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Design of vending machine through implementation of visual automata simulator and finite state machine

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Abstract
Automation which in plural terms is defined as automata is a device which works by itself. The Automata theory is studied under the fields of computer science and discrete mathematics. It is the study of the abstract machine in theoretical computer science. It is developed in such a way that is automatically follows a sequence of operation which is predetermined/already decided. The word automata comes from the Greek word αὐτόματα, which meaning "self-making". The statement mentioned in the end results to a conclusion that it automatically processes the development of a particular work. One of the application of Automata Machine is in Vending Machine. Automata principle is widely being used in lots of programs advanced from the idea of Finite State Machine (FSM). This study will consider the layout of Vending machine (Vending Machine), which improves the note book providing facility within the campus, illustrated with the aid of using an application. An efficiency of Vending Machine is taken into consideration as a problem. Automata principle is employed in the layout of the Finite State Machine to improve performance, and visual automata simulator (VAS) is used as a way. Finally, the study will propose a design for Finite State Machines with fewer states. As a result, we can see how we can improve the Vending Machine's performance and layout fee.

Keywords: Visual Automata Simulation (VAS), Automata Theory, Vending Machine and Non deterministic Finite State Machine

1. Introduction

Vending machines are electronic devices that collect money and return products based on the quantity of money inserted. They are used to provide various things such as toffees, coffee, and other items. The design that uses automata principle is responsible for the efficiency of the Vending Machine (Vending Machine). A finite-state automaton is a collection of all conceivable states as well as commands for transitioning from one state to another in response to external input. It's also known as a finite state automaton, or FSM (FSA). It is a mathematical instrument that is used to perform processes with inputs and outputs. It can be used to create a variety of software, including circuit or protocol verification systems, as well as the lexical analysis component of a compiler. It is also frequently employed in many physical systems, such as elevators and automatic traffic lights, to aid the control unit [1-3].

Moore and Mealy state machines are two forms of finite state machines. The Mealy machine, also known as a Synchronous Finite State Machine, is a state machine that only accepts input commands and produces an output that is a function of the inputs and current state. Moore Machine, also known as Asynchronous Finite State Machine, is a state machine that only needs entering commands and outputs the current state's outcome [4]. The efficiency of the Vending Machine that is used in the design directly influences the number of states as well as the number of steps used/used. In this paper, the aim is on the efficient design of Vending Machine improved from the basic state diagram based on non-deterministic finite state machine (NFSM). After which we will imitate a model with the help of Visual Automata Simulation (VAS). The proposed Vending Machine simply provides four types of note books. They are: 400 pages with fifty rupees (50) price, 300 pages with forty rupees (40) price, 200 Pages with price as thirty rupees (30) and 100 pages with twenty rupees (20) price. The user is required to insert the correct amount (mentioned above) for the note books he needs/requires. The machine then counts and checks if accurate amount of money is given and after confirmation provides the user with the required note book. The user also has option to cancel the process. These designs/operation are designed using different simulators, VAS, which is a new tool considered for this design.

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Also, it's compatibility allows us to use it with other tools. This aim is to design Vending machine for note books and the objective is to provide the note books to students in the campus. It is a multi-note book machine with NFSM based design. It is designed to provide note books which depends on the user selection for a specific type:- 400, 300, 200, 100 pages. The user then enters the denomination according to which the note book is provided. The option for canceling the process is also provided which means the customer can at any point of time cancel the buying process. The basic operations of this Vending Machine is to provide the note book based on the denomination entered and then machine vends the note book. All the prices of the product are provided above. The efficiency of the vending machine is improved using visual automata simulator.

Here, description of Vending Machine includes a clever approach and obstacles are kept in consideration. Basically, Vending Machine provides variety of products when money is provided to it. The Vending machine are a way more practical, easy to use and easily accessible for the user than the normal purchasing ways, they are found in many places for different kind of product such as snacks, toffees, cold drink, coffee, tickets and many other products. The efficient and accurate designing of these Vending machines can be in different ways by using micro controller and field-programmable gate arrays (FPGAs) boards. The Basic operations of the Vending machine is that the user provides the machine with the amount, the amount counter sends it the money inserted in the Vending Machine by the user to the control unit. The operation buttons gets active to choose the products that the user wants. According to the Vending Machine's internal processing, Vending Machine dispatches the correct note book when user provides the machine with accurate amount. If any change needs to be returned the machine returns the remaining amount. When selected product is not available, Vending Machine will reject the process and the process gets automatically canceled. The states in the state diagram are as follows: (initial state, user preference, money inserted by user). The proposed vending machine is in its first state of design, waiting for the user to submit their desire. The user selects the note book after the starting stage. Then, depending on the note book the user selects, the transition occurs into one of four states (select 1, select 2, select 3 or select 4). After that, the machine waits for the user to insert the money, which can only be in one of three denominations: 50, 20 or 10 rupees. When the machine has received the desired amount, it will enter the acceptance state/phase. The transition will go to a stage where the machine will go to a specific state dependent on the total amount of money when the user selects the 400-page note book.

2. Basic definition and description of vending machine
2.1 Basic understanding of vending machine
A vending machine is an automated machine that offers products to the user such as snacks, toffees, beverages, cigarettes and lottery tickets after the user inserts cash, a credit card or a specifically designed card into the machine, depending on the machine's design. The first vending machine is thought to have been invented in England in the early 1880s. Vending machines can be found in many nations and customised vending machines that provide less popular products than typical vending machine items have recently been developed [4].

2.2 About finite state machine
A finite-state machine (FSM), sometimes known as a finite automaton, finite automaton, or simply a state machine, is a mathematical model of computation. It's a machine that can only be in one of a finite set of states at any given time. In response to some inputs, the Finite state machine can change from one state to another; this is referred to as a transition. A list of states, the beginning state, and the inputs that trigger each transition comprise a Finite state machine. There are two forms of finite-state machines: deterministic and non-deterministic finite-state machines. Any non-deterministic finite-state machine can be built as a deterministic finite-state machine.

2.3 Understanding of deterministic finite automata (DFA)
A deterministic finite automaton (DFA)-also known as deterministic finite acceptor (DFA), deterministic finite-state machine (DFSM) or deterministic finite-state automaton (DFSA)-is a finite-state machine that accepts or rejects a given string of symbols by running through a state sequence uniquely determined by the string in the theory of computation, a branch of theoretical computer science. The phrase "deterministic" refers to the computation run's uniqueness. Warren McCulloch and Walter Pitts were among the first researchers to suggest a concept akin to finite automata in 1943, in quest of the simplest models to encapsulate finite-state machines [15].

2.4 Description of vending machines
In this section, we look at the definition of Vending Machine, as well as the innovative method and obstacles that were encountered. To be more specific, when money is entered into a vending machine, it produces a variety of products. Vending machines are more practical, easier to operate and accessible to users than traditional purchase methods. They can be found everywhere for a variety of products such as snacks and cold beverages, coffee, tickets, notebooks, and other items that are a part of our daily lives [9]. These machines can be implemented in a variety of methods, including using a microcontroller and a field-programmable gate arrays board (FPGA board).

2.5 Understanding the Advantage of Using NFA over DFA
These constraints are not necessary for a non-deterministic finite automaton (NFA), also known as a non-deterministic finite state machine. Every DFA (deterministic finite automata) in particular is also an NFA. The word NFA is often used in a narrower sense, referring to an NFA that is not a DFA, however this is not the case in this article.

3. Principle working of vending machine
A vending machine can be termed as an automated shop. Products are already loaded that it the products are already into the machine and are available to purchase, which are in general 24 by 7. Vending products are generally seen to provide freshly made beverages, toffees, cans, snacks and fresh food. But nowadays it seems like there is a limit into what can be vended nowadays. Generally in Vending Machines each item has its own selection number or a button which corresponds to a particular product. Users enter the amount and choose the corresponding number or button associated with the product they want and then wait

for their chosen product to be dispensed.

The process of the Vending Machine can be defined as follows:-

1. The money is entered by the user, which is then sent to the control unit by money counter.
2. The buttons for the operation are activated to choose the product that user wants. Following the Vending Machine's functioning, Vending Machine dispenses the products when user inserts the correct amount for the product.
3. If the money entered is such that vending machine has to return some change, then the Vending Machine returns the change.
4. If the product to be supplied to the user is not available then the Vending Machine rejects the service and returns the amount provided by the user [10].

4. Efficiency of advanced vending machine

What is the real goal of the proposed model? The main goal/aim is Energy efficiency when Vending Machine is in commercial use. Efficiency also on its own proves the efficient use of Vending Machine with minimum management expenditure. The LCD is one important feature in an intelligent Vending Machine, which includes a large table top office with vending service machines that have enough area potentially to in order to support 6 (six) to 14 (fourteen) inch LCD screens.

5. Challenges

Different Challenges are faced during any research and the following mentioned points are some of the complications faced while developing the proposed model i.e. advanced vending machine (VM).

1. **Opportunities enabled by mobile phones:** All the accepting of payments and transfer processes with latest communication technology [11].
2. **Increased user interaction:** An increase in user interaction through the vending machine as a result of activation from people's smart phones, which have the most up-to-date features and facilities and are aligned with the most up-to-date technology [9].
3. Exchanging necessary and secure information between vending operators and customers when the vending machine is in operation. Vending machine operators can reduce maintenance costs and boost machine availability by using this management.
4. **Software flexibility:** As new technology and software emerge, the compatibility of features is updated in order to improve.

6. Finite state automata

Automation which in plural terms is defined as automata is a device which works by itself. The Automata theory is studied under the fields of computer science and discrete mathematics. It is the study of the abstract machine in theoretical computer science. It is developed in such a way that is automatically follows a sequence of operation which is predetermined/already decided. The term automata is derived from the Greek word αὐτόματα which means 'self-making'. The statement mentioned in the end results to a conclusion that it automatically processes the development of a particular work [15].

Automata Theories (AT) are a type of computational system machine that can be defined as an abstract. Because it operates on a fundamental premise of software's digital circuits and electronic devices, Automata Theories are critical. It can also be used to validate any system, including finite state automata (FSA). State of Limitation Automata is a mathematical tool or paradigm that can be used to create any computer machine. Finite state automata encapsulate the input and output that are transmitted between states [16].

Finite State Automata can be represented by a 5-tuple or symbol $(Q, \sum, \delta, q0, F)$, where Q stands for finite non-empty set of states. $\sum$ is a finite non-empty set of inputs. δ is a function that Maps $Q \times \sum$ to Q is called transition function. Q0 is the initial state. F is the set of final states [12]. $\delta (q, w\, a)=\{p\epsilon q | \exists r \in \delta (q, w): p\epsilon \delta(r, a)\}$ (1) An equation (1) describe the theory of transition δ computing an accept state in such a way that every state q, which refer to the user selection and sequence of money insertion p and every string w expressing the sequence of transition r and the letters used to refer to the specific type of selection [12].

7. Deterministic finite automata

A deterministic finite automaton (DFA)-also known as deterministic finite acceptor (DFA), deterministic finite-state machine (DFSM) or deterministic finite-state automaton (DFSA)-is a finite-state machine that accepts or rejects a given string of symbols by running through a state sequence uniquely determined by the string in the theory of computation, a branch of theoretical computer science. The phrase "deterministic" refers to the computation run's uniqueness. Warren McCulloch and Walter Pitts were among the first researchers to suggest a concept akin to finite automata in 1943, in quest of the simplest models to encapsulate finite-state machines [16-18].

8. Analysis of vending machine
8.1 Vending machine

A vending machine is an automated machine that offers products to the user such as snacks, toffees, beverages, cigarettes, and lottery tickets after the user inserts cash, a credit card, or a specifically designed card into the machine, depending on the machine's design. The first vending machine is thought to have been invented in England in the early 1880s. Vending machines can be found in many nations and customised vending machines that provide less popular products than typical vending machine items have recently been developed.

8.2 Finite state machine

A finite-state machine is called a deterministic finite automaton in automata theory if each of its transitions is uniquely determined by its source state and input symbol, and each state change requires reading an input symbol.

A deterministic finite automaton (DFA)-also known as deterministic finite acceptor (DFA), deterministic finite-state machine (DFSM) or deterministic finite-state automaton (DFSA)-is a finite-state machine that accepts or rejects a given string of symbols by running through a state sequence that is uniquely determined by the string in the theory of computation, a branch of theoretical computer science.

8.3 Working of vending machine

The customer can choose from four distinct types of note books, each with a different price: 400 pages, 300 pages, 200 pages, and 100 pages for Rs. 50, Rs. 40, Rs. 30 and Rs.

20. The prices are also listed below in the table. The machine can accept any combination of Rs. 50, Rs. 20 and Rs. 10; but, if the user inserts any other form of money, the machine would reject it. In addition, if the user makes an error, such as selecting an unavailable book or inserting money that is less than the amount required, the system will refuse to provide the book.

S. No.	Note Book	Price
1.	400 pages	50
2.	300 pages	40
3.	200 pages	30
4.	100 pages	20

There are four options: (s1, s2, s3, s4), (select 1, select 2, select 3, select 4) and (select 1, select 2, select 3, select 4). Specifically, s1, s2, s3 and s4. S1 was used to choose a 400-page note book. S2, S3 and S4 stand for 300, 200 and 100 pages of a note book, respectively. The user specifies three different denominations. 50 Rupees, 20 Rupees and 10 Rupees, 1, 2, 3 inputs, respectively, represent 50 Rupees, 20 Rupees, and 10 Rupees. When the user wants to stop the procedure, the cancel option, symbolised by the letter "c," is used. The suggested Vending Machine cannot offer money for return or change if the user cancels the procedure or inserts more money than the required amount. The user should cancel his request only before inserting any money because the money does not return. We chose Non-deterministic Finite Automata (NFA) over Finite State Machine (FSA) modelling for the suggested vending machine since it does not require input symbols for state transitions and can transition to zero or more states for a given start state and input symbol [5]. This separates it from a deterministic finite automaton (DFA), in which all transitions are decided uniquely and all state transitions need an input symbol. Non-deterministic finite automata (NFA) are a type of non-deterministic finite automata that allows the user to simply select multiple choices from a given state [13].

8.4 Different states and the state diagram
The following states are represented in the state diagram: user selection, beginning state, and amount entered/inserted by the user. The machine waits for the user to select the note book in the first state of design, which is the beginning state. After going through the above steps, the user is supposed to choose a book. The transition will then proceed into one of four states (select 1, select 2, select 3 and select 4) or (s1, s2, s3, s4), depending on the book the user selected. After that, the machine will wait for the user to insert money, which can only be in the following denominations: (50, 10 and 20) Rupees. The machine will analyse and enter the acceptance state once the desired amount has been inserted. When the user selects a 400 (four hundred) page note book, the Vending Machine will enter a state. When the user enters a sequence of money, the machine will enter a state based on the total amount of money. For example, if the user enters 20 and 20 Rupees, the machine will enter the "20 rupees" state, then the "40 rupees" state. At any point in time, the machine decides whether or not to deliver the note book or not.

9. Implication of research
Automata theory studies are abstract machines that describe,

as well as addressing computational issues, in a much more simple and clear way than other approaches. Grasp input and output processes from a logical standpoint necessitates the use of virtual machines and an understanding of how to operate them. Automata theory study is defined as a recognisable formal language that aids researchers in improving applications in artificial intelligence (AI), compiler design, and other computer domains that rely on computational theory. The effectiveness of a vending machine is determined by a number of factors, all of which must be beneficial to both the user and the service provider. The ultimate goal is to increase efficiency, and this is based on the architecture of the Finite State Machine (FSM) used in the future Vending Machine (VM). Increasing facilities in response to client expectations, demands, technology, and time constraints, among other factors.

10. Conclusion
The proposed Vending Machine design is investigated using NFSM automata theory and the Visual Automata Simulator programme. Constructing a finite state machine, which has fewer states and can provide quick response service. It was thought on how to improve efficiency and reduce design costs. With this tool and the right design, VM's efficiency may easily be improved for a variety of applications. Reduced complexity in the areas of time and space improves the overall efficiency of the VM system. The goal of this VM's future development is to improve it by adding additional books and scaling the types of items it includes to meet the needs of students. We also recommend that the machine be designed to accept ATM cards rather than paper money. In order to convert the vending machine to an intelligent method, it will also be feasible to improve efficiency and reduce complexity by employing appropriate automata machines.

11. What this research paper offers
11.1 For fellow researchers
This research paper studies extensively the topic of automata and its implementation into day to day. This Research paper covers a varied amount of details on the theory of automata, finite automata and Visual Automata Simulation (VAS). Many research paper were studied for the outcome of this research paper. Therefore this research paper is the result of understanding of many works and in depth study on the topic. Any fellow researcher who aspires to write a research paper can refer to this work drawing in varied idea from the same. Also this research paper helps anyone to understanding the topic better as it involves practical implementation of the idea we study in our theory.
Given the works studied and covered for this work to come to life anyone who refers to this work also gets exposed to ideas of many great minds and all the works which were referred for this work are all mentioned below.

11.2 For students
While preparing for this Research paper a lot of work and study was done which involved studying basics to covering high level topics. All the understanding was therefore summarized in this research paper, any student who wants to understand automata from scratch and its application in real life can refer to this work.
In the last, students, researchers are advised to go through articles [17-24] to know about Emerging Technologies and

their importance (including issues and challenges) in the near future.

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