Department of Computer Science and Engineering
College of Engineering
Qatar University

# Senior Project Report

## Intelligent Mobile Target Visitation of a UAV using DRL: A Practical Implementation of the Work by Hendawy *et al.*

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2021

This project report is submitted to the Department of Computer Science and Engineering of Qatar University in partial fulfillment of the requirements of the Senior Project course.

# Declaration

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

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# Abstract

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# Acknowledgment

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# 1 Introduction and Motivation

## 1.1 Problem statement

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

## 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

The third and final concept of the project is hardware realization for drone visits. The hardware part is essential in the implementation in the real world, where the simulation sometimes strays from the truth. There is a lack of hardware implementations in the field of research regarding drones with deep reinforcement learning (DRL) ,and most of the research papers focus on the simulations.

According to the literature review, the convolutional neural network (CNN) models were used in the majority of the papers for object detection. Also, the controller boards and custom drone kits were used instead of commercial drones. Those kits give the researcher and user more flexibility since the drone is customizable in hardware and software. But in our design, we will use commercial drones so that we focus on the DRL, not the actual drone build process.

Quadcopter unmanned aerial vehicle (UAV) with arducopter autopilot installed on raspberry pi microcomputer board and intel neural computer stick 2. **Khan21** used the drone in the agriculture field to spray pesticides and monitor the crops. Unlike our work, the drone was limited to specific boundaries and fixed targets such as crops. They used a Raspberry Pi microcomputer board attached to the drone, which will handle two different operations. Firstly, control the drone using an open-source Software called arducopter autopilot which will handle the trip of the drone and autonomous flight option. The second operation is to deal with the Intel neural computer stick 2, which will deploy the CNN model and deal with the computation part **Khan21**. Although this work is close to ours, there are some differences, one of them is using a custom drone as it is not considered since we are limited in the time. Since we will use the Anafi drone, we will use the Olympe to control the drone, which will be installed on the raspberry pi, finally using CNN only is not enough DRL will make the drone more intelligent and accurate.

An example of commercial drone usage with onboard computer that transforms drones into autonomous and the usage of data and image filtration. The hardware architecture in **Wang18** work for this paper includes a DJI commercial drone and an onboard computer called manifold, which is from the same manufacturer. Also, onboard sensors like camera,GPS and inertial sensor are included, finally an external battery for the manifold computer and Wi-Fi adapter that is used for connection between the drone and the onboard computer. This hardware architecture is Inspirational, and our design is somehow close to it with minor changes in the onboard computer and the existence of the sensors. Image and video processing techniques were used, such as segmentation to keep detecting moving targets was presented in **Wang18**. For the navigation part, they used predetermined waypoints related to historical path cost. However, in our work, probability and mobility patterns will be used to guess the target's location.

Use embedded system connected and attached on the UAV for image processing and mobility pattern recognition, which shortens response time and saves transmission bandwidth. **Zhao18** work used quadrotor UAV supported with GPS module and Pix Hawk flight controller. The power sources in the architecture were two lithium batteries, one for the drone and one for the embedded system. The system uses NVIDIA Jetson development kits which give enough computing power for the processing and communication between the flight controller and the system. The Jetson board is connected to the flight controller using serial communication while connected to the ground controller using Wi-Fi. In communication, section will help us in our work to determine the best way to communicate between the development board and the drone without any delay or interference **Zhao18**.

# 3 Requirements Analysis

## 3.1 Functional requirements

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## 3.2 Design constraints

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## 3.3 Design standards

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## 3.4 Professional code of ethics

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### 3.5 Assumptions

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## 4 Proposed Solution

### 4.1 Solution overview

The proposed solution consists of two main sections: a drone and a control section. The user will import the mobility pattern and the constraints to the control section, which is a laptop. Then the user will send high-level commands to the drone agent, which will apply certain operations such as start/stop etc. Once the user finishes importing the mobility pattern and starting the drone mission, the drone will begin to take off and begin to visit the area to scan for getting the most number of mobile targets using DRL model. Users will keep receiving live updates and the status of service on the control section using Wi-Fi. Most of the connections in the system are wireless, which will have benefits and drawbacks.

### 4.2 High level architecture

Figure 1 shows a high-level architecture of a complete working system, in which a group of connected tools and devices are combined into a single system.In the next section, hardware and software details will be presented in a more detailed way

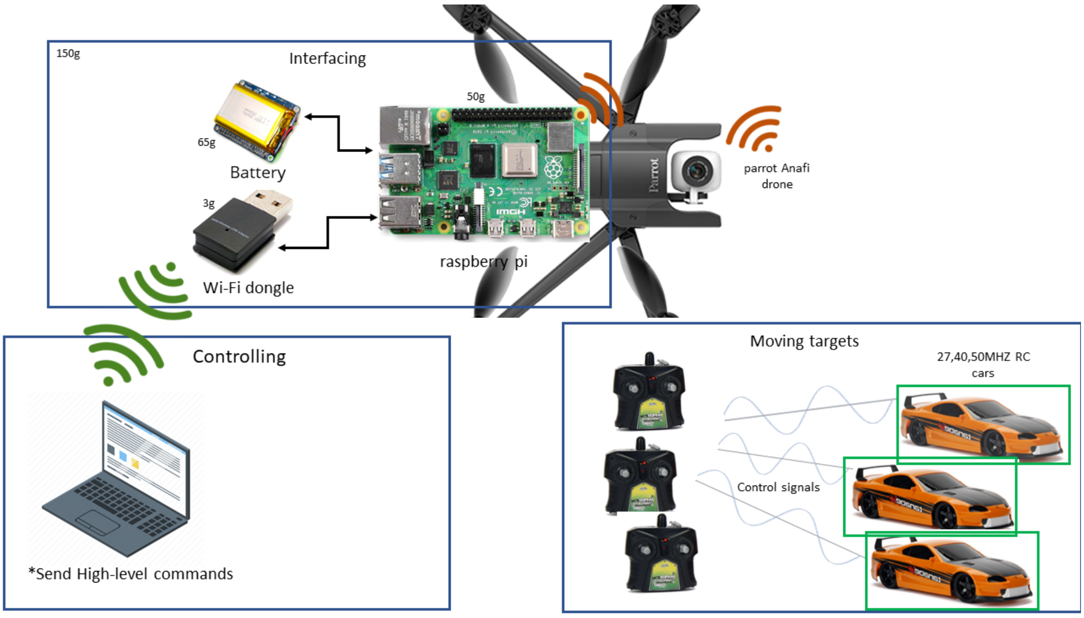


Figure 1: High-Level Architecture

## 4.3 Hardware/software to be used

### 4.3.1 Software

The software section contains three primary parts simulation, training, and application. The first part will focus on simulating the environment, testing the models, and flight control. Before discussing the software to be used, we will use the operating system, the base for our software applications. We selected Ubuntu 18.04 operating system for several reasons. One key reason is the compatibility because parrot Olympe and Sphinx are only supported on limited distributions and operating systems. Another reason its a lite os and can be installed on the onboard computer that will be attached to the drone.For the simulation part, using Sphinx and gazebo software is very helpful in visualizing the environment and how drone flight and apply the model.[more talk about simulation].In the training part, we used the simulation tools to generate some training datasets. We use a website called roboflow which helped us labeling the objects and generate new datasets from the existing ones with modified constraints like rotation and scaling. For the object detection model, google colab notebook was a sufficient tool to start training using CNN Yolov5.[more talk about roboflow/training].Application software used in this project was parrot Olympe to send commands to the drone and control the flight trip and how the drone moves.[more talk about application software].

### 4.3.2 Hardware

python script. Good flight time support, ANAFI drone has a 2700mAh battery which can fly up to 25 min which is good enough in our application. Finally, the support of Wi-Fi 802.11 and GPS features is essential in our project. The second important device is the Raspberry Pi which will be used as an onboard computer and will handle several tasks—connecting to the drone using a Wi-Fi interface. Controlling the drone by executing the python scripts to send/receive fly control instructions to the drone. Apply the machine learning and DRL models, which will be synchronized with the control part.Send/receive high-level commands and results to the laptop/pc ground station. It is connected using another 2.4GHz Wi-Fi interface with the help of a Wi-Fi adapter dongle connected to the Raspberry Pi through USB. The power source for the Raspberry Pi will be a lithium battery with the power board will be attached to the board, and its 4000mAh lithium battery will provide enough power and time for our application.

# 5 Proof of Concept

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# 6 Market Research and Business Viability

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# 7 Project Plan

## 7.1 Project milestones

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## 7.2 Project timeline

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### 7.3 Anticipated risks

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## 8 Short Guide

Please read the guides available online about the right way to write LaTeX such as how to include a math symbol in text (e.g. $x$ not x) and a proper noun with all capitals (e.g. SQL not SQL).

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

### 8.1 Abbreviations

To add an abbreviation (e.g. UAV), append the following line in the list of abbreviations portion in main.tex:

```
\newacronym{uav}{\textsc{uav}}{unmanned aerial vehicle}
```

To use the abbreviation, there are 3 ways to do so:

1. In a normal case: `\gls{uav}`
2. For its plural form: `\glspl{uav}`
3. In the beginning of a sentence: `\Gls{uav}`
4. A combination of cases 2 and 3: `\Glspl{uav}`

For example:

> An UAV has many unique features. UAVs have been used in many different applications.


Figure 2: The arch linux logo

## 8.2 Figure

## 8.3 Equations

$$
\begin{align}
E_p &= mgh = mg(x_f - x_i) \tag{1}\\
E_k &= E_t + E_r \nonumber\\
E_t &= \frac{1}{2}mv^2 \tag{2}\\
E_r &= \frac{1}{2}I\omega^2 \tag{3}\\
I &= \frac{1}{2}MR^2 \tag{4}\\
\omega &= \frac{v}{r} \nonumber\\
E_k &= \frac{1}{2}mv^2 + \frac{1}{2}I\left(\frac{v}{r}\right)^2 \tag{5}
\end{align}
$$

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

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

## 8.4 Simple table

Table 1: Slope, intercept and their uncertainties

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

## 8.5 Table from a csv file

Table 2: Translational and rotational energies.

| $m$ kg | $v_m$ $\mathrm{m\,s^{-1}}$ | $E_t$ J | $\delta E_t$ J | $E_r$ J | $\delta E_r$ 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 |

## 8.6 Graph from a csv file

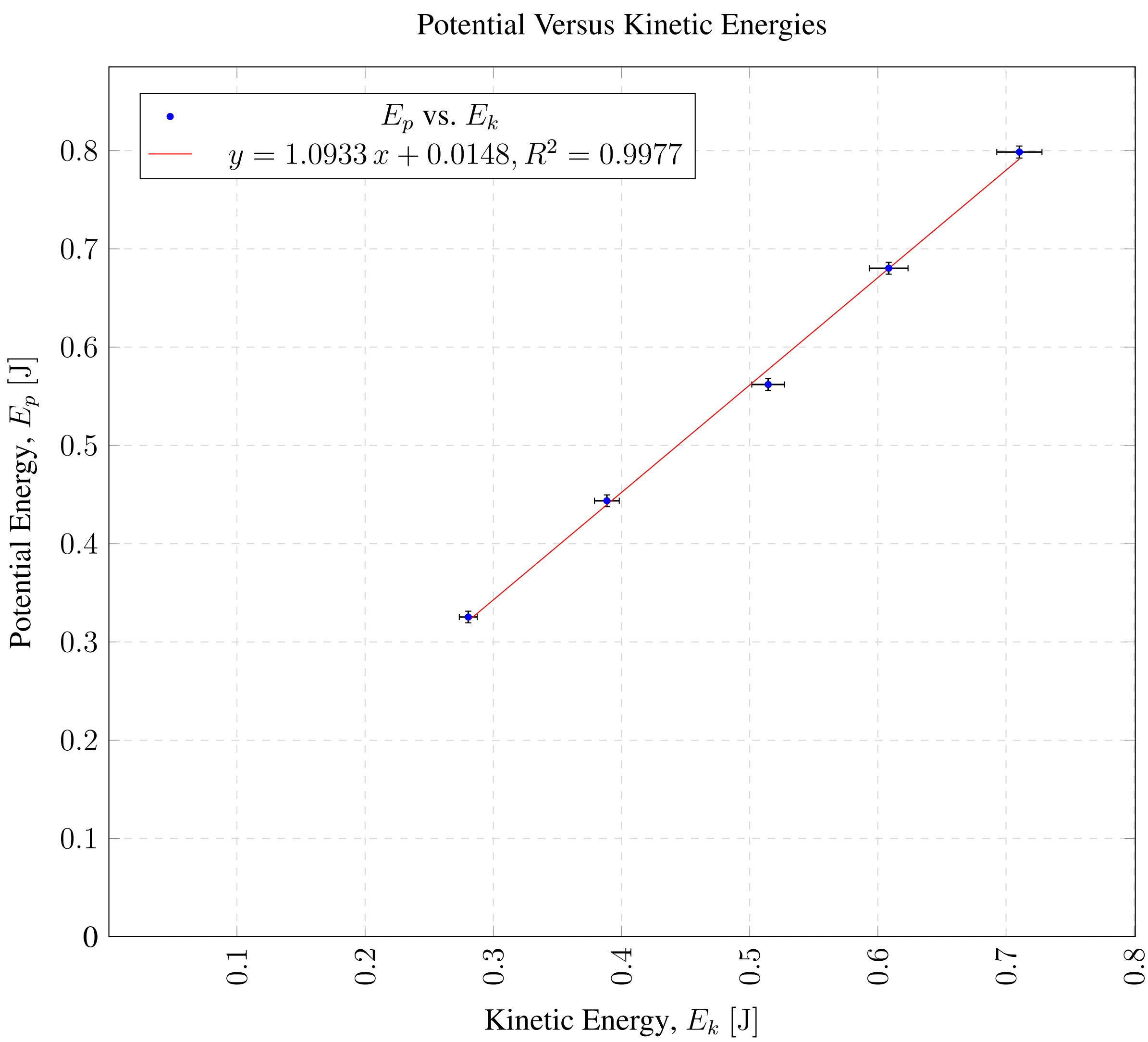


Figure 3: The relationship between potential and kinetic energies.

## 8.7 Citations

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

## 8.8 Cross-references

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

`\label{eq:<name>}`.

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

# Appendix

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