For use by the Project lecturer	Approved		Revision required	

Feedback

This is a weak reaction to the comments in Rev 0.
Approved as the project scope is correct.

Approved

To be completed by the student

PROJECT PROPOSAL 2023

Project no	PdV3	Revision no	1

Title	Surname	Initials	Student no	Study leader (title, initials, surname)
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Project title

Laser pointer turret based mosquito air defence system

Language editor details	Language editor signature
Vedre Hartman	
Student declaration I understand what plagiarism is and that I have to complete my project on my own.	**Study leader declaration** This is a clear and unambiguous description of what is required in this project. Approved for submission (Yes/No)
Student signature	Study leader signature and date 20/6/2023

1. Project description

What is your project about? What does your system have to do? What is the problem to be solved?

The problem addressed in this project is the development of an automated system to shoot mosquitoes using a non-lethal laser turret. A non-lethal system is developed as a proof of concept. Mosquitoes carry dangerous diseases, such as malaria and dengue fever. Insect repellents are not 100% effective and need to be regularly reapplied to remain effective. Thus, the problem addressed in this project is to develop a new type of mosquito air defence system.

The concept is to detect mosquitoes using a camera and then "shoot" them down using a laser that is controlled by a turret system. In this project the mosquitoes will be in an enclosed tank. The project will entail the first principle design of an object detection algorithm that can recognise mosquitoes, a multi-target tracking algorithm which can track and make predictions for multiple targets, and a control system for the laser turret which can “shoot” at the target mosquito.

2. Technical challenges in this project

Describe the technical challenges that are *beyond* those encountered up to the end of third year and in other final year modules.

2.1 Primary *design* challenges

A fundamental challenge in the design of the laser pointer turret based mosquito air defence system is the reliable detection and localisation of mosquitoes. To achieve this, an algorithm must be developed that can associate detections of mosquitoes over time to track their movement. Additionally, a reliable prediction algorithm must be developed to predict the future state of mosquitoes based on their previous states. A core design challenge is to convert the position of a detection into an angular coordinate that the laser turret can target. The laser turret system must target a position with sufficient accuracy to illuminate the body of a mosquito while being able to move with enough speed to track it.

2.2 Primary *implementation* challenges

A primary implementation challenge is real-time detection and association of mosquito movements over time, with prediction of their future states, all on an embedded platform. A suitable model to represent mosquito motion must be selected to create an accurate state prediction model. Developing a control model for the laser turret and detecting the actual position of the laser is also a significant challenge. Implementing a turret system will sufficient speed and accuracy poses a critical challenge. Obtaining sufficient mosquitoes for testing and demonstration is an additional practical challenge.

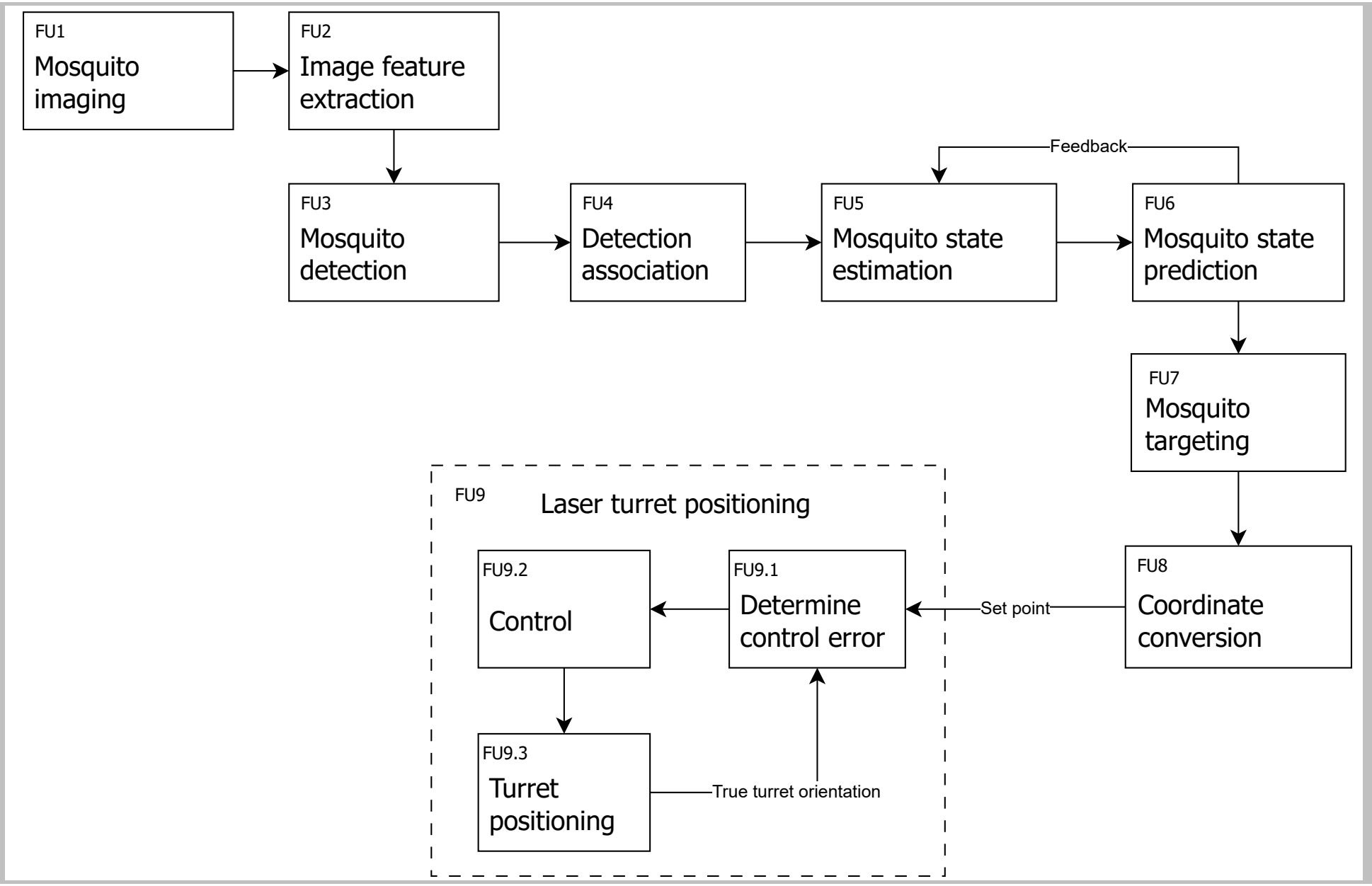
3. Functional analysis

3.1 Functional description

Describe the design in terms of system functions as shown on the functional block diagram in section 3.2. This description should be in *narrative format*. DO NOT use a bullet list.

The system will image the mosquito enclosure (FU1). The system will then extract the features from the image (FU2). The system will detect all the moving mosquitoes in the enclosure (FU3). The system will then associate the mosquito detections over time to determine the past movement of the mosquitoes (FU4). The system will then determine the current state of the mosquitoes using the movement history (FU5). The system will then use the current state of the mosquitoes and a model for the movement of mosquitoes to predict the future state of the mosquitoes (FU6). The system will then select a mosquito to target (FU7). The position of the target mosquito is then converted from rectangular coordinates into angular coordinates that can be targeted by the laser turret (FU8). The laser turret must the move to the target position. The system must then detect the actual position of the laser. This will be used as feedback to adjust the position of the laser to reach the target position (FU9).

3.2 Functional block diagram (this should not be a flow diagram)



4. System requirements and specifications

These are the core requirements of the system or product (the mission-critical requirements) in table format **IN ORDER OF IMPORTANCE**. Requirement 1 is the most fundamental requirement.

	Requirement 1: the fundamental functional and performance requirement of your project	**Requirement 2** (Number 2 in the order of importance)	**Requirement 3**
1. Core mission requirements of the system or product. Focus on requirements that are core to solving the engineering problem. These will reflect the solution to the problem.	The system must track and illuminate mosquitoes with a laser in an enclosure.	Detect moving mosquitoes in the enclosure.	Track mosquitoes over time. (Associate mosquitoes detections between frames.)
2. What is the target specification (in *measurable* terms) to be met in order to achieve this requirement?	The system must be able to illuminate a mosquito every 5 seconds.	The system must have a 0.9 probability of detection and a 0.05 probability of false alarm. Detection will be performed at an update interval of 500ms.	After 5 seconds there must be a minimum of 0.9 probability of correct association in each step of tracking the mosquitoes.
3. Motivation: Defend the specific target specification selected, i.e. the value. *Why* will meeting the specification given in point 2 above *solve the problem*?	5 seconds is a reasonable amount of time to acquire the next mosquito and reposition the laser to be ready for the next "shot".	90% is a high probability of detection and 5% is low enough that little time will be wasted on false alarms (mosquitoes that do not exist).	The system must be able to associate mosquitoes from one frame the next to target the mosquitoes. 90% is high yet reasonable probability of correct association. 90% is an acceptable rate for most tracking systems.
4. How will you demonstrate at the examination that this requirement and specification (points 1 and 2 above) have been met? Be explicit about how you will *prove* these were met.	The display will indicate the time that has elapsed since the targeting began until the mosquito has been illuminated. The constant llumination of mosquitoes by the laser will demonstrate correct functioning of the system.	The system will have a display that shows the video feed with the mosquitoes identified. This can be paused and inspected to verify that the requirement is met.	The display will show the tracks (lines) that follow a specific mosquito over time.
5. Your own design contribution: what are the aspects that *you will design and implement yourself* to meet the requirement in point 2? If none, *remove this requirement.*	The image processing system, the prediction algorithm of the mosquitoes future location, the targeting algorithm, and the control system for the laser turret.	The detection algorithm will be developed by the student and implemented on an embedded microprocessor.	The target tracking algorithm will be developed by the student.
6. What are the aspects to be taken off the shelf to meet this requirement? If none, clearly indicate "none". Explicitly indicate what tasks library functions will be used for (if relevant to the project).	The embedded platform, the camera, the laser, the motors, the motor drivers, and the power supply will be off the shelf.	The embedded platform, the camera, and the display will be off the shelf.	The embedded platform will be off the shelf.

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	Requirement 4	Requirement 5	Requirement 6
1. Core mission requirements of the system or product. Focus on requirements that are core to solving the engineering problem. These will reflect the solution to the problem.	Control the position of the laser to illuminate the target position (set point).		
2. What is the target specification (in *measurable* terms) to be met in order to achieve this requirement?	The laser must be able to illuminate the set point within 2 seconds accurate to within 1mm.		
3. **Motivation:** Defend the specific target specification selected, i.e. the value. *Why* will meeting the specification given in point 2 above *solve the problem*?	The laser must be able to reach the set point within one second such that the overall system specification is reached. A typical mosquito is 2mm wide thus the precision must be at least half this.		
4. How will you demonstrate at the examination that this requirement and specification (points 1 and 2 above) have been met? Be explicit about how you will *prove* these were met.	The system will draw a 1mm circle around the set point and indicate if the laser reached this target within 2 seconds.		
5. Your own design contribution: what are the aspects that *you will design and implement yourself* to meet the requirement in point 2? If none, *remove this requirement.*	The turret model and control system with set point, settling time, and overshoot will be developed by the student.		
6. What are the aspects to be taken off the shelf to meet this requirement? If none, indicate "none". Explicitly indicate what tasks library functions will be used for (if relevant to the project).	The motors, turret housing, motor drivers, and the power supply will be off the shelf. The laser will be off the shelf.		

5. Field conditions

These are the REAL WORLD CONDITIONS under which your project has to work and has to be demonstrated.

	Real world field condition 1	Real world field condition 2	Real world field condition 3
Field condition requirement. In which field conditions does the system have to operate? Indicate the one, two or three most important field conditions.	The mosquitoes will be in an enclosed tank where the lighting conditions will be controlled.	If mosquitoes cannot be obtained a suitable substitute will be used.	
Field condition specification. What is the specification (in measurable terms) for this field condition?	The tank must be at least 1 metre wide. All the sides of the tank except the front facing side will have a white lining.	The substitute will be a similar flying insect.	

6. Student tasks

6.1 Design and implementation tasks

List your primary design and implementation tasks in bullet list format (5-10 bullets). These are *not* product requirements, but *your* tasks.

- The student needs to develop a mosquito detection algorithm.
- The student needs to develop a detection association algorithm.
- The student needs to develop a mosquito state prediction algorithm.
- The student needs to design a control system and interface for the laser turret.
- The student needs to select appropriate hardware for the laser turret.
- The student needs to select an appropriate camera.
- The student needs to acquire a laser that will be able to kill mosquitoes.

6.2 New knowledge to be acquired

Describe what the theoretical foundation to the project is, and which new knowledge you will acquire (*beyond* that covered in any other undergraduate modules).

- The student needs to learn how to develop computer vision algorithms.
- The student needs to learn how to associate, track, and predict the movement of objects.
- The student needs to learn how to model a laser turret.
- The student needs to learn how to interface and control a turret system.
- The student needs to learn how to interface and work with live video.
- The student needs to learn how to control motors.