ÇANKAYA UNIVERSITY

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COMPUTER ENGINEERING DEPARTMENT

Final Project Report

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CENG 408

Innovative System Design and Development II

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Abstract

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot aboard. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by onboard computers. The goal of this study is to create a autonomously flight for drone according to the coordinates entered by the user. During the flight, the drone will calculate the shortest route to the destination and will determine a new route to overcome the obstacle if there is any obstruction. Besides these, the user can specify some coordinates and the drone does not enter the forbidden zones. We will do all this in a simulation program. Ultimately, this system should create providing autonomous flight . Key words: UAV(unmanned aerial vehicle), UAS(unmanned aircraft system), autonomously flight, and ground-based controller.

1.Introduction

1.1 Motivation

In this section we will briefly explain what the system does. Drone may encounter many obstacles when moving from one point to another and drone must reach the target point without hitting the obstacles and we are automating this system. Our project goal is to make the drone autonomous flight. Drone will flight to the user-specified destination and drone will notice the obstacles with the camera system and the it will change its way to avoid hitting the obstacles.

2. Literature Search

2.1 UAV’s Collision Avoidance Technology

Collision avoidance is very significant requirement for autonomous UAVs. The UAV system should have the capacity to plan and re-plan, if it is necessary, its own flight. This results in the requirement for a high level computing environment where flight algorithms can be run. The flight planning operation requires knowledge of the UAV's environment; including airspace, land, weather, restricted areas, obstacles and other UAV traffics. The UAV must plan the optimal route for its mission path according to local environment, flight time and fuel usage. If anything happens, the UAV must have the capacity to do the essential configurations and re-plan its mission path [5]. Zhihai He states that once we have the right information about the vehicle motion and its navigation environment, control and guidence laws can be designed to navigate the UAV’s mission path and avoid obstacles. We use the following approaches to deal with the natural instability and image noise motion analysis, and develop a low complexity, accurate and reliable scheme to estimate the motion fields from UAV navigation videos. We use the motion field knowledge to estimate motion parameters of the UAV correctly and refine the motion measurements from other sensors. With the existing knowledge that we have, we can generate the range map for objects in the field [6].

2.2 UAV’s GPS Tracking System for Its Navigation Technology

The UAV should be design with a GPS tracking system and programmed to be able to fly autonomously from one location to another with the use of GPS tracking system coordinates. Also, safety and toughness due to the possibility of collision with different kind of objects should be considered [7]. Environmental conditions are also very important to use UAVs. UAVs are expected to travel in high altitudes according to the way they invented. They are highly sensitive vehicles to wind and other weather conditions. These kind of extremely dynamic conditions should be considered in a real time manner. For example, if we consider the effect of the wind, this is a real concern for the flight of UAVs [4].

2.3 The Optimization of UAV’s Battery Lifetime

Ordinary UAVs are powered by onboard batteries with limited capacity but UAVs are expected to carry out long missions. A fully autonomous UAV management system that can optimize the operations of battery lifetime to extend their operation time is highly desirable for today's technology. Many UAVs are only convenient for short distance uses, that's why their applicability is restricted. To optimize the battery performance of UAVs, it is important to know their state of charge and optimize the operations accordingly [4].

2.4 Self Features of UAV

Position, velocity, and attitude are also known as the navigation states of UAV. The sensors used to measure these quantities are called navigation sensors: an inertial measurement unit (IMU) and global positioning system (GPS) receiver [8]. Operational requirements for these kinds of UAVs typically include flying close to the ground and in relatively narrow spaces with a lot of obstacles. This introduces problems for a simple application of technologies used in larger UAVs. In particular, the rotary wing UAV platforms used in those scenarios provide vertical take-off and landing and hovering capability, but they are originally unstable systems requiring high-rate and accurate attitude and position data to be automatically controlled [9].

3. Software Requirements Specification

3.1 Introduction

3.1.1 Purpose

The purpose of this document is describing the autonomous flight for drones. This project aims at developing navigation algorithms for autonomous drones. This document includes detailed information about requirements of the project. It reflects the identified constraints and proposed software functionalities. Moreover, the SRS document explains how to develop navigation algorithms for autonomous drones. This document explains how concerns of the system requirements are met.

3.1.2 Scope of Project

Unmanned aerial vehicles (UAVs), commonly known as drones, have actually been around for about a century. In this days, using of UAVs is improving rapidly as costs are falling with developing technology. Apart from drones controlled by remote control, with the improving technology autonomous drones were manufactured. These autonomous drones must be programmed with many alternative responses to the different challenges to fulfill their tasks. Some of these problems are UAV's collision avoidance technology, the optimization of UAV's battery life time and UAV's GPS tracking system for its navigation technology. The first problem is limited battery lifetime. Typical drones are electric vehicles, running on-board batteries. Therefore, the performance of drones are severely forces by limited battery lifetime. Many drones are appropriate for short range trips, which significantly limits their feasibility. To optimize the battery performance of drones, an intelligent management system is required to follow up the real-time charging status and optimize operations accordingly. Second problem is available GPS / INS systems. It does not supply requests of drones because of a few reasons. First, GPS signals alone are extremely low and unusable in specific environments like deep canyons; second, GPS signals are susceptible to jamming and interference. The topic we are working on this project is UAV's collision avoidance technology. In order to perform autonomous collision avoidance, as already anticipated an UAV has to be endowed with different capabilities: the capability to develop situational awareness and identify potential threats for flight safety ("sense") and the capability to perform evasive maneuvers and then recover its nominal trajectory ("avoid").In addition to this capabilities autonomous drones must have camera system or laser system. Because it must change its direction, speed or height to see objects around it. The autonomous collision avoidance module is dependent to the flight control system: in case of predicted collision, it has to ask for trajectory modification and then nominal mission recovery1. Obviously, although the sense and the avoid function are conceptually independent, they effect each other deeply. We will focus on collision in this project. We will use the camera system in this project. we develop appropriate logic and algorithms for real-time sensors and we will test it in a simulation program after that we will implement it in embedded systems to provide technology flight demonstration.

3.1.3 Glossary

Term	Definition
Sense	A situational awareness capability.
Avoid	A decision making capability.
Embedded system	An embedded system can be thought of as a computer hardware system having software embedded in it

Term	Definition
Autonomous	Not subject to control from outside; independent

3.1.4 REFERENCES

1. " Multisensor based Fully Autonomous NonCooperative Collision Avoidance System for UAVs " (PDF). Retrieved 06 October 2008. Retrieved from http://www.fedoa-old.unina.it/1836/1/Fasano_Ingegneria_Aerospaziale_Navale_e_della_Qualita.pdf

3.1.5 Overview of the Document

The second part of the document describes functionalities of the autonomous flight for drones. Informal requirements are described and it is a context for technical requirement specification in the Requirement Specification chapter. Requirement Specification chapter is written for software developers and details of the collision avoidance technology of the drones are described in technical terms.

3.2. Overall Description

3.2.1 Product Perspective

Autonomous system has artificial intelligence, it means that it can learn new things and even develop new action plans on their own in the face of new problems. Autonomous drones are advanced drones programmed with numerous action plan algorithms determined by people against emerging problems. They are equipped with a large number of reaction options, taking into account the various problems they may encounter during their tasks.

3.2.2 Development Methodology

For developing the project, we have planned to use Scrum which is an agile software development methodology. On scrum projects, every member of the project team (which includes the scrum team and stakeholders) has the opportunity to know how the project is going at any given time. A Scrum process is distinguished from other agile processes by specific concepts and practices, divided into the three categories of Roles, Artifacts, and Time Boxes. Scrum is most often used to manage complex software and product development, using iterative and incremental practices. Scrum significantly increases productivity and reduces time to benefits relative to classic “waterfall” processes. Scrum processes enable organizations to adjust smoothly to rapidly-changing requirements, and produce a product that meets evolving business goals.2

3.2.3 User Characteristic

3.2.3.1 Participants

3.2.3.2 Participant can be all people.

3.3 Requirements Specification

3.3.1 External Interface Requirements

3.3.1.1 User Interfaces The user interface will be worked on Windows.

3.3.1.2 Hardware Interfaces

Required for drone the body of a drone comprises of a fuselage, plane wings, tail rotor and canopy, multi-rotor frame and arms. Also, it requires power supply with corresponding platform, sensors, actuators.

3.3.1.3 Software Interfaces

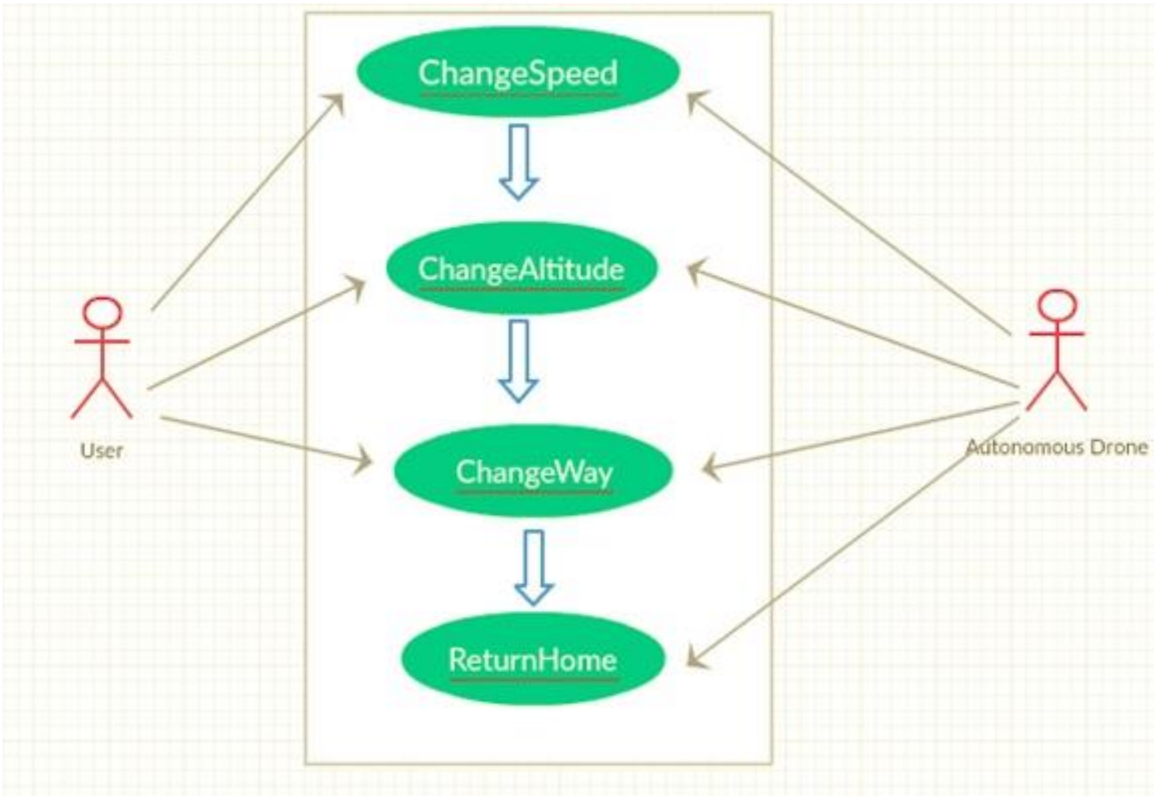
There are no external software interface requirements.

3.3.1.4 Communications Interfaces

There are no external communications interface requirements.

3.3.2 Functional Requirements

3.3.2.1 Profile Management Use Case



Use Case:

- Login
- Start Flight
- Stop Flight
- Update Location

Brief Description: First use case diagram explains the basic operations which is related to entering system of user .Also user can use Start Flight and Stop Flight .Apart from these, drone can use the Update Location function.

Initial Step by Step Description:

1. Only users can login the system.
2. Users can make it start to flight whenever he/she want. They do this by giving the coordinates to the system
3. users can make it stop to flight whenever he/she wants.
4. Drone can update its location.

3.3.2.2 Settings Menu Use Case

Use Case:

• Change Speed

• Change Altitude

• Change Way

• Return Home

Brief Description: Second use case diagram explains reaction to any obstacles is related to drones and users. They can use Change Speed function, Change Altitude function, Change Way function. And finally only drone can use Return Home function.

Initial Step by Step Description:

1. When the drone encounter the obstacle or near the arrival point, both user and drone can change drone's speed.
2. When the drone encounter object or obstacle, both user and drone can change drone's altitude.
3. When the drone encounter object or obstacle, both user and drone can change drone's way.
4. When the drone encounter damage or emergency, it should be back its home.

4. Software Design Description

4.1 Introduction

4.1.1 Purpose

The aim of this Software Design Document is providing the details of project titled as "Autonomous Flight For Drones". The purpose of this project is to autonomously fly the drone according to the coordinates entered by the user. During the flight, the drone will calculate the shortest route to the destination and will determine a new route to overcome the obstacle if there is any obstruction. Besides these, the user can specify some coordinates and the drone does not enter the forbidden zones. The intention is, in fact, to ensure that the drone does not enter military territory or that it does not exceed the stated height when near the airport. Finally, when an emergency is encountered during the flight, the drone will notice the danger and return home. We will do all this in a simulation program. The target audience are users of drones. Simulation will do that according to coordinates entered by user, drone will autonomous flight from the starting point to destination point and during this flight when the drone encounter the obstacle, it will aim to determine itself a new path and reach the destination point.

4.1.2 Scope

The main purpose of this project is to enable the drone to go in the automatically determined coordinates, not by a user. The user specifies the starting and ending point, and determines the height, speed, and route until it reaches the destination from the drone's location. One of the purposes of doing autonomous drone is to avoid the difficulties that arise from the inability of the user to control the drone after a certain place and to prevent accidents from happening. For example, if the drone meets an unexpected obstacle after a certain distance, the user will have difficulty controlling the drone or will not be able to show the desired reflex in time, but the autonomous drone will quickly overcome obstacles in a timely manner with its own decision-making mechanism when compared to the obstruction. However, due to the bad weather conditions of the Drone, there may be some bad situations that can occur during the flight, for example in the foggy and windy weather it can be difficult to determine the direction by drone or it can not to notice objects and it can get into collision. But we will not deal with the weather-related difficulties in this project and we will ensure that the drone reaches the destination point without hitting the obstacles and the drone will continue on its way without entering the area in some given coordinates (military zones, banned zones and airports, etc.). We will do all of these situations in the simulation environment, not the actual drone.

4.1.3 Glossary

Term / Definition

Own Decision-Making Mechanism Artificial Intelligence.

SDD Software Design Document.

4.1.4 Overview of Document

The remaining chapters and their contents are listed below. Section 2 is the Architectural Design which describes the project development phase.Also it contains class diagram of the system and architecture design of the simulation which describes actor, exception, basic sequence, priority, pre-condition and post condition. Additionally, this section includes activity diagram of scenario generator.[1]

4.2 Architecture Design of Simulation

4.2.1 Profile Management

Summary: This system is used by drone's user. The user will specify the starting and ending points. The user should clicks the start button to run the system. The system and the drone will be turn off when the user clicks on the exit button.

Actor: Drone , user.

Precondition: User must run the program.

Basic Sequence:

1. The user must specify the starting and destination point.
2. The user must click the start button to start the flight.
3. The system will shut down when the user clicks the exit button. Exception: It will give an error message if the battery charge is insufficient according to flight status. Post Conditions: None Priority: Medium

4.3 Use Case Realization

Autonomous Flight For Drones

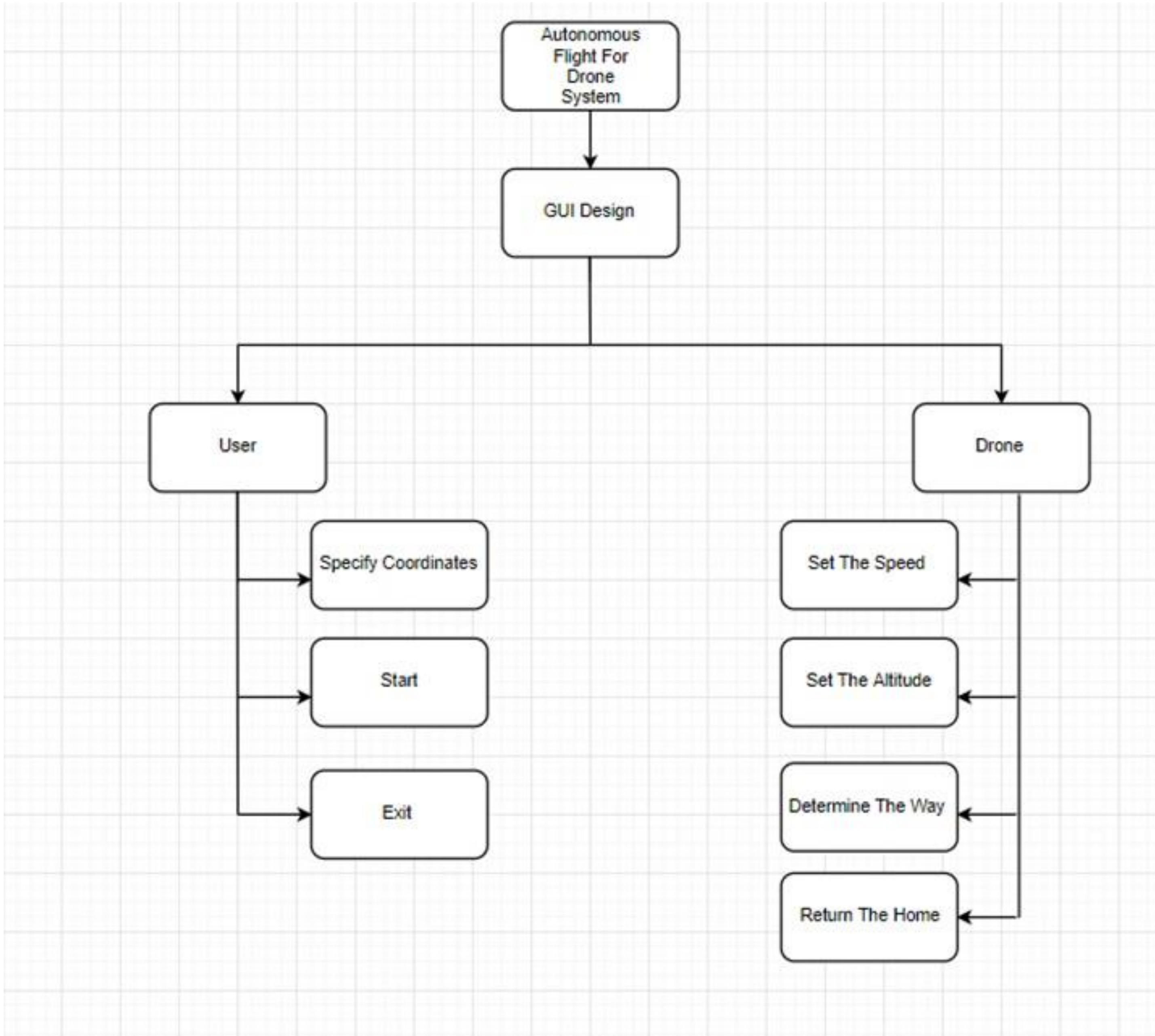


Figure 1. Autonomous Flight For Drone Block Diagram

4.3. 1 Brief Description of Figure 1

Components of the Autonomous Flight For Drone Project are shown in the Figure 1. All designed systems of the simulation are displayed in the block diagram in the figure. There are two main components of the system which have their own sub-systems.

4.3. 1. 1 User Design

There are three sub-systems in this design that are Specify Coordinate, Start and Exit. The user enter the system the coordinates of the drone. When the user click to start button, the drone will begin to flight and to turn off the system, user should click to exit button.

4.3. 1. 2 Drone Design

There are four sub-systems in this design that are set the speed, set the altitude , determine the way and return the home. The drone determines its own speed according to its position. Drone determines the height of it according to its speed and position. Drone determines the height of the itself according to its speed and position. Drone returns to home in case of emergency.

5. References

[1] " Software Design Document"[Online]
Available: http://cengproject.cankaya.edu.tr/wpcontent/uploads/sites/10/2017/10/SDD_Simulacrum.pdf

[2]" What is agile? What is scrum?" [Online] Available: https://www.cprime.com/resources/what-is-agile-what-is-scrum/[Accessed: 12- Dec- 2017].

User Guide

AUTONOMOUS FLIGHT

FOR

DRONES ON SIMULATION

May 2018

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Introduction

Scope and Purpose

The purpose of this product is to autonomously fly the drone according to the coordinates entered by the user. During the flight, the drone will calculate the shortest route to the destination and will determine a new route to overcome the obstacle if there is any obstruction. Simulation will do that according to coordinates identified by user, drone will autonomous flight from the starting point to destination point and during this flight when the drone encounter the obstacle, it will aim to determine itself a new path and reach the destination point.

How It Works?

2.1 MATLAB Installation and Compiler

To run the simulation program first of all you should install at least 2017 version of Matlab on your computer. You can enter MATLAB by double-clicking on the MATLAB shortcut icon (MATLAB 7.0.4) on your Windows desktop. When you start MATLAB, a special window called the MATLAB desktop appears. The desktop is a window that contains other windows. The major tools within or accessible from the desktop are

- The Command Window
- The Command History
- The Workspace
- The Current Directory
- The Help Browser
- Run and Time button

This page include create a new script before start to write codes and run it.

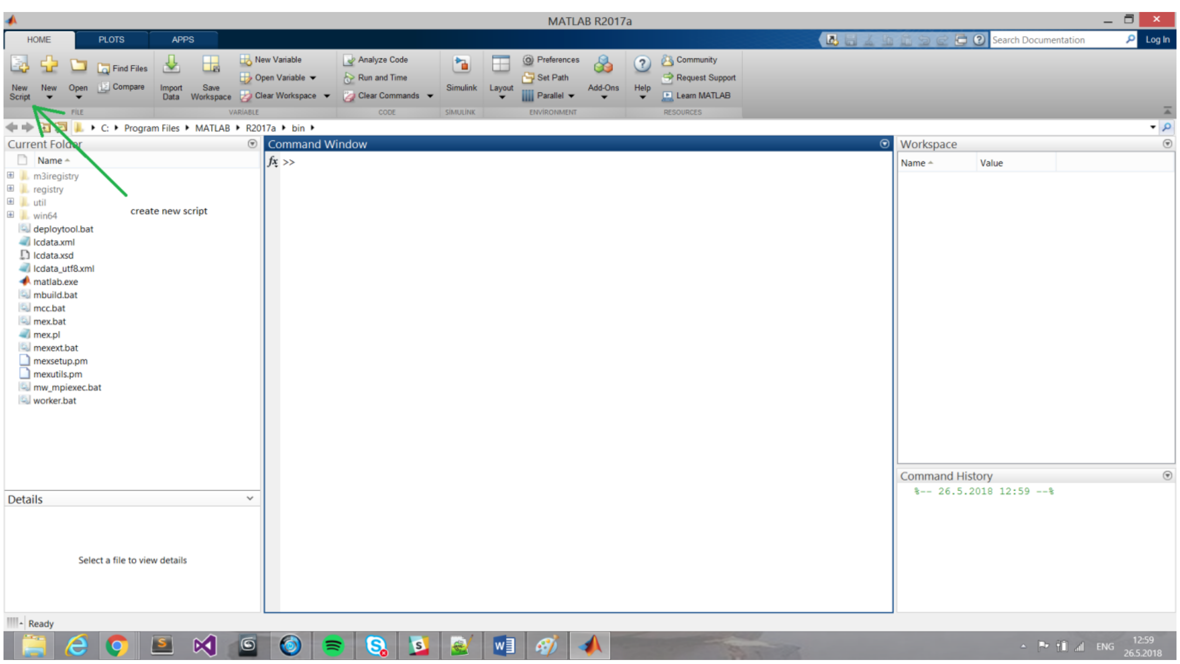

Figure 1.1: The graphical interface of MATLAB to create new script

After create a new script, you will see this page on your screen and this page will help to show where codes are written and how it run.

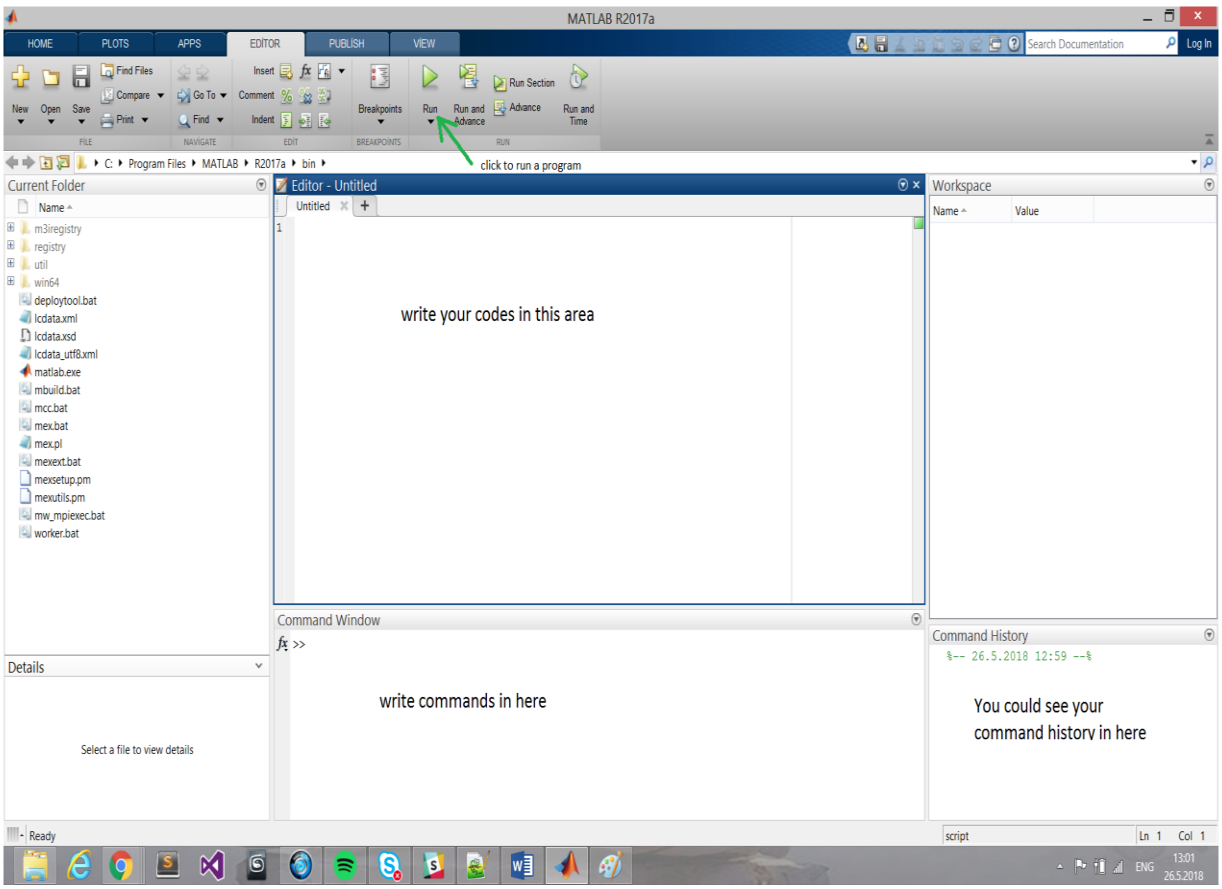

Figure 1.2: The graphical interface to the MATLAB workspace

2.2 How to Access Codes

You can reach codes in this website (https://github.com/CankayaUniversity/ceng-407-408-project-autonomous-flight-for-drones/blob/master/BitirmeProjesi.m).

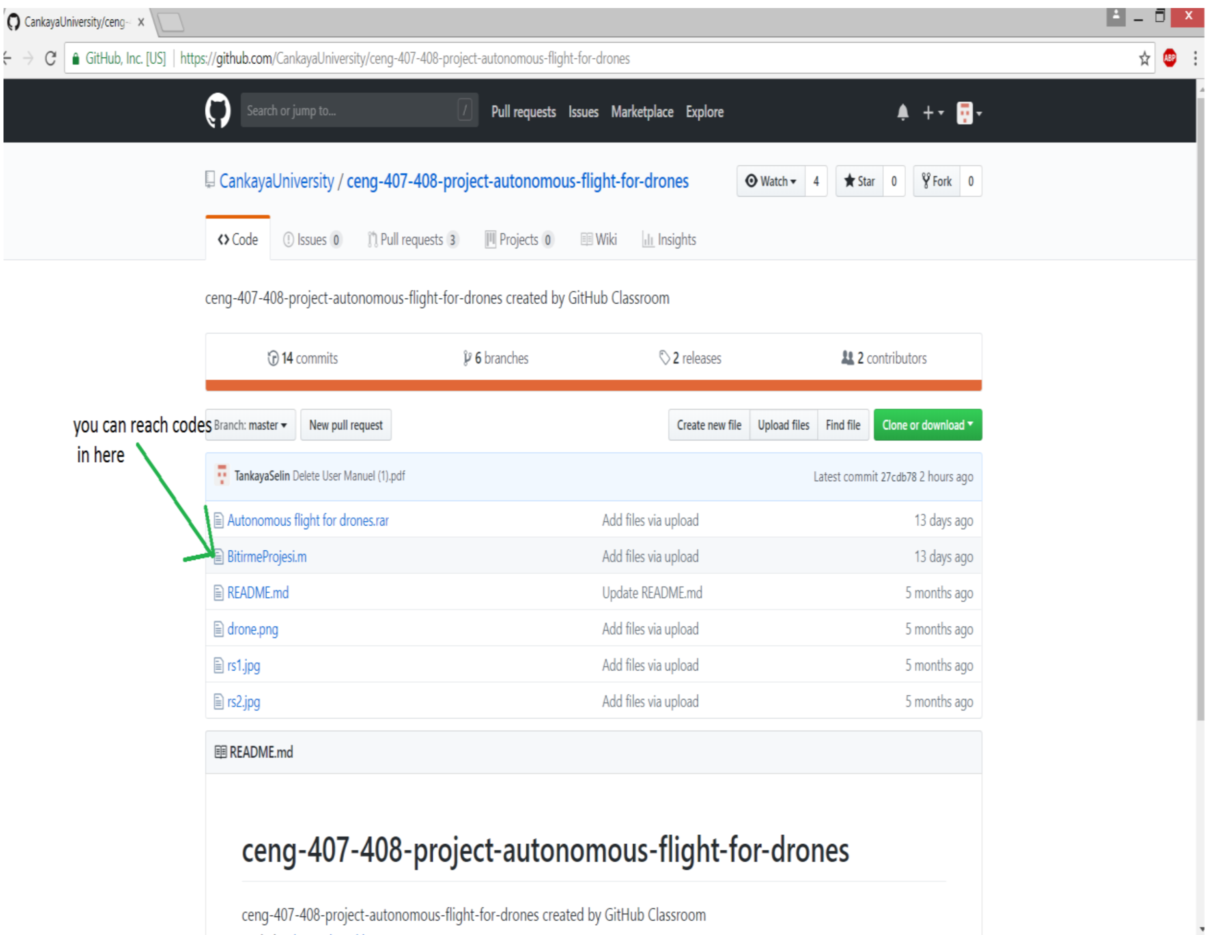

Figure 1.3: The graphical interface shows how to reach codes

After open “BitirmeProjesi.m” file, you will see codes on the screen and you can copy all codes from here.

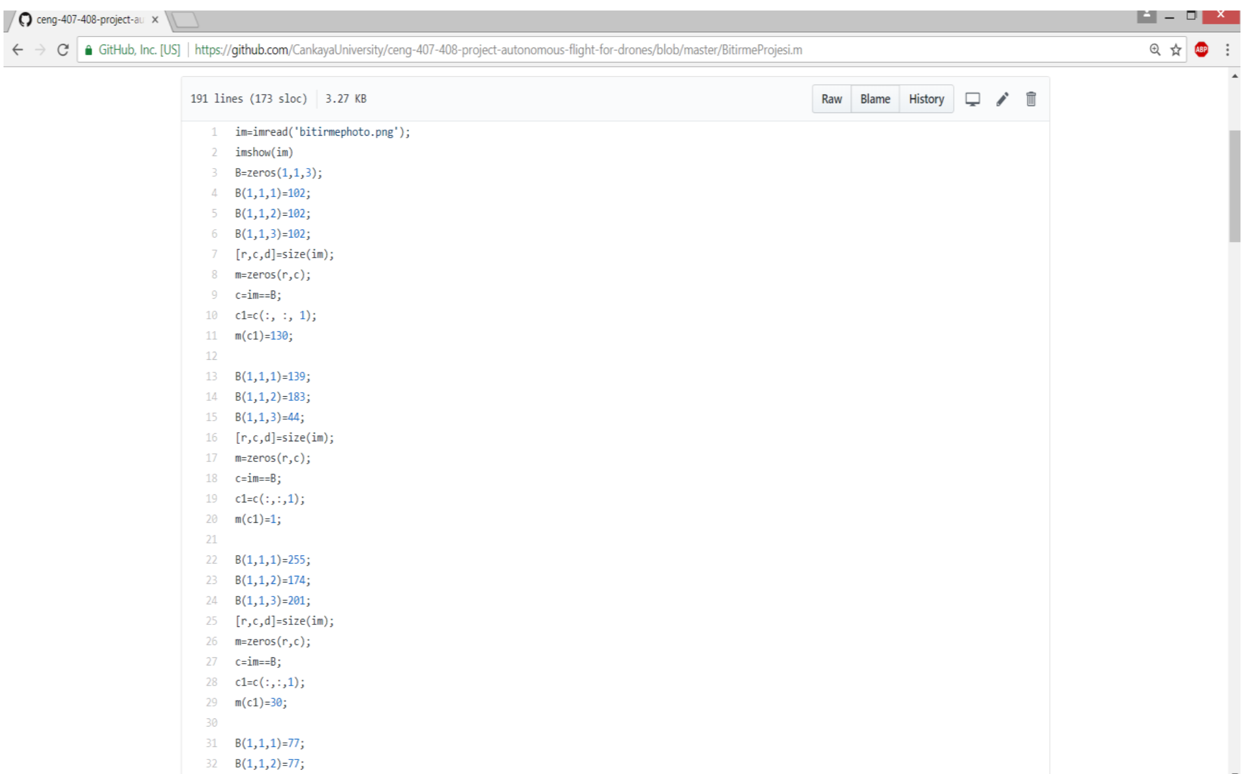

Figure 1.4: The graphical interface include codes on the website

2.3 Start Simulation

This page shows that how to start simulation after write the codes.

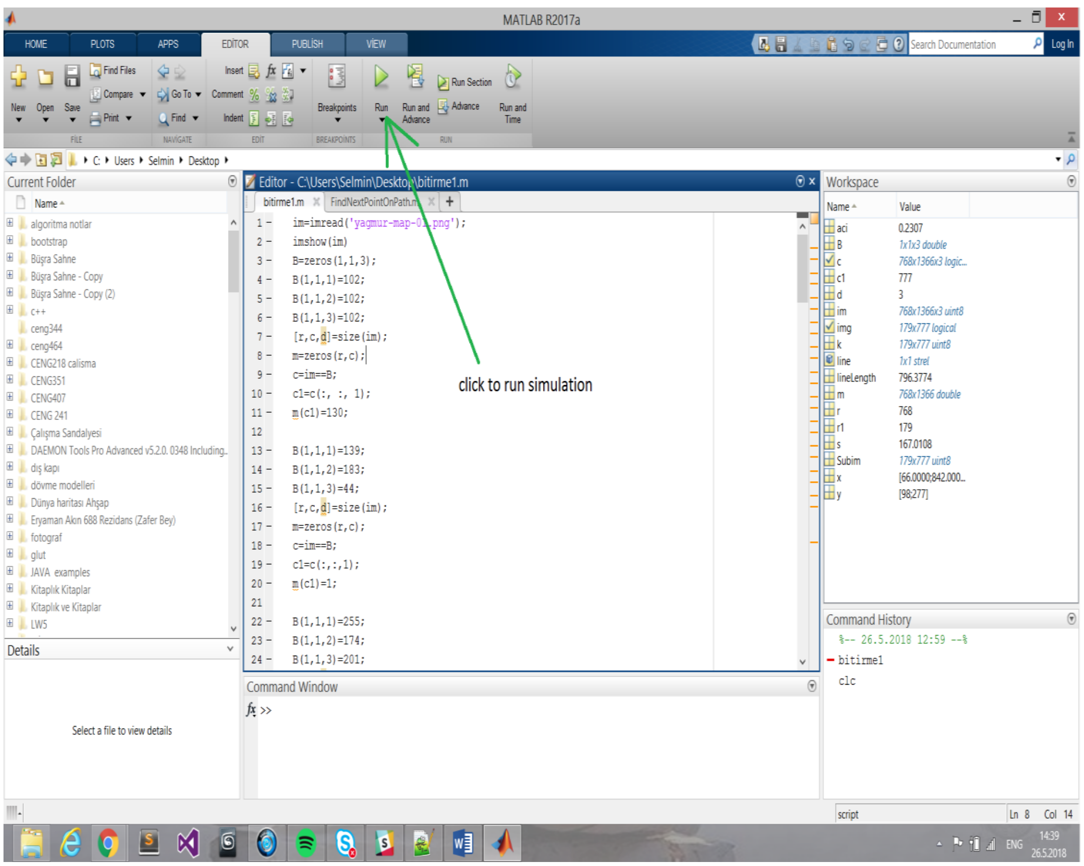

Figure 1.5: The graphical interface shows to run program

You will see map on your screen after click “Run” button and To determine a coordinate on the map, you should use mouse and click a somewhere on you want to determine starting point and ending point.

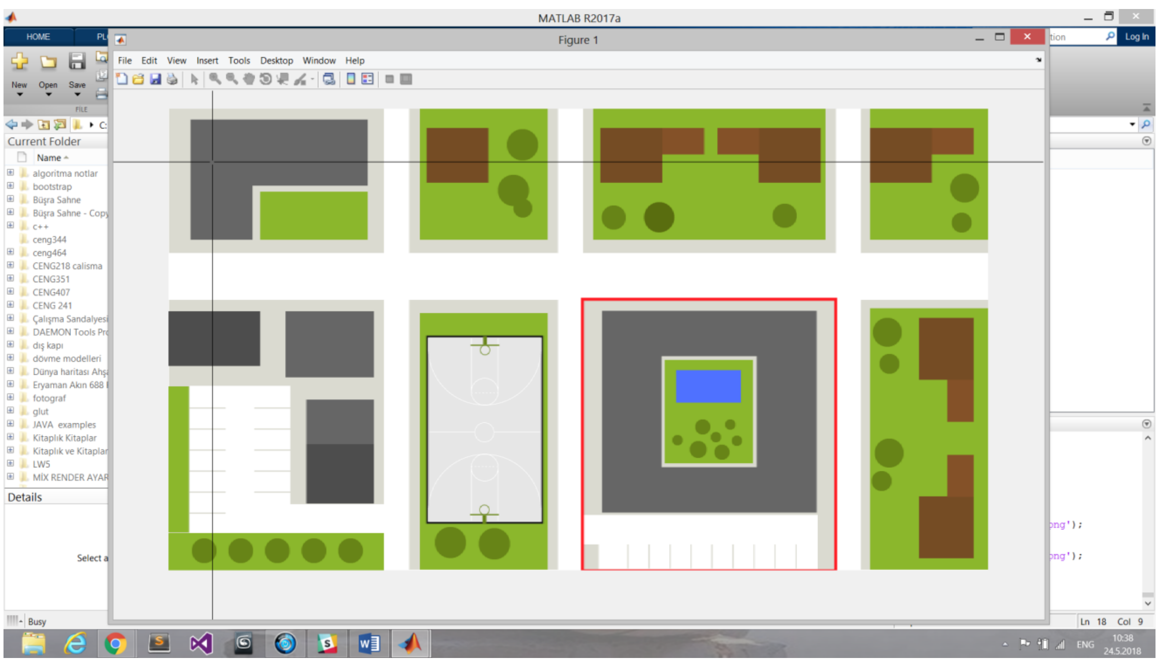

Figure 1.6: The graphical interface of map

The simulation will start automatically after all these operations. And the drone will begin to move from the starting point to the ending point.

INSTALLATION & COMPILATION GUIDE

This guide will describe how to install and compile simulation of drone.

Prerequisites

Matlab R2017a should be installed to run and compile the project. Newer versions will work however older versions won't open the project correctly. Matlab 2017 should be installed to compile the project. Older versions won't compile the project.

Compiling and Running

1.Create new script on matlab.

2.Reach the codes from our website.

3.Copy all codes in editor on the matlab.

4.Finally run the simulation program from 'Run' button.