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A handwritten signature in blue ink, appearing to read 'Berlikozha', is written over a faint, light blue grid background.

Development of IoT solution for collecting
disposable plastic bottles in private Kazakhstani
university

THESIS

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Bauyrzhan Berlikozha

Abstract

Today, conversion of plastic bottles is one of the most profitable segments of the conversion market. I, you and many of us know that plastic is a global environmental problem in modern civilization, especially in private University like SDU. No way is the production of plastic bottles not so expensive, plastic is a cheap raw material, so far no one is going to stop this production.

The aim of my project is to create a prototype plastic bottle collecting system on the Arduino platform. It works on 2 levels. When objects detected with specific sensors, three sensors implemented, if all sensor's outputs are equal to zero, that shows the bottles are passed correctly. Arduino's sensor counts only the the passes bottles, according to how much were putted, the machine will give one refreshing candy with a fruit flavor for each bottle. At the end of the working day it will be something like this: a report for 1 working day will be displayed on the screen of the device. A report in the form of how many bottles this highly intelligent device has collected, it will also publish on social networks (instagram).

The goal of the thesis is not just the collecting bottles; I have worked on improving it as smart and clever system. Because, such kind of terminals can be located on crowded places, also in some European countries like Germany, Spain and Asian Japan, people can use this system for ticket payment in public transports or can buy food for homeless animals. It shows that they have qualified organizing service system. The important part of my job is starting from private university's place to collect some dates to analyze them.

Аңдатпа

Бүгінгі күні пластикалық бөтелкелерді конверсиялау конверсия нарығының ең тиімді сегменттерінің бірі болып табылады. Мен, сіз және біздің көпшілігіміз пластик қазіргі өркениеттегі, әсіресе SDU сияқты жеке университеттегі жаһандық экологиялық проблема екенін білеміз. Пластикалық бөтелкелер шығару соншалықты қымбат емес болғандықтан, пластмасса арзан шикізат болып табылады, сондықтан бұл өндірісті әлі ешкім тоқтата алмайды.

Менің жобамның мақсаты - Arduino платформасында пластикалық бөтелкелерді жинаудың прототиптік жүйесін жасау. Ол 2 деңгейде жұмыс істейді. Нысандар белгілі бір сенсорлармен анықталған кезде, егер сенсордың барлық шығысы нөлге тең болса, үш сенсор қолданылады, бұл бөтелкелердің дұрыс өткізілмегенін білдіреді. Arduino сенсоры өткізіп алған бөтелкелер санын есептейді, олардың қанша орналастырылғанына байланысты, машина әр бөтелке үшін бір сергітетін жеміс-жидек кәмпитін шығарады. Жұмыс күнінің соңында бұл келесідей болады: құрылғының экранында 1 жұмыс күніне арналған есеп пайда болады. Бұл өте ақылды құрылғы жинаған бөтелкелер саны туралы есеп, ол сонымен қатар әлеуметтік желілерде (инстаграммда) жарияланады.

Диссертациялық жұмыстың мақсаты тек бөтелкелерді жинау емес; Мен оны ақылды және ұғымды жүйе ретінде жетілдірумен жұмыс жасадым. Бұл типтегі терминалдар адамдар көп жиналатын жерлерде, сондай-ақ Германия, Испания және Азияда Жапония сияқты кейбір Еуропа елдерінде орналасуы мүмкін болғандықтан, адамдар бұл жүйені қоғамдық көліктерде жол жүру билеттерін төлеу немесе үйсіз жануарларға тамақ сатып алу үшін пайдалана алады. Бұл олардың білікті ұйымдастырушылық қызмет жүйесіне ие екендігін көрсетеді. Менің жұмысымның маңызды бөлігі жеке университетте оларды талдаудан басталады.

Аннотация

Сегодня конверсия пластиковых бутылок является одним из самых прибыльных сегментов рынка конверсии. Я, вы и многие из нас знаете, что пластика является глобальной экологической проблемой в современной цивилизации, особенно в частном университете, таком как SDU. Так как производство пластиковых бутылок не так уж и дорого, пластмасса - дешевое сырье, поэтому пока никто не собирается останавливать это производство.

Цель моего проекта - создать прототип системы сбора пластиковых бутылок на платформе Arduino. Работает на 2 уровнях. Когда объекты обнаруживаются определенными датчиками, используются три датчика, если все выходы датчика равны нулю, что показывает, что бутылки правильно пропущены. Датчик Arduino считает только количество пропущенных бутылок, в зависимости от того, сколько было помещено, машина выдаст одну освежающую конфету с фруктовым вкусом на каждую бутылку. В конце рабочего дня это будет примерно так: отчет за 1 рабочий день будет отображаться на экране устройства. Отчет в виде количества бутылок, собранных этим высокоинтеллектуальным устройством, он также опубликует в социальных сетях (instagram).

Целью дипломной работы является не просто сбор бутылок; Я работал над улучшением его как умной и восприимчивой системы. Поскольку терминалы такого типа могут быть расположены в людных местах, а также в некоторых европейских странах, таких как Германия, Испания и Азиатская Япония, люди могут использовать эту систему для оплаты билетов в общественном транспорте или покупать продукты питания для бездомных животных. Это показывает, что у них есть квалифицированная организующая система обслуживания. Важная часть моей работы начинается с того, что в частном университете собираются несколько дат для их анализа.

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To my family

Thank you all for being the best inspiration and support for me! You can never find it, and I have had the joy of my life! And for being a regular!

Thank you because it is very good for all people, you make me believe in a better world with people like you! Thank you for adding a new meaning to my life, love!

Thank you for always thanking you for your kind words. You do not know how many times you have survived a mental illness. Thanks for your healing, thank you very much!

I just want to say thank you with grateful relief because, if I had lost, you will inspire and make me become a better person! I love you so much.

I never wanted to be in debt. But look a big thank you. I'm so impressed with your kindness!

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Nomenclature

DBMS database management systems

DBs Databases

ES Ethernet Shield

LCD Liquid Crystal Display

SMS Short Message Service

SMS Short Message Service

SQL Structured Query Language

WMS Waste management systems

1. Introduction

Nowadays smart networks address several global issues such as resource shortages, climate change, population aging, and globalization. They are gradually being used in a large number of sectors for that purpose. Transport, health care, energy, safety and security, logistics, ICT, and manufacturing are key sectors in this context. That's how I chose a project that was related to the global ecology issue.

How to Solve a Waste Usage Problem? It is difficult to burn, such that a normal cycle of decomposition will continue for 200 years while burning plasticity emits toxins of a high-risk level. Secondary processing of plastic waste seems to be the only rational solution to this issue. For your own company, it's an excellent idea that doesn't involve massive financial expenses. All these facts show here that devices (technology) can also help to make our world healthier for our generation. As experience from developed countries such as Germany shows, Japan's commodity recycling is a specter that requires special attention. There are many ways to make people safer, cleaner ecosystems, and better economic life with the government's help funding. Germany recycled 93.5 percent of its PET bottles in 2015, reports a new report by Forum PET. The analysis describes deposits as the key explanation for high recycling rates, stating that most customers use reverse vending machines to return PET bottles. Forum PET also states that the amount of PET reused in new bottles rose from 24 percent in 2013 to 26 percent in 2015. Considering the tough market conditions for the use of recycled PET over virgin material, these innovations are described as 'impressive.'

The success of Germany with bottle deposits is in contrast to the collection systems in some US states. For example, in California, in 2016 more than 300 bottle redemption centers shut down. [1].

1.1 Aims and Objectives

At the current rate of global population growth and consumption of resources, it appears clear to me where we're going to end. Needless to say recycling is one of the most important things we can do to keep our planet sustainable. Recycling is a very promising area for robotics. Over the next few decades I imagine a future where waste-collecting robots will be moving through air, land, and water, reaching difficult areas to help us cleaning our environment. [2]. Process automation in recycling or identifying ways that can classify these objects such as plastic bottles, are necessary and valuable for better efficiency in the quality of the selection process. The purpose of this research is to propose a system that is able to perform digital image processing and use in extracting edge in plastic bottles, subsequently calculating characteristics and assigning them to different types of plastic.

In recent years, robotic cleaners have taken major attention in robotics research due to their effectiveness in assisting humans in floor cleaning applications at homes, hotels, restaurants, offices, hospitals, workshops, warehouses and universities etc. Basically, robotic cleaners are distinguished on their cleaning expertise like floor mopping, dry vacuum cleaning etc. Some products are based on simple obstacle avoidance using infrared sensors while some utilize laser mapping technique. Each cleaning and operating mechanism of robotic floor cleaners has its own advantages and disadvantages. Let's say in example, robots utilizing laser mapping are relatively faster, less time consuming and energy efficient but costly, while obstacle avoidance based robots are relatively time consuming and less energy efficient due to random cleaning but less costly. Peoples have environmental conscious will throw waste plastic bottles into trash, otherwise throw away, thus caused environmental pollution. Therefore, in order to reduce plastic bottles environmental pollution, encourage peoples to make good use of renewable resource, and for the benefit of social, it is very necessary to research a kind of plastic bottle recycling unit which integrates recycling function, processing function and incentive function together.

1.2 The feature of the work

Waste management systems vary depending on the type of waste and the regulations that apply; some basic processes can be distinguished. In addition to major logistics processes, such as transportation, storage and transshipment, waste flow includes the following specific processes (see Figure 1.1).

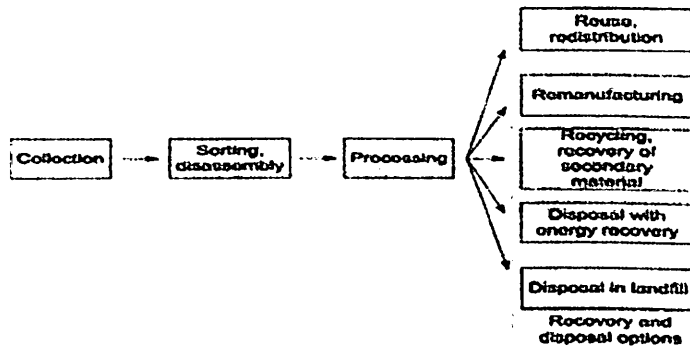


Figure 1.1: WMS process

The waste stream starts at the facilities logistics of the collection. The collection procedure actually reproduces a heterogeneous stream of waste, which requires processing to be re-processed. The separate fragments will be done when sorting breaks heterogeneous material flowing. Statically or manually description is characteristics of sorting. Also using technology that dynamically finds the attributes of objects which have been automatically filtered. At the end of the WMS process, the facility is processed and subjected to various recovery and disposal alternatives. According to the relevant EU law, these alternatives are hierarchical with priority of use and disposal at waste disposal as their preferred option [3].

In terminal, there are 4 steps to reach acceptance. First one is about passing across sensor, second is about pushing into package, third step is about notification of information to display, fourth is about gift for work which was done, in my case is candy for user. The important missions are: collecting disposal bottles in private university and scroll up the motivation of people (in my case students) to reach cleanest, analyzing amount of plastic bottles. It means that with data of how many bottles were collected in private place (universities hall, canteen e.t.c), it gives opportunity to prediction analyze (see Figure 1.2).

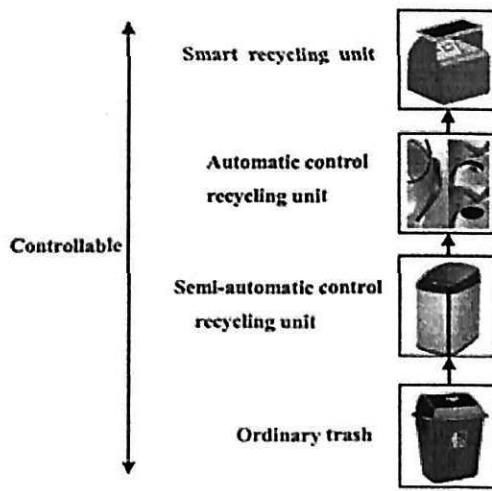


Figure 2. Collector controllable evolution (evolution tree branches).

Figure 1.2: Evolution tree branches

1.3 Types and modules of collecting service system

Service system of Japan

The principles for the separation of garbage in Japan depend on the area and the requirements of the municipal authorities, but most often the waste is divided into four categories, which are somewhat different from the usual separation. Here, fireproof, combustible, recyclable and bulky waste is placed in different bins. Moreover - for each type of waste special packages of a certain color and volume are designed to make it easier to distinguish which type of waste is in them. On large items that, of course, do not fit in packages, special stickers are glued. To ensure that everything is sorted correctly, follow the workers serving the garbage truck. The garbage collection machine arrives at certain hours. By this time, residents take out their bags, and since they are transparent, scavengers have the opportunity to track whether the waste is sorted correctly. If there are violations, packages do not accept. Garbage truck arrives not only at certain hours, but also on certain days. Each type of waste is removed exactly on the appointed day of the week, on which day it is established by the municipality. So, in the city of Kita-Kyushu on Tuesday and Friday they take out combustible garbage, on Wednesday - cans and bottles, on Thursday - packing plastic. If you take out, say, plastic garbage on Tuesday, they simply will not accept it from you. Nevertheless, if you try to leave the packages at the garbage truck, they will set

a fine for the entire housing cooperative. (see Figure 1.3) [4].

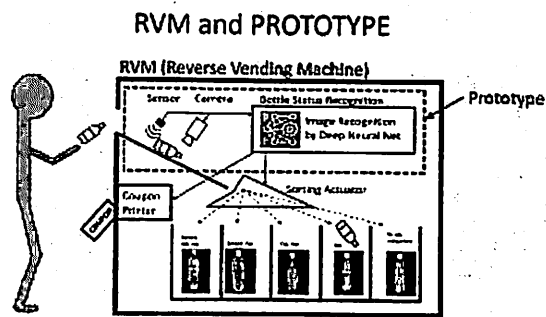


Figure 1.3:

The day for the removal of bulky items is usually set separately: residents call the garbage collection company and make an application, they are informed there when a garbage truck arrives for furniture. It is for furniture, because household appliances do not belong to bulky garbage. Its disposal must be paid separately. There are many ways to do this. It can be taken to the store where the equipment was purchased and paid to the manufacturer for disposal. Or you can pay for the disposal of goods in this store, in return they will be given a special sticker. It can be glued to old equipment and taken out to garbage bins - a garbage truck will pick it up and take it to the scrap. This practice has led to good results: the utilization of household appliances gives the country more than 1 million tons of iron and 50 thousand tons of non-ferrous metal per year. Attempts to throw away unnecessary equipment and electronics without payment will result in fines of several hundred dollars. But there are not so many cases of such unconsciousness - organization and love of order in the Japanese are in the blood. [5].

So that the guests of the country also abided by the rules of separate collection, the Japanese installed special bins on the streets: the holes in them were made so that nothing but what they were intended for did not enter. If the urn box is for tetrapacks, you cannot squeeze a glass bottle into it. In order to make it clear what category of waste this or that waste belongs to, on all packages of goods there is a marking that tells where to throw it away. For example, on yogurt it is indicated that the lid should be thrown into plastic trash, and a cup - into combustible waste.(see Figure 1.4) [6].

According to the Council of PET Bottle Recycling, based in Tokyo, about 564,000 tons of plastic beverage bottles were sold in the nation in fiscal 2009. Of



Figure 1.4:

the quantity, municipal governments collected 287,000 tons of used bottles and businesses collected 150,000 tons. The total recycling rate was 77.5 percent. Of those recycled, about 158,000 tons became new products. The Japan Containers and Packaging Recycling Association, based in Tokyo, said that more than half of the collected bottles were turned into textiles and only 2.5 percent were recycled into brand new plastic bottles. [7].

Service system of Germany

Each year, Germany "produces" about 412 million tons of garbage - industrial and domestic. This is approximately 500 kilograms on average per inhabitant of the country. Statistics calculated that out of this amount, 125 kilograms are organic waste, almost the same amount is paper, cardboard and glass, which are thrown into special containers, 30 kg are bulky items like old furniture, refrigerators that have served their age, etc., and about 220 kilograms - residual waste, of which the bulk (168 kg) is construction waste: broken brick, pieces of concrete, fragments of plaster, drywall, ceramic tiles, iron reinforcement and so on. [8].

Almost two-thirds of all garbage is recycled in Germany, which allows it to be disposed of, including half of all plastic garbage, the most problematic. This is more than in any other country in Europe. About 45 million tons are burned after sorting and processing at special plants. But this garbage is beneficial. Gas turbines that are installed in such plants generate electricity. In addition, the gases generated during combustion after cleaning are used for heating. By the way, only gases passed through special filters are emitted into the atmosphere, so the pipes of the incineration plants smoke slightly and almost odorless. [9].

In Germany, the system of recycling plastic waste and packaging - the Dual System Deutschland (DSD) - was introduced in the early 1990s. The new law obliged manufacturers to finance the collection, sorting and recycling of the plastic they created, and also introduced a minimum threshold for products made from recycled materials. The funds received were transferred by DSD to Grüner Punkt, which for many years has been a monopoly in waste management. Since 2005, similar companies began to appear throughout the country and the Grüner Punkt monopoly disappeared. The system works in such a way that at first all collected packaging waste is sent to primary sorting, where workers remove foreign objects from the garbage. After that, the waste is sent to specialized factories, where the plastic is mechanically separated into different grades, it is pressed and evenly cut. The resulting pieces under the influence of high temperatures are converted into granules, which can then be used to produce new bottles, plastic containers and other products. [10].

In Germany's terminal systems you have to pay a deposit for most of the plastic bottles you buy. This is usually 25 ct per bottle. Once it is empty, you can bring it back to the supermarket and get your deposit back by putting it in a bottle recycling machine. Bottle recycling machines are usually located near the entrance of supermarkets. If you put your bottle into the round hole, the machine will spin it around to scan the barcode. The bottle then disappears into the machine, which displays the amount of money that you will get back. If you have got more than one bottle, keep putting them in, one after the other, and then press the green button. Next, the machine will print your receipt. Always keep your receipt! The amount at the bottom is the cash you get back from recycling your bottles. If you want to buy something else in the supermarket afterwards, you can hand this receipt to the cashier and you will get the amount of money deducted from your bill. If you do not want to buy anything new, you can also just hand in the receipt and get your money back [11]. (see Figure 1.5).

Service system of China

In a country that is one of the largest garbage producers on the planet, until recently there was no separate collection system. About how the situation has changed recently, and what is being done with garbage in China – in my work. [12]. Nevertheless, the garbage men are not able to sort out all the waste: some of them could well have a second life, but they still don't reach the recycling points.

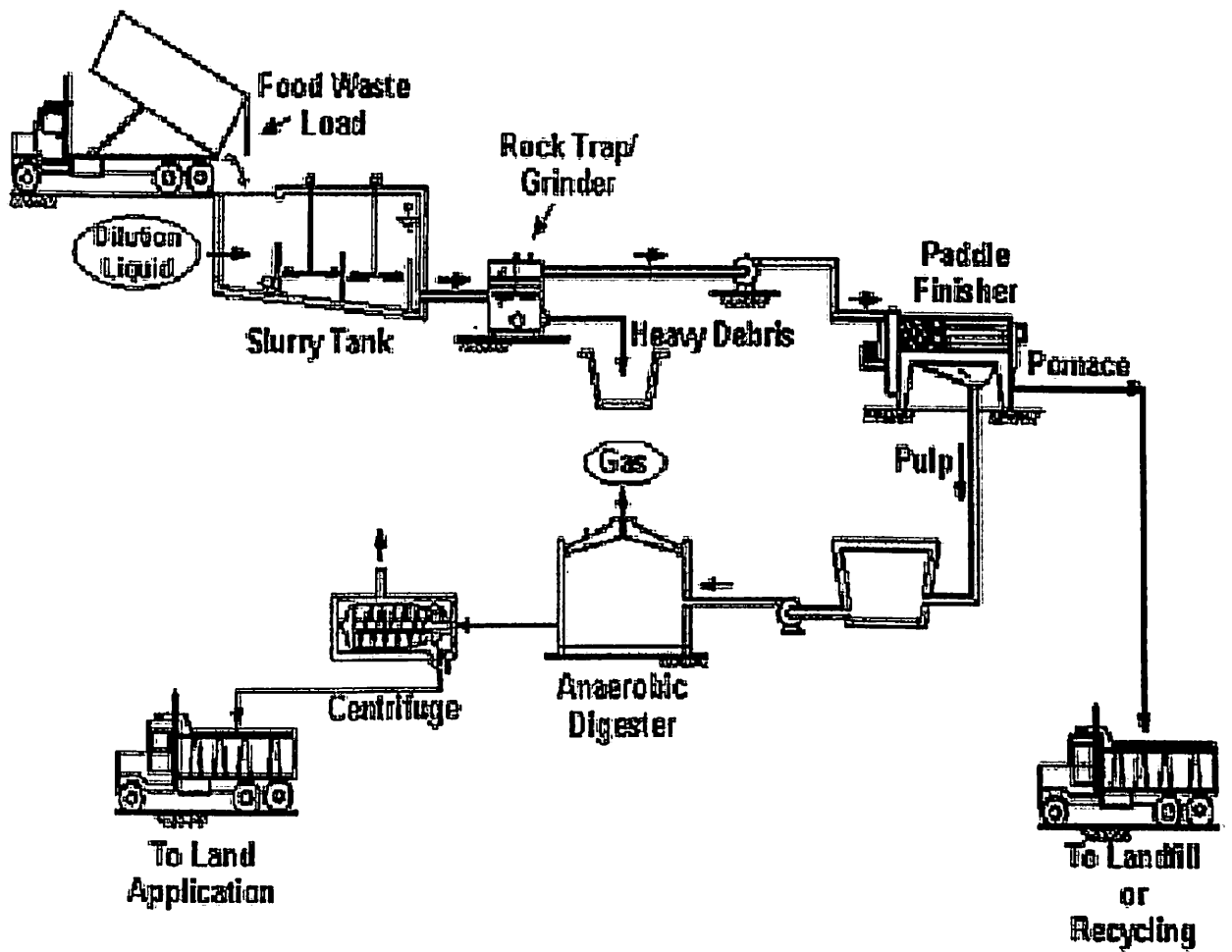


Figure 1.5:

To solve this problem, the Chinese government is accustoming the population to self-sorting garbage. [13]. Now more and more often on the streets of big cities you can see mobile plastic receiving stations where they take bottles.

Also, during the campaign for the ecology, millions of Beijing residents received three colorful buckets as a gift from the city authorities, each of which is intended for a separate type of garbage. This, as conceived by the mayors, should encourage residents to sort waste. Gradually they should be accustomed to this and the urns on the streets.

They consist of two compartments “recyclable waste” and “other waste”. So far, you can throw garbage in any compartment - under pressure from the public, the penalty for dishonest sorting of garbage was removed at the stage of discussion of the bill - but over time, the government plans to fine those who leave garbage in an inappropriate department. [14].

According to the law on garbage, which came into force on January 1, 2009, waste is not just garbage, but an “inefficient resource”. And so that residents can clearly see what effect can be achieved by sorting it, special units for food waste

were delivered in many yards in Beijing. [15].

The leftover food thrown out by residents of the house is processed into ecologically clean compost for 24 hours. Then the janitor fertilizes them with green spaces in the yard.

In addition, the fare on the Beijing subway can be paid with empty plastic bottles. “For each bottle, a passenger receives from 0.1 yuan to 0.5 yuan,” says Ekaterina Ryabova, an English teacher in Beijing. “It is enough to accumulate about twenty used bottles, and then lower them into one of the vending machines located at metro stations - and you will get a free ticket.” [13].

Income Recycle Co Ltd installed the first of its upgraded smart recycling machines, named Maltipac, for polyethylene terephthalate (PET) plastic bottles, glass bottles, and metal cans in Beijing on June 7. The only recycling company with the ability to produce food grade PET material in China, Incom partnered with Norwegian recycling machine suppliers TOMRA Sorting Solution to modernize and digitalize its recycling system. The new machine was installed at the Lianxiangqiao branch of Wumart, a well-known supermarket chain based in Beijing and one of Incom’s recycling partners. China Resources C’estbon Beverage (China) Co Ltd is another partner. With this new set of machines, Incom hopes to introduce the deposit-refund system to China’s recycling industry. Popular in European countries, the system encourages PET bottle recycling by incentivizing the return of plastic bottles. Each returned bottle earns the recycler 0.2 yuan [13].(see Figure 1.6).



Figure 1.6:

Process of system with RFID

Information technologies (IT) occupy a new place in our life, proving their advantages in the field of waste management, in particular when collecting them

as previously in other areas. Remote monitoring of the state of the garbage container and obtaining information about when it is necessary to empty it is important for utilities and employees of garbage collection companies.

Armed with this information, the contractor will be able to limit visits to the places where garbage containers are installed to the moment of their filling, which will reduce the frequency of unnecessary departures and will save staff time and money, as well as fuel and depreciation of vehicles.

In addition, proportional tariffication systems provide for the creation of an information infrastructure that will ensure effective interaction between households and the municipal service.

Billing households for garbage collection depending on the amount of waste actually removed can be a powerful means of stimulating waste reduction and phasing out of landfills.

This part provides an overview of the technologies available in this sector and possible ways to introduce new data collection technologies to improve waste management.

The collection of data from household owners during direct interviews provides valuable information on the nature of the accumulation of household waste in a particular municipality, and the processing of this information on a computer provides technical support that fully justifies the work of the specialists conducting these surveys.

The results of this type of research make it possible to identify all the differences between how household owners estimate the amount of waste they produce and the actual amount of waste generated. After identifying such inconsistencies, various comprehensive information campaigns can be developed to work more actively with homeowners and change their established habits. Relevant information can be sent on address leaflets or in the form of SMS messages.

Another way to optimally collect reliable information is to develop the design of garbage containers equipped with data collection systems.

An example of the transition from a passive to a more active waste bin concept is Opti'System containers from Plastic Omnium, a leading manufacturer of waste collection equipment. According to this relatively recently developed technology, each container is equipped with ultrasonic sensors and remote information transmission systems that send the necessary SMS messages to the corresponding

database of the local municipal service when the container becomes close to full.

Each message updates the specified database of the local municipal service, which allows continuous monitoring of the condition of containers and saves staff time and fuel. The GPS system of the “traffic light” (red, yellow and green) sends a signal to the municipal service office, indicating the urgency of collecting waste from a specific container. Such a warning system will exclude overflowing containers from parking lots from our lives and facilitate the implementation of public initiatives aimed at efficient waste management.

Opti'System is currently undergoing testing at the Perth and Kinross City Council in Scotland. According to the estimates of this municipal council, the cost of a garbage collection machine is 10 pounds (15 euros) per mile, which includes fuel, labor and depreciation. At the very beginning of testing, Opti'System gave good results. When used in France, the average filling of garbage containers at the time of waste collection was 82percent (the national average is 50percent). In addition, the initial results already yielded a 40percent reduction in the number of containers collected and a 39percent reduction in distance traveled.

Modern wireless technologies also have an impact on the waste collection industry. We are currently witnessing the rapid development of the wireless technology market - radio frequency identification (RFID), Wi-Fi, global positioning systems and GPRS. According to ARC Advisory Group, wireless technologies have already become the basis for building networks in homes and offices around the world and will soon find universal application, as a result of which they are likely to affect our lives even more strongly both in industrial plants and in the field . ARC Advisory Group predicts that the global market for wireless industrial applications over the next 5 years will grow at a 26percent average annual growth rate. In 2005, the volume of this market amounted to dollar 325.7 million, and by 2010, according to the forecast, it will amount to over dollar 1 billion.

From the point of view of the waste collection industry itself, wireless technology is increasingly used in RFID tags. Microchips can be integrated into wheeled garbage containers, which, when scanned by the sensor of the garbage collection machine, will give a signal about their belonging to a particular household. The garbage collection machine can also be equipped with a weighing system for the contents of the containers, after which this data will again be associated with a particular house. Data will be recorded on the on-board computer, and this will

determine how much waste is generated in a particular household.

The advantage of these tags and the corresponding weighing technology is that they allow not only to identify individual garbage containers, but also individually confirm data on the rate of waste accumulation for each household. The use of identification tags also allows operators of the relevant services to track the movements of each container to avoid loss.

However, you should be realistic about the current capabilities of these technologies. The basic principles of wireless technology are well known to everyone, but their practical application for waste collection is still a fairly new area. Weighing garbage containers at the time of their emptying, along with the already wide enough range of possible applications, has serious potential for new future uses.

Proportional tariffing of garbage collection services. The advantages of using this system were tested in the south of France, in the city of Sictom Loir-et-Sarthe, where local municipal services faced the problem of the high cost of waste management and the low level of their recycling. The municipality applied two-flank attack tactics - introducing tariffs for waste collection services based on the real amount of waste, as well as RFID technology.

Garbage containers with a personal identification marker were issued to each household. After that, during 2004, the municipal service installed Plastic Omnium's Ecosourcing identification and weighing system for 44,000 residents in the 5 regions it serves. After 8 months, the percentage of waste recycling increased from 15percent (average) to 57percent, and the cost of recycling decreased by 10percent in parallel with a decrease in the volume of waste generated.

HID Global RFID tags help municipalities and waste management companies optimize the speed and accuracy of data collection by allowing them to pay for the amount of waste actually thrown away and implement programs that encourage waste management. [16].

RFID solutions support the identification and tracking of waste streams. Labels attached to garbage containers allow controlling the quality of sorting, recording the number of container installations and the weight of its contents. Tags simplify billing processes and support bonus programs. Tank and container manufacturers choose HID Global passive proximity transceivers operating in the LF, HF, or UHF bands. The robust construction is resistant to moisture, chemicals, shock and temperature changes. Trash can tags and insert tags are easy to install

in standard sockets on metal and plastic tanks in accordance with DIN 30745. [16].

Additional designs provide flexibility and versatility for labels for tanks and containers, regardless of their size, shape or material.

The main results of this technology

We are all interested in the emergence of an international incentive system for the proper disposal of waste. And, as noted earlier, RFID technology is one way to solve this problem. Data collection will allow:

- reduce the amount of waste disposed of at the university;
- reduce the amount of waste lying in containers on the territory;
- increase the efficiency of waste management;
- give the authorities real evidence in favor of providing grants for waste management initiatives, which ultimately will increase the percentage of waste sent for recycling;
- collect individual data on households (for example, by the magnitude of participation in the waste management program);
- increase the percentage of waste sent for recycling;
- to improve the quality of services in the field of waste collection due to more efficient route planning of waste collection machines, proportional tariffication and identification of companies providing low quality services.

In this work RFID was used to enhance existing sorting processes, in other scenarios RFID allows to establish sorting where it is not economically feasible so far. In the EU, manufacturers of electronics equipment are complying with the extended producer responsibility for the recycling of their products collaboratively. End-of-life products of all producers are collected and recycled together and producers are charged for the disposal of their products on the basis of their market share. Therefore there is no incentive for producers to change the design of a product in order to facilitate its recycling, as competitors would benefit from these changes to a great extent. RFID tags in electronics products would allow for the individualization of the collaborative producer responsibility system, as identification in collection or recycling facilities would permit the assignment of producer-individual recycling. At the end of the waste management process chain, objects are processed and subjected to a variety of recovery and disposal alternatives. [17].

2. Instruments and technologies

2.1 Arduino technologies

Arduino - is a small board with its own processor and memory. The board also has a couple of dozens of contacts to which you can connect all kinds of components: light bulbs, sensors, motors, kettles, routers, magnetic door locks and everything that works on electricity.

In the Arduino processor, you can download a program that will manage all these devices according to a given algorithm. Thus, you can create an infinite number of unique cool gadgets made by yourself and on your own idea. In order to understand the idea, take a look at the illustration. It does not reflect the millionth share of all possibilities, but it still gives an initial idea.

Arduino gained its frenzied popularity due to its simplicity and friendliness. Even a complete zero in programming and circuitry can master the basics of working with Arduino in a couple of hours. Thousands of publications, textbooks, notes on the Internet and an excellent series of Arduino video tutorials in Russian will contribute to this.

Arduino IDE Programs for Arduino are written in regular C ++, supplemented by simple and intuitive functions for controlling input / output on contacts. If you already know C ++ - Arduino will become a door to a new world where programs are not limited by the scope of a computer, but interact with the outside world and influence it. If you are new to programming - not a problem, you can easily learn, it's simple.

For the convenience of working with Arduino, there is a free official Arduino IDE programming environment that runs on Windows, Mac OS and Linux. With

it, downloading a new program in Arduino becomes a matter of one click, just connect the board to the computer via USB. Although for more inquiring minds, it is possible to work through Visual Studio, Eclipse, other IDEs or the command line, newcomers will use the visual programming environment XOD IDE.

You do not need a soldering iron. Complete devices can be assembled using a special dummy board, jumpers and wires absolutely without soldering. Designing has not been so quick and easy.

To describe and to get explanation just follow the work flow of Arduino in my work. This is how system flows (see Figure 2.1).

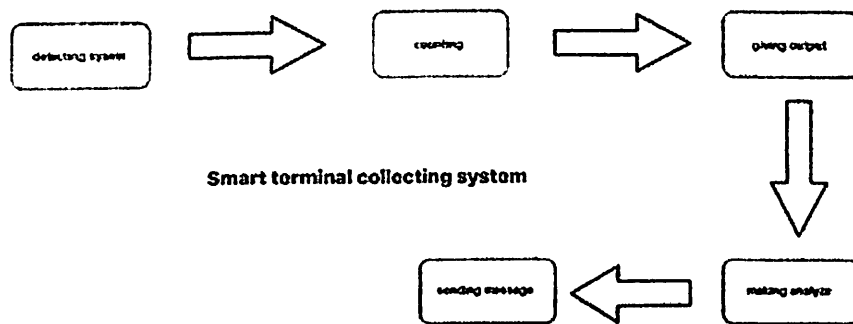


Figure 2.1: Work flow

Another distinguishing feature of Arduino is the presence of expansion cards, the so-called shields, or simply “shields”. These are additional boards that are placed like sandwich layers on top of an Arduino to give it new features. For example, there are expansion cards for connecting to a local network and the Internet (Ethernet Shield), for controlling powerful motors (Motor Shield), for obtaining coordinates and time from GPS satellites (GPS module), and many others. [18]. (see Figure 2.2).

Ethernet Shield (ES)

Ethernet Shield will allow you to play the role of a full-fledged network device: communicate with similar devices, with ordinary computers, printers, Internet services and other network resources.

An Ethernet Shield was used to create:

- for remote control of the device via the Internet;

• to display data from online services like Yahoo! Traffic and Climate.com

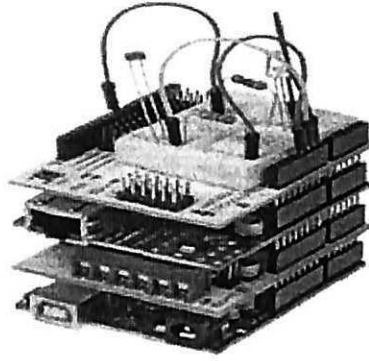


Figure 2.2: Shields

- for maintaining a protocol of sensor readings in the cloud storage;
- to run a small web server;

The board is based on the Wiznet W5500 chip, which supports TCP and UDP protocols. Up to eight connections can be open at the same time.

Ethernet Shield is manufactured in Russia by Amperka. Characteristics:

- Ethernet chip: Wiznet W5500
- Working voltage: 5V
- Buffer Size: 32 KB
- Connection Speed: 10/100 Mbps
- Occupied pins: SPI (MISO, MOSI, SCK) and 10
- Dimensions: 69 / 53 mm (RJ45 protrudes several mm)

To connect to a local network, use the standard 8P8C (RJ45) connector on board. Connect one end of the twisted pair patch cord to a router or hub, and the other end to an Ethernet Shield. For communication with the control board, the SPI interface is used. Ethernet Shield takes the MOSI, MISO, SCK pins on the ISCP connector and the 10th as CS for the W5500 chip. [19].

Motor Shield (2 channels, 2 A)

Connect a motor to your Arduino. This is not entirely trivial, the outputs of the microcontroller are low current, so the current of the motor with direct connection will disable them. This problem is solved by the so-called H-bridge

It allows you to control the speed and direction of rotation of the motor using the logic signals of the microcontroller.

One of the most popular H-bridges is the L298P chip. Motor Shield is an expansion board for the Arduino based on the L298P chip, which allows you to control motors with a voltage of 5-24 V in separate power mode and 7-12 V in combined power mode.

The board has 2 independent channels. You can connect to them to choose from:

- A couple of DC motors.

- One two-phase stepper motor.

- One DC motor with a current of up to 4 A, if you combine the channels.

The outputs for each of the motors are made in the form of a terminal block with a screw, so soldering is not required.

During acceleration and braking, the motors themselves induce short-term reverse current of large magnitude, which can burn out the contacts of the microcontroller. Motor Shields are equipped with return diodes to prevent this.

The Motor Shield has a set of end-to-end Arduino Rev3 pads, which means that you can freely install other expansion cards that use idle pins. However, you won't be able to pick up a bookcase of several Motor Shields to independently control a large number of engines: all boards will work in parallel, since they use the same pins. But you can bite or bend the control legs and throw them on unoccupied pins to achieve independent work.

It is possible to select a power source on the board: from the Arduino board or from an external source connected to the "and plus" and "-" terminals. Separate mode is selected by default, but by rearranging the jumper, you will connect the Arduino and Motor Shield power circuits, and it will be enough to power only one of the boards.

On the board are LED indicators showing the direction and speed of each channel and the power supply.(see Figure 2.3) [19].

Studio's GPS Bee

Seeed Studio's GPS Bee module enables you to determine coordinates in space, speed and exact time using UTC using GPS satellites.

The module is made in the XBee form factor. When used with an Arduino, for example, this makes it possible to connect it in the same way: to the socket

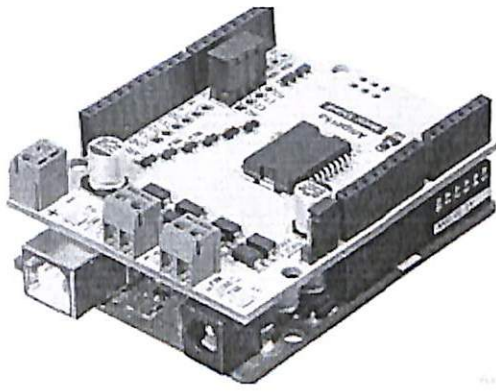


Figure 2.3: Motor Shield (2 channels, 2 A)

on the Wireless Shield. Also, you can easily make a robot with GPS, if you use the Strela platform.

Communication, as with all XBee modules, is done via serial connection. For data transfer, the standard NMEA protocol for GPS devices is used.

The GPS module is supplied with an external antenna. To improve reception, keep the antenna horizontal and with as few obstructions as possible for the radio waves above it. It can take up to two minutes to establish a connection with the satellites.

You can read more about using and programming the module on the manufacturer's website. (see Figure 2.4). [19]..

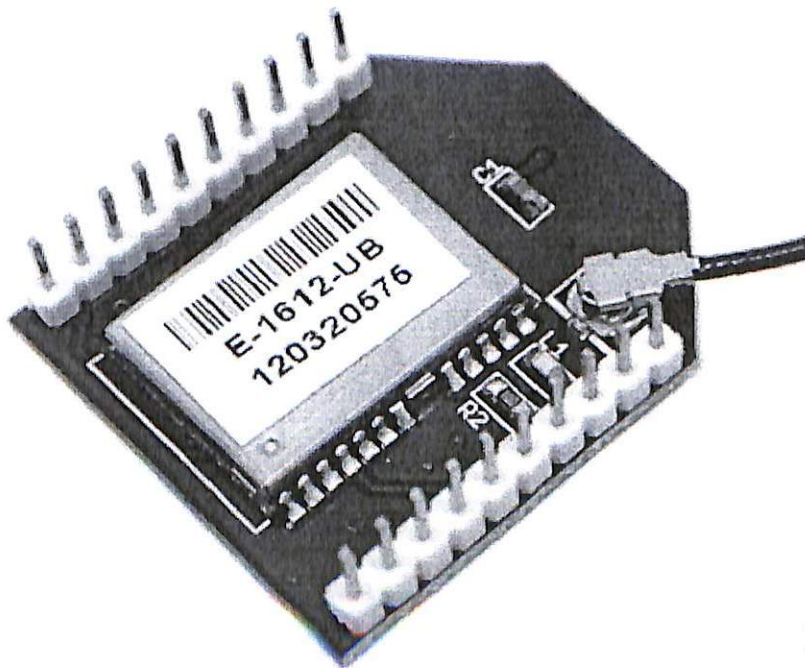


Figure 2.4: Studio's GPS Bee

Characteristics:

- Permissible supply voltage: 2.7–3.6 V
- Peak current consumption: 150 mA at 3.6 V
- Connection current consumption: 120 mA
- Tracking current consumption: 44 mA
- Antenna Sensitivity: 30dB
- The accuracy of determining the position on the plane: 2.5 m
- Time Accuracy: 30 ns
- Speed accuracy: 0.1 m / s
- Maximum coordinate refresh rate: 4 Hz
- Maximum measured speed: 515 m / s

2.2 LCD, servomotor, IR sensor.

This work demonstrates the construction of a radial rangefinder using an IR sensor mounted on a servomotor and 4 LEDs. The distance is measured in each of 4 positions (15, 65, 115, 165 degrees), and the brightness of the four LEDs corresponds to the distance to the object.

This project uses a 5V L4940V5 voltage regulator to power the servo. This is the best solution, for several reasons. Although the servo drives consume a small amount of current when stationary, when executing commands, the current can reach several hundred milliamps, which can lead to power surges. If the supply voltage is insufficient, the servo shaft will move unstable. Therefore, servos must be provided with a separate power source. (see Figure 2.5)

To verify the code of this part (see Figure 2.6)

IR Sensor Circuit and Working Diagram

A motion sensor is most often used to turn on lighting when you walk or are near it. With it, you can save electricity and save yourself the trouble of flipping a switch. This device is also used in alarm systems to detect unwanted intrusions.

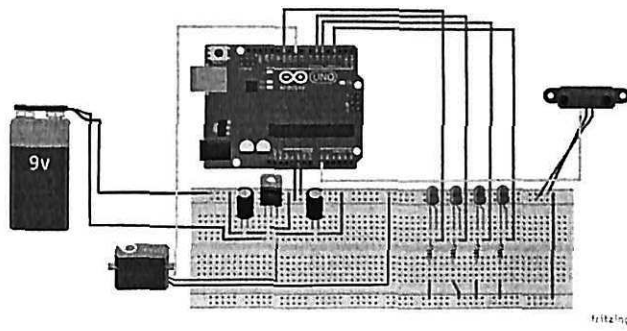


Figure 2.5:

In addition, they can be found on production lines, they are needed there for the automated execution of any technological tasks. Motion sensors are sometimes called occupancy sensors. (see Figure 2.7).

Servo Motor Import

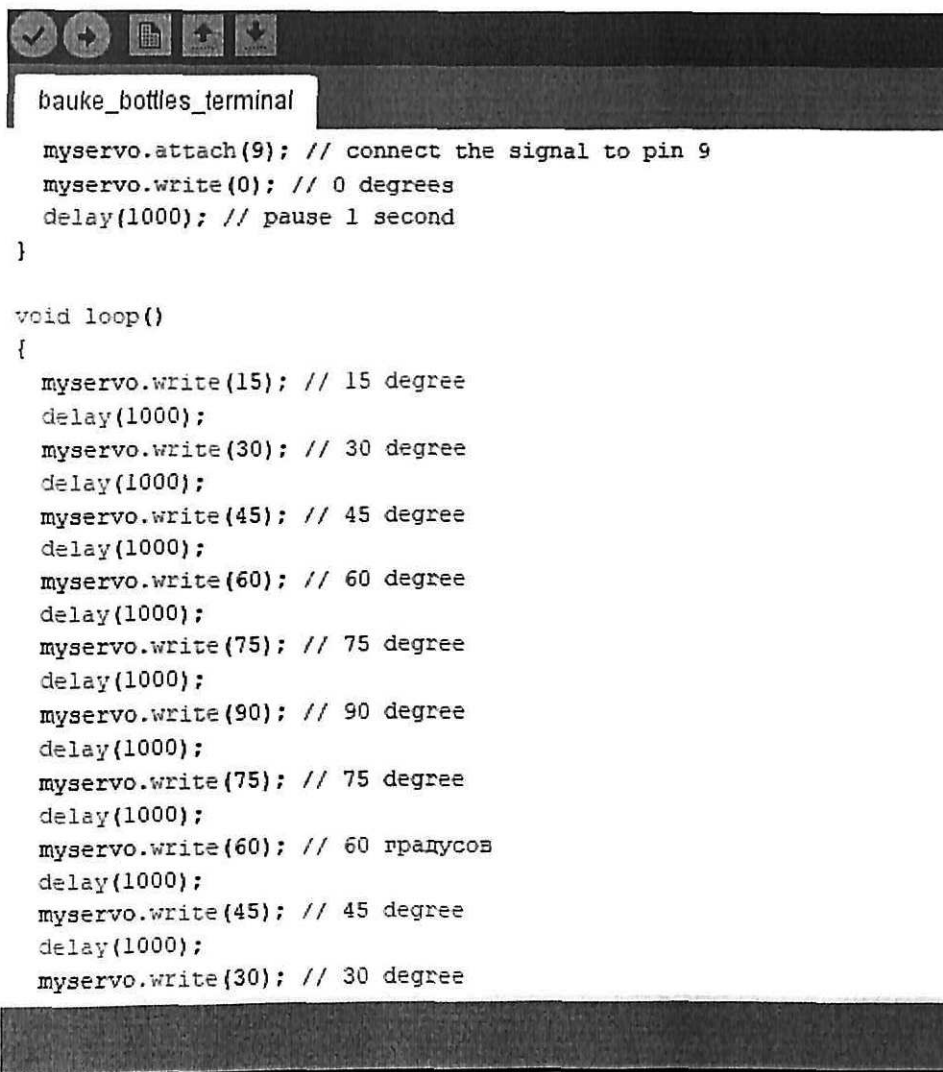
In general, the servo is connected by 3 wires: power, ground and signal. Usually the power is a red wire and can be connected to the + 5V pin on the Arduino board. The black wire ground is connected to the Arduino GND pin, the signal wire is usually yellow, the wire is connected to the digital pin of the Arduino controller. It should be noted that powerful servos can create a large load, in this case it must be powered separately (not via the + 5V Arduino output). The same is true for the case of connecting multiple servos at once. Ensure that the drive and controller are connected to a common ground.[20]

A library include Servo.h is a set of additional commands that allows you to enter a program in a simplified format. Here we use the library for working with Servo.h servos. (see Figure 2.8).

Liquid Crystal Display

Display Summary: The MT-16S2H LCD display is a backlit text display. The image is similar to the displays of old mobile phones like Nokia 3310 or Siemens C35. The screen has 16 contacts for power supply and interaction with the control electronics. Only 6 of them can be used to control the display output. The display is based on a chip compatible with HD44780, which is the de facto standard for LCD screens.

The main feature of the display is the unusual numbering of the outputs. There are 16 of them, but they do not go in order, but in a very non-trivial way. And only three of them are signed: 14, 1 and 16. This is quite enough. (see Figure 2.9).

A screenshot of a terminal window titled "bauke_bottles_terminal". The window contains the following C++ code for controlling a servo motor:

```
myservo.attach(9); // connect the signal to pin 9
myservo.write(0); // 0 degrees
delay(1000); // pause 1 second
}

void loop()
{
  myservo.write(15); // 15 degree
  delay(1000);
  myservo.write(30); // 30 degree
  delay(1000);
  myservo.write(45); // 45 degree
  delay(1000);
  myservo.write(60); // 60 degree
  delay(1000);
  myservo.write(75); // 75 degree
  delay(1000);
  myservo.write(90); // 90 degree
  delay(1000);
  myservo.write(75); // 75 degree
  delay(1000);
  myservo.write(60); // 60 градуса
  delay(1000);
  myservo.write(45); // 45 degree
  delay(1000);
  myservo.write(30); // 30 degree
```

Figure 2.6:

We stick the display with our 16 legs into the breadboard. We bring +5 V power to the rails of the breadboard power supply and ground with the Arduino.

The backlight of the display is a separate circuit that is not connected with the rest. You can turn it on by applying +5 V to the 15th contact of the display and connecting the 16th contact to ground. By connecting these two contacts with the corresponding rails, you can turn on the Arduino and see that the display lights up.

Next, you need to connect the circuit responsible for displaying characters. For this purpose, contacts 1, 2 and 3 on the display are intended. Before connecting, disconnect the Arduino from power.

The first is the earth. Connect it to the rail of the earth.

The second is nutrition. Connect it to the +5V rail.

The third is contrast. To get the most contrasting image, connect it to the ground rail. We can apply an arbitrary voltage from 0 to 5 V to this contact,

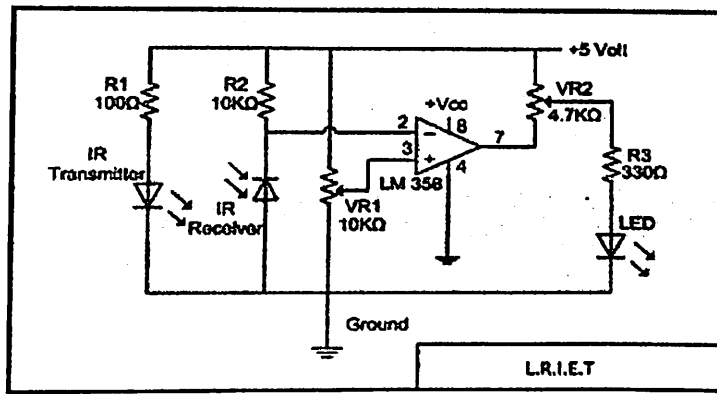


Figure 2.7: Circuit IR sensor

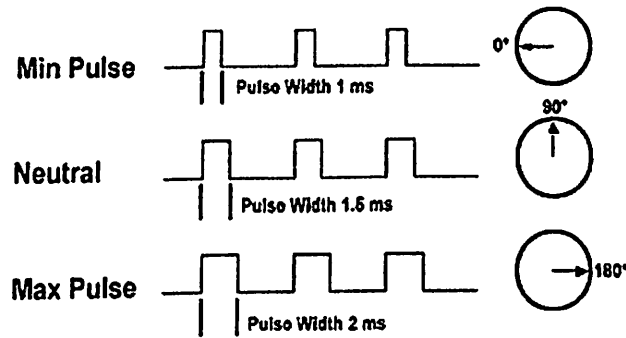


Figure 2.8: How servo motor works

the higher it is, the dimmer the image will be, but at the same time the power consumption will decrease. To enable smooth adjustment of contrast, we can apply the output signal of a potentiometer to this contact.

After connecting, if you turn on the Arduino, we can see the rectangular familiarity. Depending on the combination of text colors and backlighting, they can be both bright and clearly visible, and barely noticeable. This is normal: in any case, the text will look great.

Every time in the for loop the variable i changes, which means the cursor position.

After 200 ms, the inscription is cleared and displayed in a new place;

running letters on the display can also be done using the while Arduino loop. To get full understanding see Figure 2.10.

Wiznet W5500 Ethernet chip

The W5500 chip, the latest addition to the WIZNet line of popular Ethernet chips, is a functionally complete chip for an embedded Ethernet controller to provide a wired TCP / IP connection, making it easier to connect devices and systems using SPI (high-speed serial peripheral interface) to the Internet. The W5500 can meet the needs of users in a stable connection to the Internet with a

14	13	12	11	10	9	8	7	6	5	4	3	2	1	16	15
----	----	----	----	----	---	---	---	---	---	---	---	---	---	----	----

Figure 2.9: Numbering of the outputs

```

bauke_bottle_terminal_LCD$
#include <Wire.h> // library for I2C protocol
#include <LiquidCrystal_I2C.h> // library for display

LiquidCrystal_I2C LCD(0x27,16,2); // assign a name to the display

void setup() {
  LCD.init(); // LCD initialization
  LCD.backlight(); // display backlight

  LCD.print("Today I have collected %N bottles!"); // display the inscription
  delay(1000);
}

void loop() {
  //move the inscription to the right
  for (int i = 0; i < 10; i++) {
    LCD.setCursor(i, 0);
    LCD.print("Today I have collected %N bottles!");
    delay(200);
    LCD.clear(); // clear the screen
  }
  // move the inscription to the left
  for (int i = 10; i > 0; i--) {
    LCD.setCursor(i, 0);
    LCD.print("Today I have collected %N bottles!");
    delay(200);
  }
}

```

Сохранено

Figure 2.10: LCD code

single chip to implement the TCP / IP, 10/100, Ethernet MAC and PHY stack. The TCP / IP hardware stack supports TCP, UDP, IPv4, ICMP, ARP, IGMP, PPPoE. [20]..

The new and improved W5500 network controller has a faster and more universal SPI interface (up to 80 MHz), as well as the possibility of more flexible use of the RAM buffer for temporary storage of general purpose data, which is an advantage when using cheap control microcontrollers (MCUs) limited RAM. Positive is the reduction in energy consumption of components of the hardware level and functioning software implemented through advanced solutions of the physical layer (PHY). The W5500 supports Ethernet applications that use the popular low-cost 8/16 bit microcontrollers. Ethernet capabilities can be added to existing applications without the need to upgrade to a more expensive MCU and

complete front-end hardware and software. [21].

Thanks to the 3rd generation crystal design that has been improved and its geometry reduced (to increase the compactness of the solution due to the use of 'SiP' (System-in-Package) design methods), the W5500 controller significantly reduced not only power consumption, but also the size of its case.

The W5500 can also function as a regular Ethernet transceiver using a third-party software implemented TCP / IP protocol. Its Ethernet transceiver has an easy way to update firmware (add new features) using pre-firmware (ex: OS and RTOS TCP / IP stack '), taking advantage of the TCP / IP hardware implementation in the new chip.

Unlike designs that require third-party software to handle basic network operations, the W5500 provides hardware-based firewall protection measures, which cannot but affect the reliability of the developed equipment. [20]..

2.3 Arduino's import libraries

The arduino library is a kind of program code stored not in a sketch, but in external files that can be connected to your project. The library stores various methods and data structures that are needed to simplify working with sensors, indicators, modules, and other components. Using ready-made programs greatly simplifies work on projects, because you can focus on the basic logic without wasting time on a lot of little things.

Today, a huge number of libraries have been created that can be easily found and downloaded on the Internet. The vast majority of libraries are distributed under a free license, so there is no need to search for "pirated" versions. The main thing is to learn how to look for the necessary libraries suitable for your Arduino IDE, connect them and use them correctly.

As on many other platforms, the capabilities of the Arduino programming environment can be significantly expanded through the use of libraries. Libraries expand the functionality of programs and carry additional functions, for example, for working with hardware, data processing functions, etc. A number of libraries are installed automatically with the development environment, however you can also download or create your own libraries.

Standard libraries: EEPROM - read and write to "read-only" memory.

Ethernet - for connecting to the Internet through an Arduino Ethernet expansion card.

Firmata - for interacting with applications on a computer using a standard serial protocol.

GSM - for connecting to a GSM / GRPS network via a GSM expansion card.

LiquidCrystal - for working with liquid crystal displays (LCD).

SD - for reading and writing data to an SD memory card. Servo - for controlling servomotors.

SPI - for interaction with peripheral devices via the serial SPI interface.

SoftwareSerial - for implementing serial interfaces on any digital outputs.

Starting with Arduino 1.0, the NewSoftSerial library (author Mikal Hart) is used as the SoftwareSerial library.

Stepper - for controlling stepper motors.

TFT - for displaying text, images and graphic primitives on the Arduino TFT screen.

WiFi - for connecting to the Internet through the Arduino WiFi expansion board.

Wire - a library for working with a two-wire interface (TWI / I2C), which allows you to receive or send data between a network of devices or sensors.

The Matrix and Sprite libraries are no longer part of the standard redistributable software.

Specialized Arduino Due Libraries:

Audio - play audio files from an SD memory card.

Scheduler is an implementation of multitasking.

USBHost - Interaction with USB gadgets, such as a mouse or keyboard.

Specialized Libraries Esplora:

Esplora - this library allows you to easily interact with various sensors and drives on the Arduino Esplora board.

Specialized Arduino Robot Libraries:

Robot - The library provides access to Arduino Robot features. [22].

Supporting Libraries:

Messenger - for processing text messages received from a computer.

NewSoftSerial is an improved version of the SoftwareSerial library.

OneWire - device management (from Dallas Semiconductor), working on the

protocol One Wire.

PS2Keyboard - read characters from a PS2 keyboard.

Simple Message System - sending messages between a computer and Arduino.

SSerial2Mobile - sending text messages and e-mail from a mobile phone (via AT-commands and SoftwareSerial library).

Webduino is an implementation of an extensible web server (for use with an Arduino Ethernet expansion card).

X10 - sending signals through power lines using the X10 protocol.

XBee - for communicating with XBees wireless modules in API mode.

SerialControl - remote control of other Arduino via a serial interface.

Libraries can be managed in three different places: inside the IDE installation folder, inside the main folder and in the library folder inside your album. Selecting libraries at compile time will update the libraries present in the distribution. This means that the library located in the "libraries" folder in your album takes precedence over other versions of libraries.

The same thing happens with libraries present in additional processor cores. It is important to note that the version of the library that you put in your album may be lower than the one in the folders of the IDE distribution or processor core. However, it will be used at compile time. When you select a specific kernel for your board, the libraries present in the kernel folder are used instead of the same libraries that are present in the IDE distribution folder.

Last but not least, this is how the Arduino (IDE) software is updated: all files in the folder where you installed the IDE are deleted, and a new folder with fresh content is created.

Therefore, it is recommended that you install libraries only in the thumbnail folder so that they are not deleted during the upgrade process of the IDE.

3. Implementation

3.1 Implementing hardware and software

This part of work describes the core modules of implementing between hardware technologies and software programs. The complex of processing and manufacturing of consumables for a 3D printer should produce materials in an automated mode, with minimal human involvement. To do this, in the processing and manufacturing complex supplies installed inexpensive and simple micro-controller ArduinoUNO. For automation of a complex of materials processing and 3D printer supplies need to install several sensors. For the implementation of the project, IR receivers were selected. IR receiver has a property that allows the sensor to ignore large the amount of unnecessary light noise, for example from lighting lamps and the sun, so as an infrared receiver only receives an infrared signal. Signal IR receiver will receive from the IR diode, which is installed in the control panels. The IR diode is installed opposite the IR receiver. As an IR receiver was TSOP34836 receiver selected. (see Figure 3.1).



Figure 3.1:

An infrared diode is installed opposite the IR receiver. It is also connected to the Arduino and is always on. A 100-400 ohm resistor is installed between

the diode and the Arduino to limit the current. The infrared diode connection diagram is shown in Figure 3.2 .

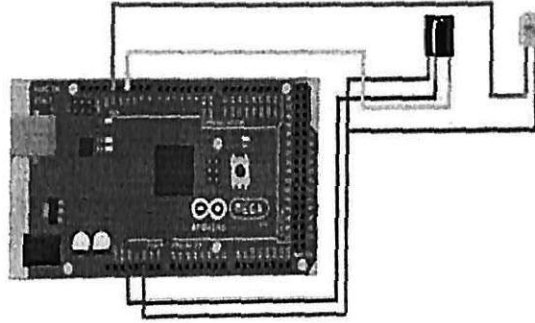


Figure 3.2:

As I indicated above, our terminal must have a very strong case (frame). The frame was made using a 3D laboratory. With the help of 3D tags located at our university, we made an approximate sample of the frame, made of plastic. To better catch information see Figures 3.3 , 3.4

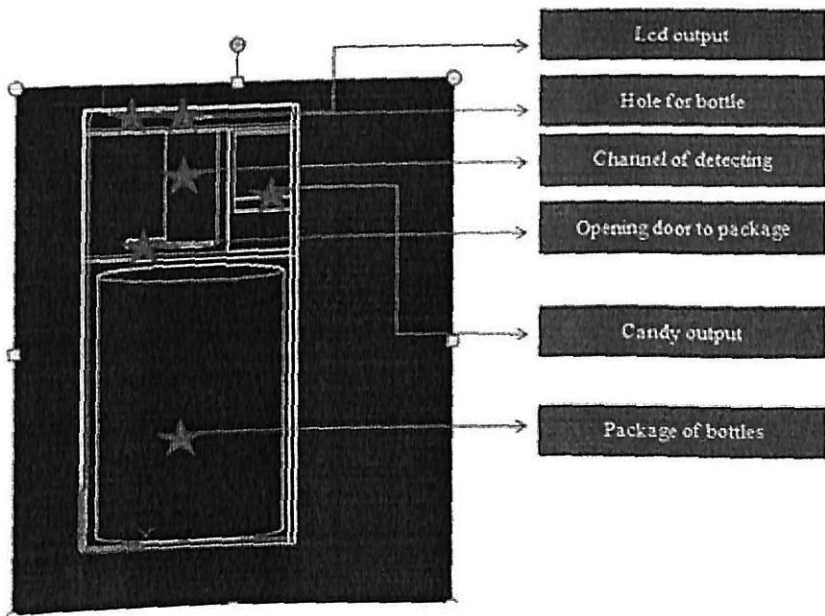


Figure 3.3:

3.2 Software Tools

PHP

PHP (the recursive acronym for the phrase PHP: Hypertext Preprocessor) is a common, open source, general-purpose programming language. PHP is specifically designed for web development and its code can be embedded directly into

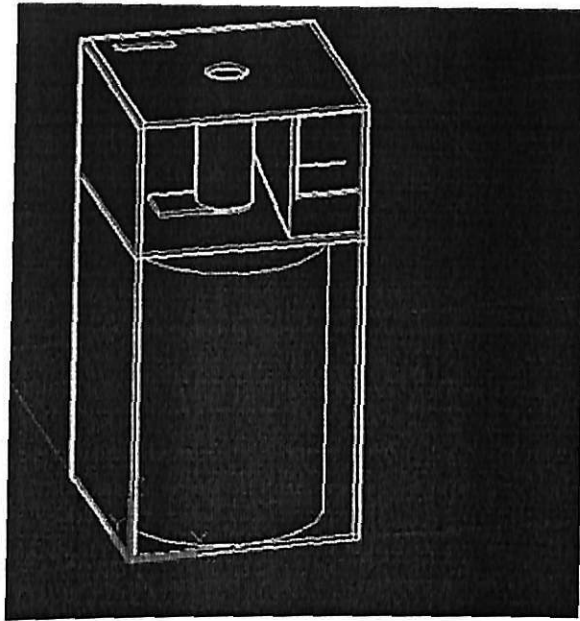


Figure 3.4: Head view.

PHP differs from JavaScript in that PHP scripts are executed on the server and generate HTML that is sent to the client. If a script similar to the above were placed on your server, the client would receive only the result of its execution, but could not figure out which code produced it. You can even configure your server so that regular HTML files are processed by the PHP processor, so that customers will not even be able to find out if they receive a regular HTML file or the result of a script.

Thus, the php language is, as it were, a kind of connecting link, core, central processor that performs all automation operations on a remote web server. Checks some conditions. In general, it does everything that makes web programming languages.

And the main advantage of php language is that it is focused on working with web servers. It has a lot of features that allow you to interact with server databases, such as mysql and so on ... work with e-mail, mail, work with the file system on a web server.

That is, all these features are built into the php language. There are certain functions that allow you to do this quickly and conveniently. In contrast, if you installed some other programming language on the web server.

MySQL

Databases (DBs) are understood as systems of storage and data processing for access to which the language SQL (Structured Query Language) is used. There are

many different database management systems (DBMS), but in terms of hosting MySQL DBMS is usually used. The reasons for this are the actual orientation of this DBMS to hosting tasks, availability on all popular server operating systems, as well as the ease of configuration and administration. When choosing between different DBMSs, you need to consider that if your web project does not have a particular load and complexity of decisions, and you, as a programmer and administrator, do not have sufficient qualifications and experience in working with various DBMSs, MySQL alternatives for you in this case not very much and you should definitely choose MySQL.

MySQL is one of the most popular and most widespread DBMS (database management system) on the Internet. It is not intended to work with large volumes of information, but its use is ideal for Internet sites, both small and large enough.

MySQL is distinguished by good speed, reliability, flexibility. Working with her, as a rule, does not cause great difficulties. MySQL server support is automatically included in the PHP package.

An application on PHP that uses a database to store information (in particular, MySQL) always works faster than an application built on files. The fact is that the databases are written in C ++, and writing a program in PHP that would work with a hard disk more efficiently than a database is an insoluble task by definition, since PHP programs basically work more slowly than C ++ programs, since PHP is an interpreter, and C ++ is a compiler.

Interaction with the database occurs using the Database Management System (DBMS), which decrypts queries and performs operations with information in the database. Therefore, it would be more correct to talk about a query to a DBMS and about interacting with a DBMS from a Web application. But since this complicates the perception somewhat, we will always say "database" everywhere, implying the DBMS.

The following types of databases exist:

- hierarchical
- relational
- object oriented

The hierarchical database is based on a tree structure of information storage. In this sense, hierarchical databases are very similar to the file system of a computer.

In relational databases, data is collected in tables, which in turn consist of columns and rows at the intersection of which the cells are located. Queries to such databases are returned by the table, which may again participate in the next query. The data in some tables, as a rule, are connected with the data of other tables, whence the name "relational" comes from.

In object-oriented databases, data is stored as objects. It is convenient to work with object-oriented databases using object-oriented programming. However, to date, such databases have not yet reached the popularity of relational databases, because so far they are significantly inferior to them in performance.

Hybrid DBMSs combine the capabilities of relational and object-oriented databases.

Web applications typically use relational databases. We will consider an example of the database on which most forums are based, including the one that we will further develop. This database stores information about forum authors (authors), forum names (forums), forum topics (themes) and, in fact, the messages themselves (posts). (see Figure 3.5)

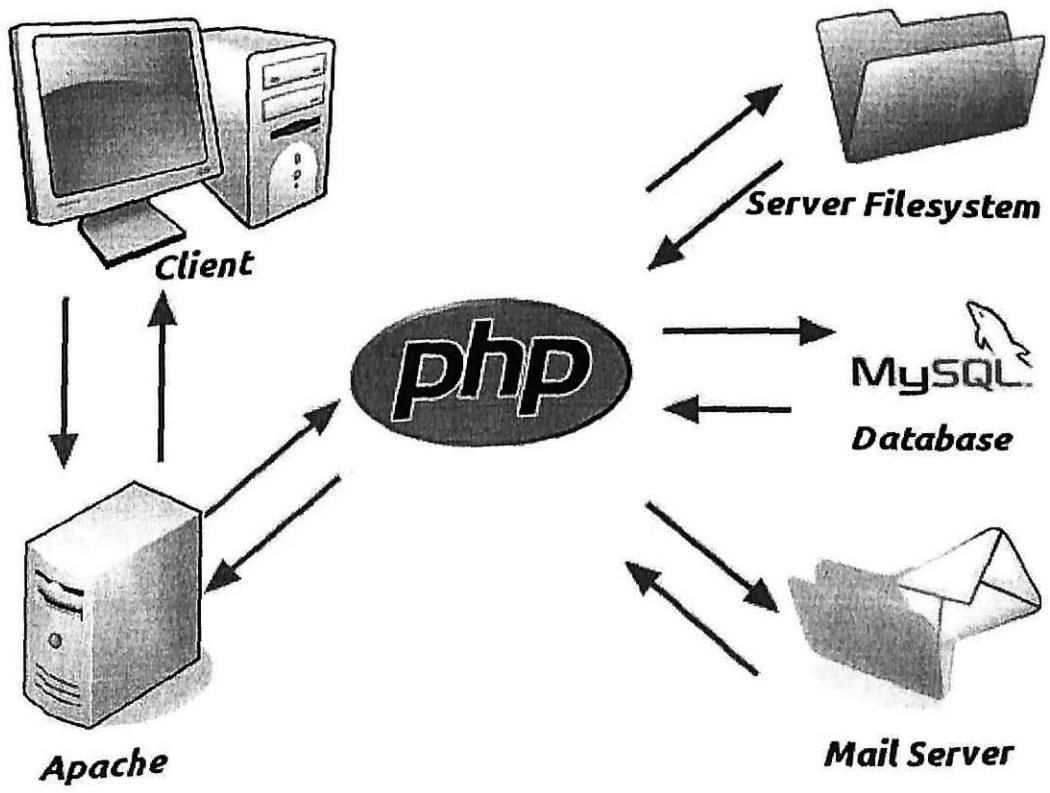


Figure 3.5:

3.3 Connection between hardware and software

The first connection scheme is installed at the output of the terminal.

She stands in a container of material that has been recycled and exited from the crusher.

As soon as the material to be recycled ends in the container, the recycled material ceases to exit the crusher.

Collected material ends and a connection appears between the IR receiver and IR diode. As a result, the microcontroller sends a signal to the relay, which in turn turns off the receiving device.

The second connection scheme is installed at the output of the 3D printer consumables. As soon as the receipt of the 3D printer consumables from the MiniTPA ends, a connection appears between the IR receiver and the IR diode, which in turn feed a signal to the Arduino microcontroller. Arduino, in turn, sends a signal to the relay, which turns off the MiniTPA.

A third wiring diagram is installed in front of the coil, which wraps the consumables of the 3D printer. As soon as the receipt of consumables ends, a connection also appears between the IR receiver and the IR diode. A signal is sent to the Arduino, which turns off the fishing line winding engine.

All these sensors used are connected to one Arduino microcontroller and work interconnected with each other. In order for Arduino to turn off our devices, you need to use a relay. The relay uses a four-channel 5V relay module for Arduino PIC ARM AVR

PART 1: - Arduino Web client Application: read sensor's attribute and destinate them to the webserver. - PHP/MySQL Application: processes POST requests that are sent to the server and serves pages for connecting clients.

PART 2: - Data Visualization: The PHP application will use the Javascript Framework D3.js to display the values stored in the database as graphs. This will allow you to go to the last days to watch the readings.

Equipment requirements:

- Arduino
- Sensors

- Shields

- Boards
- USB
- Resistors
- Cables
- Acrylic
- PCB
- LCD

Programming.

It requires access to a web server (perhaps from a free hosting company) with the ability to run PHP applications as well as create databases. (possibly cPanel with phpMyAdmin) see Figure 3.6.

In the query of MySQL you need put this code:
**CREATE TABLE `recycling_machines` smartrecycling (
 `id` INT(255) NOT NULL AUTO_INCREMENT,
 `location` VARCHAR(255) NOT NULL,
 `amount` VARCHAR(255) NOT NULL,
 PRIMARY KEY (`id`)
) ENGINE = MYISAM ;**

Preparing for PHP Files
 You make three files:

conec.php

In this file will connect to our database

CODE:

```
<?php
function Connection() {
  if (!($link=mysql_connect("your_ipserver","your_user","your_pass"))) {
    exit();
  }
  if (!(mysql_select_db("recycling_machines" $link))){
    exit();
  }
  return $link;
}
?>
```

Figure 3.6:

The program is written in the ArduinoIDE program. The program sketch is

```

include <Wire.h> // Connect the library to work with the I2C extender
ports
include <IRremote.h> // Connect the library for working with IR signals
include <IRremoteInt.h>
constint RECV PIN 1 = 11; // 11 port is used for the 1st IR receiver,
going with YES
49
constint RECV PIN 2 = 10; // 10 port is used for the 2nd IR receiver,
coming from MiniTPA
constint RECV PIN 3 = 9; // 9 port is used for the 3rd IR receiver,
going with OU
constintRelay Chn 1 = 5; // 5 port is used for the 1st relay module
(YES)
constint Relay Chn 2 = 6; // Used 6port for 2nd relay module (MiniTPA)
constintRelay Chn 3 = 7; // Used 7 port for the 3rd relay module
(WELL)
IRrecv1irrecv1 (RECV PIN 1);
IRrecv2irrecv2 (RECV PIN 2);
IRrecv3irrecv3 (RECV PIN 3);
Decode1 results1 results1;
Decode2 results2 results2;
Decode3 results3 results3;
constintledPin = 13; // Input on the inclusion of IR diodes
voidsetup ()
pinMode (RECV PIN 1, INPUT); // initiate as input
pinMode (RECV PIN 2, INPUT); // initiate as input
pinMode (RECV PIN 3, INPUT); // initiate as input
pinMode (ledPin 1, OUTPUT); // initiate as an output to 1 relay
pinMode (ledPin 2, OUTPUT); // initiate as an output to 2 relays
pinMode (ledPin 3, OUTPUT); // initiate as an output to 3 relays
pinMode (ledPin 4, OUTPUT); // initiate as an IR diode output
Serial.begin (9600); // * set the communication speed. In our case, with
computer * /
Irrecv1.enableIRIn1 (); // enable the first receiver

```

```

Irrecv2.enableIRIn2 (); // enable the second receiver
fifty
Irrecv3.enableIRIn3 (); // enable the third receiver
voidloop ()
digitalWrite (ledPin, HIGH); // IR diode lights up
if (irrecv1.decode1 (and results1)) // if the signal came to the first IR receiver
digitalWrite (ledPin 1,! digitalRead (ledPin 1)),
Serial.println ("ledPin 1
! digitalRead ");
// the first relay is turned on, which disables YES
irrecv.resume (); // accept the following command
if (irrecv2.decode2 (and results2)) // if the signal came to the second IR
receiver
digitalWrite (ledPin 2,! digitalRead (ledPin 2)),
Serial.println ("ledPin 2
! digitalRead ");
the second relay is turned on, which turns off the Mini-TPA
irrecv.resume (); // accept the following command
if (irrecv3.decode3 (and results3)) // if the signal came to
the third IR receiver
digitalWrite (ledPin 3,! digitalRead (ledPin 3)),
Serial.println ("ledPin 3
! digitalRead ");
the third relay is turned on, which disables the NU
irrecv.resume ();

```

A database is an organized data collection. Data is usually organized to model aspects of reality in such a way as to support processes that require information. For example, modeling the availability of hotel rooms so that you can find a hotel with vacancies. [23].

First we try to get the IP address for our Arduino project using DHCP. If all is well, we go to the Network Time Protocol server to find out the current time and date. This is done only once when power is applied to avoid overloading the NTP server, as this is a serious problem. You can read more about NTP server abuse issues in the Arduino forums.

The NTP procedure first allows ro.pool.ntp.org to obtain the IP address of the NTP server. Please note that I use the national NTP server group instead of the global one.

As soon as we have the IP address of a working NTP server, we will have time. For this, I used a slightly modified version of the NTP code provided by OpenReefs..

The DS1307RTC library requires time to be stored in the tm structure. Most importantly, years have been measured since 1970, so you need to subtract this from the value returned by the year () function. Then we call the RTC.write () function to update the RTC timer.

We want to write to the MySQL database every 10 minutes. To do this, we use two integer variables: minutesnow, which stores the current minute, and minutesnext, which stores the time for the next database operation. We read the RTC time every 5 seconds. If minutesnow is equal to minutesnext, we first calculate the next value for minutesnext, then measure the temperature and humidity and record the time and values recorded in the MySQL database.

To insert data into the database, we first connect to the MySQL database. Just for verification, we show the last 5 entries. To insert data, we need to build a query string. Particular attention should be paid to the time and date fields. Insert a space in the wrong position and you will get a MySQL error. The solution was to convert the date and time to a string, then I used the trim () function to remove the spaces. In addition, I converted the strings to character arrays, which were then used to build the query. The temperature and humidity data are truncated to two decimal places, so the accuracy of the recorded data is about 1percent.

Then we execute the query and check the result by reading the last record in the database. Finally, we close the database connection; This is useful if you are recording data at long intervals.

The final code is quite large, occupying a huge area of ROM and RAM. In the future, I intend to create a smaller version of this code to work on Arduino Uno boards. [24].

3.4 SMS

The idea to make your own GSM thermostat did not come up immediately, but after disappointment in turnkey solutions. Read a review of the POER WiFi thermostat and the available GSM / SMS thermostats. The Wi-Fi thermostat turned out to be useless in terms of stopping problems with the boiler (power outage for a long period, the boiler's reluctance to light up at -20, etc.), which leads to freezing of water in the house and repair costs, and the finished thermostats seem to me very uncomfortable with an excessively high price (an average of 7-10 thousand). Creating your own GSM thermostat allows you to make a product for a reasonable price (up to 3 thousand rubles) that will be tailored to the specific wishes of the creator and will exceed the ready-made solutions for 9 thousand rubles in capabilities. The initial idea was taken from the topic "Heating Management in a Country House (GSM)". You can also download ready-made sketches for the device there, however, I highly recommend to understand programming for Arduino and write your sketch that meets your personal needs. So you will get not only an inexpensive GSM thermostat, but also a new hobby that will captivate you for at least a few weeks.

Text messaging has spread around the world, and an increasing number of web applications have built-in SMS messages to notify users of events, sales, or coupons directly through their mobile devices.

In this work, I cover the basics of text messaging with the PHP Premium option.

To filter promotional SMS and other messages from strangers, each SMS control must begin with a password that cannot be found in a random SMS. Filtering by phone number is common in similar projects, but it can play a trick on you (for example, if in the event of an accident you need to urgently get information from a place or send some control commands, but for some reason the phone registered in the thermostat will not be by hand (money runs out, the battery runs out, it is forgotten at home - there are a lot of options.) The password can be used from any phone, and the probability that strangers will dial it "by accident" is practically zero (unless, of course, the password is banal, such as "Bottles are collected!". redpolozhim, for example, that a password is set « pass ». Further commands are entered on one line and are separated by a delimiter. I have it, ' ".

The commands are executed in the sequence from left to right, the case of letters does not matter.

The main teams:

"T = x" sets the temperature to be automatically maintained at x degrees.

"H = x" sets the hysteresis to automatically maintain the temperature.

"A = 1/0" turns on or off the automatic temperature control on the first relay.

"TW = 1/0" (or "W = 1/0" or just "W" to turn it on) turns on or off SMS alerts about the temperature exceeding the set limits.

"TH = x" the upper limit of the permissible temperature.

"LL = x" lower limit of permissible temperature.

"VW = 1/0" (or "VW" for inclusion) allows or prohibits the sending of alarm sms in case of power failure in the network.

"G = x" the upper limit of the gas level in the room (in percent). "G = 0" disables gas leak monitoring.

"R = xxxx" sets the values of the four relays. 1 = on, 0 = off, - = leave as is. Example: "R = -1-0" turns on the second relay, turns off the fourth relay, the rest remain unchanged. Abbreviations are allowed, for example, "R = 1" - includes the first relay, the rest without changes.

"S" status (sends in SMS everything that is usually visible on the device screen - all data). The same can be achieved without sending SMS, just by calling the thermostat number for free (in this case, the data is sent only when calling from the admin phone). The thermostat will drop the call and send an SMS with the status to the admin number. The modem will not answer other people's calls.

Identified problems. When external data arrives at the modem (incoming call, received SMS), the modem sends to the buffer data that interferes with the normal parsing of responses that at this moment come from the commands when sending data to the Internet server. As a result, the device is "choked" with the left information and sending fails. So far I have not figured out how to deal with this. It seems to be a trifle - the likelihood that someone will call in those very 5-10 seconds when the data is sent is very small, but, on the other hand, it is the lack of thought in such trifles that distinguishes the "bytecode" from the normal code. It is much more unpleasant that while the Arduino sends data to the server and parses the modem's responses, it misses calls, and, therefore, incoming SMS. In short, somehow "in Chinese" happened. If someone bypassed this problem -

write what options are there.

The algorithm for sending SMS-messages about the temperature exceeding the permissible limits has been changed. Previously, boundaries were calculated automatically when the desired temperature changed. For example, with the lower / upper border 5/8 at 20 degrees, the borders were 15-28, when switching to 10 degrees, they became 5-18. All this worked fine, but caused an undesired trigger when the temperature switched. For example, in the above example, when the house has 20 degrees, the trigger does not work, but it is worth translating the temperature by 10 degrees (when you need to leave), and the trigger fires immediately, since the new border of 18 is less than the real 20 degrees. As a result, we had to either wildly raise the limits or turn off the notification for one day so that the temperature dropped to acceptable limits, but we had to remember to turn on the alerts again later. The same situation was when translating the temperature from 10 degrees to 20, only the lower temperature alert worked, since the real 10 degrees were less than the new minimum border of 15 degrees. In the new firmware version, the boundaries are set not by relative, but by absolute values, for example, from 8 to 28 degrees, so that the trigger does not work in vain. With a long absence, of course, you can set narrower boundaries to get information about a malfunction of the boiler faster. ((see Figure 3.7).

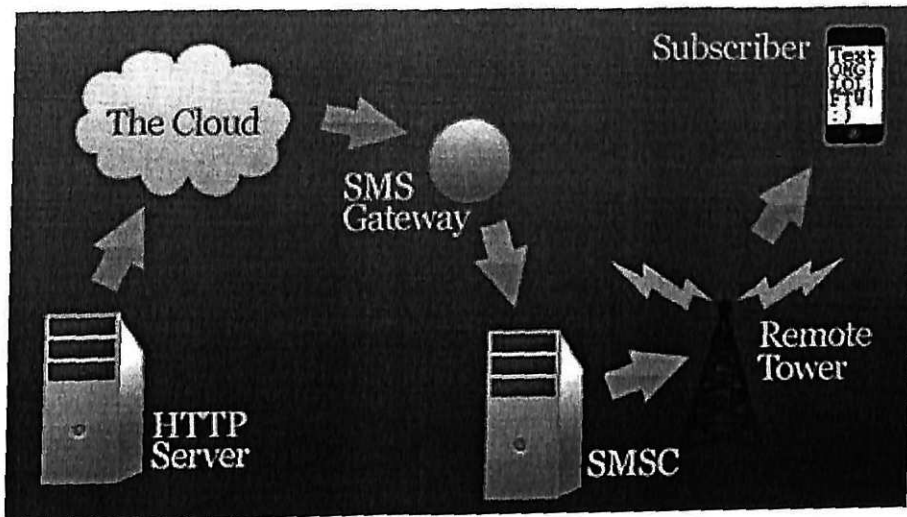


Figure 3.7: Sending a text message (SMS)

SMSC operations can be described as:

Receive text messages (SMS) from wireless users

Text message storage

Forwarding text messages

Text messaging (SMS) to wireless users

Maintenance of unique timestamps in text messages

When a user sends a text message (SMS message) to another user, the message is saved in an SMSC (SMS center) that delivers it to the addressee when it is available.

An SMS center (SMSC) is responsible for processing SMS operations on a wireless network.

When an SMS message is sent from a mobile phone, it first gets to the SMS center

Then the SMS center redirects the SMS message to the recipient.

The main responsibility of SMSC is the routing of SMS messages and the regulation of the process. If the recipient is unavailable (for example, when the mobile phone is turned off), the SMSC will save the SMS message.

It will forward the SMS message when the recipient becomes available or the maximum storage period of the message expires.

Connections:

To connect to the SMS gateway, you must register in our service and replenish your account in the most convenient way.

To configure the integration of your software, use the API section with the protocol description, and also download ready-made libraries for different programming languages. See Figure 3.8).

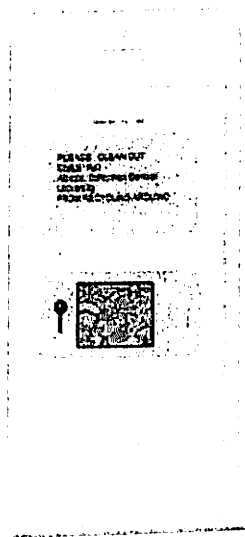


Figure 3.8:

4. Future Work

For future work according to this project, research and thesis is planned to collaborate Arduio UNO system with Computer Vision technologies to recognize the volume of bottles and to make filtration by size. Also make smarter system for recycling the plastics which will be collected by terminal. And try to build close interaction with 3D laboratory which located in technopark in SDU. This kind of networking will help to re-produce our garbage for ourselves. Plan for future to re-use of plastics by own smart system.

Also create second terminal with display which going to show motivation cite for our students to collect plastic bottles and by collected data from both terminal make analyze by using Machine learning which requirements are more usable. The same way negotiate with shopping centers, Magnum cash/carry and with zoo shops to install the terminal on their working place and for giving some amount of discount for product.

5. Conclusion

The collection of plastic bottles in our time is relevant technological process. Collecting disposable plastic bottles positively affects the environment. Also, the collection of plastic bottles allows you to save money on the purchase of supplies for MiniTPA-100. The main task in collecting plastic is to obtain consumables for the Arduino UNO and the structure of the terminal frame.

In this master's work, an automated complex was developed collecting plastic. Thus, the goal that was set before us was achieved and an automated complex for collecting plastic bottles was created. The developed program was compiled and no errors were detected.

•

References

- [1] A. G. Kulkarni, A. K. Parlikad, D. McFarlane, and M. Harrison. (). Networked rfid systems in product recovery management, [Online]. Available: [, %20Proceedings%20of%20the%202005%20IEEE%20International%20Symposium%20on%20Electronics%20and%20the%20Environment,%20New%20Orleans%202005,%20pp.66-71..](#) (accessed: 2005).
- [2] R. Shinshir. (). Ridon: Automaton on robotics industrial, [Online]. Available: <http://spectrum.ieee.org/automaton/robotics/industrial-robots/042110-recycling-robots>. (accessed: 2002).
- [3] A. Jordon. (). Alex: Proceedings hicss, [Online]. Available: <https://www.computer.org/csdl/proceedings/hicss/2009/3450/00/09-06-02.pdf>. (accessed: 2005).
- [4] (). Hatake: Wasteful-mottainai, [Online]. Available: <https://www.weforum.org/agenda/2019/08/the-japanese-have-a-word-to-help-them-be-less-wasteful-mottainai/>. (accessed: 2000).
- [5] (). Yamato: Plastic fantastic tokyo recycle waste, [Online]. Available: <https://www.japantimes.co.jp/life/2017/06/10/environment/plastic-fantastic-tokyo-recycle-waste/#.Xrk2JGgzY2x>. (accessed: 2007).
- [6] (). Konan: Musor i othodov na baze sovetskogo opyta, [Online]. Available: https://www.1tv.ru/news/2018-05-15/345545%20v_yaponii_reshili_problemu_musora_i_othodov_na_baze_sovetskogo_opyta. (accessed: 2003).
- [7] (). John: Plastic recycling waste system, [Online]. Available: [\]https://solutions.tomra.com/ai-ebook?utm_medium=ppc&utm_term=recycling-20systems&utm_campaign=S-5DUS-US-CE+Ebook&utm_source=adwords&hskw=recycling-20svstems&hsa_ad=424025243988&](https://solutions.tomra.com/ai-ebook?utm_medium=ppc&utm_term=recycling-20systems&utm_campaign=S-5DUS-US-CE+Ebook&utm_source=adwords&hskw=recycling-20svstems&hsa_ad=424025243988&)

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- [8] J. S. Donald and N. L. Shtain. (). Germany recycling system, [Online]. Available: <https://www.howtogermaany.com/pages/recycling.html>. (accessed: 1999).
- [9] L. J. David and F. W. Morgan. (). David: Plastic materials, [Online]. Available: <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data>. (accessed: 2000).
- [10] K. Yertern. (). Kenny: Plastic garbage, [Online]. Available: <https://www.bafu.admin.ch/bafu/fr/home/suche.html#plastic-20bootles>. (accessed: 2001).
- [11] T. Group. (). Eijin develops eco-friendly wet-strong printing paper made 100 percent with recycled polyester derived from used pet bottles. (accessed: 2013).
- [12] C. Howard and P. Brian. (). "Recycling symbols on plastics - what do recycling codes on plastics mean, [Online]. Available: [The%20Daily%20Green%20\(Good%20Housekeeping\)](#). (accessed: 2012).
- [13] E. China. (). "Plastic recycling in china", [Online]. Available: http://plasticrecyclingpelletmachine.sell.everychina.com/sell-plastic-washing-recycling-machine.html?ads=s&am=LYJ&site=1&adcid=8173510306&adgid=84238853003&loc=9063093&kwd=bottle-20recycling&tid=kwd-300899235288&mctp=p&rank=&net=g&gclid=EAIaIQobChMIq7rHveCr6QIV10MYCh31WAoOEAAAYAAEgLD_BwE. (accessed: 2015).
- [14] J. F. Howard and M. Brat. (). "Pet bottle washing line, [Online]. Available: https://mabo118.en.made-in-china.com/product-group/iqoEJYedJQhU/PET-bottle-washing-line-catalog-1.html?gclid=EAIaIQobChMIq7rHveCr6QIV10MYCh31WAoOEAAAYAAEgK7LvD_BwE. (accessed: 2012).

- [15] (), [Online]. Available: <https://www.ft.com/content/360e2524-d71a-11e8-a854-33d6f82e62f8>.
- [16] C. Howard and P. Brian. (). "Recycling symbols on plastics - what do recycling codes on plastics mean, [Online]. Available: [The%20Daily%20Green%20\(Good%20Housekeeping\)](#). (accessed: 2012).
- [17] *The Role of Product Identity in End-of-Life Decision Making*. Auto-ID Centre White Paper, Cambridge, 2003.
- [18] *What is an Arduino*. Cambridge, 2005.
- [19] *Arduino Ethernet Shield Volume 1*. Cambridge, 2005.
- [20] L. T. Jinny. (). Hardware part of arduino, [Online]. Available: <http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=fr&msg-id=50084>. (accessed: 2010).
- [21] H. M. Christopher. (). Arduino equipments in nowadays, [Online]. Available: <https://www.jameco.com/jameco/workshop/howitworks/how-servo-motors-work.html>. (accessed: 2017).
- [22] B. Q. Ivan. (). Arduino uno programming skills, [Online]. Available: <https://arduino-tech.ru/programmaya-chast/ustanovka-dopolnitelnyh-bibliotek/>. (accessed: 2009).
- [23] E. JM, *Combining polyethylene and polypropylene: Enhanced performance with PE/iPP multiblock polymers*. Palgrave Macmillan, 2017.
- [24] R. Hatti-Kaul, *Industrial biotechnology for the production of bio-based chemicals - a cradle-to-grave perspective*. Lund University, 2012.