T.C KARABÜK UNIVERSITY FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER ENGINEERING

GRADUATION PROJECT

AUTONOMOUS FIRE DETECTION AND FIGHTER ROBOT

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2020 JUNE

AUTONOMOUS FIRE DETECTION

AND

FIGHTER ROBOT

Aykut YILMAZ & Berk Kutay KORKMAZ

Karabük Üniversitesi

Mühendislik Fakültesi

Bilgisayar Mühendisliği Bölümünde

Bitirme Projesi Tezi

Olarak Hazırlanmıştır.

KARABÜK

HAZİRAN 2020

2020 JUNE

Aykut YILMAZ ve Berk Kutay KORKMAZ tarafından hazırlanan “AUTONOMOUS FIRE DETECTION AND FIGHTER ROBOT” başlıklı bu projenin Bitirme Projesi Tezi olarak uygun olduğunu onaylarım.

Dr. Öğr. Üyesi. Omar DAKKAK ....

Bitime Projesi Danışmanı, Bilgisayar Mühendisliği Anabilim Dalı

..06..../06…..../2020

Bilgisayar Mühendisliği bölümü , bu tez ile, Bitirme Projesi Tezini onamıştır

Dr. Öğr. Üyesi. Hakan KUTUCU ....

Bölüm Başkanı

"Bu projedeki tüm bilgilerin akademik kurallara ve etik ilkelere uygun olarak elde edildiğini ve sunulduğunu; ayrıca bu kuralların ve ilkelerin gerektirdiği şekilde, bu çalışmadan kaynaklanmayan bütün atıfları yaptığımı beyan ederim."

Aykut YILMAZ – Berk Kutay KORKMAZ

ABSTRACT

Graduation Project

PROJECT NAME: AUTONOMOUS FIRE DETECTION FIGHTER ROBOT (ADFR)

Many fires have occurred in the past and as a result, many lives and property losses occurred.Many studies are carried out today to reduce these destructions (loss of life and property). Although the general causes of fires are obvious, fighting fires is not always easy. Therefore, scientists are working on unmanned and autonomous robot systems. In this context, many studies have been done and continue to be done. The main purpose of our project is to minimize the losses that will occur while interfering with these fires.

Keywords : Extinguishing, Autonom, Fire, Arduino, Embedded Programming

TEŞEKKÜR

Bu tez çalışmasının planlanmasında, araştırılmasında, yürütülmesinde, oluşumunda ilgi ve desteğini esirgemeyen, engin bilgi ve tecrübelerinden yararlandığım, yönlendirme ve bilgilendirmeleriyle çalışmamı bilimsel temeller ışığında şekillendiren sayın hocam Dr. Öğr Üyesi. Omar DAKKAK'a sonsuz teşekkürlerimizi sunarız.

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CHAPTER 1

Introduction

Lıterature Revıew

1.1.1. A Brief History of Robotic Systems and Autonomy

Looking at the history of science, many studies have been carried out to create an infrastructure for robotic systems. From these studies, robotic systems realized by **El-Cezeri**, who lived in the 1100s, can be shown as preliminary studies with written records. However, the word robot in the sense we use today is mentioned in the game called "**Rossum's Universal Robots**", which was first written in 1920. After this date, different types of industrial robots were developed and used in the industry as a dyeing machine operating with automatic control in the 1940s and later as a robot. Robots as machines that do business automatically, available. It has an important place in industrial production.

In addition to robotic systems, in 1956, John McCarthy Artificial Intelligence emerged as a science made the definition that made it come out. According to this definition, it will be possible to build intelligent machines with artificial intelligence. The first example of this is the mobile robot named **SHAKEY**, which was developed in 1966, that senses its surroundings and acts by making decisions.In 1980, 3rd generation robots were defined as "**perceiving their environment, producing a plan with their perceptions and acting accordingly**". This definition actually constitutes the basic framework of autonomous robots. Despite this definition, the applications known mainly in the field of robotics until the 90s are industrial robots.

Looking at the present day, robotics; It has been declared as a sub-area such as information and communication technologies; countries have created road maps. Although robots were used for dirty and dangerous jobs for humans, today, they are used in more than 40 sub-areas, from healthcare operations and patient support, agriculture practices and production systems to entertainment and transportation.

Autonomous in all these areas applications stand out. Now, smart cleaning robots have taken their place in the house of many of us, with unmanned aerial vehicles, cargo can be sent to homes or they can go to work with an autonomous vehicle.

Looking at these subdomains, autonomous robots that can be used in the future production systems within the scope **of Industry 4.0** have actually been developed to a great extent. The most important of these robot groups are autonomous cars. (Emo, 2020)

1.1.2. Basic Features of Autonomous System

It is common in the scientific literature to model autonomous systems as intelligent and interactive factors in general. In this context, while examining the features of autonomous systems, it is necessary to look at the characteristics factor. Its main factors are autonomy, adaptation, sociability and positioning. Autonomy means having almost all control in determining the actions that a factor will perform. In this way, it can move on its own. Adaptation is to adapt to changing environmental conditions. Sociability is the ability of a factor to interact with other factors or people. We can define positioning as the action of a factor using the sensor data it receives from its surroundings, which will affect its environment. (Topçu Ö. Ü., 2014)

Figure 1.1. Autonomous Features

It has some important abilities to make these basic characteristics means that. Autonomy requires the ability to decide on its own to accomplish the tasks set. In this context, the most important component of choosing a task suitable for today's **increasingly complex and dynamic environments and performing the selected task effectively is the decision making mechanism**. The most important component of decision making is to make goal deliberation. We can briefly define purpose inference as determining which goal we will pursue. Being able to draw goals requires situational awareness. This is making you smart; means that he knows the situation of himself, his environment and other factors and can decide accordingly. Instead of reacting only to environmental impacts, a factor must pursue its own goals, that is, be proactive. A purpose is not valid in all cases. (Topçu, 2015)

1.1.3. Intelligent Autonomous Systems

The impact of technology and science on human and human life is incredible. Some of the major scientific and technological developments in particular, we can also call these technological leaps, have radically changed the way people live (working and living conditions, etc.) and order (legal order, etc.). These technological leaps have led to the start of new periods for humanity. As an example, we can give the industry (industry) and information age. If we consider the industrial revolutions in the history of humanity, the period of machines started with the scientific and technological developments and the mass production has grown like an avalanche. In particular, transportation routes have been shortened, markets have grown, and the world has stepped from local to global. (Topçu 5. S., 2020) Similarly, the short-term developments in information technologies and systems have started the information age and as a result human life has completely changed. From the simplest, information systems have penetrated every area from our daily life (e-mail, etc.) to all weapon systems (target tracking, etc.). In particular, the rapid digitization of all kinds of information has facilitated access to information, and a new cyberspace has led to the birth of the field. (Defense, 2013)

Societies and countries that can catch technological leaps have taken their place in the modern world and have come to the position of creating, producing and directing this technology. What technological leaps are waiting for us in the near future?

Many futurists will be able to answer this question differently. However, in the near future, systems in people's lives have been replaced by; will transfer many jobs to systems that can decide on their own, adapt to changing environmental conditions, act in accordance with their own goals and duties, and interact with other systems. Such systems are generally called **Intelligent Autonomous System**. It is expected that there will be a new technology revolution as autonomous systems take their place in people's lives. (İşçi, 2014) As a result, humanity will have to adjust its entire order, workflows, systems, living and working conditions according to this new situation. What? Classically intelligent autonomous systems are systems that can decide autonomy in the foreground and act according to their own goals, act accordingly, adapt to changing environmental conditions and interact with other systems. (NRL, 2012)

1.2. PROJECT PURPOSE

Figure 1.2 The Project Purpose

Our autonomously operating robot will extinguish at a certain distance (in the **range of 5-10 cm**) by focusing on the fire within the three-dimensional motion axis in any position (platform area). **After completing the extinguishing process, taking a tour around itself;**

1-If there is a **new fire target**, it will focus and extinguish the target.

2- If there is no new target, it will **finish patrolling**.

1.2.1. The main criteria of the project ;

- **Autonomy:** A mechanical and programmed robot that can move unmanned, patrol and extinguish fire without the need for outside intervention.
- **Design** (Performance, Cost, Simplicity):

  Performance: Robot sizes are designed to be small and light in weight to increase performance. By avoiding excess material, the robot is aimed to move faster.

  Cost: Different types of materials are combined using composite materials and optimized for the robot. In this way, cost savings have been achieved.

  Simplicity: Instead of complex machine languages, a higher level language suitable for the purpose was used in programming the robot. By avoiding excessive parts, a more efficient solution is provided.

- **Applicability:** The fire extinguishing robot, which we will create as a small model, can be applied in real life and used in required units by realizing a bigger design.

CHAPTER 2

2.1 HARDWARE

2.1.1 Materials Used in The Project And Design And Development

2.1.1.1 Arduino

Arduino is a physical programming platform consisting of an **I / O** card and an development environment that includes an application of Processing / Wiring. Arduino can be used to develop interactive objects that work alone, as well as to software that runs on a computer (such as **Macromedia Flash, Processing, Max / MSP, Pure Data, SuperCollider**). Ready-made cards can be purchased or information on hardware design is available for those who want to produce it themselves.

Arduino boards consist of an Atmel AVR microcontroller (**ATmega8 or ATmega168 in old cards, ATmega328 or ATmega4809** in new ones) and the side elements required for connection to programming and other circuits. Each board has at least one **5 volt** regulator integrated and a **16 MHz crystal oscillator** (some are ceramic resonators). Since a bootloader program is written to the microcontroller before, no external programmer is needed for programming. (https://www.arduino.cc/, 2020)

Figure 2.1. Arduino And Motors

2.1.1.2. Infrared Receiver

The infrared detection system can be divided into photon detectors and thermal detectors used for the medium infrared measuring system, according to the function of detection, can be divided into five categories. Infrared detection technology is widely used in modern science and technology, defense and industrial and agricultural fields

Figure 2.2. Arduino & İnfrared Receiver Connection

2.1.1.3. Step Motor

The electro-mechanical device that converts electrical energy into a rotational motion is called a step motor. Stepping motors are also called stepping motors. Motors that change the angular position in steps, driven by very sensitive signals, are called step motors. The step motors move in specific steps.

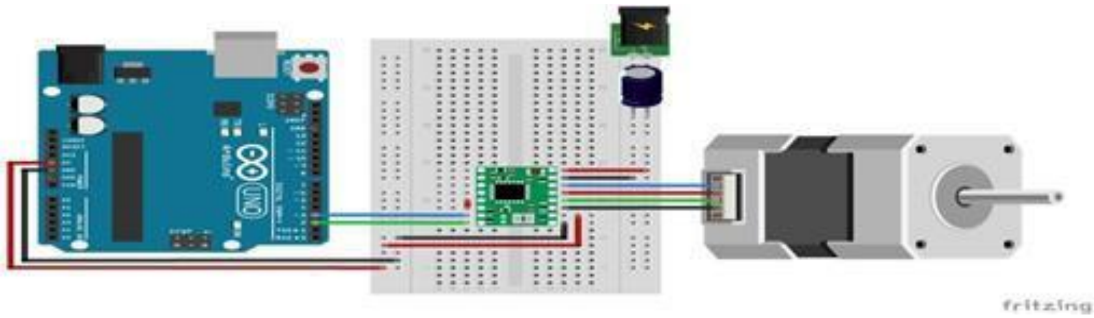

Figure 2.3. Arduino & Step Motor Connection

2.1.1.4. The Main Skeletal System Of The Design

First of all , We thought about the design of the vehicle and created it in a 3D printer by drawing ,by integrating the Arduino board on the vehicle, we made it more functional against external impacts. We placed it on the wheel system so that the vehicle can move faster to the specified target.

2.1.1.5. Power Use In The Project

To estimate the battery to be used in the wheels and fire extinguishing system, and to place it in the project in the most appropriate way. To Integrate The Hardware Components To Be Used In The Circuit We will use infrared receiver leds to detect the fire extinguishing process.

2.1.1.6. What We Will Use For Fire Fighting Process ?

Fire extinguishing will be done with foam or water. For this, it is considered to use syringes and pistons.

2.1.1.7. What İs The Turret System ?

Moving mechanism to be used to target faster in fire extinguishing, we will use this system for better targeting in our project. Since the vehicle has a 360 ° turning angle; It has infinite degrees of freedom since it can move in the x, y, z axes and finally there is no articulated system. The turret system on the vehicle has a 120° of freedom.

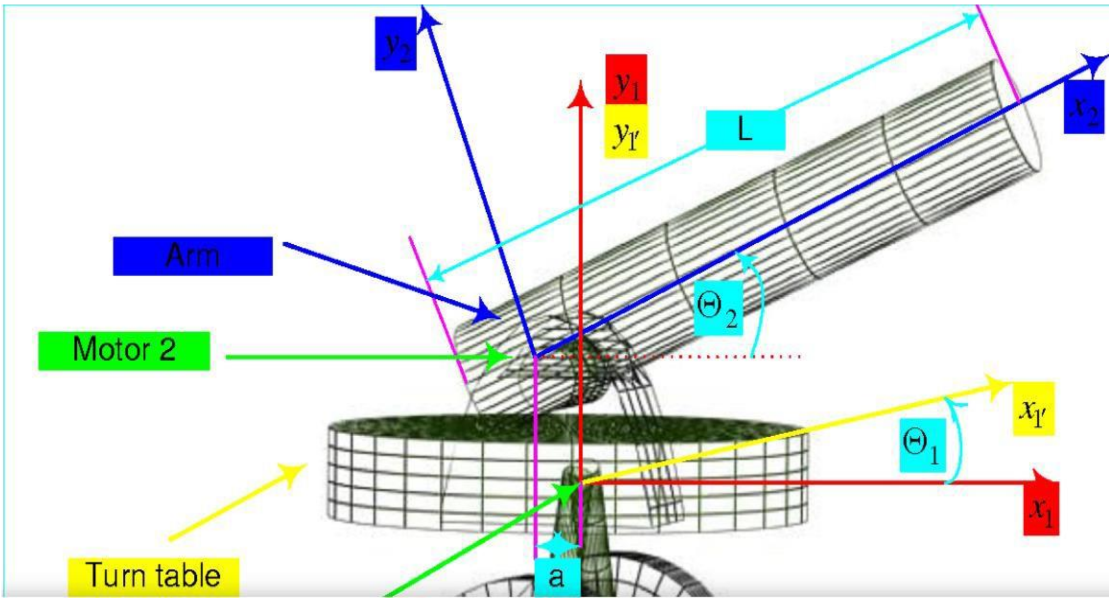

Figure 2.4. Turret System

CHAPTER 3

3.1 SOFTWARE

3.1.1. Arduino Programming

The main component of the project will be programmed with arduino. C ++ and an appropriate arduino programming card will be used. All the necessary software will be written to ensure that the robot works quickly and effectively, and all electronic component control will be provided.

The reason Arduino was chosen; Coding is convenient and many documentation, auxiliary resource is included in the Internet.

We used C and C ++ as the arduino coding language. Stepper motors have been selected, which enable operation with very precise signals, so intervention can be made more precisely. Stepper motors have been selected, which enable operation with very sensitive signals, so that more precise response to fire can be achieved

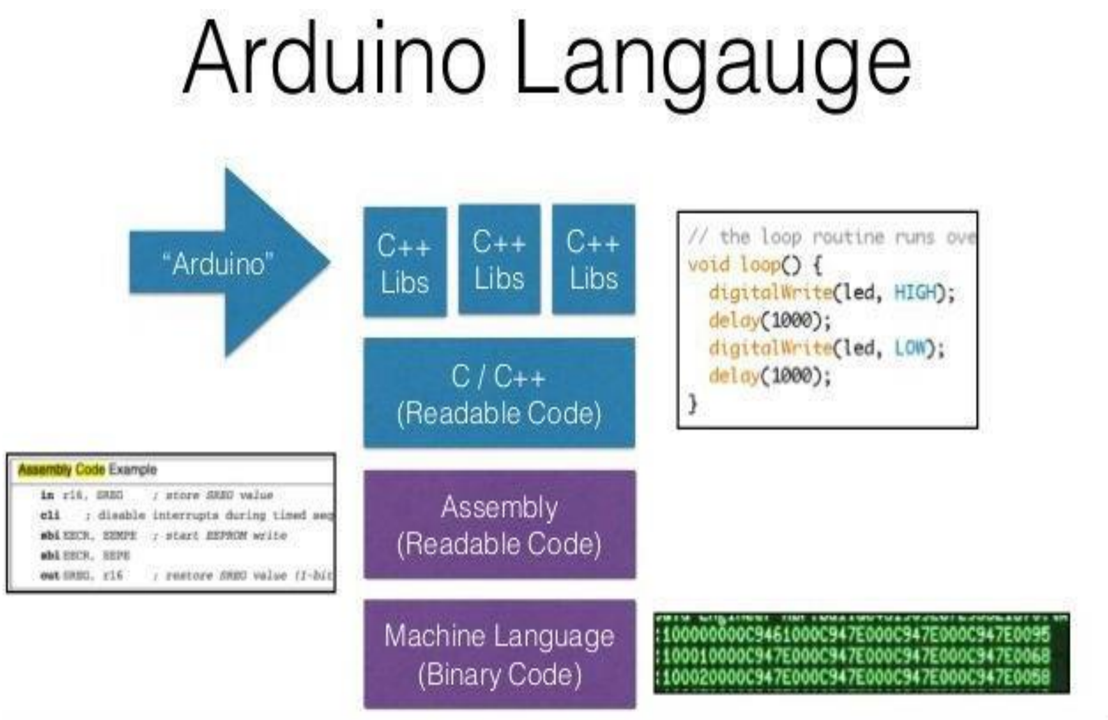

Figure 3.1. Languages Used in Arduino Programming

3.1.2. C Programming Language

The C programming language began to be developed in 1972 by Dennis Ritchie at the Bell Laboratory. The C programming language is a structured language. One of the purposes of development is the implementation of the UNIX operating system. The C programming language is a medium language. Arduino is one of the languages used in programming.

Figure 3.2. Languages Used in Arduino Programming

3.1.3. C++ PROGRAMMING LANGUAGE

It is an object oriented and high level general-purpose programming language developed in 1979 by Bjarne Stroustrup in Bell Labs. The first name of C ++ is dil C with classes ”and it functions as an extension of the C programming language. The creator of C ++, Bjarne Stroustrup, developed this programming language as a student. Stroustrup, who does not see the programming languages that he uses both functionally and high-performance, has created his own programming language and helped to reveal one of the most important software languages in computer history. Arduino is the language used in conjunction with the C language.

3.1.4. Software And Algorithms To Be Used İn The Project

Software And Algorithms To Be Used İn The Project-1

Figure 3.3. Sample Arduino Sketch Screen

Software And Algorithms To Be Used İn The Project-2

The following fire extinguishing algorithm has been designed to respond to the fire as soon as possible. The priority of this algorithm is to make the intervention easy after its detection in a short time. Vertical targeting algorithm will be used in the software to perform this operation. In this algorithm, target scanning will be done with matrix calculation.

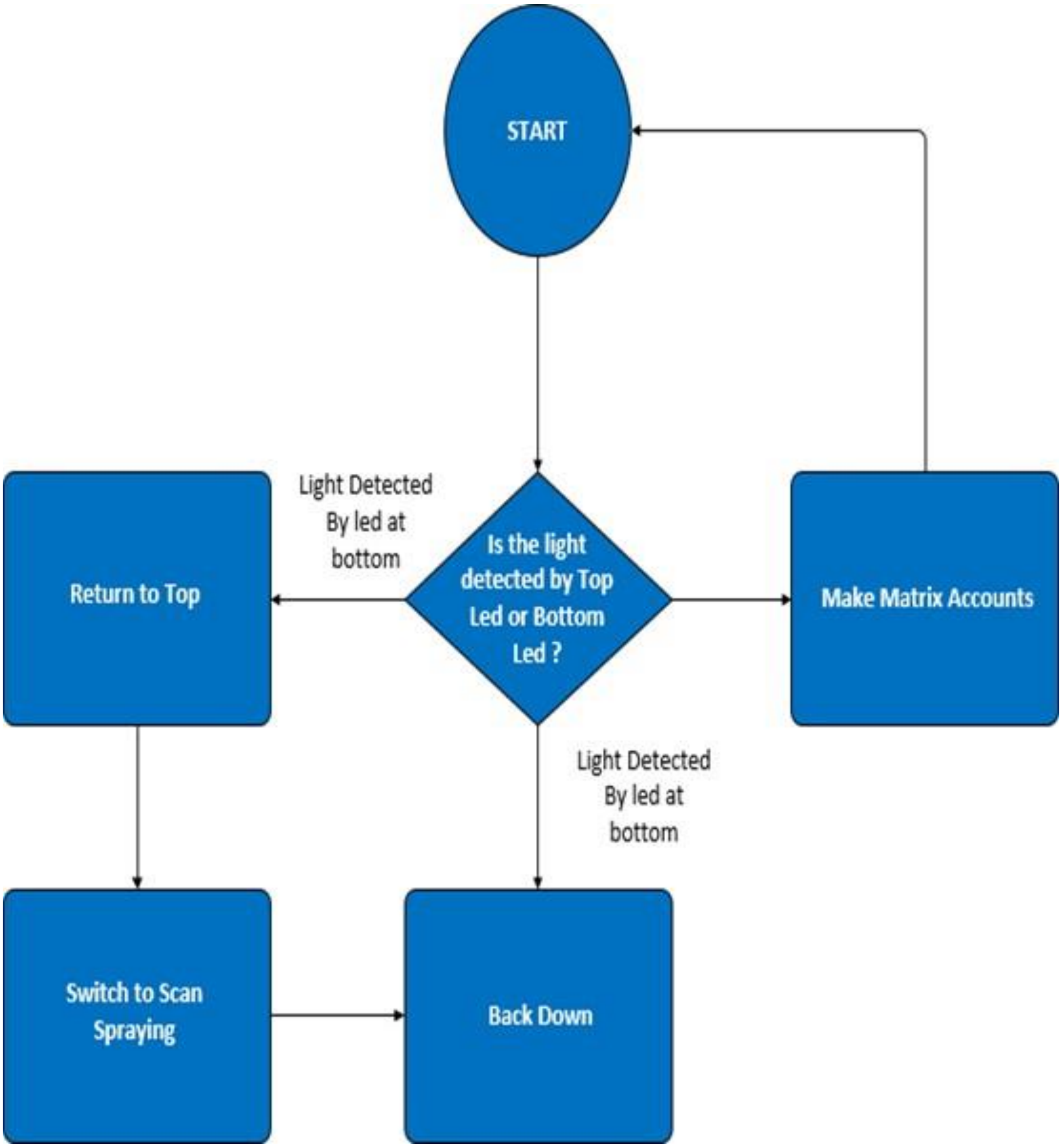

Figure 3.4. Vertical Aiming Algorithm

Software And Algorithms To Be Used İn The Project-3

In this algorithm, motion, patrol, detection and intervention operations are explained, respectively. In this context, the working principle of the robot is explained.

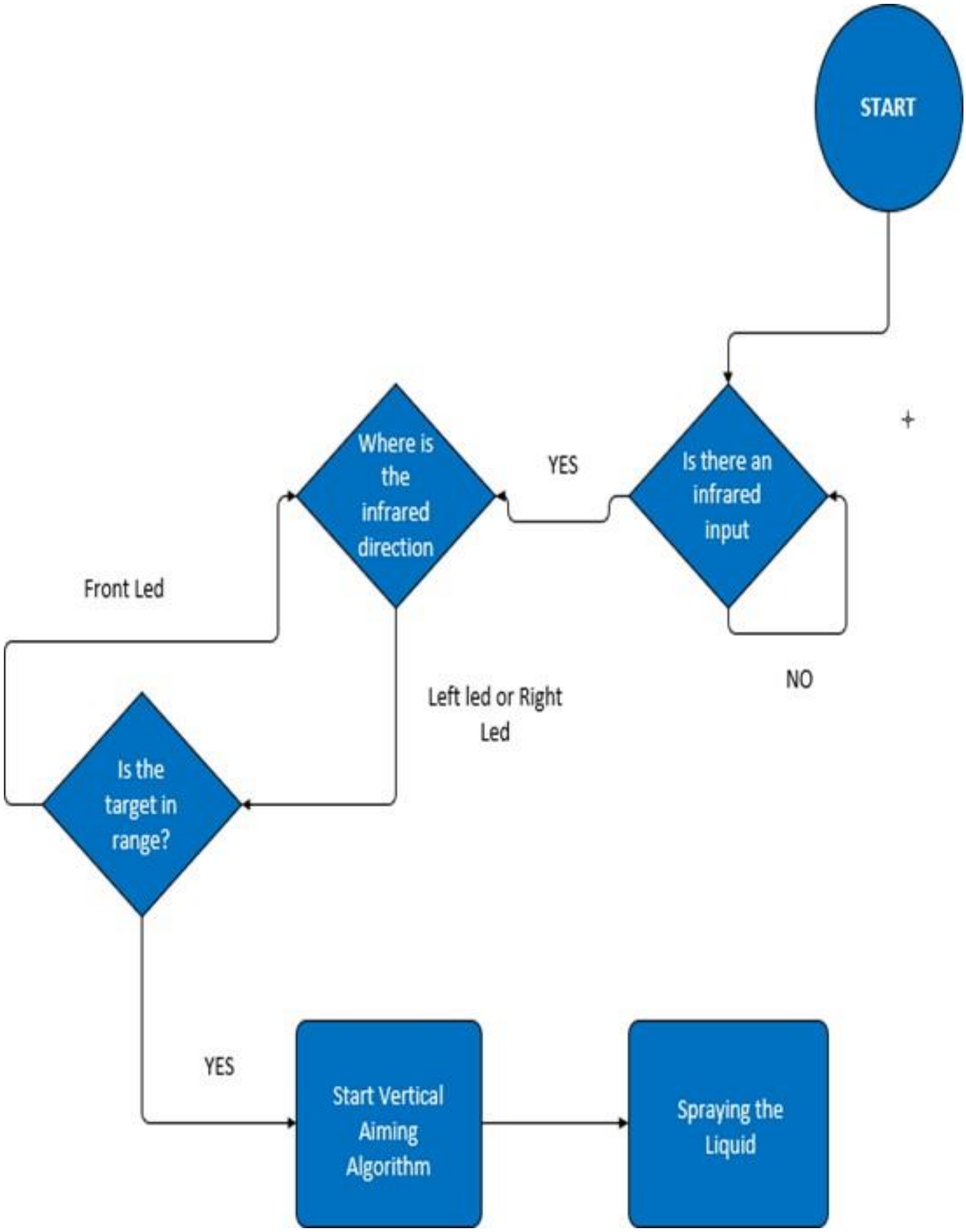

Figure 3.5. General Operating Algorithm of the Robot

Software And Algorithms To Be Used İn The Project-4

The software of the project is written in the arduino programming language. (C and C ++ language and libraries) . Project software was realized in version 1.8.12. Some sample source codes have been added to make the study better understandable.

```
#define range 100
int sensor[9]; //The sensor array was defined as integer for 9 sensors.
double sensorx = 0; //sensor x = right leds - left leds
double sensory = 0; // sensor y top leds - bottom leds
double sensorsum = 0; //the sum of all sensors is returned. When the sensor sum reaches a certain value, it indicates that there is a flame in the environment.
float servo = 180; //pwm value created for the angle of the servo, initial value is 180.
void setup() { //The function where the initial values are written.
  // put your setup code here, to run once:
  Serial.begin(115200); //It provides serial communication with USB attached.
  pinMode(A0, OUTPUT); //defined as output pin.
  pinMode(2, OUTPUT); //  " "
  pinMode(3, OUTPUT); //
  pinMode(4, OUTPUT); //
  pinMode(5, OUTPUT); //
  pinMode(6, OUTPUT); //
  pinMode(7, OUTPUT); //
  pinMode(8, OUTPUT); //
  pinMode(9, OUTPUT); //
  pinMode(10, OUTPUT); //
  pinMode(11, OUTPUT); //
  pinMode(12, OUTPUT); //
  pinMode(13, OUTPUT); // "  "

  digitalWrite(A0, 1); //We returned true by typing A0 (servo mosfet), 1, and activated it.
  digitalWrite(2, 0); //
  digitalWrite(3, 0); //
  digitalWrite(4, 0); //
  analogWrite(5, 180); //servo pwm sends angle information of servo, initial value 180. means analog write pwm write.
  digitalWrite(6, 1); //wheels engine is 'enable', activated.
  digitalWrite(7, 1); //pump 'enable' activates the motor.
  digitalWrite(8, 0); //right dir.
  digitalWrite(9, 0); //right step.
  digitalWrite(10, 0); //left dir.
  digitalWrite(11, 0); //left step.
```

Figure 3.6. Some of The Source Codes We Wrote For The Project-1

Software And Algorithms To Be Used İn The Project-5

```
  digitalWrite(11, 0); //left step.
  digitalWrite(12, 0); //pump dir.
  digitalWrite(13, 0); //pump step.
  delay(300); //300 millisecond cooldown. Time was saved for the servo to come to its initial angle.
  digitalWrite(A0, 0); //servo MOSFET(IRFZ44N).
}

void loop() {
  firewait(); // The firewait function was started.
  while (sensorsum > 20) { // as long as the sum of the sensors is greater than 20.

    calcSensor(); // sensor calculation function started.
    //fmonitor();
    calcMove(); //motion calculation function is started. calcSensor(); //The firewait function was started. calcServo(); //servo calculation function is started.
  } //Exit the loop if it is less than 20.
  firescan(); //patrolling, after the fire is extinguished.

}
void firewait() { //The first function to run when the robot is turned on.
  while (sensorsum < 30) { //as long as the sum of sensors in the environment is below 30. calcSensor();
    readbutton(); //reading buttons. Serial.println("bekleme...");
    delay(2000); //2 seconds standby time set, for energy saving.
  }
}

void firescan() {

  digitalWrite(A0, 1); //we have activated the mosfet of the servo (activated to apply the angle we sent to the servo)
  delay(100); //100 milliseconds wait.
  servo = 200; //servo start value was 200 (initial value was 180, angle was increased to keep the turret up while scanning)
  analogWrite(5, servo); //We sent the value we defined as servo = 200 to servo pwm, which is the number 5 pin.
  delay(1000); //We delayed 1 second, we gained time for the servo to go to the target angle.
  digitalWrite(A0, 0); //closed servo
  digitalWrite(6, 0); //the enable of the motion engines has been activated.
```

Figure 3.7. Some of The Source Codes We Wrote For The Project-2

Software And Algorithms To Be Used İn The Project-6

```
digitalWrite(6, 0); //the enable of the motion engines has been activated.
if (sensorx < 0) { //if the sensor x value is less than 0.
  digitalWrite(8, 0); // right direction dir
  digitalWrite(10, 1); // left dir
} else {
  digitalWrite(8, 1); // right dir
  digitalWrite(10, 0); // left dir
}
for (byte j = 0; j < 160; j++) {
  for (byte k = 0; k < 255; k++) { //pulse loop
    digitalWrite(9, !digitalRead(9)); //the step pin is printed on the reverse pin.
    digitalWrite(11, !digitalRead(11)); //The reverse of the step pin is printed.
    delayMicroseconds(abs(k - 100)); //seconds between pulses (pulse amplitude), (k-100) is for soft landing and takeoff.
  }
  calcSensor();
  if (sensorsum > 30) { //if the total value of the sensor is more than 30. j + = 1000; // increase the value of j by 1000.
  } //finish the patrol loop.
}
digitalWrite(6, 1); //we closed the motion motors 'enable' and patrol finished.
}

void readbutton() {


 while (analogRead(A2) < 250 ) {
  digitalWrite(7, 0); digitalWrite(13, !digitalRead(13));
  digitalWrite(12, 0); //fluid draw direction. delay (20);
 }
 while (analogRead(A2) < 1000 and analogRead(A2) > 950) {
  digitalWrite(7, 0);
  digitalWrite(13, !digitalRead(13)); digitalWrite(12, 1);
  delay(8);
 }
 while (analogRead(A2) < 720 and analogRead(A2) > 500) { //analog reading converts the 0-5 volt range to a reading between 0-1024.
```

Figure 3.8. Some of The Source Codes We Wrote For The Project-3

Software And Algorithms To Be Used İn The Project-7

```
while (analogRead(A2) < 720 and analogRead(A2) > 500) { //analog reading converts the 0-5 volt range to a reading between 0-1024.
  inject(); //The inject function is running. The shot is being made.
}
digitalWrite(7, 1); //we deactivated the 'enable' of the pump motor.
}
void calcMove() {
  calcSensor();
  digitalWrite(6, 0); //'Enable' motion motor drivers.
  if (abs(sensory) > abs(sensorx)) // We scan the sensors horizontally and vertically, in which direction the difference is big, it makes the first move in that direction.
  {
    if (sensory > -50) {// forward: If the sensor reads the value up, go forward
      digitalWrite(3, 0); // right dir: direction value required for forward direction
      digitalWrite(10, 0); // left dir: direction value required for forward direction


    } else {
      digitalWrite(3, 1); // right dir: direction value required for reverse direction
      digitalWrite(10, 1); // left dir: direction value required for reverse direction
      sensory /= 2; // The number of pulses is halved so that the robot goes back less. for fire fighting
      if (servo > 160) { //if the servo value is greater than 160
        digitalWrite(A0, 1); // servo is activated.
        delay(100);
        servo--; // Decrease the servo value by 1.
        analogWrite(5, servo); // write servo value in pwm
        delay(100);
        digitalWrite(A0, 0); //turn off servo.

      }
    }
    for (int i = 0; i < abs(sensory) * 3; i++) { //Pulse loop in forward and reverse direction.

      digitalWrite(9, !digitalRead(9)); digitalWrite(11, !digitalRead(11)); delayMicroseconds(150); // pulse amplitude
      if (sensor[4] > 350 and servo < 150) { // if the servo value is less than 150, and the middle led detects high light
        i += 10;
```

Figure 3.9. Some of The Source Codes We Wrote For The Project-4

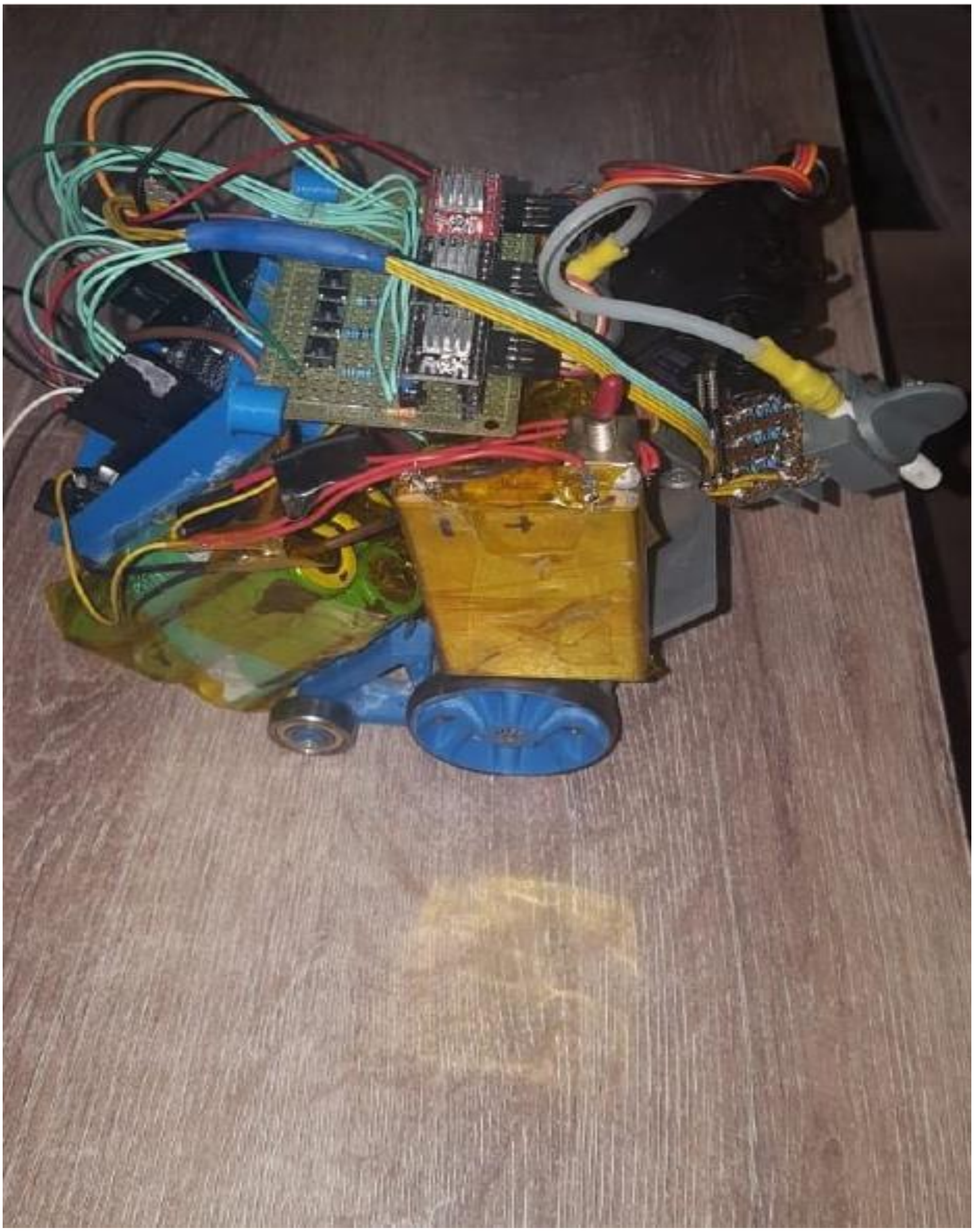

Figure 3.10 Photo From The Final Version Of The Project - 1

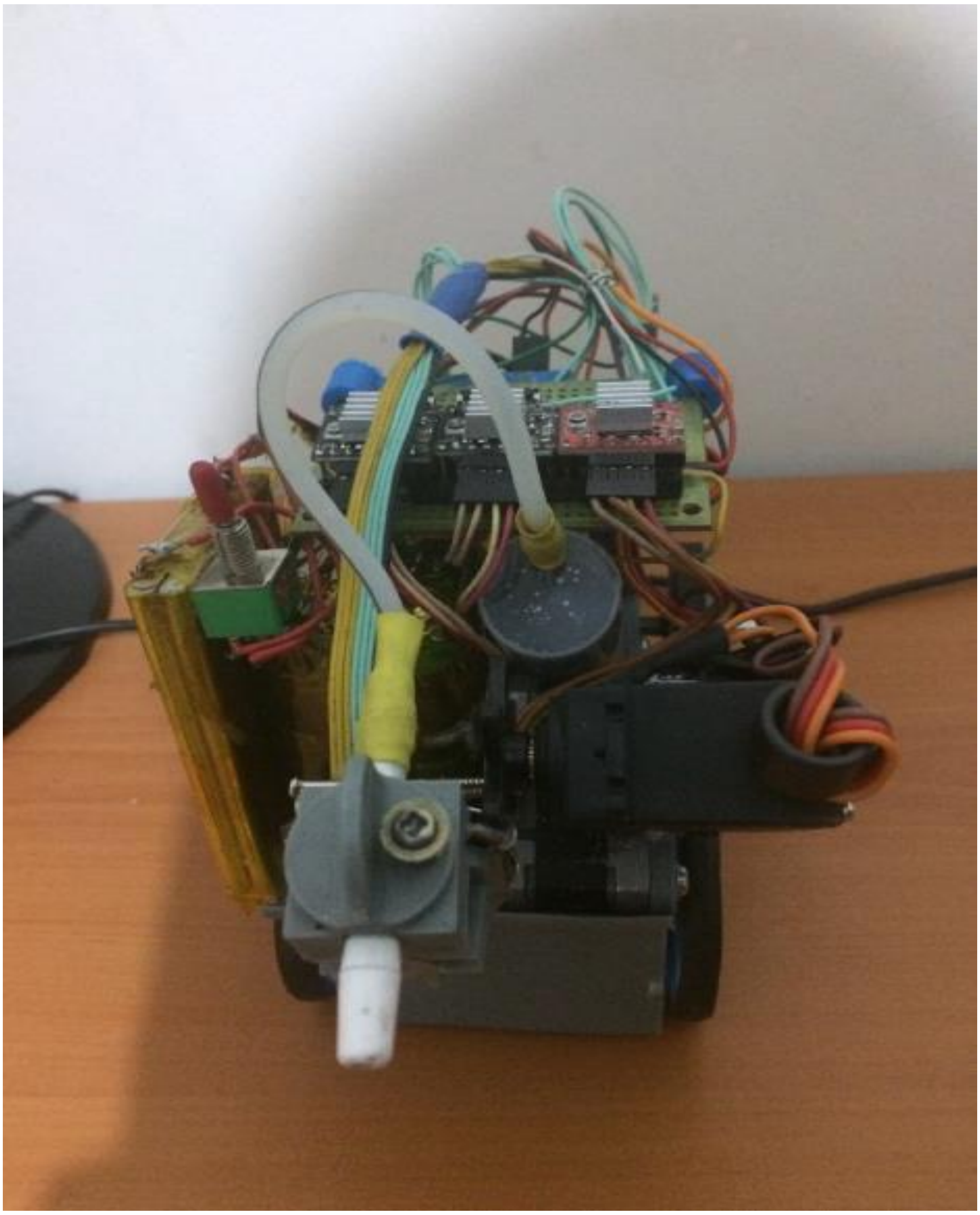

Figure 3.11. A Photo From The Final Version Of The Project - 2

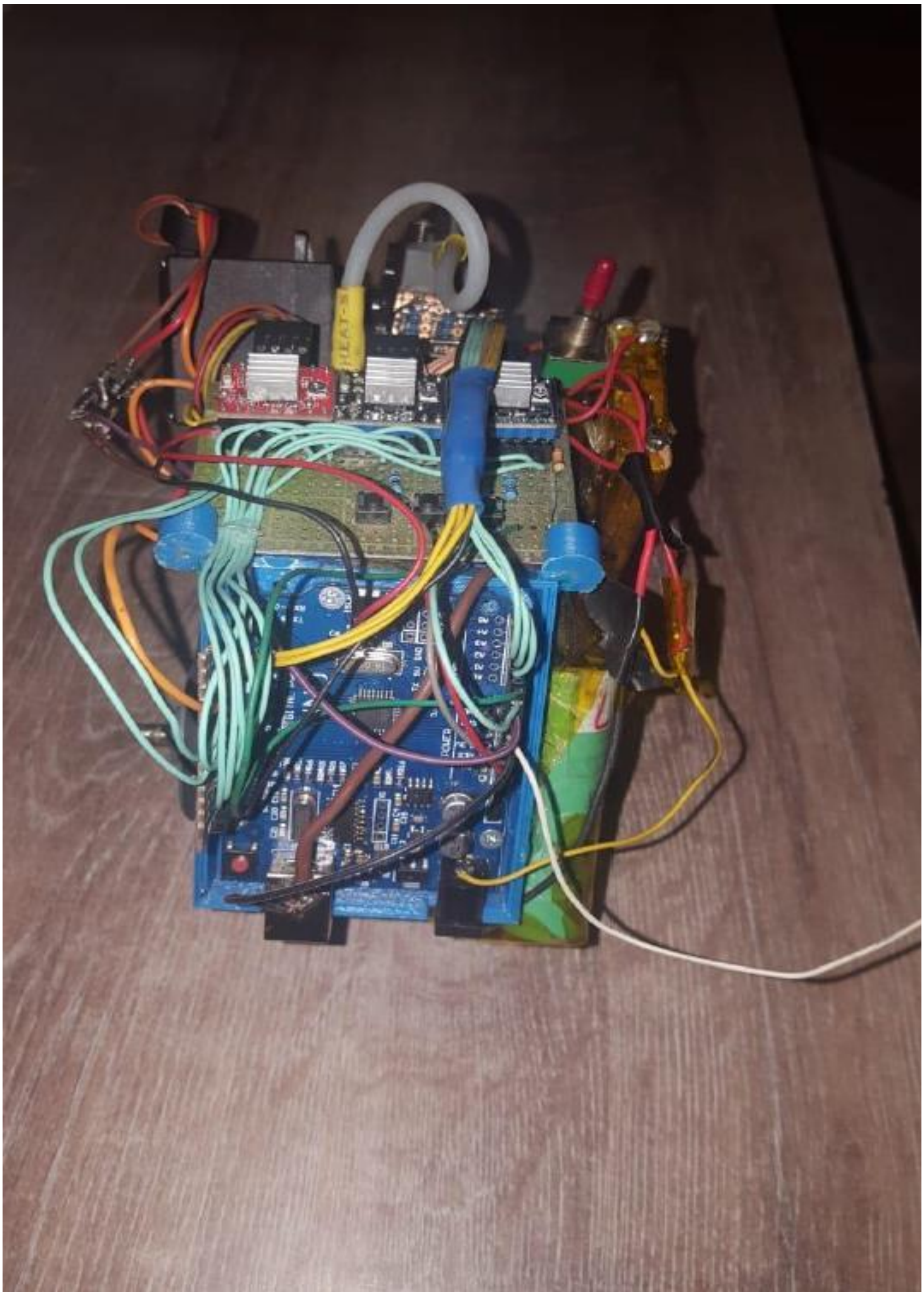

Figure 3.12. A Photo From The Final Version Of The Project - 3

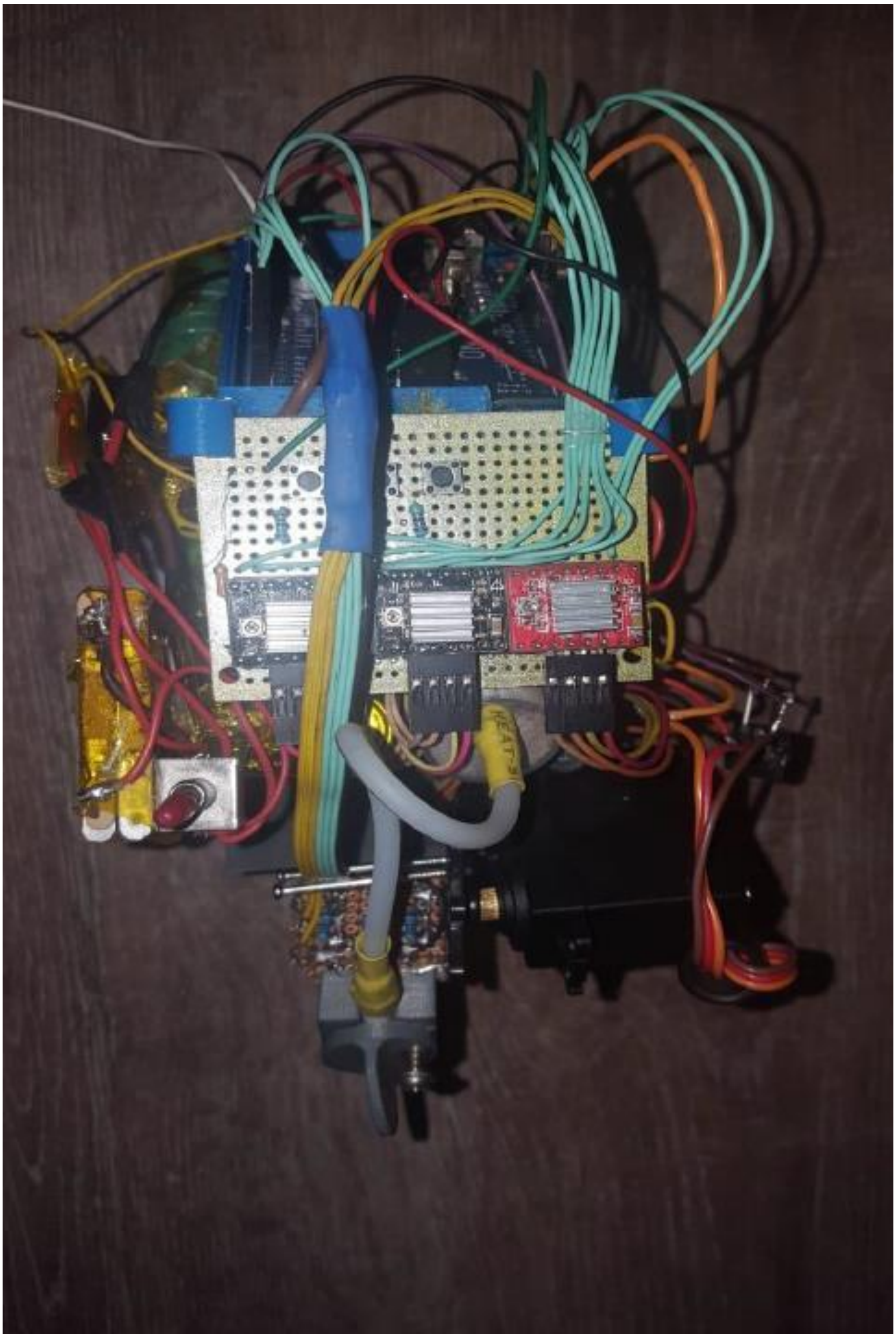

Figure 3.13. A Photo From The Final Version Of The Project - 4

CHAPTER 4

4.1 PROJECT TEAM AND DEFIITION DEFINITIONS

Aykut Yılmaz

- Arduino programming and Sensor programming.
- Test phase and electronic connections.

Berk Kutay Korkmaz

- Electronic connections and arduino programming.

- Arduino programming and Sensor programming.

4.2 WEEKLY DETAILED WORKING CALENDAR

WORK PACKAGE / WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13
Creating Project Draft													
Investigation of Materials to be Used													
Procurement Of Materıals													
Project Commencement													
Project Equıpment (Mechanıcal Parts Combınıng)													
Project Software (Programmıng)													
Platform Preparatıon													
Completıon Of Test Stage And Defıcıencıes													
Project Presentatıon													
Project Report Wrıtıng													

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Curriculum Vitae

Aykut YILMAZ 1994 yılında KARABUK’de doğdu; ilk ve orta öğrenimini KARABUK’de tamamladı. 2013 yılında KARABUK Üniversitesi Mühendislik Fakültesi Bilgisayar Mühendisliği Bölümü’nde öğrenime başlamıştır.

İlgi Duyduğu Teknolojiler: C++, Java, Embedded Programming, Kernel Programming, Defense Industry Technologies

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Curriculum Vitae

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İlgi Duyduğu Teknolojiler: Java, Embedded Programming, Big Data, Machine Learning, Web Technologies, Geographic Information Systems

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