Indoor Drone Navigation System
(I.D.N.S)

Prepared For: Lockheed Martin Corporation
497 Electronics Pkwy,
Liverpool, NY 13088

Prepared by: Alan Alper, Brett Baker, Danny Delannes-Molka, Shane Griffin, Dakota Handzlik, Igor Kuzmich, Danyang Luo, Vladimir Tattybayev

CSE 453 Students, School of Engineering and Applied Sciences - SUNY University at Buffalo

February 19th, 2020

Distribution Statement: This document is intended for use by the University at Buffalo CSE453 drone navigation team, Dr. Kris Schindler, and Lockheed Martin employees only.

Table of Contents

1. Abstract

This requirement document proposes an indoor navigation system for a drone which can pilot itself to a given destination. A drone should know its position relative to the indoor environment using QR codes placed around the environment with constant known distances. Once a drone reads such QR code, it's two dimensional position will be known since the position of every distinct QR code is known. The altimeter of a drone shall provide the third dimensional position. Assuming there to be a designated flight height, all of the two dimensional movements will be done in that height. Such height should have no obstacles. The drone shall move vertically once its localized to the desired destination. An object detection system shall be active at all times to ensure the prevention of collision. This system will include computer vision and/or ultrasonic sensor to avoid an object and find alternative paths for the drone.

2. Introduction

2.1. Project Overview

The purpose of the project is to develop a software package enabling autonomous aerial drone navigation in an unspecified indoor warehouse environment. The drone must be able to detect and avoid objects within the warehouse. Additionally, the drone must be able to approach a payload within a tolerance specified by Lockheed Martin.

2.2. Document Overview

This document lays out the requirements for the Indoor Drone Navigation System project given to the University at Buffalo CSE 453 drone navigation team by Lockheed Martin. It covers all assumptions and requirements for this project, including a discussion of hardware, software and safety considerations. It also contains a list of deliverables and a proposed schedule for the project. All specifications herein are subject to the approval of the Lockheed Martin team, and may be changed throughout the lifetime of the project as deemed necessary

3. Requirements

3.1. Hardware Requirements

3.1.1 Drone Type:

The drone must be an aviation-based system in order to increase the feasibility of payload delivery. The drone must have a downward facing camera to allow for vision based localization of packages. Additionally, the drone should have ultrasonic sensors to prevent collisions.

3.2. Software Requirements

3.2.1 User Interface

The user should be able to set waypoints for the drone from a remote location. The system must relay controls to the drone, which will then navigate to the designated location. The interface should also report the drone's status and location in real time.

3.2.2 Reusability

The software must be designed so that it can be scaled for larger use, such as a multi drone system. It must also be reusable and not specific to a certain drone or platform.

3.3. Safety Requirements

3.3.1 Designated Flight Height:

There will be a designated flight height/zone, in order to increase redundancy and avoid collisions between drones and obstacles.

3.3.2 Object Avoidance:

The drone shall contain an object detection and avoidance system. If a drone were to detect an object on its flight path, it will find an alternative path to prevent a collision with the detected object.

3.3.3 Remote Controller Override:

The remote control must be able to override the software commands, allowing facility employees to take control of the system in the event of an emergency.

3.3.4 Collision Damage Control:

In the event of a collision an emergency response system shall activate. This protocol will immediately deactivate the drone's motors to prevent further damage to the drone or the environment.

3.3.5 Software Watchdog:

System software shall contain a software watchdog in case of a system timeout.

4. Design Assumptions

For this project the following assumptions will be made:

4.1. Environment

The main goal of this project is a drone capable of autonomously navigating an unspecified distribution center. We shall assume that any warehouses using this system are OSHA compliant. Additionally, we will assume certain qualities regarding the warehouse infrastructure:

- Storage areas shall be free from accumulated materials and detritus. No machines, materials, or persons shall be in the walkway while the drones are active.

- There shall be an area above all shelving units that can operate as a "free fly" zone. More specifically, there must be at least a 1 meter high altitude band somewhere near the top of the warehouse in which no obstacles will be present.

4.2. Packages

Along with navigation, the project has the practical goal of transporting packages between locations. We will assume the case of a uniform package stationed on the ground at a given waypoint. The drone must be able to approach the top of the package location within a tolerance to be determined by Lockheed Martin. All testing will be done without a physical package present. Further developments in the mechanical aspects of payload delivery are feasible for future iterations, but are beyond the scope of the current project specifications.

5. Deliverables

The primary deliverables for this project are a completed drone navigation software package and periodic progress reports.

5.1 Software:

The software package will facilitate the use of aerial drones as automated couriers inside an unspecified warehouse environment. It will be installed onto a prototype drone to demonstrate its capabilities. Video evidence of the navigation software's functionality will contribute to the final report's documentation. The drone must be able to arrive at a remotely determined destination - within a tolerance to be specified by Lockheed Martin - in order to consider a payload pickup or delivery "successful".

5.2 Reporting:

Progress reports will be provided at regular intervals. These reports will continue until the end of the twelve week production period. A final report delivered at the end of the twelve weeks will describe the development process and finished product.

6. Proposed Schedule

We plan to adopt an agile development strategy for this project. The work will be broken into four 3-week long sprints, each of which will have its own objectives.

	Sprint 1 Initial Design	Sprint 2 Early Implementation	Sprint 3 Adjustments	Sprint 4: Finalization
02/09 - 02/15				
02/16 - 02/22				
02/23 - 02/29				
03/01 - 03/07				
03/08 - 03/15				
03/16 - 03/22				
03/23 - 03/29				
03/30 - 04/04				
04/05 - 04/11				
04/12 - 04/18				
04/19 - 04/25				
04/26 - 05/02				

Table 1: Breakdown of sprint periods

6.1. Sprint Breakdown

Sprint 1 - Initial Design:

- Select a drone that fits the project specifications.
- Select sensors that can be integrated onto our drone of choice.
- Prepare a budget breakdown for all necessary hardware.
- Design and present requirements to Lockheed Martin.
- Locate relevant APIs and ROS packages.

Sprint 2 - Early Implementation:

- Integrate with drone hardware.
- Add sensors and a secondary processing system.
- Set up communication protocols.
- Design test environment for ROS simulations.
- Run ROS simulations to test functionality.

Sprint 3 - Adjustments:

- Address any significant challenges that arose during the previous sprint.
- Tweak and optimize control and navigation systems.
- Submit any potential redesign documentation to Lockheed Martin for approval.

Sprint 4 - Finalization:

- Prepare and submit all necessary documentation, including:
  - User manual
  - Maintenance manual
  - Final design specifications
- Finalize all systems, prepare test (live, videotaped, or simulated) to present as proof of functionality.