INGENIA SE | COURSE 2022-2023

System Requirements Specifications (Final)

Hell-ix Team

May 23, 2023

Contents

1. Preface

The purpose of this System Requirements Document is to outline the specifications and design considerations for an autonomous racing drone project. The document provides a comprehensive guide for stakeholders and the Hell-ix Group to understand the project's goals, requirements, and limitations. The scope of this document includes a detailed analysis of the drone's functional and non-functional requirements, system architecture, communication protocols, and hardware specifications.

The following table displays information about the different issues of the document during the development of the project.

Table 1.1: Version Control

Issue	Date of Issue	Reason for Issue
1.0	25/11/2022	Initial Issue
1.1	26/02/2023	Minor Corrections
2.0	15/03/2023	Review and Addition of Requirements
3.0	22/05/2023	Review of Requirements & Corrections

2. Introduction

The system proposed consists of an autonomous racing drone to compete against another similar system in various tasks. The system is composed of a small UAV, a vision system to detect the environment of the drone, and a central computer to process data from the vision system and direct the UAV.

3. Glossary

UAV Unmanned Aerial Vehicle, flying robot which does not require a human to operate.

GCS Ground Control Station, stationary computer responsible for controlling the UAV.

GUI Graphical User Interface, type of interface that allows users to interact with software through graphical elements, such as buttons and icons.

Bezier curves mathematical method for generating smooth curves that the GCS uses to generate trajectories for the drone.

PID controller Proportional-Integral-Derivative controller, control algorithm used to maintain a system at a setpoint by adjusting inputs based on the difference between the setpoint and the system output.

API Application Programming Interface, a set of protocols and tools used for building software applications. APIs allow different software components to communicate with each other.

4. User Requirements Definition

Here, you describe the services provided for the user. The nonfunctional system requirements should also be described in this section. This description may use natural language, diagrams, or other notations that are understandable to customers. Product and process standards that must be followed should be specified.

Competition/Deadline/URS/ST-001

Function The system should be functional before the end of May 2023

Description

According to the project management, the drone should be able to compete by the end of May 2023. This will be the end of the INGENIA SE Project.

Competition/Environment/URS/ST-002

Function The drone will fly in an enclosed space inside the university

Description

In order to meet the legal constraints, the drone shall fly inside the university area and below a specific height. Also, the space shall be enclosed to ensure the drone stability and avoid severe atmospheric disturbances that could damage the drone because of its light weight.

Competition/Environment/URS/ST-002.1

Function The system must comply to current regulations on drone flights

Description

The drone must comply with the following regulations:

- Reglamento de Ejecución 2020/746
- Real Decreto 1036/2017
- Reglamento Delegado 2019/945
- Reglamento de Ejecución 2019/947

Competition/Environment/URS/ST-003

Function The team shall design a competition in coordination with the other team

Description

The team shall negotiate with the other team the trials and rules of the competition, as well as the winning conditions.

Competition/Environment/URS/ST-003.1

Function The competition should have a speed test

Description

The test should accurately determine if the drone can take off, fly in a straight line and land successfully.

Competition/Environment/URS/ST-003.2

Function The competition should have a precision test

Description

The test should measure the ability for the drone to detect a circle in an image and position itself relative to it in order to allow a laser beam coming from the drone to hit the circle.

Competition/Environment/URS/ST-003.3

Function The competition should have an obstacle avoidance test

Description

The test should comprise obstacles to test the ability of the drone to detect and avoid those obstacles.

Competition/Environment/URS/ST-003.4

Function The competition should have a point system

Description

To determine the champion of the competition, a scoring system should be designed with defined scoring criteria for each test. The scoring mechanism should evaluate the performance of each team and assign a numerical value to their results. The team with the highest cumulative score at the end of the competition will be declared the winner.

Competition/Environment/URS/ST-003.5

Function The competition should value style

Description

A jury shall be responsible for determining the drone with the most stylish design and/or impressive control tricks, based on visual aesthetics and performance during the competition. The jury shall include an expert in the field of drone design and operation (Ricardo Sanz), with knowledge and experience in evaluating the technical and aesthetic aspects of drone performance.

5. System Requirements Specification

Drone/Flight/SyRS/SY-001

Function The drone shall be able to fly in a controlled manner

Description

Controlled manner is defined as the ability of the drone to maintain stable flight conditions, maintain a specific altitude, and follow a predefined flight path with minimal deviation from the planned trajectory. Controlled manner is further specified with the following numerical constraints:

- Altitude: The drone shall be able to maintain a specific altitude within a tolerance range of +/- 10cm.
- Stability: The drone shall maintain a stable flight pattern with minimal pitch, roll, and yaw deviations from the intended flight path, with a tolerance range of +/- 5 degrees.
- Trajectory: The drone shall be able to follow a predefined flight path with minimal deviation, within a tolerance range of +/- 20cm from the intended trajectory.

Drone/Motors/SyRS/SY-001.1

Function The drone shall be able to lift its own weight plus the components mounted

Description

To participate in the different races the drone shall fly on its own. In order to achieve this, it has to self-propel, so the motors shall provide with the necessary power to lift its own weight and the components mounted.

Drone/Networking/SyRS/SY-001.2

Function The GCS shall be able to manipulate the drone manually in case of security threats or unexpected events

Description

In case of any security threats or unexpected events, the manual control system shall be used to ensure the safety of the drone and the surrounding environment. The manual control system should be able to control the drone's movement in various directions, including forward, backwards, left, right, up, and down. It should also be able to adjust the speed and altitude of the drone in response to the remote control signals.

Drone/Networking/SyRS/SY-001.3

Function The GCS shall be able to control the movement of the drone automatically

Description

In order to ensure the reliable and safe operation of the drone, it is necessary for the drone to

have a control system that is capable of controlling the movement of the drone automatically. This means the drone shall be equipped with an automatic control system that can be remotely accessed and controlled through a remote control device.

Drone/Onboard Computer/SyRS/SY-001.4

Function The GCS should relay information about the status of the drone

Description

The GCS should be able to provide real-time feedback on the drone's status, including its location, altitude, battery life, and any potential errors or malfunctions. This feedback should be easily accessible and clearly displayed on the remote control device to ensure the user has complete awareness of the drone's status.

Drone/Onboard Computer/SyRS/SY-001.5

Function The drone shall have automatic lift-off and landing procedures

Description

The drone shall be designed with automatic lift-off and landing procedures to facilitate safe and efficient operation. The automatic lift-off procedure shall enable the drone to take off from a stationary position without requiring manual input from the operator. The automatic landing procedure shall enable the drone to land in a safe and controlled manner, without requiring manual input from the operator.

Drone/Onboard Computer/SyRS/SY-001.6

Function A control algorithm shall run onboard the drone

Description

To enable autonomous operation, the drone shall be equipped with a control algorithm that runs onboard. This algorithm shall be responsible for processing sensory inputs and controlling the drone's movements based on programmed objectives.

Drone/Flight/SyRS/SY-002

Function The drone should have visual indications of its current status

Description

The drone should be designed with clear and easily visible visual indications of its current status. These indications should include information such as battery level, altitude, speed, and any active modes or commands. The visual indications should have high contrast and brightness and should be easily distinguishable from a distance. They should also be positioned in a way that is visible to the operator during operation, without obstructing the view of the drone or causing distractions.

Drone/Battery/SyRS/SY-003

Function The battery installed in the drone shall be large enough to ensure the competition is completed

Description

The battery system equipped on the drone shall be sufficient to complete all tasks with no need for a recharge. Therefore, the battery capacity shall be sufficiently large.

Drone/Battery/SyRS/SY-003.1

Function At any moment during the competition, there should be at least two battery replacements for the drone

Description

During the competition, it should be required that the drone is equipped with a minimum of two replacement batteries, available at any moment. These batteries should be charged and ready for use, to ensure the uninterrupted operation of the drone throughout the competition.

Drone/Onboard Computer/SyRS/SY-004

Function The drone shall be able to navigate autonomously

Description

The drone shall be designed and programmed with the ability to navigate autonomously, following a predefined path and avoiding possible obstacles.

Drone/Vision System/SyRS/SY-004.1

Function The drone should detect and avoid obstacles in its path

Description

In the second stage of the competition, the drone should be able to avoid obstacles of the following categories:

- Hoops
- Poles
- Doors
- Split Rectangles

Therefore, the drone should be able to distinguish between obstacle types and decide its trajectory based on this information.

Drone/Vision System/SyRS/SY-004.1.1

Function The system shall detect obstacles using a camera mounted on the drone

Description

A camera shall be used to collect information about the surroundings of the drone. Specifically, information about object types, distance, angles, etc. shall be collected.

Drone/Flight/SyRS/SY-004.1.2

Function The drone must react in time to obstacles in its path

Description

The complete process of capturing, sending, processing, receiving and reacting shall be performed sufficiently fast so that the drone shall not collide with obstacles in its path.

Drone/Flight/SyRS/SY-004.2

Function The drone shall be able to follow a target position

Description

The drone shall be equipped with a control system and sensors that enable it to track and follow a specified target position accurately and reliably. The control system shall be capable of interpreting and executing commands from the GCS, and shall be designed to ensure the safety of the drone and surrounding environment.

Drone/Flight/SyRS/SY-004.3

Function The GCS shall generate trajectories for the drone using Bezier curves

Description

The Ground Control System (GCS) shall have direct responsibility for controlling the movement of the drone. It shall generate a trajectory consisting of a set of target positions defined by Bezier curves, which shall be transmitted to the drone's control system for execution.

6. Software Requirements Specification

Software/Source Code/SRS/SO-001

Function The source code shall be traceable

Description

The source code shall be located in a repository so that changes can be tracked and previous versions are accessible.

Networking/Communications/SRS/SO-002

Function The software shall be able to communicate the drone and the GCS

Description

A communications software shall be designed so that the drone can communicate with the GCS wirelessly in order to transfer the collected data by the sensors in the drone and receive instructions from the computer.

Networking/Communications/SRS/SO-002.1

Function The control system shall have a fail-safe mechanism in case of connection loss

Description

The control system shall have a fail-safe mechanism that triggers when the connection between the drone and the GCS is lost or disrupted. This mechanism shall perform the last assigned task and remain in its current position.

Networking/Communications/SRS/SO-002.2

Function The control system shall have an automatic landing mechanism in case of connection loss

Description

If the connection between the drone and the GCS is lost for a period of 30 seconds or longer, the drone shall initiate a controlled landing procedure. This procedure shall involve the drone descending slowly and vertically until it reaches the ground.

Networking/Communications/SRS/SO-002.3

Function The control system shall cooperate to estimate the position of the drone

Description

Both the drone and the GCS estimate the position of the drone using sensor information, odometry and a mathematical model. The GCS compares the current drone estimate with its own to obtain deviations from the target.

Networking/Communications/SRS/SO-002.4

Function The drone shall send images to the GCS

Description

The onboard computer shall not perform any image processing, sending captured images directly to the GCS for processing.

Central Computer/Vision/SRS/SO-003

Function The software shall be able to process images

Description

A processing pipeline shall be created which takes images as inputs and produce obstacle detections as outputs. The detections shall then be processed into instructions for the drone to execute.

Central Computer/Vision/SRS/SO-004

Function The GCS shall have access to battery status

Description

The drone shall be equipped with a battery monitoring system that continuously measures the battery's remaining charge level. This information shall be transmitted to the GCS, which shall provide real-time battery status updates to the user. The remote control system shall use this information to warn the user when the battery level is low, allowing the user to take appropriate actions to ensure a safe landing and battery replacement if necessary.

Central Computer/Vision/SRS/SO-005

Function The software shall complete a control loop fast enough to ensure the reactivity of the drone

Description

In order to ensure the reactivity of the drone, the processing pipeline shall be as lightweight as possible by making use of optimizations and efficient technologies.

Software/Programming Language/SRS/SO-005.1

Function The software shall use a compiled programming language

Description

The programming language shall be compiled in order to minimize the latency between detection and the consequent instruction.

7. Note on the Final Requirements

The requirements shown in this document are the result from numerous modifications that have been made along the project, depending on the viability of the proposed objectives, and they have been adjusted to the capacities of both teams to satisfy them. Nonetheless, finally the system could not be validated to satisfy the needs of the client, so it did not make sense to change the requirements again to adapt them to a positive verification since that would lead to a mislead between client's needs and the requisites establishment by part of the team.