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Implementation of Finite State Automata on Pizza Vending Machine System

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ABSTRACT

This study aims to implement Finite State Automata (FSA) on a pizza machine. FSA is a theoretical computational model used to describe the behavior of a system that can change discretely from one state to another. A pizza machine is a machine used to make pizza automatically. In this study, we design and implement FSA on a pizza machine to regulate the pizza making process. FSA consists of a number of states and transitions between those states. Each state represents a certain stage in the pizza making process, such as adding ingredients, mixing dough, and baking. The programming language and algorithm used are appropriate for implementing FSA on a pizza machine. When the machine is turned on, it will start in the initial state. Then, based on the input given, the machine will switch between different states according to the specified transition rules. By implementing FSA, this study successfully automated the pizza making process on the machine. This reduces dependence on human intervention and increases production efficiency. By using FSA, the pizza machine can operate automatically and produce pizza with high accuracy and efficiency. This study contributes to the development of automation in the food industry and improves the understanding of how to apply FSA in the context of real-world applications. In this study, FSA is used to control a muffin machine, but the FSA concept can also be used in various other automation applications.

Keywords : *Finite State Automata; Pizza Machine; Prototyping Method*

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1. INTRODUCTION

Pizza is a contemporary food that is very popular with the public, especially in big cities in Indonesia. Based on this, there was an increase in pizza sales in several branches in Indonesia which resulted in a lack of efficiency in ordering at several outlets in each branch. Which is caused by high purchases by the public. Therefore, to overcome this inefficiency, the researcher plans to develop an automatic Vending Machine system.

This research aims to implement Finite State Automata (FSA) on a pizza machine where there are 6 variants namely cheese pizza, meat pizza, mushroom pizza, chocolate pizza, egg pizza and wine pizza. The results of this study show that FSA is effective in organizing workflows on pizza machines, reducing the need for human intervention, and increasing production efficiency. This research contributes to the development of automation in the food industry and broadens the understanding of FSA implementation in the context of real-world applications.

Finite State Automata is not a physical machine but a mathematical model of a system that accepts discrete inputs and outputs (Ririn Suharsih, 2019). In this study, we designed and implemented an FSA on a pizza machine to manage the pizza making process. The FSA consists of a number of states and transitions between those states. Each state represents a specific stage in the pizza making process, such as ingredient addition, dough mixing, and baking. We use a programming language and a suitable algorithm to implement the FSA on a pizza machine. When the machine is turned on, the machine will start in the initial state. Then, based on the given input, the machine will

switch between different states according to the specified transition rules. By using FSA, we managed to automate the pizza making process on the machine.

Vending Machine is a sales machine that will issue the results of goods or a product which after the buyer puts some money into the existing machine box (Wicaksono et al., 2019). Finite State Automata (FSA) or Finite State Machine (FSM) is a mathematical modeling which receives input and then produces output where this machine has a limited number of states and can move from one condition to another based on inputs and transitions. FSA has a set of states that can produce decisions. Each state can switch from one state to another if it meets the conditions that have previously been defined. The working principle of FSA is as follows:

1. Accepts the input string.
2. Reads or scans the initial character substring with controls according to the initial conditions.
3. Uses the control and the scanned start character is moved to the new state.
4. This process continues until all strings are scanned or read.

If the last state is in the set of predefined end states, then the string is accepted or recognized last state is in the set of predefined end states then the string is accepted or recognized by the FSA. Otherwise, the string is rejected or not recognized by the FSA. By applying the concept of Finite State Automata (FSA), it can make an automatic pizza machine have output results according to the input from the user.

2. LITERATURE REVIEW

The implementation of Finite State Automata (FSA) in vending machine systems has been extensively studied, with emerging applications in food automation. Below is a structured literature review analyzing existing research and technological implementations relevant to pizza vending machines.

2.1. Theoretical Foundations of FSA in Vending Systems

Finite State Automata provide a robust framework for modeling discrete state transitions in automated systems. Key studies demonstrate:

1. Basic operational logic: FSA effectively manages sequential processes like item selection, payment validation, and product dispensing through defined states (idle, selection, payment, dispensing).
2. Error handling: FSA enables systematic responses to scenarios like insufficient funds, out-of-stock items, or payment timeouts by reverting to previous states or triggering alerts .
3. Multi-product management: Researchers have implemented FSA in vending machines with diverse menus by assigning unique states to each product category, as seen in snack and traditional meal dispensers.

2.2. Case Studies in Food-Based Vending Machines

1. Non-Pizza Food Applications
   Yoghurt vending machines: A 2019 study simulated an FSA-driven system for a yoghurt dispenser, using states to manage user input validation, payment processing, and inventory updates.
2. Pizza-Specific Implementations
   While no studies explicitly document FSA in pizza vending machines, PizzaForno's operational framework (2024) aligns with FSA principles:

State-like processes: The system transitions through (refrigeration), selection, cooking, and dispensing phases, managed by sensors and automated controls.
Inventory management: A FIFO (First-In, First-Out) system tracks stock levels and expiration dates, analogous to FSA's state transition rules.
Payment integration: User interactions via touchscreen interfaces and payment gateways mirror FSA's input-response mechanisms.

2.3. Methodological Approaches

1. Simulation-based design: Studies frequently use FSA modeling tools to simulate vending workflows before hardware implementation, reducing development errors.
2. Modular state partitioning: Complex systems (e.g., multi-ingredient pizza machines) benefit from dividing operations into substates, such as crust selection, topping customization, and baking duration adjustments.
3. FPGA integration: Field-Programmable Gate Arrays (FPGAs) paired with FSA logic enable real-time responsiveness in vending systems, as demonstrated in generic beverage machines.

3. METHOD

The method used in this statement is the prototyping method, which is used in the process of analyzing how the pizza making machine works and designing the simulation application of this machine.

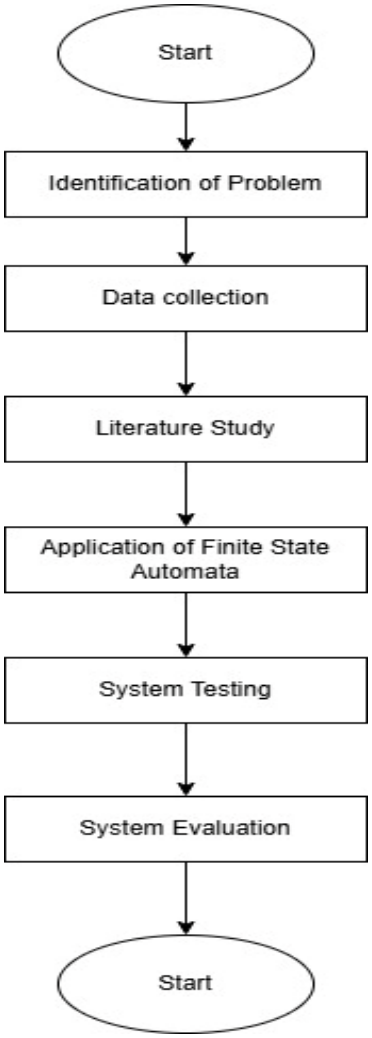

Figure 1. Method

3.1. Prototyping

Prototyping is the process of creating a prototype of a specific software application prototyping denotes as an aspect of the application that is not necessarily exactly the same as the final result. This method is usually used in developing applications where the requirements specifications are incomplete or not clearly known (Kaunang, 2019). Figure 1 shows the stages carried out in the prototyping method in this study, namely:

1. Communication, namely being able to collect data for research needs in communication, where the data needed is data that is a requiment of research.
2. Quick plan, namely being able to plan what you want to do according to the requiments that have been collected.
3. Fast Design Modeling is to do the design needed in a study and can be the basis for making prototypes.
4. Prototype Construction, which can develop prototypes in accordance with the design.
5. Delivery and Development Feedback, namely being able to evaluate the prototype design, whether it is as intended or not.

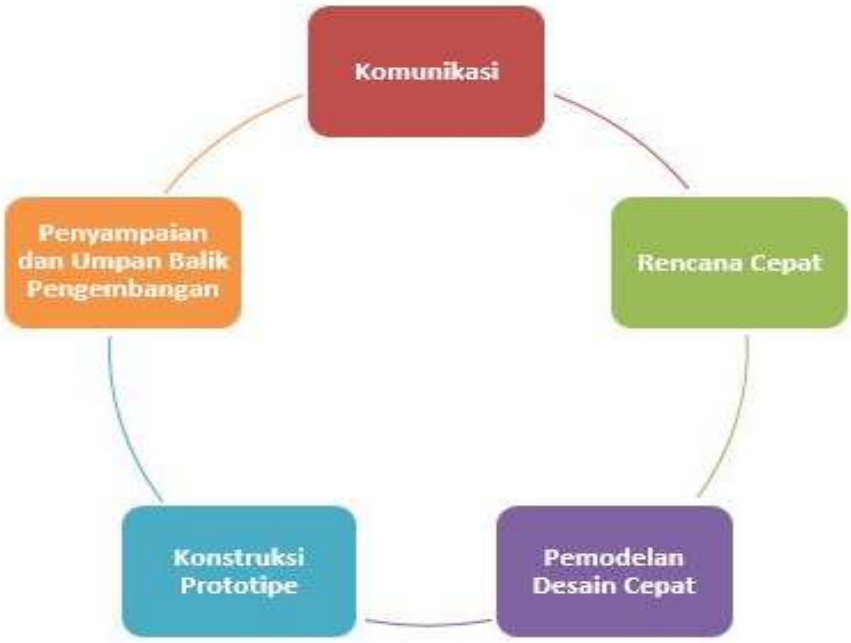

Figure 2. Prototyping Model

3.2. Formal Specifications

Formal specifications are specifications described in the form of a language that is formally described to describe what must be done in the software. In this study using model-oriented formal specification techniques by creating a model using mathematical objects such as sets and sequences.

3.3. Implementation

After the formal specification step is ready, the next step is to implement the formal specifications that have been determined previously. In the automatic pizza making machine simulation application, the FSA concept is applied to model the pizza making process automatically, where the formal specifications are implemented into a program that applies the FSA concept.

4. RESULTS AND DISCUSSION

4.1 Finite State Automata

The concept used in this research uses FSA to read and recognize the model in the pizza automatic machine operation, namely by processing the input given and then processing it into the input checking operation until the last state will then carry out the process according to the input path. The FSA that will be used is Non-Deterministic Finite State Automata (NFA). This concept will recognize the input symbol ordered from the initial state to the final state to the process which consists of state components, alphabet, transition, initial state and final state or defined by five tuples, the formula is as follows: $M = (Q, \sum, \delta, S, F)$.

4.2 Implementation User Interface

The design and flow will be explained as follows:

Figure 3. FSA Chart of Vending Machine

The display above is an image of the FSA graph of the Pizza Vending Machine System.

Figure 4. Vending Machine first page

On the main display of this vending machine, you will see a prominent logo of the vending machine brand. This is accompanied by the attention-grabbing words “Welcome to Pizzaria Vending Machine for Rp.15000 Only”. Not only that, there is also a “Start” button that invites you to explore the next view. The distinctive brand logo and catchy welcome phrase give users a fun and challenging impression to start their adventure with this Vending Machine. By pressing the “Start” button, you will be directed to the next display that will open up to the Vending Machine's ordering page.

Figure 5. Ordering Page

In Figure 4 of this Vending Machine, you will see a logo located in the upper left corner. At the top, there is a sentence inviting you to order Pizza. Then, below that, you are asked to enter your name as a visitor. After that, there are various Pizza options that you can choose from by checking the box that matches your choice, such as Cheese Pizza, Meat Pizza, Mushroom Pizza, Chocolate Pizza, Egg Pizza, and Wine Pizza. At the bottom center of the display, there is a "Select" button that directs you to the next page to continue the payment process.

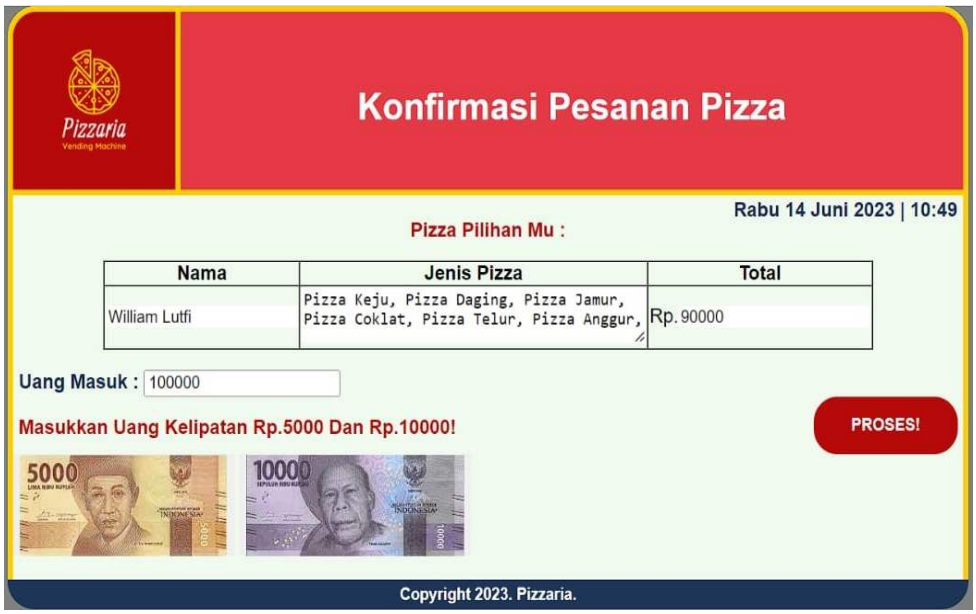

Figure 6. Confirmation and Payment Page

In Figure 5 of this Vending Machine system, you will see a logo located at the top left corner. At the top, the words "Confirm Pizza Order" indicate that this is the step to confirm your order. Underneath, there is a table that displays the name of the orderer, the type of Pizza selected, and the total price to be paid based on the selections you have made in the previous view. This table gives a clear picture of the order you have made. Furthermore, below the table, it displays the amount of money that has been inserted into the Vending Machine according to the amount that has been ordered in the previous view. This amount should correspond to multiples of Rp.5000 and Rp.10000 for each selected Pizaa price and money that can be inserted into the Vending Machine. For example, if the total price is Rp 90,000, then 9 notes of Rp 10000 must be inserted.

On the center right of the display, there is a "Process" button that will process whether your order is correct. Once you press the button, you will be redirected to the next page that will continue the pizza ordering and delivery process. With this structured and clear display, Vending Machine ensures that every step of your order can be processed accurately and efficiently.

Figure 7. Receipt Page

In Figure 7 of this Vending Machine system, you will see a logo located at the top left corner. Above it, the words “Pizzaria Receipt” indicate that this is the step to print your order receipt. Below that, there is a table with the details of your order from the previous step. This table contains information about the orderer's name, the type of Pizza selected, and the total price to be paid. Furthermore, below the table, there will be the amount of money that has been inserted into the Vending Machine according to the order that you have selected earlier. This information confirms that your payment is in accordance with the given order.

At the bottom center of the display, there is the phrase “Please pick up your pizza under the machine”, which directs you to pick up the pizza you have ordered. This indicates that your order is ready to be picked up and enjoyed. There is also a button that directs you to the next page to print the receipt. By pressing the button, you can print the receipt as proof of your order. With this complete and clear display as shown in Figure 8 below, the Vending Machine provides a practical and organized experience in the process of ordering and picking up pizza.

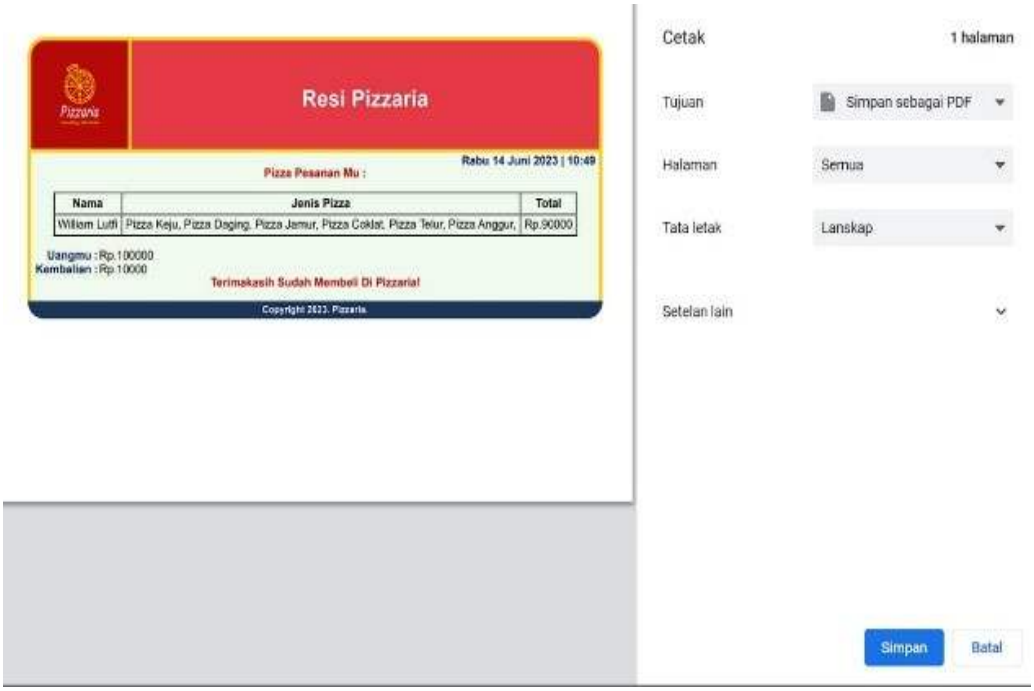

Figure 8. Receipt Printout

5. CONCLUSION

Based on the research results along with the analysis of the Finite State Automata (FSA) explanation on the automatic pizza machine, it is concluded that the Finite State Automata (FSA) effectively organizes the workflow on the pizza machine, reduces the need for human intervention and improves production efficiency. In this study, FSA is implemented on a pizza machine to automate the pizza production process. FSA is used to describe system behavior that can change discretely from one state to another. Each state in the FSA represents a specific phase in the pizza making process, such as adding ingredients, mixing dough, and baking. The pizza machine switches between different states based on given inputs and according to defined transition rules.

By implementing FSA, this research successfully automates the pizza-making process on the machine. This reduces reliance on human intervention and improves production efficiency. By using FSA, the pizza machine can operate automatically and produce pizza with high accuracy and efficiency. This research contributes to the development of automation in the food industry and increases the understanding of how to apply FSA in the context of real-world applications. In this research, FSA is used to control a muffin machine, but the FSA concept can also be used in various other automation applications.

Suggestions for further research from this research are that in 1 item of purchase you can only taste one flavor in this automatic pizza machine, and also for the future, hopefully this machine has a process if we buy only 1 item but we can process or add various flavors of toppings in it.

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