

## 1 Declaration

2 This report has not been submitted for any other degree at this or any other University. It is  
3 solely the work of us except where cited in the text or the Acknowledgements page. It describes  
4 work carried out by us for the capstone design project. We are aware of the university's policy  
5 on plagiarism and the associated penalties and we declare that this report is the product of our  
6 own work.

7 Student:

Date:

8 Signature:

9 Student:

Date:

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Date:

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## 13 **Abstract**

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## 21 **Acknowledgment**

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# 1 Introduction and Motivation

## 1.1 Problem statement

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## 1.2 Project significance

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## 1.3 Project objectives

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# 2 Background and Related Work

## 2.1 Background

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## 2.2 Related work

One of the essential ideas of the project is navigating and tracking the objects while minimizing the required time to detect all targets. Various methods and approaches were studied and implemented in previous research papers with different constraints and goals in mind. The methodology and algorithm in each paper was different as some of them used AI related algorithms while others relied on heavy mathematical calculations to determine the best path. In paper **hua21**, the main idea was to propose a navigation algorithm that enables each UAV to determine its own movement locally and track pedestrians (mobile targets), it focused on multiple drones to cover a specific area. **pen21** took the advantage of DRL to develop an online path planning algorithm based on double deep Q-learning network (DDQN). The constraints were to minimize the energy consumption of the UAV, the objects on the ground were not stationary and were following a Gauss-Markov movement pattern. Author **hua20** aimed to propose a reactive real-time sliding mode control algorithm to navigate a team of UAVs (UAS). The area was divided into multiple sub-areas using the Voronoi partitioning technique, each drone was responsible for a sub-area, he implemented his ideas for both types of targets, stationary targets and mobile.

All the mentioned papers presented their solutions using different simulation software. However, none of them was implemented in the real-world which questions the reliability of the algorithms.

## 3 Requirements Analysis

### 3.1 Functional requirements

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### 3.2 Design constraints

<i>Name</i>	<i>Description</i>
Power supply	The Anafi and the Raspberry Pi must be battery powered because they are mobile (with ?? voltages DC/mAh)
Flying range/altitude	The flying range of the Anafi is limited by the signal strength of the communication between the computer and the Raspberry Pi. Also, the altitude is dictated by the Anafi's maximum height it can reach and the performance of the drone at a certain height.
Flying time	The maximum flying time must be lower than the Anafi's 25 minutes max flight lower than the Raspberry Pi's ?? minutes
Transmission delay	The delay in the communication between the Raspberry Pi and the Anafi must be acceptable
Payload/weights	The Raspberry Pi with its peripherals should not exceed the maximum load the Anafi can carry.

Table 1: Technical design constraints

<i>Type</i>	<i>Name</i>	<i>Description</i>
Economic	Cost	The cost of the entire system must not exceed x \$
Environmental	Light source	The Anafi requires good lighting to take pictures of the targets
Safety/Security	Secure communication	The communication between Anafi-Raspberry Pi and Raspberry Pi-computer should be uninterrupted and secured against interference
Safety/Security	Safety	The Anafi must know how to return to base should there be a discommunication with the computer
Ethical	Privacy	The drone must not invade the privacy of the entities other than the targets
Ethical	Privacy	The monitored targets must be acceptable by law to be tracked
Environmental	Eco-friendly	The system only uses electricity and emissions
Sustainability	Modularity	The system must be such that the DRL algorithm can be swapped with an improved one easily
Reliability	Efficiency	The DRL should perform as expected all the time

Table 2: Practical design constraints.

### 138 3.3 Design standards

<i>Standard</i>	<i>Usage</i>
IEEE 802.11	To be used in the communication between the Raspberry Pi and the Anafi and the Raspberry Pi and the computer
WPA2	To be used in securing the communications above
GPS	To be used by the Anafi to convey its position to the Raspberry Pi
SSH	To be used between the Raspberry Pi and the computer
JSON-RPC version 2.0	Communication protocol used to control the components of the simulated Anafi
Google Protocol Buffers	To be used by Gazebo for the message passing between its server and client

Table 3: Design standards table.

### 139 3.4 Professional code of ethics

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### 147 3.5 Assumptions

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## 155 4 Proposed Solution

### 156 4.1 Solution overview

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## 4.2 High level architecture

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## 4.3 Hardware/software to be used

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## 5 Proof of Concept

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## 6 Market Research and Business Viability

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## 196 **7 Project Plan**

### 197 **7.1 Project milestones**

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### 205 **7.2 Project timeline**

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### 213 **7.3 Anticipated risks**

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## 221 **8 Short Guide**

222 Please read the guides available online about the right way to write L<sup>A</sup>T<sub>E</sub>X such as how to include  
223 a math symbol in text (e.g.  $x$  not x) and a proper noun with all capitals (e.g. SQL not SQL).

224 Below are examples of different constructs in a report. You can copy-paste and change the  
225 content. For more information, refer to the relevant package manual in CTAN.



Figure 1: The arch linux logo

## 226 8.1 Figure

## 227 8.2 Equations

$$E_p = mgh = mg(x_f - x_i) \quad (1)$$

$$E_k = E_t + E_r$$

$$E_t = \frac{1}{2}mv^2 \quad (2)$$

$$E_r = \frac{1}{2}I\omega^2 \quad (3)$$

$$I = \frac{1}{2}MR^2 \quad (4)$$

$$\omega = \frac{v}{r}$$

$$E_k = \frac{1}{2}mv^2 + \frac{1}{2}I\left(\frac{v}{r}\right)^2 \quad (5)$$

228 where  $E_p$  is the potential energy,  $E_k$  the kinetic energy,  $E_t$  the translational energy and  $E_r$  the  
229 rotational energy.

$$\begin{aligned} \frac{\partial E_p}{\partial m} &= \frac{\partial}{\partial m}(mgh) \\ &= gh \end{aligned}$$

$$\begin{aligned} \frac{\partial E_p}{\partial g} &= \frac{\partial}{\partial g}(mgh) \\ &= mh \end{aligned}$$

$$\begin{aligned} \frac{\partial E_p}{\partial h} &= \frac{\partial}{\partial h}(mgh) \\ &= mg \end{aligned}$$

### 230 8.3 Simple table

Table 4: Slope, intercept and their uncertainties

Slope		Intercept (J)	
Value	Error	Value	Error
1.0933	0.0300	0.0148	0.0157

### 231 8.4 Table from a csv file

Table 5: Translational and rotational energies.

$m$	$v_m$	$E_t$	$\delta E_t$	$E_r$	$\delta E_r$
kg	m s <sup>-1</sup>	J	J	J	J
0.055	0.17	0.000 79	0.000 01	0.280	0.007
0.075	0.20	0.001 50	0.000 02	0.387	0.010
0.095	0.23	0.002 51	0.000 03	0.512	0.013
0.115	0.25	0.003 59	0.000 03	0.605	0.015
0.135	0.27	0.004 92	0.000 04	0.706	0.018

## 232 8.5 Graph from a csv file

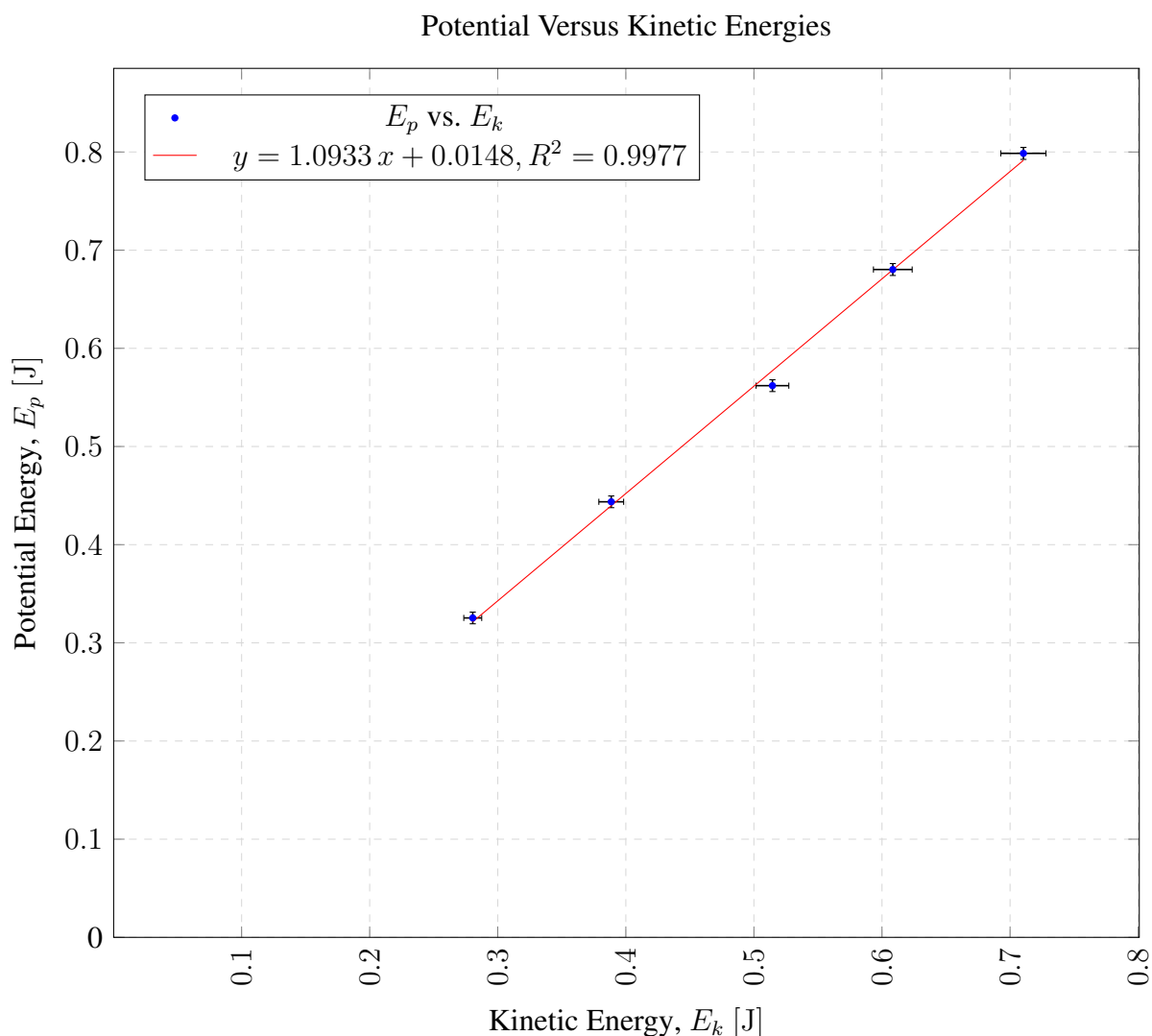


Figure 2: The relationship between potential and kinetic energies.

## 233 8.6 Citations

- 234 • **in-text citation:** use `\cite{dirac}` to produce **dirac** or `\textcite{dirac}` to  
 235 produce **dirac**
- 236 • **citation in parentheses:** `\parencite{knuthwebsite}` produces [knuthwebsite]  
 237 (for IEEE, this has no difference to the `\cite{}` command above.)

## 238 8.7 Cross-references

239 Label using suitable names with the following format: figure `\label{fig:<name>}`, tables  
 240 `\label{tab:<name>}`, sections `\label{sec:<name>}` and equations

241 `\label{eq:<name>}`.  
242     **Then when cross-referencing, use `\cref{<type>:<name>}`**  
243 **(or `\Cref{<type>:<name>}` when used at the beginning of a sentence)**



## 244 **Appendix**

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