UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

An Intelligent, Real-Time, Offline Camera Surveillance System

Mechatronic Project 478
Project Proposal

Mr EW Pretorius

Supervisor: Prof J Du Preez

12 April 2021

saam vorentoe · masiye phambili · forward together

Department of Mechanical and Mechatronic Engineering
Departement Meganiese en Megatroniese Ingenieurswese
Privaat Sak X1, Private Bag X1, Matieland, 7602
Tel: +27 21 808 4204 | www.eng.sun.ac.za

ENGINEERING
EZOBUNJINELI
INGENIEURSWESE

Plagiarism declaration

I have read and understand the Stellenbosch University Policy on Plagiarism and the definitions of plagiarism and self-plagiarism contained in the Policy [Plagiarism: The use of the ideas or material of others without acknowledgement, or the re-use of one's own previously evaluated or published material without acknowledgement or indication thereof (self-plagiarism or text-recycling)].

I also understand that direct translations are plagiarism, unless accompanied by an appropriate acknowledgement of the source. I also know that verbatim copy that has not been explicitly indicated as such, is plagiarism.

I know that plagiarism is a punishable offence and may be referred to the University's Central Disciplinary Committee (CDC) who has the authority to expel me for such an offence.

I know that plagiarism is harmful for the academic environment and that it has a negative impact on any profession.

Accordingly all quotations and contributions from any source whatsoever (including the internet) have been cited fully (acknowledged); further, all verbatim copies have been expressly indicated as such (e.g. through quotation marks) and the sources are cited fully.

I declare that, except where a source has been cited, the work contained in this assignment is my own work and that I have not previously (in its entirety or in part) submitted it for grading in this module/assignment or another module/assignment.

I declare that have not allowed, and will not allow, anyone to use my work (in paper, graphics, electronic, verbal or any other format) with the intention of passing it off as his/her own work.

I know that a mark of zero may be awarded to assignments with plagiarism and also that no opportunity be given to submit an improved assignment.

Signature:

Name: EW Pretorius Student no: 21660654

Date: 12 April 2021

Abstract

Acknowledgements

Table of contents

List of figures

List of tables

List of symbols

A	Wing area
c	Chord length
α	Angle of attack

1 Introduction

1.1 Background

Camera surveillance has become commonplace in modern life. It is often found in infrastructure security systems, medical fields and, more recently, in intelligent security systems and agricultural industries. Recently, rapid development of intelligent camera surveillance technologies (ICST’s) has become possible through its integration with machine-learning and computer vision techniques. This has had significant implications regarding the versatility of intelligent camera surveillance systems (ICSS’s) and has opened up a wealth of development opportunities in industries not typically associated with these systems.

Object identification and tracking methods has reduced the need for constant human monitoring of footage, which can be time-consuming and expensive. Image-compression techniques have improved footage-storing capabilities by reducing the data size of recordings, which, in turn, has lowered the amount of data storage required (Ibrahim, 2016). The viability of autonomous vehicles in recent times would also not be possible without the improvements made in computer vision and the algorithms developed in conjunction with it.

This project aims to explore the viability of designing and implementing an offline, real-time, intelligent camera surveillance system (ORICSS) for use in remote locations as proposed by Prof J Du Preez and conducted by Mr EW Pretorius.

1.2 Objectives

ICSS’s are only as reliable as the infrastructure it is built on. For most ICSS’s, internet connection and steady power supply are an absolute requirement to function optimally. As a result, most of these systems can only be installed in areas where infrastructure is adequately sophisticated to accommodate it. This limits its use to medium- to large institutions and wealthy individuals in urban areas with sufficient funds to invest in ICST’s.

This places a constraint on where ICST’s can be implemented as well as the amount of people who have access to it. This project therefore aims to design and implement an ORICSS at low cost and with low energy demand. This will be done to not only further expand the capabilities of ICSS’s, but to introduce new possibilities in the future industries.

The system hardware will consist of multiple wi-fi cameras as sensors and a Raspberry Pi as processing hardware and wi-fi server. Software implemented in the system will be parallel C based code with non-real time openCV-based machine learning to periodically clean up non-interesting images. In an effort to ensure viability of the system in remote locations, where internet access is sporadic, code will be run offline, and a low power consumption system will be explored.

1.3 Motivation

South Africa is well-known for its high levels of both violent and non-violent crime. The country, in recent history, is often listed as one of the most crime-infested societies in the world. In particular, housebreaking is a pressing concern for citizens. Nearly 1.3 million households, or 5.8% of all households, have been affected by this crime between 2019 and 2020 (Stats SA, 2020).

As can be expected, many households have invested heavily in home-security systems. Barbed wire- and electric fences are commonplace, and many now prefer installing camera surveillance systems (Minnaar, 2012). The main deterrent surveillance systems provide is the discouragement of would-be criminals by fear of being recognized by authorities who would much easier be able to identify them using the footage captured while the crime was being committed.

Recently, the development of sophisticated machine-learning algorithms and computer vision technology have presented the opportunity to further improve these systems. Number plate- and facial recognition technologies aid law enforcement with reactive measures to crime prevention. Examples of this are the tracking of vehicles and perpetrators using object identification of number plates and facial recognition from smart security surveillance cameras.

These technologies are implemented most commonly in high net-worth neighbourhoods in urban areas where internet infrastructure is readily available and highly reliable. Rural communities and -properties do not have comparable access to this type of infrastructure. Some of these communities lack basic cell phone reception from cell towers or simply struggle with reliable connection from these services. Farms are especially vulnerable to violent housebreaks due to their remote nature. Even if residents manage to alert neighbours or the authorities, help is usually far away, and response times are slow.

2 Literature review

2.1 Development of Machine Learning

The term "machine learning" was first coined in 1952 by Arthur Samuel of IBM and is based on a model of brain cell interaction published in 1949 by Donald Hebb (Foote, 2019). Samuel developed an algorithm for playing the game of checkers which attempted to calculate the winning odds of each "player" for each position. A function in the computer program ran a so-called minimax strategy to determine the next move and a "reward" function to determine its effectivity. Based on the results of each move, the algorithm would effectively learn which moves led a better odd of winning the game.

2.2 Machine Learning in Image Recognition

Machine learning further expanded into the realm of image recognition with the development of the perceptron mark 1 by American psychologist Frank Rosenblatt. The perceptron used binary classification to separate a given set of data into two categories. Figure 1 depicts an example of this concept. The perceptron mark 1 would be fed a set of data and categorize each item as either linearly separable or nonlinearly separable. (Loiseau, 2019)

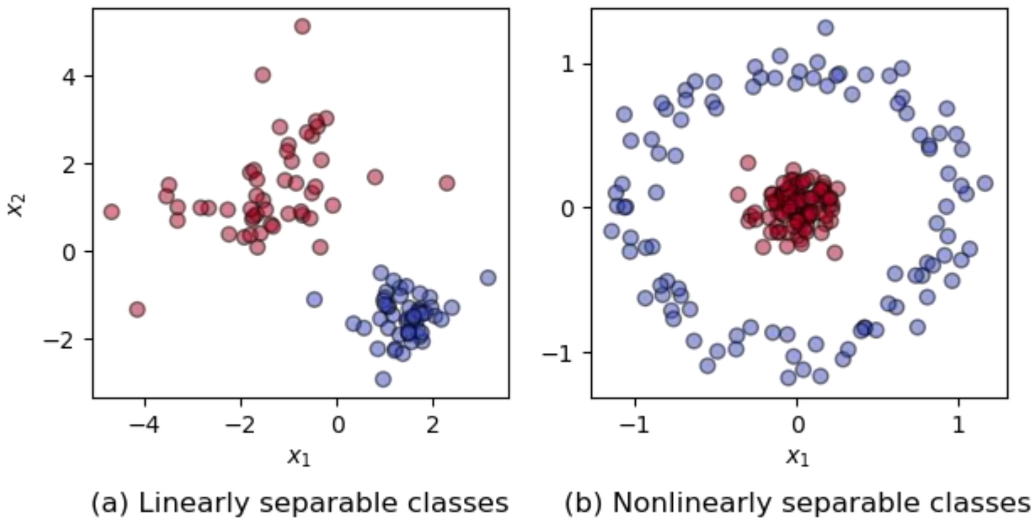

Figure 1: An example of linearly separable- and -nonseparable classes

3 Planned Activities

This chapter of the proposal expands on the planned activities in the execution of the project and the order in which milestones will be achieved.

3.1 Literature Review

Conduct an in-depth review on the various aspects of the project. Further research will be done on machine learning techniques as it pertains to image processing. Existing systems will be reviewed to gain greater understanding of the scope of the ICSS and its subsystems. Interfacing of components, setting up a wi-fi server on a Raspberry Pi and further understanding of the use of OpenCV libraries. More information regarding the components to be used and recommended operating system, software, interfacing components will be established. Different methods for powering the system will be explored.

3.2 Procurement of Components

All hardware components identified as necessary for the start of the project will be procured. This includes a Raspberry Pi, three wi-fi cameras and the interfacing components they require.

3.3 Installation of Operating System and Software Development Programs

A Linux operating system is recommended due to its effective hardware interfacing properties and availability of many programming tools. OpenCV will be installed to access its variety of machine learning libraries among other useful programming resources. Visual Studio will be used as IDE for programming purposes.

3.4 Establish Communication Between the Camera and the Computer

Three different wi-fi cameras will be used in this project. Initially, communication between a single camera and the computer will be established. The advantage of initially using a single camera is to speed up the progress of the project by avoiding interfacing problems from any of the three cameras. Each camera will most likely present unique problems, stalling overall progress.

3.5 Setting Up Directory for Camera Footage

Before real-time image processing can be set up, non-real-time image processing will first be performed. This is facilitated by the storage of footage obtained from the camera. This will involve setting up a specific directory for footage to be stored for later use.

3.6 Write Code for Non-Real-Time Image Processing

The advantage of first performing non-real-time image processing is that predetermined footage scenarios can be recorded. This allows the programmer to experiment with existing footage to sort out simpler problems commonly encountered and eliminate small bugs before more complex factors come into play.

3.7 Implement Simple Image-Processing Algorithm

The first image-processing algorithm to be implemented will be simple in order for the programmer to become familiarized with the process. A simple image-processing technique like filtering or object labelling will be done.

3.8 Implement a Complex Image-Processing Algorithm

A more complex image-processing algorithm will be implemented. This can include more sophisticated object identification or image-compression.

3.9 Set up All Three Cameras

The two cameras unused up until this point will not be set up and configured in a similar way as the first. The same process followed for the first camera will now be performed. Code will be written in such a way as to run parallel actions on all cameras at the same time. For this, the same code developed up until this point will be used. Any debugging or unexpected problems will be solved.

3.10 Further Functionality

Further functionality to the ICSS will be added following the AGILE project management blueprint. Improvements such as suppression of uninteresting background data and cleaning up of non-interesting images to save on storage space will be implemented. Further refinement of existing code will take place.

3.11 Set up Raspberry Pi Server

With the ICSS now at a functioning level, a Raspberry Pi server will be set up to process code from the cameras. Connectivity between the components will be established and tested.

3.12 Installation Requirements

The physical installation requirements for the ICSS will be explored. This includes possible low-power power sources and solar panels. Possible wiring between components and housing of said components will be done.

3.13 Testing Phase

With all components in working order, testing can begin. Trial runs simulating real-life scenarios will be performed to test functionality and present possible bugs.

3.14 Evaluation of Feedback

Feedback from trial runs will be analysed to identify problems.

3.15 Improvement on System

Problems identified during the system's evaluation will be fixed.

3.16 Final Testing

To ensure the system functions as expected, a final test will be conducted. This test will incorporate facets which will test all functions of the system including software and hardware specifications. Data will be collected from all testing criteria to serve as performance measurements of the system in order to compare it with existing systems.

3.17 Finalizing Report

Documentation of all aspects concerning the completed ORICSS will be compiled into a final report. A detailed account of all the work involved in making the system will be provided. A performance review will be included in the report which will compare the functionality of the ORICSS to similar products available on the market.

4 Risk Assessment

This part of the proposal outlines possible risks that may be presented in the execution of the project which can hinder the successful completion thereof.

The biggest risk undertaken in this project is the time frame in which it must be completed. If some or several stages of the project cannot be completed within its specified timeline, a significant possibility of failure to meet project goals can be expected.

Without cutting back on some of the functionality, a mitigation strategy of this risk is to set up a detailed time schedule for completing certain tasks. This will ensure that, if a deadline is missed for whatever reason, proper measures can be implemented in a timely manner to avoid reducing the capabilities of the ICSS. The June/July holidays will also be utilized to work on the project to ensure on-time completion and to push its progress ahead of schedule. This will be done to create a buffer zone in the schedule in case future tasks take unexpectedly long to complete.

Another significant risk to the project is hardware malfunction. If this were to occur, sourcing of new components will be necessary. This presents another risk to the completion of the project in the case that components have to be sourced from outside the country. Due to the effects of the Covid-19 pandemic, sourcing of components from overseas are unsure at best since major delays in its delivery are a common occurrence.

To mitigate this risk, an effort will be made to source components locally as far as possible. Only if hardware problems are encountered early on and cannot be replaced from a local source, will attempts be made to import the necessary components.

5 Conclusions

Intelligent camera surveillance systems are experiencing renewed growth thanks to the progress made in machine learning technologies. Their use is, however, limited to locations where sufficient financial and infrastructural capability exists. This presents the opportunity for expanding the capability of ICSS's to rural and less-developed regions by developing a low cost ORICSS with low power requirements and offline capabilities.

The project team is equipped with the necessary skills required for the completion of the project.

6 References

Foote, K. D. (2019, 03 26). A Brief History of Machine Learning. *Dataversity*, pp. 1-2.

Ibrahim, S. (2016). A comprehensive review on intelligent surveillance systems. *Commincations in Science and Technology*, 1-2.

Loiseau, J.-C. B. (2019, March 11). Rosenblatt's perceptron, the first modern neural network. *Towards Data Science*.

Minnaar, A. (2012). PRIVATE SECURITY COMPANIES, NEIGHBOURHOOD WATCHES AND THE USE OF CCTV SURVEILLANCE IN RESIDENTIAL NEIGHBOURHOODS: THE CASE OF PRETORIA-EAST. *Research Gate*, 108-110.

Stats SA. (2020). *Housebreaking is the number one crime in South Africa.* Stats SA.

Appendix A Budget

This appendix lists the expected costs incurred throughout the project.

Activity	Time Cost	Cost for Time	Running Costs	Capital Costs	Facility Cost	Labour (MMW)	Material (MMW)	Total Cost
	hr	R	R	R	R	R	R	R
Literature Review	25	11250	250	-	-	-	-	11500
Component Procurement	1	450	50	21930	-	-	-	22430
Installation of Software Requirements	4	1800	-	-	-	-	-	1800
Establish Camera-Computer Communication	8	3600	-	-	-	-	-	3600
Set up Directories	4	1800	-	-	-	-	-	1800
Non-real-time code	8	3600	-	-	-	-	-	3600
Simple Image-Processing Algorithm	12	4800	-	-	-	-	-	4800
Complex Image-Processing Algorithm	40	18000	-	-	-	-	-	18000
Set up all three cameras	20	9000	-	-	-	-	-	9000

Further Features	30	13500	-	-	-	-	-	13500
Raspberry Pi Server	8	3600	-	-	-	-	-	3600
Installation Requirements	8	3600	-	-	-	-	-	3600
First Testing Phase	120	-	500	-	-	-	-	500
Evaluation of Feedback	8	3600	-	-	-	-	-	3600
Improvements to System	30	13500	-	-	-	-	-	13500
Final Testing	120	-	500	-	-	-	-	500
Finalizing Report	80	36000	-	-	-	-	-	36000
Total	526	128100	1300	21930	0	0	0	151330