Warehouse Drone Collision Avoidance Project Plan

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List of Abbreviations

A.I. Artificial Intelligence.

Fontys Fontys University of Applied Sciences.

KPI Key Performance Indicators.

RACI matrix Responsible-Accountable-Consulted-Informed matrix.

STG2 Graduation Project.

TBD To Be Determined.

Definitions

Artificial Intelligence The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

Deep Learning A subset of machine learning in artificial intelligence that makes use of artificial neural networks..

OpenCV OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code (1).

Chapter 1

Introduction

This chapter serves to introduce and describe the background information, context, and stakeholders of this project. A description of the reporting structure is also included.

1.1 Background Information

This project has been assigned as graduation project by Seacon Logistics. The product that will be developed along the course of this semester will ultimately be used to write a thesis on, which is done to satisfy the final requirement set by the Graduation Project (STG2) module. This document specifically exists to fulfill the first requirement of the module, as well as to document the current plan for the project. The latter part is done so that an agreement on what is supposed to be done can be formed on paper.

1.2 Context

"Seacon's mission is to be the Logistics Chain Director, with a focus on overseas logistics, forwarding and distribution and supply chain solutions. Warehousing forms a basis that is linked to the other core services." (2)

As the warehouses of Seacon are vital to their business, efficiency and innovation is the key to staying ahead of the competition. This project will form the basis of a larger project with the aim to semi-automatize Inventory Control & Management of said warehouses.

1.3 Stakeholders & Affiliates

Within this project, there are 3 groups of stakeholders: The student, Seacon Logistics, and Fontys University of Applied Sciences (Fontys). The latter 2 groups shall throughout this document be referred to as either "Seacon" or "the company", and "Fontys" or "the university", respectively. The table below lists individual stakeholders, to which group they belong to, and what their roles are.

Name	Company/Institute	Role	RACI Role	Email
Tristan van Vegchel	Fontys/Seacon Logistics	Student/Developer	Responsible	Tristan@vanvegchel.eu
Sander Bruinsma	Fontys	Tutor	Informed	S.bruinsma@fontys.nl
Geert Monsieur	Fontys	Examiner	Informed	G.monsieur@fontys.nl
Kai-Arne Reiter	Seacon Logistics	Company Supervisor	Consulted, Informed	Kreiter@seaconlogistics.com
Mark Vromans	Seacon Logistics	Manager Engineering & IT	Accountable, Informed	Mvromans@seaconlogistics.com
Wilfried Beerens	Seacon Logistics	Manager Shared Services Center	Informed	Wbeerens@seaconlogistics.com
Fred Lemmen	Seacon Logistics	Senior Application Specialist	Consulted	flemmen@seaconlogistics.com

Table 1.1: List of stakeholders with their respective roles.

Stakeholders, aside from their regular roles, also have a Responsible-Accountable-Consulted-Informed matrix (RACI matrix) role assigned to them. For a description of the roles, please refer to figure 1.1.

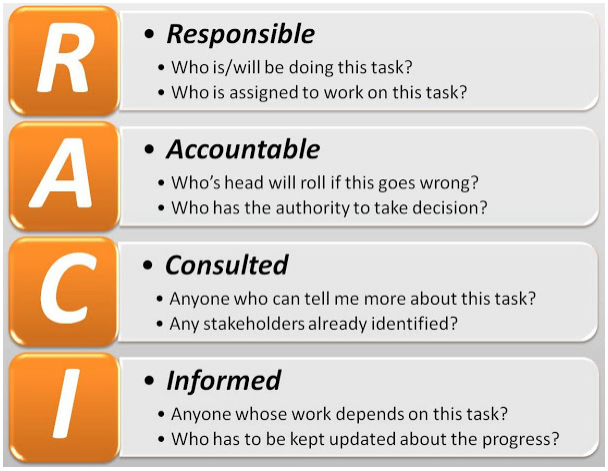

Figure 1.1: Descriptions of the RACI matrix roles.

1.4 Problem Description

Seacon its warehouses contain a lot of storage goods. As part of Inventory Control & Management, these goods are counted and checked. This is currently done manually by sending out employees to the desired location. As these employees are getting scarcer, Seacon Logistics is looking towards a semi-autonomous solution using drones. According to Seacon, current suppliers are too expensive, do not provide a complete product, and come with a lot of uncertainty among service costs. Moreover, no supplier can guarantee support for 3-10 years, which is a requirement set by Seacon. Hence, Seacon is looking towards developing their own solution by building on open source tools.

1.5 Reporting Structure

The remainder of this document will firstly be dedicated to a project description. This chapter will contain an assignment description, the minimal requirements, and descriptions of the epics with their sub-activities. Also included is the tools/frameworks that might be made use of. Secondly, the scope is defined. This consists out of the time scope, responsibilities and expectations of the intern, responsibilities of the company, and the financial scope. Thirdly, a planning is given. This also includes tools/strategies used to facilitate creating a proper planning. Finally, major risks are discussed and workarounds are given.

Chapter 2

Project Description

Here, the details of the assignment are described. This includes things such as minimal requirements, the defining of epics and their sub-activities, and tools/frameworks that are planned to be used.

2.1 Assignment Description

The assignment is to research Artificial Intelligence (A.I.) approaches and (based on the research) develop a solution to provide drones with collision avoidance functionality. The drone should be able to get to a destination while avoiding obstacles along its path. The minimal requirements is to have the following:

- To have a trained model or alternative solution that provides the collision avoidance.
- A way of testing and demonstrating. Preferably by connecting the solution to a real drone. A simulation, however, will also suffice.

While the forthcoming research will play a big role in the decision of framework, components etc, the preliminary decision will be to use Keras and/or Tensorflow as framework, as these are most generally suitable. As language Python will be used, as most documentation for deep learning frameworks is available for Python, as well as that Python provides functionality for relatively easy implementations of simulations. Another reason is that the drone that will be used for development comes with a Python SDK.

In a warehouse, there are 5 entities that should be kept into consideration when it comes to collision avoidance: forklifts, pallets, humans, other drones, and the environment itself. All entities can either be stationary or moving, with the exception of pallets.

This assignment will be the first step of completing the roadmap of a bigger project, with the goal ultimately being having multiple drones operate semi-autonomously in the warehouses while performing tasks such as checking for anomalies of goods and barcode scanning. For the full road-map, please refer to figure 2.1.

A way to measure the effectiveness of a solution is through the use of Key Performance Indicators (KPI). While eventually the biggest KPI will be the averted costs of replacing the current system, for the scope of this project the most important KPI will be the collision/collisions avoided ratio.

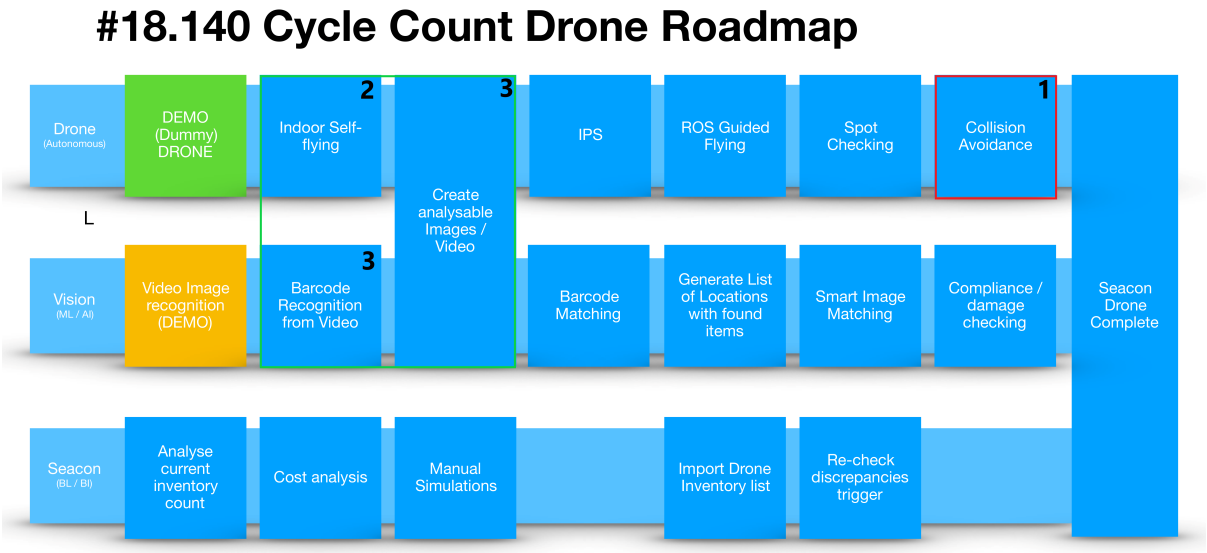

Figure 2.1: Roapmap of the Seacon drone project.

In figure 2.1, a few parts have been highlighted and given a number. These numbers indicate a priority in descending order, with 1 being the highest and thus most important. The parts highlighted with a red outline are considered crucial requirements for success, while the green ones will be considered optional extensions. More information regarding these extensions is given in chapter 3.

2.2 Epics and Activities

While use cases might not be very applicable within the scope of this project, 5 epics with their own stories and tasks have been defined. For the 5 epics with their descriptions, please refer to the list below. For a more detailed table containing the stories and complexities, please refer to appendix A.

- **Drone Control:** The drone should be able to move towards a set destination, with the use of scripts.
- **Demonstration and Testing Environment:** A suitable testing and demonstration environment should be set up. This includes a potential simulation environment, but also details such as what things should be tested in order to truly evaluate robustness.
- **Environmental Awareness:** The drone should make use of its visual and sensory equipment to register what's around it.
- **Collision Avoidance:** The drone should be able to avoid colliding with both stationary and moving objects without human assistance.
- **Pathing:** The drone should know where it is going, where it is now, and where it came from.

Chapter 3

Scope

This chapter contains everything that should be explicitly mentioned regarding responsibilities, what will be in scope and what not, and information around the cost scope.

This project will have a duration of one semester, or roughly 100 working days. The initiation is on 02/09/2019, and the final deliverable is due on 07/02/2020 latest. During this semester, the student will work the standard 40 hour workweek. Vacation days can be granted upon request, but do not add up to the working days.

3.1 Student

As stated in the Fontys regulations for graduation, during this project the student will not be burdened with tasks irrelevant to the assignment. The solution will thus exclusively consist out of software that at least is able to fulfill the minimal requirements stated in section 2.1. The student will ultimately be held accountable for the completion of the project, on the condition that all other parties fulfill their responsibilities.

Optional extensions are highlighted with a green outline in figure 2.1. These extensions include solutions that will allow actual drones to fly to a preset destination in a warehouse, as well as the inclusion of a barcode detector and scanner using the drone's camera with detection algorithms.

3.2 Seacon

Seacon will be responsible for facilitating the student with a proper working environment and substantial supervision. Seacon will also be responsible for supplying an adequately equipped drone for testing purposes. This also includes handling the purchasing of additional equipment if the drone is deemed insufficiently equipped or dysfunctional by both the supervisor and the student. Additionally, Seacon will also be responsible for supplying the necessary hardware for computing-heavy tasks such as training a Deep Learning model. Finally, Seacon should also be willing to assist in obtaining training material if necessary. Seacon has stated that the solution should be as cost efficient as possible. The student will be a compensation of €350 monthly.

3.3 University

Fontys will be responsible for assigning a university supervisor. This supervisor shall be tasked with providing feedback to i.e. reports and presentations of the student in order for the student to increase the quality of his end products and thesis. Another responsibility is giving advice regarding approaches, technologies, school-related requirements, and other contextual matters within certain limits. Finally, the student should be able to consult the university supervisor in case problems occur that might jeopardize the project.

Chapter 4

Planning

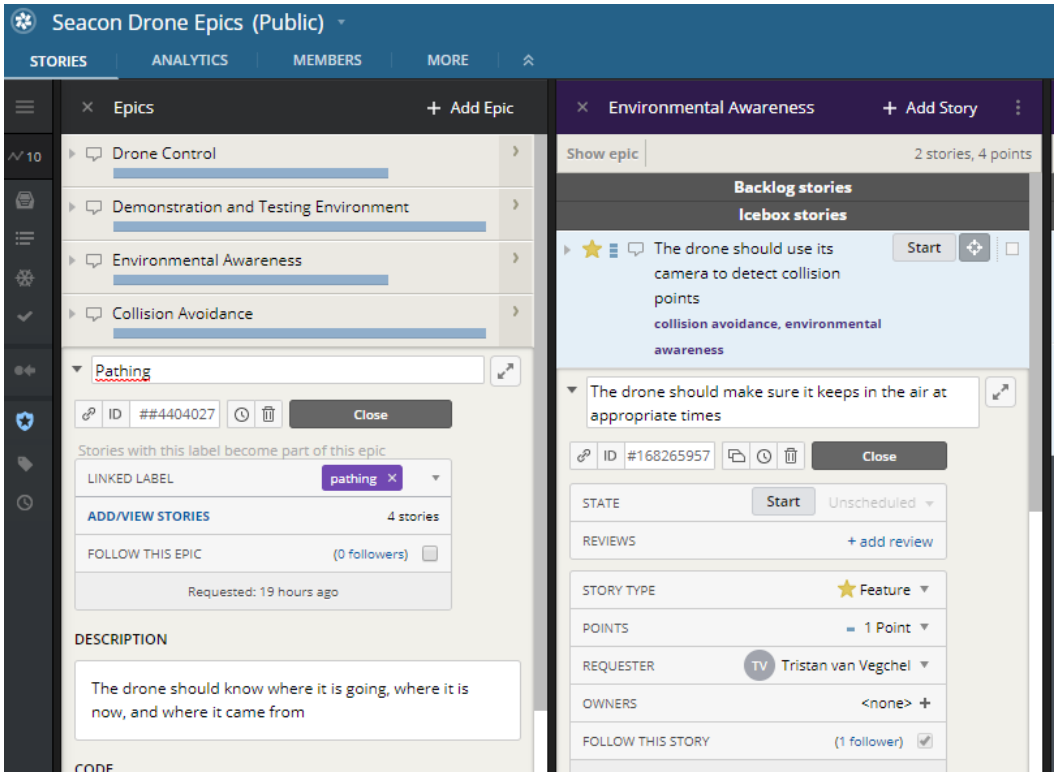

Figure 4.1: Screenshot of Pivotal Tracker interface

Each of these epics have their own sub-activities, which are listed using a tool named Pivotal Tracker. Pivotal Tracker enables users to add stories with tasks to epics, which then can be assigned to people. A backlog is then generated. Pivotal Tracker will assist in fulfilling a requirement set by Seacon. Namely, the use of the Plan-Do-Check-Act cycle and agile development. A table containing the stories of each epic is given in appendix A.

Deliverable	**Deadline**
Project Plan	27/09/2019
Midterm Report	21/10/2019
Midterm Presentation	28/10/2019 - 15/11/2019
Thesis Report	13/01/2020
Final Presentation	20/01/2020 - 07/02/2020

Table 4.1: List of school deadlines.

The school also provided a set of deadlines for a set of reports and presentations. These reports and presentations are meant to document the start, middle, and end status of the project. The deadline dates can be found in table 4.1.

Chapter 5

Risk Analysis

This chapter is dedicated to listing potential obstacles that might cause the project to stagnate. Especially in the context of A.I. development, where there often is relied on trial-and-error, a lot of uncertainties present themselves. Analyzing potential risks helps with timely detecting them in order to find a workaround if necessary.

In order to combat the majority of risks, there will be made use of agile development. weekly stand-up meetings will be held with the staff to discuss the progress and obstacles. From there on out, plans can be adjusted based on consultation from the company supervisor. The major risks are discussed in the next few sections.

5.1 A.I. Risks

A.I. development generally comes with a lot of risks. It is often hard to determine how a certain approach will work out other than trying it out. This could pose a problem when it comes to time management. However, the time lost could be minimized by doing proper research into approaches and alternatives, so that dead-ends can be recognized timely.

5.2 Drone Risks

As mentioned in chapter 3, the drone its cost should be kept to a minimum. This means that, initially, development should be done using only a front-facing camera-equipped drone. This might not be sufficient for a satisfactory solution, and while new equipment can be ordered, it will cost time nonetheless.

5.3 Environmental Risks

In the context of being a temporary employee, there are also general risks involved. Firstly, illness could pose a risk. Should this occur and become a problem, then this will be discussed with the student, company supervisor, and in severe cases the university coach. Secondly, misalignment of thoughts and miscommunication between the student and the company could distort results. Generally this should be solved internally, but in worst cases, the student will be consulted by the university coach. Finally, the risk of having an improperly defined scope is also present. This can come in forms of the assignment being too broad/specific, or the assignment being too big/small. This, however, could be averted through developing a proper project plan in combination with having regular progress meetings.

References

[1] *About OpenCV* (2019).
URL: *opencv.org/about/*

[2] *About Seacon* (2019).
URL: *https://www.seaconlogistics.com/en/about-seacon*

Appendix A

Epics & Stories

Epic	Story	Level
Drone Control	The drone should return to a charger station when battery critical	2
	The drone should continuously wait/poll for new input from scripts	1
	The drone should obey movement commands sent via a script	1
Demonstration and Testing	3D model for random pallets should be made	1
	3D model for human should be made	1
	3D model for forklifts should be made	1
	An endless path that resembles a warehouse should be made	1
	3D-controllable model of drone should be made	2
Environmental Awareness	The drone should use its camera to detect collision points	3
	The drone should make sure it maintains appropriate altitude	1
Collision Avoidance	The drone should use its camera to detect collision points	3
	The path should be recalculated in case the drone diverts from it	3
Pathing	The drone should make sure it maintains appropriate altitude	1
	The path should be recalculated in case the drone diverts from it	3
	The drone should track how far it is on its path	1
	A path should be created connecting the starting and ending coordinates	1

Table A.1: List of all epics and stories.

Above is a table containing the epic and stories. Within there, duplicate stories exist. This is due to the fact that some stories have overlap between multiple epics, and are thus included once in each of the relevant epics. Next to each story, there is also a level column. The level serves as a complexity indicator, with level 1 being the lowest complexity, and level 3 being the highest.