
Vending Machine Technologies: A Review Article

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Abstract

Vending Machines are automated machines that dispense selling products such as snacks, beverages, lottery tickets, and etc. It is vital to save time and reduce human energy. These vending machines are developed in the way of Non IoT based and IoT based methods. These Non IoT based machines are not smart and are not operated in real-time data, which are functioned when giving cash or card and inputs (vending things) of the machine. It is controlled by a microcontroller and distributed the given inputs. IoT- based machines are computerized, which have cashless payment facilities, order facility before going to the vending machine to order things, and can be identified the location of machines by the customer. These IoT-based machines are assisted to suppliers to identify the availability of the stocks. Simulation software and prototype are used to validate the machines. In this review, it is found that most of the vending machines developed are capable of operating without IoT technology, and nowadays, vending machine systems are required to implement using IoT with machine learning, and artificial technologies to satisfy the customer preferences.

Keywords: Internet of Things; Vending machines; Automatic machine; Automation; Cashless payment; and smart vending.

1. Introduction

Nowadays, automated machines are in demand for making numerous activities not only easier, but also more efficient [1, 2]. These machines require minimal human intervention to carry out the work. The machine has numerous inputs and outputs to provide service to customers [3].

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The Automatic machine operates based on electronics engineering, mechanical engineering, and electrical engineering, which is a collectivity termed Mechatronics [2]. People spend more time buying things in supermarkets as the market is crowded. Hence, it disappoints the customers and it leads to losing income to the vendors [4]. Normally people touch the things (mostly vegetables) to identify their quality. At that time, they can be affected by infectious diseases. Low hygiene and quality of most of the things are finally needed more workers to maintain the quality. Therefore, higher salary which needs to be paid to workers, and there is security issue as most of the customers use the cash payment method. As a result, design of the vending machine is the best solution to avoid these problems. The vending machine is one of these automated machines which supply needed things to the customer [4]. The vending machine can be categorized into product-oriented and service-oriented machines [5]. It distributes snacks, beverages, public transit tickets, jewelry, telephone facility, entertainment things, and etc. [5]. As it has many benefits, such as, man power is no needed, flexibility in time, saving time [7], reducing labor cost, increasing profitability, and etc. [8]. Therefore, vending machines are used commonly worldwide [4]. Amid the COVID-19 crisis, vending machine usage is increased internationally [5]. US\$134.4 Billion of the global market was estimated by using vending machines in 2020, and it is predicted as it will reach US\$146.6 Billion in 2027. According to the report [9], 1.3 % of CAGR is analyzed in the period of 2020 to 2027. Currently, vending machine owners are facing challenges from hacking and vandalism [4]. Most customers want unmanned retail models and cashless payment methods because customer behavior has changed [2]. Lack of innovation and the way of the operating machine also affect the profitability of the machine [2]. Vending machines are faced with disruption of online delivery, which is increasing income by 23% in Japan [2]. Therefore, designing a touch-less, IoT-based, voice-recognized, and face-recognized vending machine is better solution to avoid these problems. IoT applications are needed to monitor the environment, identify problems, communicate, and resolve problems without human intervention [10], and they have security issues in data sharing and privacy. Hence, security techniques are important to prevent confidential and important for device protection from some internet security threats [10]. In recent days, machine learning and artificial intelligence technologies are incorporated when developing vending machines. Therefore, it can be able to access real-time data collection, increase sales, make operation more efficient, and supply things to customer desire, which identifies the customer desire by which selected regular things are [11]. Comparison of current systems and identification of drawbacks are important in developing novel vending machine technologies as the usage of vending machine has been increase. Therefore, this article will focus on the comparison of systems developed under laboratory and factory conditions. In this article, a brief discussion on conventional methods used followed by existing IoT based vending technologies are also discussed. Then, statistical algorithms which were used in data analysis will be discussed.

2. Methodology

2.1 Non IoT based vending machine technologies

In recent past years, there were lots of vending machines developed by several research groups such as PLC based change dispensing machine, PLC based automation of multiple fluid vending machines, AVR ATmega8515 based liquid dispensing vending machine, Arduino based reversed vending machine, Finite State Machine based vending machine with auto-billing features, RFID based ration vending machine, and

touchscreen-based medical vending machines [12, 13, 14, 15, 16, 17]. These are commonly known as Non-IoT based vending machines. AVR ATmega8515 [12], Arduino UNO/MEGA [1, 13, 18, 19], 8051 [18, 19, 20], PIC [21], ARM [22], AT89s52 [17], ATmega328 [23], AT89c51 [24], MSP430G2553 [25], and PLC [15, 16] controllers are used to develop the data acquisition system of the vending machines. PLC-based vending machines are developed using Siemens (Version 7) software [15,16]. The core part of the vending machine is sensors and cameras. Some researchers used position sensors [15, 21, 18, 24, 26] and solenoids [12, 18, 23] to detect the level of fluid and to supply the fluid and IR sensors [12] and Photodiode [27] to detect the presence of coin/currency [12, 31]. Image processing techniques are used to recognize currency and data images of currency collected from a camera or scanner in a change dispensing vending machine [16]. Some of the researchers used fingerprint systems [1, 28] and aadhar ID [26] in their vending machine systems to activate the system. These are mainly used railway tickets booking vending machines. These are contained thermal printer [26] and inject printer [10] to print the tickets. The design of a high-tech vending machine is developed using an alarm system for security purposes, which is interfaced with a servo motor and a buzzer [4]. All of the designed systems and available systems in the market use a touchscreen and a keypad to input the data to the machine [1, 17, 18, 24, 25, 28, 29, 30]. Smart cards [17, 24] or RFID cards [18, 19, 21, 27] are used to access vending machines. Non IoT based vending machines commonly accept coin [16, 20, 22, 26, 31] / currency [12] / credit/ debit card for the payment methods. 16 x2 Liquid Crystal Display has been used for display purposes. Some of the studies have been used digital weight measuring systems [19] and load cell [13] to measure the weight. The finite-state machine-based vending machine is using FBGA Spartan 2 development boards [14] as a controller and is coded by VHDL language [14].

2.2 Existing IoT based vending machine technologies

Coffee vending machines, vending machines with cashless payments for snacks, smart computerized vending machines, and smart automatic juice vending machines are well-known vending machines, which are developed using IoT-based technology [20, 23, 29, 30]. Some of the developed machines were used the PIC microcontroller [21] as the brain of the system and read data from an RFID reader [21]. In some cases, thingspeak [18, 21] and database management systems [19, 20, 21,23, 24, 26,28, 29] were used to collect data from sensors [18, 21] and save the data. Some of them used the ESP8266 Wi-Fi module [20, 23, 30] to transfer data to the cloud platform and android based application [21]to access the vending machines [18, 21]. An authentication code is generated by the Blynk platform's mobile application [28] to access the data on application. Some researchers developed websites [29, 30] for payment gateway [29, 30] and accessing vending machines [29, 30]. Especially in India, Razorpay API [29] was mostly used for payment gateways. HTML, CSS, and Java are used to create an advertising platform (website) [4]. The voice-enabled vending machine is used UUGear devices to integrate multiple microcontrollers (Arduino, Nano 33 BLE, NodeMCU, and Raspberry pi) [28]. A 12w solar panel, 1820mAh lithium-Ion battery, and power management board (UPS) are used for the power source of a voice-enabled vending machine [28].Nowadays, vending machines are developed using new technologies. They are debit/credit card payment, cashless payment [31], energy-saving vending [31], smartphone interactions with Artificial intelligence [31], wireless communication [32], Global positioning system [32], facial recognition [33], voice recognition system [28] Internet of things and self-inventory [33].Initially, the vending machine faced a problem was that inserting a coin or cash could be a fraud/ difficult

to count one. The technology of credit/debit card payment [32] method is difficult to cheat the machine [27]. Today, more vending machines are equipped with cashless payment options [31]. A QR/barcode scanner is used for payment from a virtual wallet using QR/Barcode [10]. In the distant future, checkbooks, credit cards, and cash may completely disappear. This technology reduces mass adoption in a short time. Near-field communication (NFC) is paired with Google Wallet and Apple pays [33]. Recent innovations detect vendors and repair machines remotely [33]. Coco-Cola Company introduced an ultra-saving vending machine that was used to cool beverages in the daytime using airtight doors and vacuum-insulated materials. So, it reduces the consumption of energy, and this type of machine has more profitability and productivity [31]. Nowadays, vending machines can interact with smartphones in real-time and include artificial intelligence for the customer preferences. Wireless communication [32] method is used to receive messages about overview of sales trends, stock data to vendors [32]. A GPS connected to the machine is used to track the machine for customers [32]. Face recognition [33] technology helps to recognize consumers [33]. Then the machine gives preference to the customer and prevents restricted products. Self-inventory [33] machines collect data from various sensors, monitor stock, and make decisions for themselves [33].

2.3 Validation of the vending machines

Simulation of the software model [1, 12, 13, 14, 16, 19, 24, 25, 28, 31] and development of prototype [1, 12, 16, 19, 12, 24, 25, 29, 30, 31] has been done by several research groups to validate the accuracy of machine. Proteus software [13, 24] was used to simulate the operation of the machine in Arduino based reversed machine and real-time embedded-based drinking water vending machine [13, 24]. Rarely, Xilinx ISE Simulator [14] has been used for a finite-state machine-based vending machine with auto-billing [14] and this simulation software has been shown waveforms to represent which items/products are selected infinite state machine based vending machine with auto-billing [14]. Vending machines using 8051 microcontrollers have been validated with coin acceptor when input different sizes of the 5-rupee coin. Coin accepting efficiency is nearly 50% because it works while including a shape of 5 rupees [20]. Validation of mobile app is checked transaction process completed or not in the real-time process [34].

3. Data Analysis

Moore machine [14] and Mealy machine models [14] were used for Finite State Machine-based vending machine. μ Vision Keil IDE software [18] was mostly used to accelerate embedded software development and also μ Vision debugger was selected to test, verify and optimize application code [18]. In the cases of IoT based vending machines, thing speak has been used as a cloud platform to transfer data between a software application and embedded system [18, 21], and MATLAB was used to analyze and visualize processed data [18, 21], specially, in IoT based coffee vending machine [21]. Stored data are visualized in graphs and statistical distribution using MATLAB and help to send alert messages to the system in IoT-based coffee vending machines [18]. Manipulation of the functions and implementation of the software was done by MATLAB [29] and processed data is stored using MySQL database [29] in IoT-based vending machine without cashless payment [29]. MATLAB was used to visualize graph format for verifying currency values using image processing techniques in a PLC-based change dispensing vending machine [16]. A unique identification code

was used in the verification process of the vending machine [29]. Big data analytics tools and NoSQL database aiming to support smart and efficient data collection and integration [35]. Machine learning and statistics were used to analyze heterogeneous data from various sources, mapping and forecasting customer's needs with production planning, providing the right information at the right time, to the right place [35]. MapReduce, Spark, Splunk, and Skytree analytical tools were used to analyze the stored big data analysis [36]. Classification, clustering, prediction, and association rule analytical methods were applied in the IoT data analysis [36]. SVM and KNN algorithms were used to analyze data in the IoT data analysis, which is used for efficient performance [36]. DataV's data analysis is used to determine customer interactions, unique characteristics of the items, and stored patterns, which is predicted to identify how will affect the overall sales and performance of vending machines [37].

4. Conclusion

According to the systematic literature research, vending machines are mostly preferred by people to vend things. Therefore, more researchers have developed various types of vending machines according to the function of vending products or services and customer requirements which are categorized into IoT-based and Non-IOT based machines. Fewer machines are developed IOT-based worldwide. But vending machine usage is increasing worldwide in the Covid-19 situation. Hence, most companies are producing vending machine with new technologies. In this review, available vending machine technologies, limitations, and future expectations are discussed. Result of vending machine technologies, vending machines are developed using RFID, facial recognition and fingerprint system to access machine, IR sensor, coin detector or camera to recognize currency, thermal printer to print bill, keypad or touchpad to the input command, displays to show items, process instruction of the machine, Wi-Fi module to transfer data through the cloud-based transaction. These vending machine systems are used KNN and SVM algorithms for IoT-based analysis and MATLAB, DataV, and thingspeak on data analysis and visualization. For example, vend product percentages from one vending machine can be analyzed and visualized. As a result of the narrative review, various vending machines have some limitations, and solutions are discussed. They are, Finite-State Machine based vending machine reduces hardware parts because of FBGA development board can enhance productivity and is the reprogrammable system. But switching speed of the machine is less than SEEL and CMOS technology machine. The cashless payment system is best when compared to the card, cash, or coin because security is high. Mostly android mobile applications are developed for IoT-based machines. Therefore, other operating system users cannot access the machines. Photodiode and IR sensors are not accurate to measure the presence of coin or cash. In a pandemic situation, the keypad and touch screen are not hygienic, and the working period of the touch screen or keypad is a maximum of two or three years. In the early-stage, IoT machines are developed using a microcontroller and Wi-Fi module. Thus, the system needs high cost to develop in the separate part and requires external flash memory and an antenna. Microcontrollers like 8051 need to write the assembly language which is difficult to write code. Better to replace the efficient microcontroller and easy to write code for the operation. Nowadays people prefer unmanned operation, cashless payment, and new technologies into the vending machine. In recent times, vending machines are focused to develop using artificial intelligence and machine learning. Machine learning and Artificial intelligence help to vend things after recognizing customers and its works with real-time data. However, available systems require insight into IoT, AI, and machine learning for

further development. While developing the new vending machine, consider the above stage problems and develop the best one for the distant future.

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