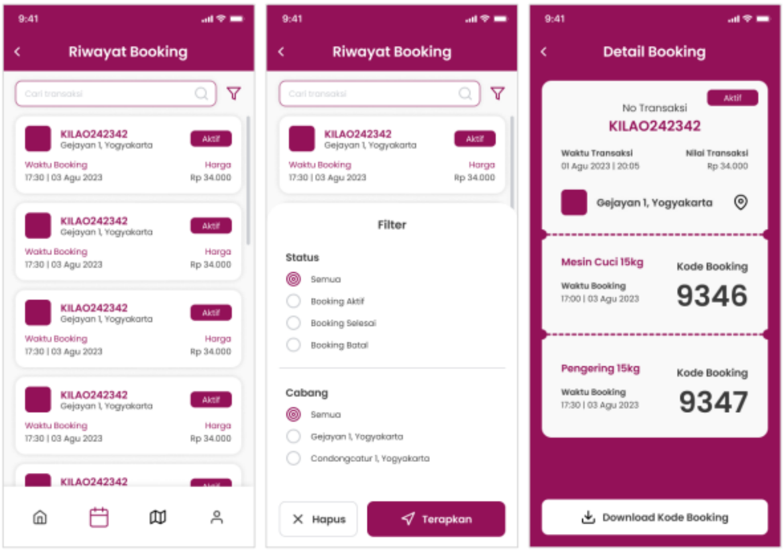
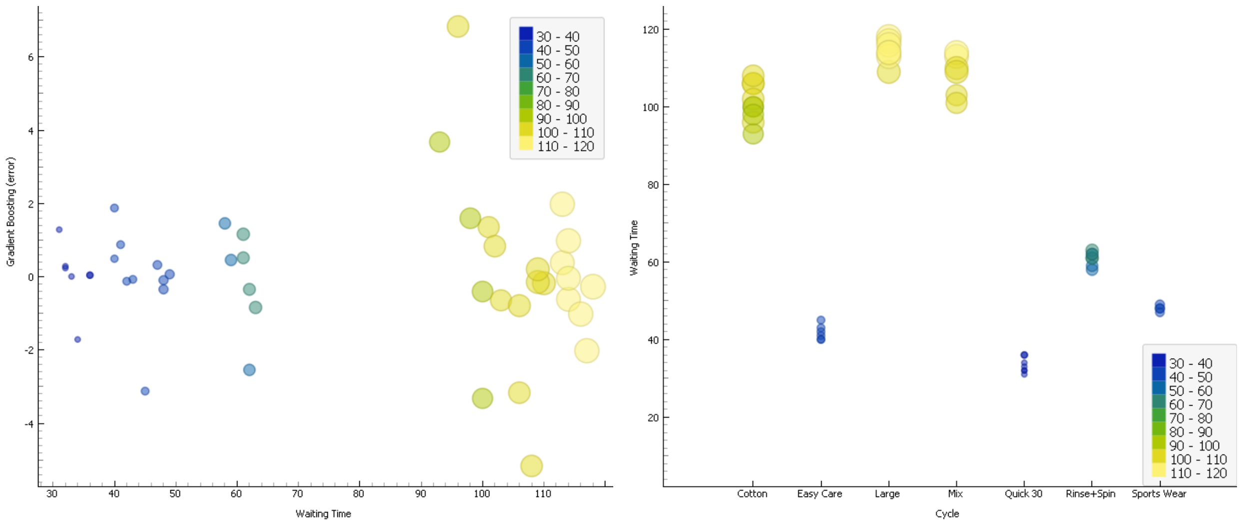


Figure 9. Mobile Application Interface

C. *Simulation Results*

After selecting the Gradient Boosting algorithm, we conducted simulations to evaluate the model's performance by comparing the actual outcomes with the predicted values. The dataset used for this simulation consists of 46 observational records collected from four different machines. Each machine has unique ID and operates under various cycle modes and spin configurations. We tracked the completion time for each washing cycle and leveraged historical data to predict the waiting time for each machine. By comparing the actual and predicted cycle completion times, we assessed the efficiency of the machines under different operating conditions. Figure 10 provides a visual representation of these results. Figure 10 (A) highlights the discrepancies and accuracies in the waiting time predictions. Additionally, Figure 10 (B) allows us to understand the performance consistency of Gradient Boosting algorithm's effectiveness in modeling such time-dependent processes according to various cycle modes.



(A) (B)

Figure 10. Performance of the Model

Since the nature of the problem is regression, metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and R-squared are selected over classification metrics (confusion matrix). **Table 1** shows a performance evaluation of the proposed approach based on the 5-fold CV procedure using the provided dataset. The model shows exceptional performance in all evaluation metrics. Its low MSE of 3.380 indicates better predictions, while its RMSE of 1.838 indicates small predictions. The MAE of 1.173 indicates that average predictions deviate from actual values by 1.173 units. The MAPE of 0.016 indicates high accuracy, with an average percentage error of only 1.6%. The R-squared value of 0.997 shows a strong relationship between predictors and outcomes. Overall, the model's performance is outstanding, suggesting its suitability for making reliable predictions.

Table 1. Evaluation Metrics Results

Model	MSE	RMSE	MAE	MAPE	R^2
Gradient boosting	3.380	1.838	1.173	0.016	0.997

D. Experts Evaluation

We employ expert review for evaluation during this phase because of funding concerns and ethical considerations. Expert review is a scientific and rigorous examination process used to determine the quality and validity of research results [32]. Expert knowledge is a valuable source of information that may be used to generate empirical data by translating the expert's opinion and evaluating the results [33], [34]. The evaluation in this project includes three specialists, two of whom are academicians from Indonesian universities and the other a professional from the laundry business association. The first expert was chosen for their experience in IoT and embedded devices. The second expert was chosen for their knowledge of business development and product value creation. The final expert is chosen based on their knowledge of laundry company services in Indonesia.

During the evaluation process, the experts received a briefing on the evaluation's important points. We conducted qualitative interviews for an in-depth exploration of the prototype. However, we focused on the evaluation of the prototype from two perspectives [35]: internal value and external value. Internal value is measured from the standpoint of stakeholders, and value is defined as profit. The external value comes from the customer's perspective, and value is defined as their satisfaction.

Table 2. Experts Assessment Related to the Prototype

	Expert 1	Expert 2	Expert 3
Internal value	The number of machines capable of communicating with the kiosk should be flexible.	Information displays in mobile applications need to be accurate and easy to understand.	The size of the kiosk should be smaller for efficient use in the limited area.
External value	The customer must be able to communicate with the system via the Android and iOS platforms.	The kiosk needs to provide additional information about the analytics transaction data.	Focus on supplying high-quality products at a cheap cost. Furthermore, the company might consider not only selling but also leasing products with warranties.

Moreover, a detailed breakdown of the specific feedback from each reviewer is outlined in **Table 2**. All experts provided positive feedback regarding the current features, particularly praising the application's capability to monitor and forecast queues. Comparing KILAO's product to other available options on the market, it offers a Unique Selling Proposition (USP) [36]. They agree that the distinctiveness is mainly caused by a few important characteristics:

1. It makes use of IoT technology to enable integration with commercially available traditional washing machines. These integrated machines can easily replace pricey coin-operated washing machines when used in self-service laundry facilities. This change expands the range of services available to users while simultaneously saving money.
2. KILAO supports a wide range of payment options, all of which may be made using a single device. These options include card payments, cash, cashless transactions, prepaid balances, and cash. By doing away with real money, this invention streamlines the customer experience and increases customer convenience. The operators of laundry facilities can also access real-time financial reports through this complete payment platform, enabling effective financial management.
3. The prototype also includes a user application supported by AI technology. Customers can benefit from this application's insights into machine availability, booking capabilities, and the use of predictive analytics to determine waiting times, which eliminates the need for physical queuing. KILAO streamlines laundry administration, improves user experiences, and stands out as a cutting-edge market solution by including these several advantages.

Conclusion

This paper introduces KILAO, an innovative self-laundry kiosk machine integrating Internet of Things (IoT) capabilities. We also developed a mobile application that offers customers the necessary information about washing machines, simplifying the scheduling of appointments. We also use artificial intelligence to predict waiting times in queues. The system was created specifically to provide seamless interactions between operators and administrators while optimizing resource use. The Kiosk machine enables consumers to choose from various laundry bundles and make payments independently through cash, cashless transactions, or card-based purchases. After the payment is successfully made, the machine will display the user's identity and start the chosen washing machine. KILAO also includes an automated monitoring system that recognizes when a washing machine is finished with its cycle, thus minimizing waiting times and improving energy usage. KILAO's unique selling point is its seamless integration with widely available traditional washing machines. The user application offers details on machine availability, booking functionality, and predictive analytics, therefore minimizing the necessity of physical waiting in line.

The potential future research will look into various crucial areas that could improve the capabilities of the laundry machine kiosk. Predictive maintenance with artificial intelligence will focus on the prediction of machine problems and the automation of maintenance programs, and thus minimizing periods of inactivity. Also, artificial intelligence can be employed to enhance energy consumption through implementing intelligent management systems, which are essential for optimizing operations. In addition, the investigation will emphasize sustainability by working on optimizing water usage and biodegradable detergents. Furthermore, we will enhance the user experience by offering insights into user preferences and areas of dissatisfaction, which will inform the development of more intuitive interfaces. Integrating with other smart home gadgets will also create a seamless experience. In addition, the implementation of voice-activated commands and natural language processing has the potential to enhance accessibility and user interaction. Ultimately, it will be essential to guarantee the ability to handle increased demands and maintain consistent performance in various settings to achieve wider acceptance.

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