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AN ALTERNATIVE TO VENDING MACHINES

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***Abstract*: In this review article for a smart vending refrigerator, the contours of the future device are thought out and outlined and all its advantages are described. This device will be controlled using Computer Vision and some other features. The main control unit will be Raspberry PI, since it is the best for this device. Also, a web application was developed in which the user registers, and the application itself transmits the user's information through an API that will be developed to communicate with the web server, and the web server will store this information. This article will analyze the systems that have been already on the market and their pros and cons, as well as consider the design, implementation and functionality of a smart vending refrigerator. Also, the paper will consider key requirements for this system, technologies used, and approaches to integration with existing infrastructures. This design plays an important role in providing comfort and productivity in various fields of activity and can be applied in many areas.**

***Index Terms*: vending machine, YOLO, fog computing, cloud computing, RPI.**

I. INTRODUCTION

The rapid development of trade requires regular introduction new trends and directions. Thus, today the vending business is becoming increasingly popular.

This type of business involves the use of automated machines for the retail sale of a wide range of goods and services.

According to statistics, about 18 million vending machines around the world offer consumers a wide variety of goods and services: from a cup of morning coffee and a can of cold cola to bananas and vending manicures.

Vending business in Ukraine is quite a promising option for obtaining profit due to relatively low capital investments, lack of high competition and relative unfilled niche.

Trading through machines is a high-tech, profitable and highly profitable business worldwide. This is one of the few areas of business that gives the maximum profit in the minimum time: invested capital turns over hundreds of percent within a few months. The key condition for the prosperity of the vending business is, of course, a high level of activity and competence of the owner.

For implementing this vending machine, the You Only Look Once (YOLO) will be used.

Moreover, for creating a software framework for the mobile application for Android and IOS the UI open-source software React Native will be discovered.

The Raspberry Pi will be used to create a smart vending machine. It has lots of advantages, some of them are: low-costing, small size. After setting up the operating system, the Raspberry Pi can be connected to output devices such as TVs or computer monitors. Users can also connect input devices such as keyboards and mice to them. The applications and uses of the Pi are completely dependent on what the buyer wants, as many features are covered.

This article proposes the creation of a smart vending refrigerator for the purchase of various products.

II. REVIEW OF LITARATURE SOURCES

Source 0 describes the real-time object detection with audio feedback using YOLO (You Only Look Once) and YOLOv3 (an enhanced version of YOLO) involves using these computer vision algorithms to identify objects in real-time video or image streams and providing audio alerts or feedback based on the detected objects.

Source [2] shows a technology or research project that utilizes the YOLO (You Only Look Once) deep learning algorithm for the purpose of monitoring the interior of a vehicle's cabin. Specifically, it employs a fisheye-lens camera, which has a wide-angle view, to capture the interior environment of the vehicle.

Source [3] mainly focuses on leveraging the strengths of this deep learning model for real-time detection of small and distant objects in challenging visual contexts. Customization and fine-tuning may be necessary to achieve the desired level of accuracy and performance for the particular application at hand.

Source [4] refers to a research paper or project that focuses on creating a compact and efficient version of the YOLO (You Only Look Once) network specifically designed for real-time object detection of a single category of objects.

Source [5] describes an approach that employs the YOLO v4 deep learning model for recognizing and identifying fig fruits within images or video frames. YOLO v4 is a sophisticated object detection algorithm known for its accuracy and real-time processing capabilities. In this context, it's applied specifically to detect and clas-

sify fig fruits in visual data, which can be valuable for applications such as agricultural quality control, inventory management, or automated fruit sorting processes.

Source [6] shows a JavaScript-based technology stack that allows developers to build cross-platform applications. It enables the creation of web, desktop, and mobile applications with a single codebase, providing native-like performance and user experiences across multiple platforms. React is used for web applications, while React Native extends this capability to develop mobile apps for both iOS and Android, making it a versatile choice for efficient and consistent app development across various devices and platforms.

Source [7] describes the Octalysis gamification framework into the development of a React Native mobile application for learning. This means designing the app with elements that enhance user engagement and motivation through gamification techniques. These techniques can include rewards, challenges, and interactive features to create an engaging and effective learning experience within the React Native framework.

Source [8] shows a mobile application built using the React Native framework. It is designed to facilitate online experiments or tests, providing users with a platform to conduct various types of experiments, gather data, and analyze results using their mobile devices. This app offers a versatile and user-friendly environment for experimentation and data collection, making it accessible to a wide range of users.

Source [9] describes creating a mobile application using the React Native framework. This approach allows for the development of a single codebase that can run on both iOS and Android platforms, providing cost-effective and efficient app development while maintaining native-like performance and user experiences on both mobile operating systems.

Source [10] refers to the use of Raspberry Pi, an affordable single-board computer, as a tool to provide excellent educational resources and opportunities. Raspberry Pi offers a cost-effective way to teach programming, computer science, and various STEM subjects to students of all ages. It enables hands-on learning, making technology and computer education accessible to a broader audience, particularly in resource-constrained environments.

Source [11] shows a solution that employs Raspberry Pi, a single-board computer, to identify and count individuals in a given area. This system can be used for purposes like tracking foot traffic in stores or monitoring attendance at events. It utilizes Raspberry Pi's computational capabilities and possibly camera modules to perform these tasks efficiently and cost-effectively.

Source [12] describes using a Raspberry Pi, a small single-board computer, as a control system for weighing machines. CODESYS is a popular software platform for industrial automation and control. This implementation likely leverages the Raspberry Pi's hardware capabilities and CODESYS programming to create a cost-effective and versatile control system for accurate and efficient weighing machine operations.

Source [13] provides an information regarding a project that uses a Raspberry Pi 3, a versatile single-board computer, to create a water dispenser system that can be controlled through voice commands. This system allows users to request hot or cold water simply by speaking to it, making it a convenient and hands-free solution for dispensing water at desired temperatures. It combines voice recognition technology with hardware control to provide a user-friendly and efficient way to access hot and cold water. Optionally, a web interface can be created for remote control, and the entire setup is enclosed for protection. This project requires knowledge of electronics, programming, and safety considerations.

Source [14] presents a project that focuses on creating an advanced video surveillance system. This system incorporates motion detection and object recognition capabilities to enhance security and monitoring. It's designed to detect and recognize objects or events of interest in real-time video feeds. This project represents advances in the field of cyber-physical systems, which bridge the gap between the physical world and digital technology for improved monitoring and control in various applications, including security and surveillance.

It is difficult to research competitors because in Ukraine only one company offers a similar functionality and they do not disclose their software and hardware, so it is difficult to research it, if we talk about other countries, there is something similar in China, but there is also very little information, the only thing that exists is what is the basis this control unit device is taken from a computer that runs on an Intel processor, but it is not known whether it is Advanced Risc Machine (ARM) or a full-fledged processor based on CISCO.

III. THE PURPOSE OF THE ARTICLE

The primary objective of this work is to develop an alternative to vending machines for the purchase of various products. Moreover, this algorithm will be implemented based on machine learning and data science.

Let's consider the situation, that you are the owner of a small office or co-working space, who would like to give the opportunity to your employees or customers to buy snacks or even ready-made meals from you, in your office without spending your own finances on them, that is, to do all inclusive. You have several options: the first is the easiest to find a company that can provide you with vending machines, will service them and fill them. This is not a bad option because you could even try to negotiate with such a company so that it pays you rent. But it should be emphasized that this option will consider small offices, co-working spaces where the flow of people is not large enough to interest the company, therefore, with a high probability, it will ignore or perhaps ask for some kind of monthly rent at best.

Another option is to purchase a vending machine yourself, service it, fill it with goods. This option is also not bad because it will be possible to earn on the goods that people will buy from your machines, but vending machines are not such a cheap thing, although it is not

known when such an investment will pay off, besides, it will need to be serviced. There is another non-obvious problem of vending machines, its size and weight, this is not a problem when it needs to be installed on the first floor, but if the floor is 2+ and the elevator or even stairs do not allow you to deliver it to another floor because this device is too big.

The third option is the most obvious in the kitchen of your office or at the administrator's desk, to make something like a buffet, to hire a separate employee who will sell it, but this option is very doubtful, although you will not need to serve anyone, but you will need to pay a person's salary every month, so we also reject this option. And the last option is a smart refrigerator or cabinet that will perform all the tasks of a vending machine, will have better and more client-oriented functionality, with the possibility of creating it individually for the client (in the case of an ordinary cabinet) and for less money. And all this will be controlled with the help of Computer Vision and some other features that will be further described in that article.

The main goal of this project is to create a replacement for standard vending machines, which will be cheaper by at least 50 % of the cost of conventional vending machines, reduce their dimensions, provided that the capacity of such a refrigerator does not decrease by more than 20 %, which will allow will make it possible to deliver and install them in places where it would be difficult to install standard vending machines. Creation of a convenient mobile interface for users, which will provide an opportunity to find refrigerators and view their contents.

IV. INTERACTION BETWEEN USER AND MACHINE

It is worth considering this system in more detail, because from this brief description, one gets the impression that this refrigerator is by no means a candidate for one of the vending machine replacements.

Let's start with the simplest – the mobile application, after installation, the user needs to register in it, and then a fork appears in this structure, it concerns the payment of goods in the refrigerator, and since this refrigerator will not be able to accept cash (in this variation of the device), payments will be made only online, so we return to the fork.

The first option – the user connects his credit or debit card, from which funds will be withdrawn directly to pay for goods that will be taken from the refrigerator. This approach has its advantages and disadvantages, the advantages include the fact that usually people will keep more money in their bank accounts than in some strange bonus accounts, so it is more likely that you will be able to avoid any debts for the goods in case the bonus account does not there will be funds. Although the user may not have enough funds in his bank account, the probability of this is much lower. The disadvantages include the fact that the responsibility of the company that will operate the system for these refrigerators increases, as it will be necessary to be much more careful about the security of users so that their payment data does not become publicly available.

For interaction between the user and the refrigerator, person needs to download the mobile application on his smartphone, and then scan the QR Code on the refrigerator itself to open it. After that he will be able to take the product that interested him. This process is depicted in Fig. 1.

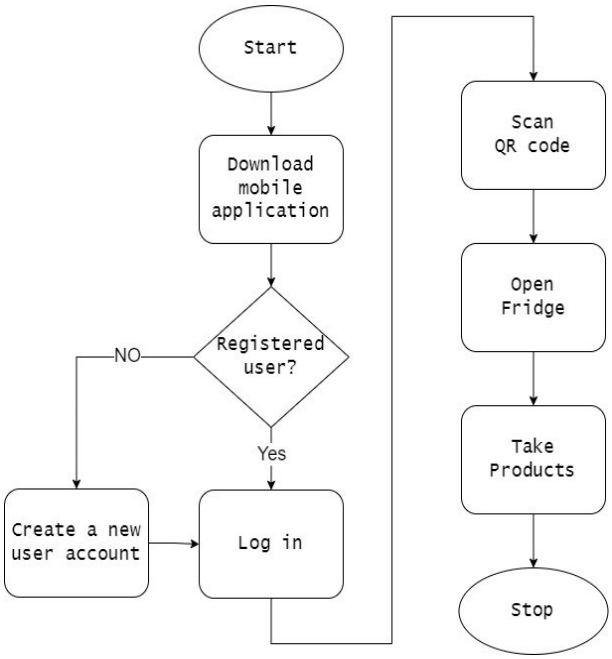

Fig. 1. The diagram of interaction between user and vending machine

Option number two is a bonus account, this option is more impressive because there is no need to keep user payment data in the system and worry that someone might steal it, instead use some proven services through which users will make payments to the company's account and, in turn, will be credited points to the user's account and everyone will win. But this method has one drawback, because the user may have too few points to pay for the product, and then his account will go into the red, and there is no guarantee that this person will replenish his account in the future to cover the debt. One of the options for solving this problem is the minimum number of bonuses on the user's account that will allow him to use (open the door) of the vending refrigerator. So, payment problems have been described, so it is worth focusing on the operation of the mobile application, Fig. 2 shows its main functions.

Its main functions are the ability to register a new user account, log in to an existing one, scan the QR Code on the refrigerator door, operate the refrigerator, such as unlocking the magnetic lock to take goods from it, as well as the rest: top up the balance, view purchase history. As you can see from the description, it would be possible not to create an application at all, but to go through several web pages in a simple web program, but there is one nuance, which is to scan the QR Code and

check whether the user is really near the desired refrigerator. A camera is required for scanning, and Bluetooth or GPS for verification. To check the presence of the user near the refrigerator, you can take the option that is implemented in mailboxes, that is, the mobile phone is connected to the mailbox using Bluetooth, and the Bluetooth signal itself must be strong enough, which is a sign that the user is close enough.

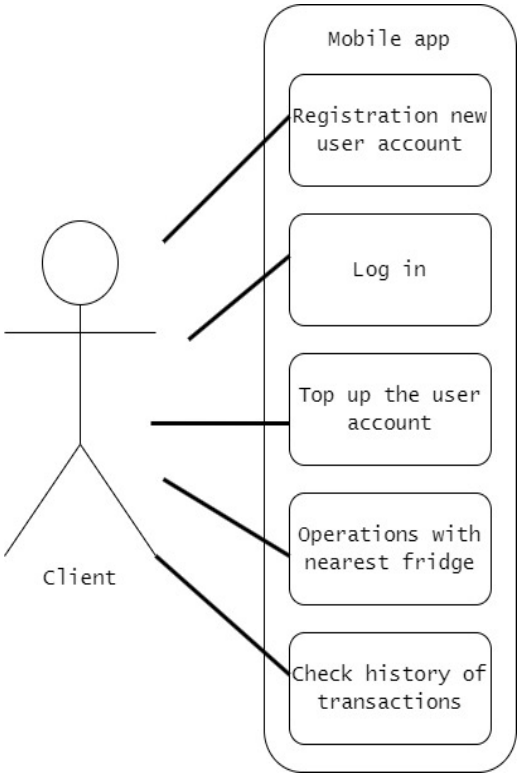

Fig. 2. The diagram of main functions of the mobile application

Now, having dealt with all the theoretical nuances (and there may be many more practical ones), you can proceed to the development options.

V. DEVELOPMENT OPTIONS

A mobile application must exist for both Android and IOS. It can be created in different languages such as Java, Kotlin for Android and use Android Studio as IDE and Swift for IOS. This is a good approach because the program will be written in languages that will work natively on both platforms and this in theory allows it to work fast enough, but this approach also has disadvantages because it takes more time and more resources to create them, especially when you create it yourself. And since the program does not require any significant computing or graphic resources, you can look towards cross-platform options such as JavaScript and its React Native or Qt or even Python. JS was chosen because the license for Qt is quite expensive, and Python for mobile devices is still new. Therefore, it is worth choosing React Native.

How the program should interact, as mentioned above, it will be used to scan and check whether the user is nearby, but not only that – all that was mentioned earlier is the direct interaction of the user with the refrigerator without intermediaries in the form of a web server (perhaps direct interaction also includes unlocking the magnetic lock) and also many operations will be carried out through an intermediate server that will store all information and will have its own API for communication between the mobile application and the refrigerator.

So, it was described above why this project needs an application, what tasks it should perform, and with which framework it will be developed.

Before describing the web server of the system, it is worth choosing which concept is better to use: cloud or fog computing. Several things are important, the speed of the algorithm for object detection, its accuracy and the final cost of the device and the system as a whole.

VI. FOG COMPUTING

It is worth starting with fog computing, the option when part of the work is taken over by a local computer that will work in the refrigerator, and the rest by a web server. As a basis, you can take Raspberry Pi 4 with 8Gb of RAM or its analogues or Nvidia JetSon Nano 4 RAM. Although if you compare them for CV, Nvidia JetSon is better suited because of its specific Graphics Processing Unit (GPU) with 128 Compute Unified Device Architecture (CUDA) Cores which are sharpened for Computer Vision. Now let's move on to the algorithms, they will all be based on supervised learning, since we will clearly know the products that will be in the refrigerator, we also need to consider how well they will work on such a small device as the Nvidia JetSon Nano. There are many variants of algorithms for object detection and most of them have become parts of other even larger algorithms such as YOLO, Detectron2, etc.

Let's start with YOLO (You Only Look Once), there are many versions of this algorithm, but we are only interested in YOLO v4 and YOLO v5. If we do not delve into the theory, these algorithms are seriously different, especially the backbones on which they are built. If YOLO v4 is a logical evolution of its predecessor YOLO v3, it uses a CSPDarknet53 backbone architecture, which is an improved version of the Darknet53 backbone used in YOLOv3. Whereas YOLOv5 is based on the EfficientDet backbone architecture, which is known for its efficiency and effectiveness in handling object detection tasks. What this gives us YOLO v5 is smaller and faster than YOLO v4 let's get to the **Ошибка! Источник ссылки не найден.**.

Comparison of YOLO v4 and YOLO v5

YOLO v4		YOLO v5
Precision	0.569	0.780
Recall	0.589	0.545
F1-Score	0.579	0.642
Time (ms)	27.90	25.40

As is seen from this table, YOLO v5 works better than YOLO v4, but YOLO v5 has its relative disadvantage, if you use it in commercial development then you need to pay for its license.

Detectron2 offered by Meta is also used for object detection. This algorithm has its advantages: firstly, it is distributed under the Apache License 2.0, which allows its use in commercial projects; secondly, it has greater accuracy and requires fewer photos for training, but is slower than YOLO v5. You can also use functions and models from the Tensorflow library, especially since it has everything ready to work with Raspberry PI.

VII. CLOUD COMPUTING

In the case of using the concept of cloud computing, a very powerful computer is not needed in the refrigerator, since all the hard work will be performed by a server with a powerful video card, this approach has its advantages, the first and foremost is speed, the speed of processing information (photos) that will be taken by a local computer, and also disappear limitations in the use of large models for object detection algorithms, which will increase the accuracy of the system. Disadvantages: renting a server with a powerful video card, for example, in AWS, will cost $3.84 per hour. And there is another minus: how quickly to transfer photos of each shelf with goods. But all these problems are not critical, because you can try to solve them, for example, to reduce the price of using a server, you can rent another one, only a simpler one, which will run the main web application that will control the entire system, and the object detection model will work on the server with GPU, it will be used only when photos are sent for processing.

So, let's sum up how the system will look in general. The concept of cloud computing will be used, where all the hard work will be done by a computer with a GPU, this will give us greater speed, better accuracy, as well as freedom in choosing algorithms and models, and the refrigerator will be controlled by a Raspberry PI 4, why because it is not expensive and has a large number of different modules, especially cameras that Raspberry offers, but more about that later in the article.

VIII. WEB FRAMEWORKS

There are a huge number of web frameworks and it is pointless to list them, the only thing worth noting is that Python Django, on which the system will be built, will be enough. There are libraries for Django that will allow you to create a project with a RESTful API, and this is exactly what is needed, since the web server must connect all the nodes of the system: the mobile application, refrigerators, and possibly a separate server with a model. The principle of operation of the server is depicted in Fig. 3.

Briefly, the preliminary idea is as follows: the user registers in the application, the application transmits the user's information through an API that will be developed to communicate with the web server, and the web server will store this information. After the user enters his mobile application, the server will send him the location of all refrigerators and what is in them. When the user opens the refrigerator, the server will prepare to process photos, which in turn will be taken and sent to the refrigerator to understand what the client took from it. And in the case of a "purchase" (the client took the product from the refrigerator), the server will deduct bonuses from his account.

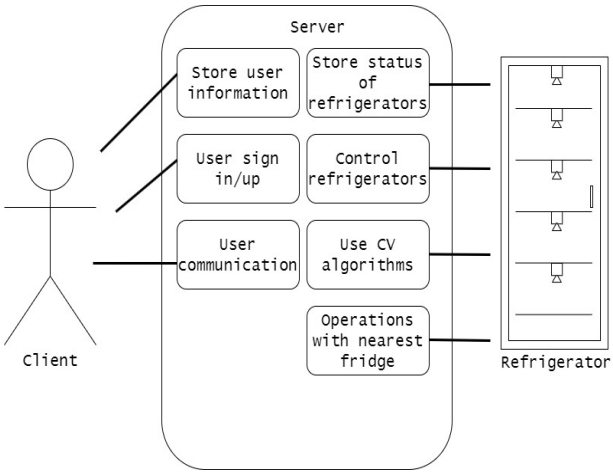

Fig. 3. The operation of the server

IX. HARDWARE

Throughout this article, a refrigerator was mentioned in which the goods will be located, although it does not necessarily have to be a refrigerator, it can be an ordinary closet. The main thing is a place that can be locked and in which goods will be placed. The main control unit will be a Raspberry PI as mentioned earlier, although other similar mini PCs can also be used. But Raspberry PI has an advantage that will be discussed later. Now it is important to think about options for checking what has disappeared from the refrigerator. Yes, it may sound strange because the article mentioned computer vision and the algorithms that will be used, but there is another option: RFID stickers.

Now in more detail about this option – RFID is a method of reading or writing information (in this case, we are interested only in reading information), with the help of radio signals, such a system consists of a reader and the RFID tag itself. In fact, the system is quite simple, but the main nuances of the RFID tag must be passive in our case, and a sufficiently large antenna is required for the reader, which will read information from the tags and heal them. There may be problems with the antenna, namely with its manufacture. The principle of operation in the project is also not difficult when each product will have an RFID sticker on the shelves where the products will be located, readers will be mounted, for example on the MFRC522 circuit or similar, which will communicate with the RFID tags and decode the signal into a convenient interface SPI,

UART or I2C which has been already processed by RPI (Raspberry PI). Also, an antenna will be mounted on the entire shelf area of the refrigerator (or cabinet) for

correct reading of labels. Thus, when the user opens the refrigerator, RPI with the help of readers begins to check in real time whether the user has taken something from the refrigerator, or it can be checked only once - after closing the refrigerator door. But this approach has one drawback, which is that the customer can deceive the machine by simply peeling off the label from the product and putting it back in the refrigerator, so the system will think that nothing has disappeared even though the product was stolen. But there are also advantages: the need for a powerful server with a video card is eliminated, which makes the operation of the refrigerator cheaper, and cameras are also not needed, which reduces the cost of the refrigerator itself.

Another option is the use of computer vision, which was mentioned earlier. In this case, you need to place several cameras on each shelf, but their number logically depends on the size of the shelf on which they will be located and the capabilities of the camera itself. As for cameras, you can use different ones: ordinary USB web cameras, but do not forget about the limited number of USB ports on the RPI itself, there are only 4 of them, you can use WiFi IP cameras, but for such cameras they can use software from the manufacturer, and it is not known whether it will be possible to use images in the project, or you can use cameras from Raspberry itself. There are already 3 generations of these cameras (module 3 in the project) with different features, viewing angles, small sizes and at a low price.

There are also ready-made libraries for these cameras that simplify their management, which is very important. But in the case of the smart refrigerator project, they have one serious drawback, the cameras themselves use their own RPI connection interface, and there is only one such port in the RPI. But if you look at the camera interface itself, it can be seen in Fig. 4 that it is actually not complicated.

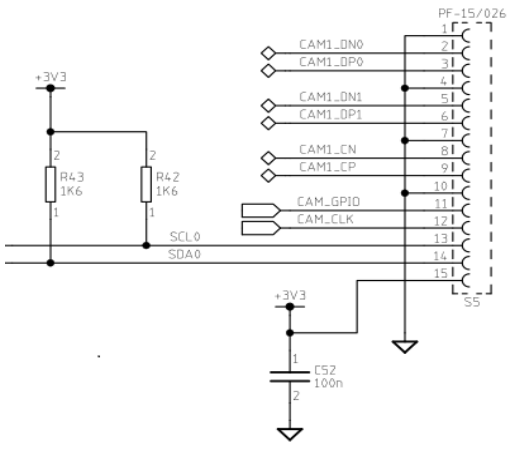

Fig. 4. The interface of the camera

X. CONNECTION INTERFACE

The diagram above clearly shows that the interface consists of 8 information signals that will be used to transmit information from the camera to the RPI, as well as 2 signals that are an I2C interface, which in theory will allow switching between several cameras using their I2C addresses. Then it remains to develop a module to which several cameras with a common I2C interface will be connected, and 8 information signals will be switched using a multiplexer, and this whole system is not so difficult to implement. A logical question may arise when using such a switch, what will happen to the delays, and they will be, but to determine whether a product has disappeared from the refrigerator, you do not need to shoot a video with a high frame rate, it is enough just to take a photo, so delays in this case can be neglected. Also, now you should choose the cameras themselves, because there are really many of them, but we stop at only 2 modules Camera Module 3, Camera Module 3 Wide, the first standard one does not have a large viewing angle, namely Horizontal Field of View 66 degrees, Vertical Field of View 41 degrees and the price in $25, the second camera has a wider viewing angle Horizontal Field of View 102 degrees, Vertical Field of View 67 degrees and a price of $35. It is necessary to test 2 to give a final answer which of the 2 cameras is better to use.

XI. BRIEF TESTING

In this project, the main task for improvement is: lowering the price of the final device, reducing the dimensions and weight, as well as the parameter that is valued only in money – customer orientation.

For now, it is worth focusing on reducing the price, as an example, a simple vending machine was taken, which will be as close as possible to the usual showcase refrigerator SandenVendo G-Snack KS8 Slave height x width x depth is 1830 x 830 x 845 mm with a weight of 240 kg and a cost of UAH 153,000. This machine is taken as a basis, which will need to be improved.

The main advantage of the solution proposed in this article is the possibility of scaling the device according to the needs of the client, but to show the advantages, it is worth taking into account the usual showcase refrigerator from liebher with dimensions (WxHxD), 59,7 x 188,4 x 65,4 cm. A vending machine of such dimensions can fit a maximum of 300 products, but to make it easier to count, all products in this example will be in the form of bottles with a volume of 0,5 liters of liquid. The refrigerator will then accommodate 64 bottles per shelf, or a total of 320 bottles, which is more than in a vending machine of similar dimensions. But there are certain nuances, since the main method of detection is cv, a certain space between the bottles is required for their correct detection. It also depends on the placement of the cameras and the cameras themselves in the refrigerator itself.

In this example, the cameras will be placed as in the Fig. 5 that is, perpendicular to the shelf. The article already mentioned the cameras of the raspberry company, namely model 3 and model 3 wide.

After conducting some tests, it was found that the model 3 wide camera at a distance of 300 mm captures

an area with a width of 700 mm and a depth of 38 mm, while the model 3 is only 370 mm by 210 mm. Simply put, from datasheet for this camera modules: module 3 has 66 degrees of horizontal field of view and 41 degrees for vertical degree of view, module 3 wide has 120 degrees of horizontal field of view and 67 degrees for vertical degree of view. Therefore, model 3 wide will be used.

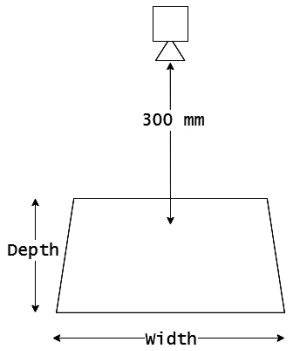

Fig. 5. The location of the camera and the area it covers

For correct operation, 2 cameras per shelf are required to fully capture them. For the correct recognition of bottles, a certain distance between them is required, namely no more than 9 bottles per chamber or 18 per shelf. Although these are all test calculations and if you raise the camera by 100mm, the area will increase and all the contours and labeling of the bottles will be better visible, which will allow you to place 32 units of the product on the shelf.

Then the refrigerator fits 160 bottles, which is: C = (q / f) / * 100 = (140 / 300) * 100=46.7 %, where C is ratio of difference amount of items in refrigerator and in vending machine in bottles to fully packet refrigerator, q – difference amount of items in refrigerator and in vending machine in bottles of 500 ml, f - amount of items in vending machine in bottles of 500 ml. It is less than in a vending machine of similar dimensions. So, the result is still not the best, but these are only rough calculations that were carried out with one camera, and not the best custom model.

As for the cost of the cameras, the price of one camera is $35, and to cover this refrigerator you need at least 10 pieces, the total amount will be $350, you also need a switch and loops to connect them all, and the Raspberry Pi itself, so the cost can be about $500, also needed magnetic lock to keep the fridge closed. But even if you take into account all these additions and leave a margin for the cost of 70,000 hryvnias, it will be: C = (f / v) * 100 = (70 000 / 153 000) *100 = 54.2 %, where C is ratio of vending machine price to difference of refrigerator price and vending machine price, v - price of vending machine in UAH, f - difference of refrigerator price and vending machine price in UAH So that is, cheaper than a regular vending refrigerator.

Regarding the Detectron2 and its model Zoo it is hard to give a lot of information because for now several models were tested for object detection and results are not good. For now exist very small pictures dataset with 2 classes water with gas and without gas, which was trained on faster_rcnn_R_50_FPN_3x model from detectron2 model Zoo sometimes this model shows good result (but this can be model overfitting also), but usually this is different types of false detection like false positive. There are 2 pictures made from different angles and different distances. Fig. 6 is made by phone and perspective of the picture is more similar to images from the dataset which is using.

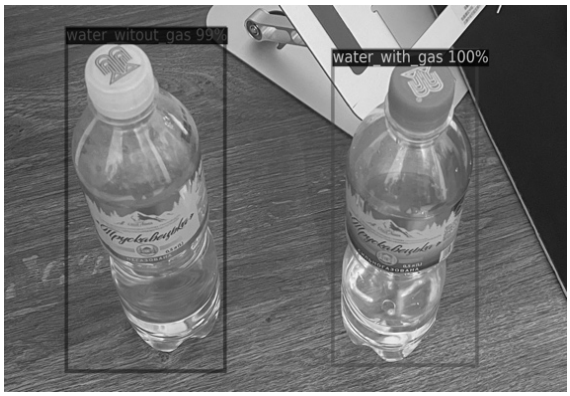

Fig. 6. Image made by phone

Good detection is seen: one bottle of water is with gas and another is without.

The detection of bottles in Fig. 7 is not so good, 2 bottles without gas were detected but the third bottle with gas was detected badly. Fig. 7 is made by using Raspberry Pi camera module from angles and distance which are described earlier on Fig. 5. This camera detected 2 times that water is with gas which is true but also that water is without gas even with a higher probability this is false positive detection. Why such behavior is seen it is hard to say, this can be an issue with hyperparameters, small image datasets, or even a bad model that is used as a base. That is why there is a need for more investigations.

Fig. 7. Image made by using Raspberry Pi camera module

XII. CONCLUSION

The need to create an alternative to vending machines was described in this article.

To sum up, namely the results of the entire project and what was needed for its implementation, a mobile

application that was developed on the React Native framework, a web server that processed the information that the RPI sent to it, and the refrigerator itself with installed cameras, were discovered.

A replacement for standard vending machines was created, which was cheaper by at least 54.2 % of the cost of ordinary vending machines, reducing their dimensions, provided that the capacity of such a refrigerator did not decrease by more than 46.7 %, which made it possible to deliver and installing them in places where standard vending machines would be difficult to install. Creation of a convenient mobile interface for users will provide an opportunity to find refrigerators and view their contents.

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