Software Requirements Specification

for

Small-Unit Drone Optimization (SUDO)(Ver 2.0)

Version 2.0

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Revision History

Name	Date	Reason For Changes	Version
First Draft	11/22/2022	Initial Draft of Document	1.0
Second Draft	3/21/2022	Second Draft of Document	1.5
Second Draft	4/20/2022	Finalizing Document	2.0

1. Introduction

1.1 Purpose

The purpose of this document is to provide an overview of all the requirements necessary for the leveraging of human perception models and sensor properties to effectively portray information and optimally position Small Unmanned Aerial Systems (SUAS) in complex urban environments. We outline the requirements for our software, which will include the necessary programs and tools to utilize for the implementation.

1.2 Intended Audience and Reading Suggestions

This document is intended for developers and project managers, seeing as how SUDO, in its current state, is primarily software. This document describes how the SUDO software will function in a general sense, and what hardware it will need to communicate with.

1.3 Product Scope

The Sudo project aims to be able to provide ground troops with an efficient way of scanning and gathering intel on areas of interest without alerting locals to their presence.

- User Interface
- Controls and Sensors
- 3D Terrain Scanning
- 3D Simulations

1.4 Definitions, Acronyms, and Abbreviations

SUDO: Small Unit Drone Optimization

ARL: Army Research Lab

3D: Three Dimensional

SUAS: Small Unmanned Aircraft System

1.5 References

- Auditory Detection Model by Joel (2013)
- Experimental Study of Quadcopter Acoustics and Performance at Static Thrust Conditions - https://www.bu.edu/ufmal/files/2016/07/aiaa-2016-2873.pdf
- Proposed Aural Detectability - Garinther (1985)
- Modeling human visual perception for target detection in military simulations - Jungkunz (2009)

2. Overall Description

2.1 System Analysis

The purpose of SUDO is to be able to employ an algorithm that can calculate distances in which a SUAS could be perceived by human targets on the drone, given parameters of auditory and visual footprints of a SUAS, as well as background and environmental auditory and visual data given to us by the Army Research Lab. This data will then be relayed to the 3D environment portion of our software, which can render a 3D perspective of detection zones and probabilities of detection within those zones.

To complete these tasks SUDO will use our engineered algorithm, the Army Research Lab research data, as well as SUAS on-board sensor equipment to create an accurate model for possible detection of the SUAS by ground targets given fixed target distance parameters.

If time permits, we also hope to incorporate software that can detect targets on the ground dynamically, so as to base the detection zones on these real targets, as opposed to fixed parameters.

2.2 Product Perspective

SUDO will consist of using auditory and visual perception models, statistical probability techniques, and some aspects of Unity 3D, a sandbox virtual environment, to allow the capture of landscapes the SUAS' sensors scan, and also give insight into its own detectability. The idea of SUDO is to allow small mobilization of intel gathering from only a few troops deployed on a mission. Certain aspects of Unity will be used to grab 3D renditions of areas that are scanned in its vicinity as Unity is an engine that can grab and model these scans efficiently at the moment.

2.3 Product Functions

The product functions of SUDO are described below with components such as

- Sensors to scan and graph an environment into a 3D model
- Data collection to determine if SUAS detectability is likely or not
- Determine the environmental factors that would affect detectability
- Determine the maximum ranges at which a SUAS can be perceived
- Project these distances with statistical probabilities of detection in the Unity Environment

2.4 User Classes and Characteristics

- US military personnel are to access the software to assess the functionality of the software
- US military personnel are to be able to test drone flights via simulated environments
- Us, the designers of the software, will initially use SUDO with a test-drone, as well as different on-board sensor equipment, to test the accuracy of our algorithms.

2.5 Operating Environment

SUDO will base its operating environment on an Urban setting, as per Army Research Lab specifications. If time permits, we will test our program with other environments as additional research.

- Software between the camera and the 3D rendition

  Unity will be used in between the communication of what data is grabbed by the sensor of the environment and the machine learning software will be able to calculate and detect self-discoverability. Drone mapping software will be used to transfer images taken by the drone to transfer for useability in Unity software.

2.6 Design and Implementation Constraints

Current Limitations of SUDO include:

- A fixed target distance parameter must be used to calculate detectability zones, since we cannot dynamically scan the environment and detect a “threat” with much accuracy as of now. We will attempt to tackle this problem as an additional exploration of our program.
- A person’s perceptiveness can vary depending on factors such as:
  - Awareness
  - Level of distraction
  - Under the influence of any mind-altering substances
  - Conditions of environment
- Limitation of drone mapping accuracy is dependent on drone camera quality

2.7 User Documentation

The documentation that will be provided will be a user manual on how to operate the software in conjunction with the drone to capture images and render them in unity.

2.8 Assumptions and Dependencies

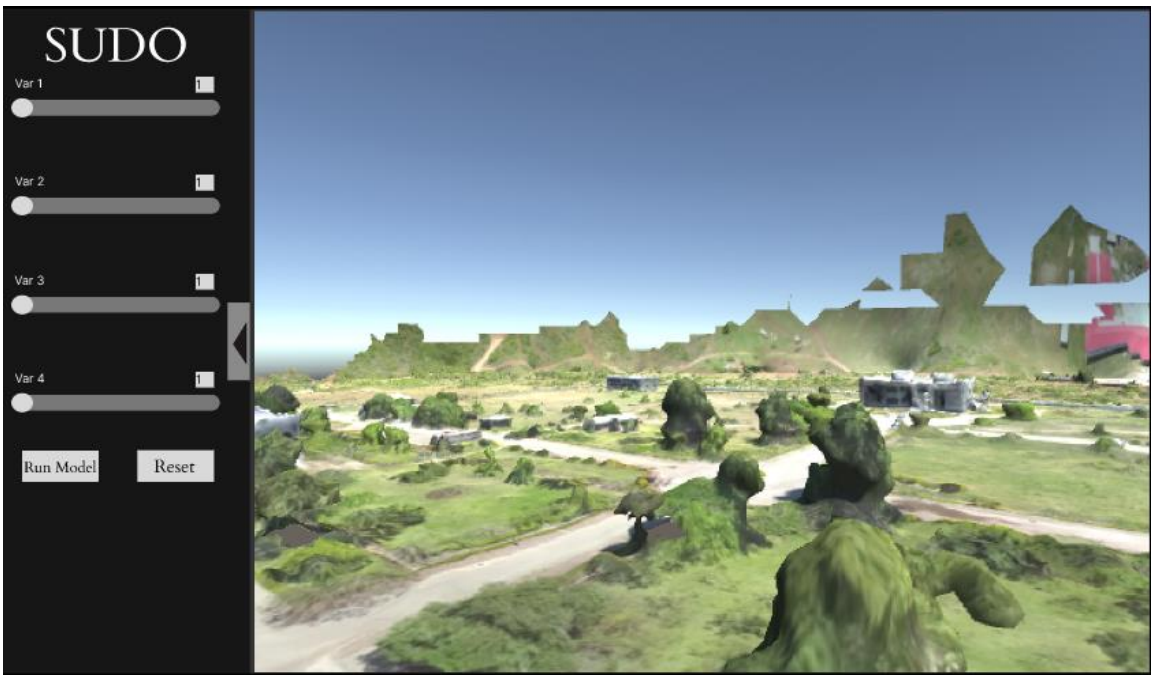
It is assumed that the Army Research lab will be adapting our findings to different SUAS platforms, and so we will be providing the sound and visual measurement of a specific SUAS (DJI Mavic Pro) to create our model. Our algorithms for the detection model are dependent on the raw data given to us by the Army Research Lab for human audio and visual perception models.

2.9 Apportioning of Requirements

Currently there is no apportioning of requirements

3. External Interface Requirements

3.1 User Interfaces



This GUI at the moment is a prototype wherein the software receives the data that the drone captured from where it was gathering the data. The sliders on the left-hand side will be able to control and change the values of the hearing threshold of the target object that is selected. While using the tablet the right-hand side of the tablet will be able to zoom in and control the view of the 3D render allowing the user to see landscapes or certain checkpoints with a good amount of detail for intel gathering.

3.2 Hardware Interfaces

SUDO will work with the camera hardware that is a part of the drone for picture samples of desired locations to map in 3D.

3.3 Software Interfaces

Software that will be used will be unity to make an interactable 3D landscape of what the drone captures and relays on the tablet and WebODM to help establish the drone mapping.

3.4 Communications Interfaces

Communication will be between the SUAS and the on-board sensor equipment such as cameras and microphones, as the drone will capture required images for use in creating a simulated environment.

4. Requirements Specification

4.1 Functional Requirements

Software

- SUDO shall create a simulation based on images received
- SUDO shall have a customizable environment for simulation
- SUDO shall let user create and customize flight paths within the simulation bounds
- SUDO shall estimate detectability distances of an SUAS based on target location parameters
- SUDO shall create statistical detection zones in the form of rings for target objects
- SUDO shall detect how far a target object is away from drone in our 3D environment
- SUDO shall calculate what range is needed to avoid drone detection based on a fixed-target distance

4.2 External Interface Requirements

Camera

- Camera shall take pictures of designated location
- Will be part of the on-board SUAS sensors

4.3 Logical Database Requirements

Not applicable

4.4 Design Constraints

The constraints of SUDO are based on the quality of equipment on-board the SUAS. Based on this equipment, specifically camera quality, perceptions or 3D renditions may vary in accuracy in the Unity engine from platform to platform.

5. Other Nonfunctional Requirements

5.1 Performance Requirements

The performance of SUDO will be determined by how accurate the auditory and perception models are in calculating detectability ranges, as well as how this model translates data into our Unity 3D environment using sensor equipment on-board our SUAS to create a simulation environment. Higher quality images fed to the Unity Engine (in addition to a solid statistical detection algorithm) will give us a higher quality rendition of the given location, but this also means Unity will take longer in rendering these simulations for use.

5.2 Safety Requirements

Not applicable as SUDO in its current state is software.

5.3 Security Requirements

Authorized users are only allowed access to the code as it will not be publicly available for use. The program itself will be able to be seen as only a demo and not to its full capabilities. Only authorized users or technicians may see the code to either update, change, or remove features or aspects of the code when needed to optimize the program.

5.4 Software Quality Attributes

SUDO will be using captured images to create 3D environments for simulation use in the Unity Engine. It will use images of target locations, and will be able to determine if a target object can detect a drone and how close the drone needs to be for detection, it will also show its detection range in unity.

5.5 Business Rules

Not Applicable as the software will be used by the military.

6. Legal and Ethical Considerations

Use of SUDO will aid soldiers in the field to know as many variables as possible before entering a situation. SUDO will be used as a reconnaissance drone to gather intelligence on people and vehicles and in using this drone for intel gathering will help minimize casualties on all sides.

Add/Remove from Requirements Document

- Remove/Change 4.2 External Interface Requirements if needed (might not be removed)
- Remove 3.4 Communication interfaces if needed (might not be removed)