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Design, Simulation and Implementation of Beverages Vending Machine Using Arduino

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Abstract:

The world today witnesses the most significant development and progress in various fields especially in electronics and artificial intelligence. Therefore, the role of the human element decreases daily and looking for ways can achieve our needs and tasks faster, more efficient, less efforts etc,. becomes increased. A vending machine has intelligent behavior characteristics as they dispense different items with no need for human intervention. This paper presents a prototype automatic vending machine with numerous inputs. and outputs. It was simulated using PROTEUS software and controlled by Arduino Mega2560. It is a coin vending machine since all transactions were done using coins throng coin acceptor. It accepts 250 Dirhams for 165 ml juice and 500 Dirhams for 330 ml cans of Pepsi, Marinda or Seven up. It is monitored by LCD and provided with GSM shield for connectivity between the machine and an owner.

Keywords: Vending machine, coinacceptor, Arduino Mega 2560, Protues software, Juice dispense.

تصميم، محاكاة، وتنفيذ آلة بيع المشروبات باستخدام الأردوينو

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الملخص

يشهد العالم اليوم تطورًا وتقدمًا كبيرين في مختلف المجالات، خصوصًا في مجالي **الإلكترونيات والذكاء الاصطناعي**، الأمر الذي أدى إلى **تراجع دور العنصر البشري تدريجيًا**، مع تزايد الحاجة إلى إيجاد أنظمة قادرة على **تلبية متطلبات الإنسان بسرعة أعلى، وكفاءة أفضل، وجهد أقل**.

تُعد **آلة البيع الذاتي (Vending Machine)** من الأنظمة الذكية التي تمتاز بسلوك آلي يسمح لها **بصرف منتجات مختلفة دون تدخل بشري مباشر**

يقدم هذا البحث **نموذجًا أوليًا لآلة بيع مشروبات آلية** ذات **عدة مدخلات ومخرجات**، تم تصميمها ومحاكاتها باستخدام برنامج **PROTEUS**، ويتم التحكم بها بواسطة متحكم **Arduino Mega 2560**.

تعتمد الآلة على **نظام الدفع بالعملات المعدنية**، حيث تتم جميع العمليات عبر وحدة **استقبال العملات**.**(Coin Acceptor)** تقبل الآلة **عملة بقيمة 250 درهمًا** مقابل **عصير بحجم 165 مل**، و**عملة بقيمة 500 درهم** مقابل **علبة مشروب غازي (بيبسي، ميرندا، أو سفن أب) بحجم 330 مل**
كما تحتوي على **شاشة عرض (LCD)** لعرض حالة التشغيل والمعلومات، بالإضافة إلى **وحدة اتصال GSM** تتيح الربط بين الآلة ومالكها لمتابعة الحالة التشغيلية وإرسال التنبيهات.

الكلمات المفتاحية: آلة البيع الذاتي، مستقبِل العملات، أردوينو ميغا 2560، برنامج بروتيوس، صرف العصائر.

1- Introduction

People need to drink fluid daily to keep their bodies active and to maintain their [1,2]. Water balancing due to excreting process. Drinking at least 1.44 L of water per day is necessary to cover the water lost. Sometimes we drink water directly or indirectly since most beverages contain around 90% of water [3]. The beverages including soft drinks and juices can meet a part of human requirements of water [4]. One way of providing hydration, vitamins, minerals, energy and phytonutrients to our bodies is drinking beverages [2,3]. Lost salts and energy are quickly replaced when we drink soft drinks and juices since they are usually absorbed more readily than water [5,6]. Drinks beverages is a vital process in our lives and culture due to rapidly thirst quenching. Some people around the world face a problem which representing in hard getting their supplies, things etc. that they need easily. Sometimes a customer can't wait long to buy his/her needs due to crowding in supermarkets or closing the stores specially at late night or any other circumstances. Therefore, the customer may feel dissatisfied, discomfort etc., which leads to lose the purchasing power of the seller and decreasing in the profit as well. As a result, a good solution to overcome these problems and others is using a vending machine [7]. It is self-service machine that can work 24/7 in different places like schools, airports, universities, gardens etc. Such these machines can supply things needed by the customers such as beverages, snacks, hot meals, transit tickets etc., Their usage appears strongly in some crises such Covid -19 pandemic [7]. Therefore, the value of the global market is predicted to grow up and reaches $146.6 Billion in 2027 compared to $134.4 Billion in 2020[8]. This happened due to possessing these machines number of advantages and benefits such as saving time and efforts, increasing profits, reliability, flexibility etc.; [9]. This is enough to make them widely used and widespread around the world since 1890 when the first vending machine was invented for offering beverages such as beer and liquor [10].

2- Literature Review

In this part, some of the previous studies and current developments, which related to the proposed system, will be discuss.

The study conducted by Kalpita Mane et al. (2024). [11] Focused on the design and development of an automated milk vending machine aimed at providing convenient access to fresh milk while supporting local farmers and reducing operational costs. The system was divided into core modules, including milk type selection, quantity input, payment through a rechargeable RFID-based card, and milk dispensing via a submersible pump with quantity measurement using a flow sensor. An LCD display was integrated to show transaction details in real time. Experimental results revealed that 36% of operators anticipated an increase in sales, 48% expected stability, and 16% predicted a decline. Furthermore, the prototype demonstrated the capability to classify milk into three quality levels—based on pH value, water content, and viscosity—with high accuracy. The system also transmitted low-stock alerts via a GSM module and maintained milk quality through temperature regulation. The study concluded that the proposed system is efficient, scalable, and user-friendly, offering a secure and convenient payment process while minimizing human intervention. These characteristics make it particularly suitable for commercial deployment and educational applications. The study conducted by Niu Yang and Zhou Jing (2015).[12] was based on the design of an

automated beverage vending machine controlled by a programmable logic controller (PLC, Siemens S7-300), with the objective of achieving a simple and efficient self-service sales system that operates without human intervention. The system was divided into fundamental modules, including the cash-handling unit, product selection, display interface, and beverage dispensing mechanism, and was developed using the KingView simulation environment to illustrate user interaction with the machine. Experimental results demonstrated that the machine was capable of recognizing three denominations of currency (1, 5, and 10 yuan) and enabling corresponding purchase options based on the amount inserted. In practical testing, the vending machine achieved sales of five orange juice units, one soda unit, and two coffee units, generating a total revenue of 17.5 yuan, while successfully executing lighting and refund responses during error conditions. The findings confirmed that the proposed system is efficient, scalable, and suitable for practical implementation, with potential applications in educational training and the development of cost-effective smart vending solutions. In 2016 [13]. Zhou Zhengjie conducted a study focused on the control of vending machines using a Programmable Logic Controller (PLC) and the design of a corresponding simulation system. The paper explains how industrial control technologies can be integrated into automated vending systems commonly deployed in public areas such as bus stations, hospitals, and shopping centers, in order to provide consumers with round-the-clock service convenience. The researcher concentrated on developing an automated control framework that incorporates currency recognition, product selection, price calculation, and precise transaction execution. The system employed optical sensors to identify and verify the authenticity of coins, with data transmitted through an internal communication unit linking the control modules to the software interface. Additionally, a simulation model was developed to demonstrate the operational workflow from currency insertion to product dispensing. The results indicated that the use of PLC technology provides the system with high operational stability, strong interference resistance, and reduced maintenance costs compared to traditional vending systems. Consequently, the proposed design was deemed suitable for commercial and educational applications, with potential scalability for future development. In 2019 [14]. Pandey and Go gate conducted a study was based on the design of a smart juice vending machine that relies on Internet of Things (Iota) technologies, utilizing an 8051 microcontroller. The primary objective was to develop an intelligent and efficient self-service vending system that operates autonomously without human intervention. The system was structured into key functional modules, including cash-handling, juice extraction, temperature control, and cooling activation when required. The machine was engineered to transmit operational data to the cloud via an ESP-8266 module, enabling remote monitoring and analytical assessment of vending activities. Experimental results demonstrated that the machine could automatically extract juice upon coin insertion, adjust temperature levels autonomously, and activate the cooling system whenever the temperature exceeded the designated threshold. The study concluded that the proposed system is efficient, scalable, and supports remote control and monitoring, making it highly suitable for low-cost smart vending implementations as well as educational and practical training environments. In 2024 [15]. Taufik Ryan Hendrosusanto et al. conducted a study was conducted on the design and simulation of an automatic tea vending machine using an Arduino Uno R3
Microcontroller and Proteus 8 software. The aim of the research was to develop an intelligent and efficient self-service vending system capable of offering multiple beverage options without human intervention. The system was structured into three primary functional modules: flavor selection, tea dispensing, and machine control, and was simulated with high precision using Proteus 8 to evaluate its operational performance. Repeated experimental tests demonstrated that the machine could successfully dispense five different tea flavors with an operational accuracy rate of 100%, according to practical trials. The system exhibited a rapid response time of less than two seconds for flavor selection, and maintained stable performance over more

than 50 consecutive operation cycles without any dispensing errors or system failures. The findings confirmed that the proposed system is highly efficient, accurate, and practical for implementation in smart vending prototypes for educational and experimental applications, ensuring a smooth and secure user experience.

3- Block diagram representation of the proposed system.

The system block diagram as illustrated in Figure.1 Show the main system components and their relationship to the Arduino board.

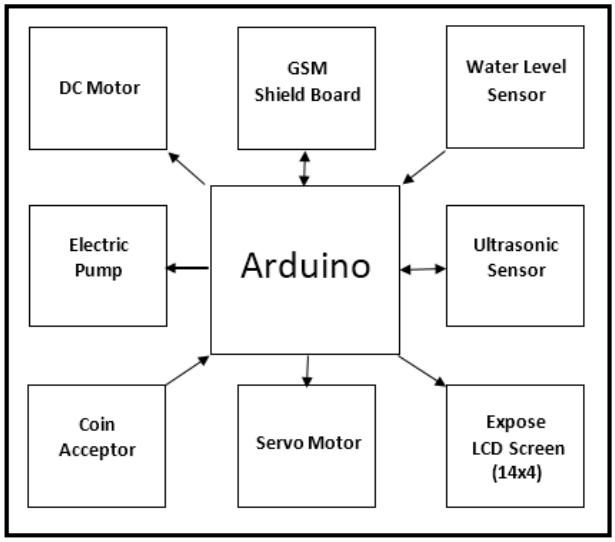

Figure.1 Block diagram representation of the system.

4- Flowchart of the system operation.

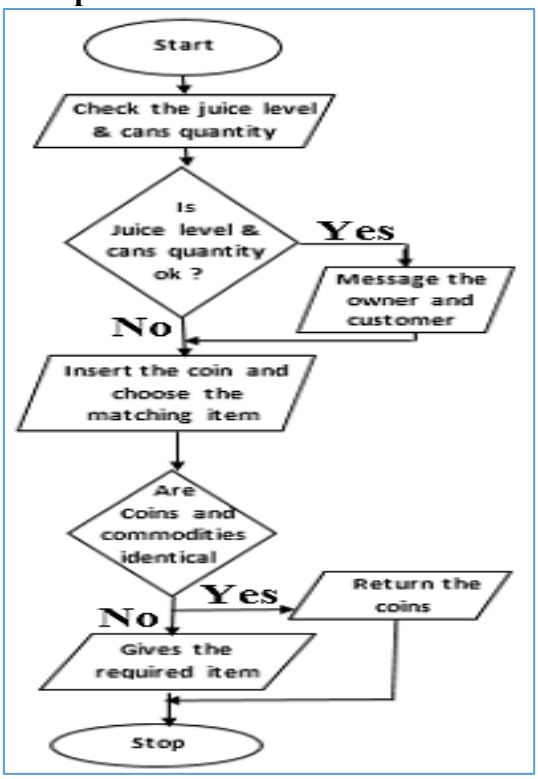

Figure. 2 The system flowchart as shown in summaries briefly the operation steps of the system.

5- System circuit simulation

The proposed machine is simulated using PROTEUS ISIS Professional software shown in Figure.3 Simulation phase helps develop and test the system before being Constructed as a prototype. It plays a significant role of any successes design and can be considered as the main factor for that. This can be done by simulating both the components of the system and its performance.

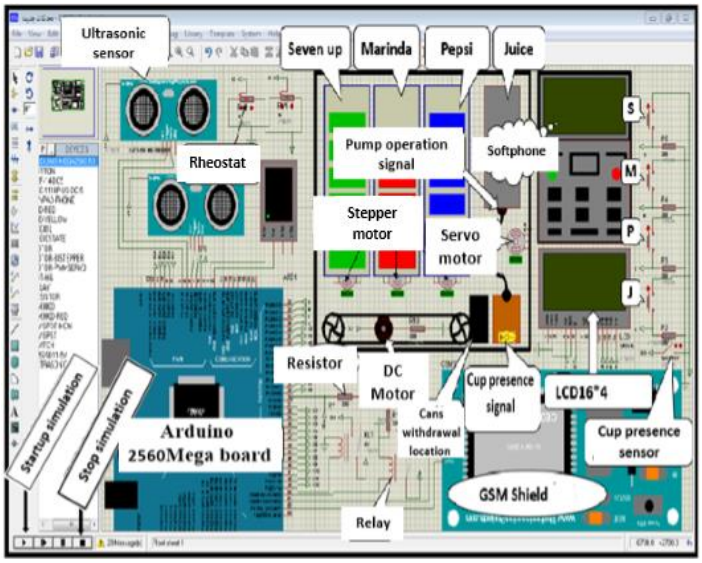

Figure. 3 simulating machines.

5.1 Simulation of the system components.

As shown in Figure 3, not all system components were available in the simulation program. Therefore, they were replaced with components and elements that have identical or similar functions. For instance, a red LED was used to represent the juice pomp, Virtual terminal instead of coin acceptor, etc. four switches "S, P, M and J" refer to which beverage was requested since S refers to Seven Up, M for Marinda, P for Repsi and J for juice, A photo sensor was represented by ON/OFF switch which sense the juice cup was presence

5.2- System Performance Simulation.

The performance of the system can be explained systematically as follows:

i. Welcome sentence and beverages prices, 250 Dirhams and 500 Dirhams , will be presented on LCD after turning on the machine catch a little time delay between them as shown in Figures 4-a and 4-b.

ii. When a user desire to buy beverages, ultrasonic sensor will sense the availability levels of the requested beverage and then will ask the user to insert suitable coin that matches the demand as illustrated in Figure 4-c.

iii. If seven up was selected, for instance by pushing the desired switch shown in Figure 4-d , the serve motor then will turn counterclockwise CCK, in case of there is a matching between the entered coin and the request. As a result, the DC motor will turn clockwise towards the outlet, which practically means that a Customer can take the request beverage.

iv. In case of the ultrasonic reading was in a range of high cans level which physically between 4cm to 33cm then the user can get his/her order in the same way mentioned above. Additionally, the proposed system can dispense beverages even if the ultrasonic reading was in low level range, namely between 34 cm to 50 cm for each category as shown Figure 4-d. Simultaneously the owner will be notified about that by sending "cans low level" message through GSM as shown in the figure 4-e.

v. The inserted coin will be rejected and returned to the user if ultrasonic sensor read over 51 cm as shown in Figure 4-g which means that there is no soft drinks or only a litter juice is available. Arduino then will inform both the owner and user via LCD and GSM respectively as illustrated in the figure. 4-f since this practically means that there are at least four cams category of the soft drinks. returning the coin which means rejecting the transition, also could happen, if the user requests two things at the same time, seven up and Pepsi, for instance as shown in figure 4-g, and then a sentence of "there is a mistake in choice" will be presented on the LCD.

vi. Finally, in case of selecting the juice switch and yellow LED was in ON state as shown in Figure. 4-h which physically means that the juice has already ordered and the juice cup is put on the right place and then a 165 ml of juice will be poured into the cup since the Red LED refers to that a sequence.

6- Practical design

Coin receiving box and coin saving. The coin receiving box will be in a balancing position where the coin inserted can't be lost as shown in Figure 5 then will be turned in left side by the servo motor for saving the money if there was a matching between the inserted coin and the request. Otherwise, the inserted coin will be rejected and returned back to the user by turning right the coin receiving box.

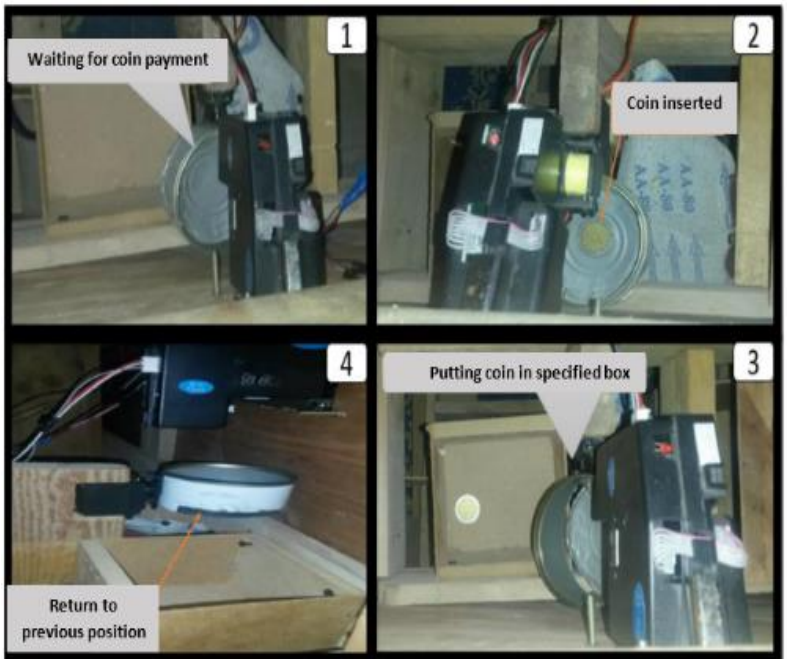

Figure 5: A coin receiving and storage box consisting of, 1- Centric Position, waiting for inserting coin, 2- Coin inserted, 3- Turn left to place the coin in the box, 4- Back to previous position in medial.

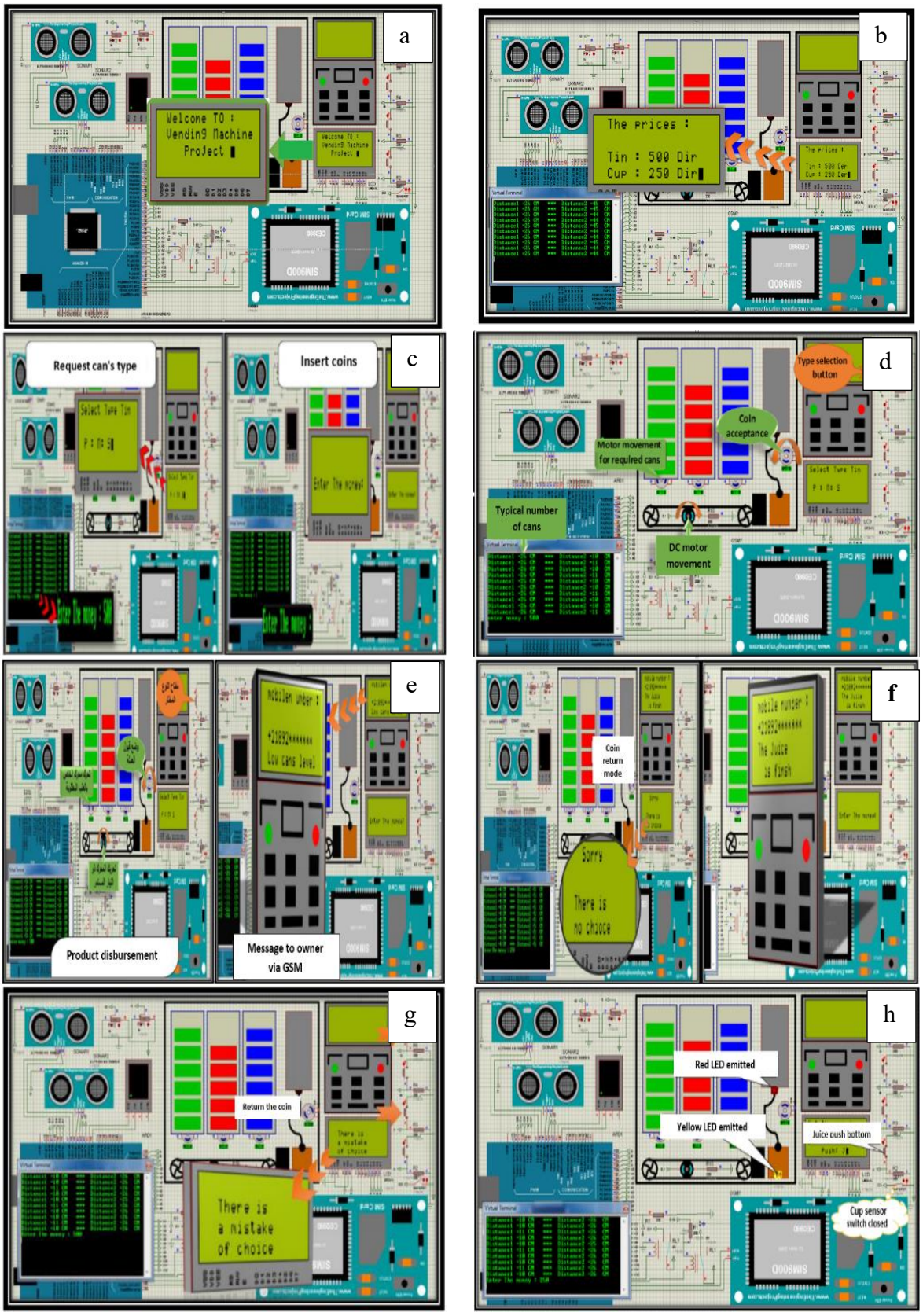

Figure 4: shows the steps foroperating the system as follows: **a:** welcome message. **b:** juice and beverage pricing **c:** set the coin for desired juice/drink d: rotate motor to coin acceptance side. **e:** GSM message to owner that the juice/drink is low. **f:** drinks/juices not available coin is refund. **g:** GSM message to owner that the juice/drink is complete. **h:** juice choosing and cup in right location.

7- Result and discussion

As it can be seen in fig. can be note that there is a linear relationship between juice demand rate and juice availability level was high availability level figure 6-a . This means that as a demand level was higher the juice availability level will be decreased as a sequence and vice versa. In contrast, the relationship that in case of soft drinks can be generally described as nonlinear figure 6-b. Hence, the demand level will be the highest as long as we are are within the level zero stage then will be gradually decreased in the next two level stages

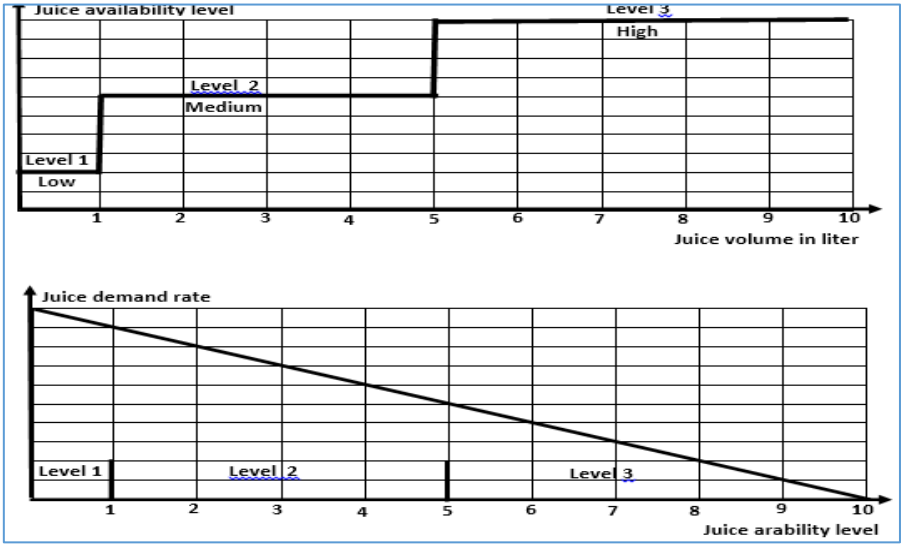

Figure 6-a: Relationship between juice demand and availability.

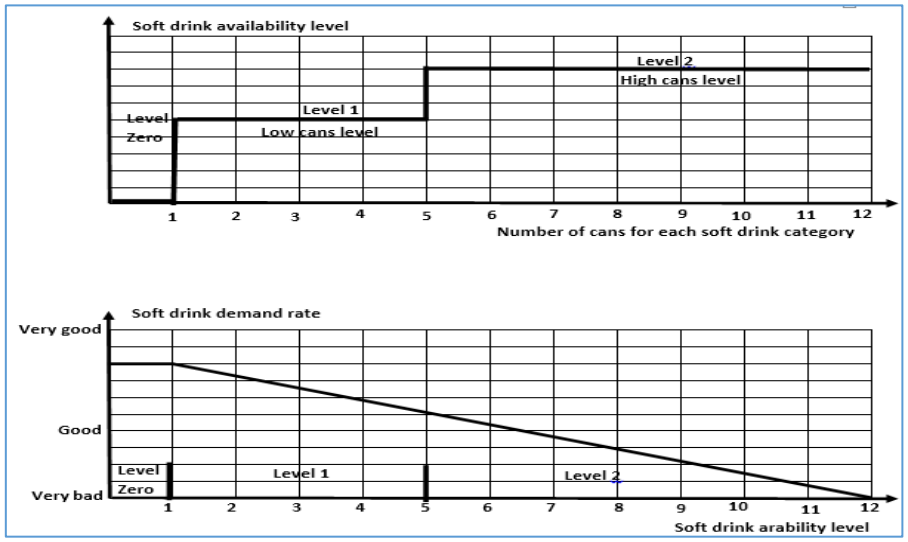

Figure 6-b: Relationship between soft drink demand and availability

8- Future Enhancement

The proposed system can be improved and developed by adding other components and features. This makes it such acceptable for general people and an easily overcome the expected challenges. One of these challenges is how to make it adapt to charges in the surrounded environment. For instance, the changes in the temperature due to the seasons of a year. For this purpose, a temperature control device can be attached to the system in order to keep the beverages temperature at the required levels. A camera could be added to the machine For some events documentation. Other juice flowers, could be added offered by Adding secondary tanks and other solve arrangements. . Other payment options, such as credit cards, paper money and

contact less PayPal, etc. Could be also added. Hence, having such there facilities can make comfortable, reliable, flexible, attractive etc.

9- Conclusion

Beverage automatic vending machine was designed, simulated and implemented successfully. The machine prototype has tested physically and is performance was as desired and expected. It is eco- friendly world machine and can be easily accessed by most people. It can be implemented almost every due to its small size. Seeing such there machines in different places of country with-24/7 working time may reflect the civilization level of that country

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Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.