



National
College *of*
Ireland

Artic Voyage

Technical Report

Vehicle Height Analysis and Routing
BSc in Computing

Conor Berkery
5/10/2017

Declaration Cover Sheet for Project Submission

SECTION 1 *Student to complete*

Name: Conor Berkery
Student ID: 12741829
Supervisor: Eugen McLaughlin

SECTION 2 Confirmation of Authorship

The acceptance of your work is subject to your signature on the following declaration:

I confirm that I have read the College statement on plagiarism (summarised overleaf and printed in full in the Student Handbook) and that the work I have submitted for assessment is entirely my own work.

Signature: _____

Date: _____

Contents

Executive Summary	6
1 Introduction	7
1.1 Background.....	8
1.2 Aims	8
1.3 Technologies	9
1.4 Structure	11
2 System.....	12
2.1 Requirements	12
2.1.1 Use Case Diagram	13
2.1.2 Requirement 1 <Vehicle measuring >	13
2.1.3 Sequence Diagram.....	15
2.1.4 Functional requirements.....	15
2.1.5 Data requirements.....	16
2.1.6 User requirements.....	16
2.1.7 Environmental requirements	16
2.1.8 Usability requirements.....	17
2.1.9 Maintainability Requirement	17
2.1.10 Portability Requirements	18
2.1.11 Reusability Requirements	18
2.1.12 Security Requirements	18
2.2 Design and Architecture.....	19
2.3 Implementation	21
2.4 Graphical User Interface (GUI) Layout.....	22
2.5 Testing.....	22
2.6 Customer testing.....	23
2.7 Evaluation	23
3 Conclusions	24
4 Further development or research.....	25
5 References	26

5.1	References	26
6	Appendix.....	28
6.1	Project Proposal	28
7	1. Objectives	30
8	2. Background.....	31
9	3. Technical Approach	32
10	4. Special resources required	33
11	5. Project Plan.....	34
12	6. Technical Details.....	36
13	7. Evaluation	37
13.1	Project Plan	37
13.2	Monthly Journals.....	38

Executive Summary

The main purposes for this project are safety, convenience and awareness. As Dublin Port continues to grow at the heart of the city so does the frequency of traffic flowing to and from it. This traffic mostly consists of Heavy Goods Vehicles which carry with them several risk factors for those driving them and the areas they travel through. The problem which I have chosen to address for the purpose of my final project is one which effects commuters from every walk of life, whether one travels by rail or by road the issue of trucks and other HGVs striking bridges is of serious concern as it endangers the life of the people on these networks and adds lengthy delays to journey times.

To remedy this situation I want to start by implementing a system that measures the height of these vehicles before they depart on their journey and to guide them on a safe route as they traverse our cities and towns avoiding any areas that may pose a concern in regards the safety of the public. The system which I have developed relies on the use of a simple webcam which passes information to a Python interpreter, through the implementation of key algorithms using OpenCV this interpreter analyses the height of the vehicle and displays the results to the driver of said vehicle, from there the driver is encouraged to engage with this information and to avail of the mapping solution provided.

1 Introduction

Having spoken to several HGV drivers the general consensus is that a project such as this would be a welcome addition. While most drivers know the height of their vehicles there are times when drivers may be in a company or rental vehicle whose heights vary from one to another. It is these circumstances I hope to remedy. Previous visits to Dublin Port have been unsuccessful in trying to interview a member of the management team to see what sort of operations would be most beneficial to them.

Time and environmental restrictions have played the two biggest roles in creating hurdles which must be overcome for the project to be a success. Having been unable to gather information in regards to the types of OS used by the Port Authority it is necessary to attempt to create a system that will be portable across multiple OS and generations of such. Physical specifications in regards hardware will also come into play as the need for a linked camera system will be integral to the project's success.

For the mapping/route planning system it may be required of me to survey the most popular routes for HGVs through the city and to integrate them into a Mapping API. Alternatively CIE have a dataset of some bridge heights in the city which if attainable would be invaluable to the integration of these two processes. So far requests for this information from CIE have been unsuccessful, but as this data was funded for and by the people of Ireland it may fall into the category for a freedom of information request. I have yet to put in for a freedom of information request as the main concern I have had is finishing the foundations of the project and providing a proof of concept, if the application receives any interest from industry or others who wish to develop it further this option will need to be revisited.

1.1 Background

Being a commuter on Dublin's DART rail service the occurrence of bridge strikes has been known to me for some time. It is an issue which has seen the loss of many hours in waiting times and frustrates and upsets even the most patient of commuters. It was not until this summer that I gave any thought to coming up with a solution that would prevent the increasing frequency of these delays. The catalyst for this came with the release of a report from CIE which outlined just how many more bridge strikes were happening and the worrying upward trend that had been recorded. With this I wanted to take the first opportunity that arose to tackle this issue.

1.2 Aims

This project was undertaken to create a self-contained application that will require minimal user input and training and provide invaluable information to the prospective users in the facilitation of safer transportation of HGVs around our cities and countryside. The project will remain as basic as possible requiring no need for user registration or admin registration. It will only require initial setup and training and from there should be a simple process to achieve its goal.

In addition to this primary function the system will attempt to incorporate a route planning mechanism. From the initial data that will be attained from the core of the project Mapping APIs will be used to successfully plan an appropriate route for the drivers to safely traverse Dublin city, avoiding any possible bridge strikes, and lead them onto the motorway system to their destination. If this can be implemented to an acceptable degree of accuracy live traffic and road traffic accident information will be fed into the system to further bolster the routing efficiency. This third implementation will rely on the use of third party API's and data management systems.

1.3 Technologies

The technologies I have experimented with and will use in the future include two programming languages and an integral library of functions to call from to assist in image capturing and rendering. Initially the goal was to learn a new programming language, Python, to implement and design the system. The main reasoning behind using Python was to add another facet to my knowledge base and to increase the likelihood of attaining a graduate position when the course has finished.

While using and programming in Python isn't incredibly difficult it does pose some barriers in comparison to a language such as Java. The Python IDE is not as easy to understand or develop within as some JDEs, namely NetBeans. Taking this into account, and with consultation from my supervisor, Java is now being considered for the main programming language as it is one which I am familiar with and NetBeans provides a relatively easy development environment. The JDE provides for easy testing and debugging, live error checking, easy visualisation of syntax and class structuring, importation of repositories and libraries and provides an adequate GUI builder. Unfortunately in the final weeks before the project was due several stumbling blocks had been encountered which Java could not overcome as it would not correctly relate some custom libraries that were needed to perform the correct calculations. The only option was to revert back to using Python but this time with the help of Spyder2 IDE and Pythonxy, a version of python specifically designed to perform calculations, which has integrated unit testing and error checking.

For mapping and route guidance various Mapping APIs will be engaged to create custom routing including mapquest and google.

Camera drivers/API.

Luckily both programming languages allow for the exploitation of an incredible library of programming functions called OpenCV. I first became interested in OpenCV when looking at ways to assist my mobility impaired brother to explore new media content which would otherwise be inaccessible to him. OpenCV is a

real-time computer vision library which allows for the user to record, view, evaluate and manipulate the images being recorded. When using it outside of this project I was only looking at its head tracking capabilities but now this focus has changed to use it to recognise objects within an image, organise them and record their values.

A custom package of convenience functions was also used called Imultis; it allows for easy searching and implementation of some of OpenCVs more useful components in relation to the project. In addition NumPy has been used to create and store arrays and to be called upon to perform some of the mathematical operations needed to carry out the project. Each of these last two facilities weren't compatible with the initial Java implementation and was part of the reason for the overhaul of the project.

1.4 Structure

The first section describes a general overview of the project and its inspirations and possible advantages.

Secondly this section specifies the projects roots, its goals and the types of technologies used to achieve these goals.

The third part of the document presents the main functional requirement, their relationship to one another and the system as a whole, possible issues that may arise and solutions to them. It also outlines other functional and non-functional requirements.

System architecture design and implementation as well as user interfacing will be discussed in fourth section. Future testing, both in lab and open world, will be presented in this section as the document evolves.

Part four contains conclusions and evaluations upon the project's completion.

Part five explores possible growth and expansion of functionality in the future.

Part six provides details in regards to information sourced and referenced including but not limited to a bibliography.

The final section is comprised of learning journals from throughout the semester and the original project requirements document.

2 System

2.1 Requirements

The key to the systems success is in its simplicity. After initial installation by a system engineer, operators of the system will be able to use the tool within an hour of being introduced to it. The ultimate goal would be to create a fully automated system whereby the driver would approach the regular check-in booth and immediately be presented with the height of their vehicle. The system should remain operational other than scheduled or unscheduled maintenance, by a system engineer, to ensure that all aspects are kept calibrated and the information secure. Following on from this with the height of their vehicles now known to them the drivers can avail of the routing functionality and set out on a safe course to their destination.

2.1.1 Use Case Diagram

2.1.2 Requirement 1 <Vehicle measuring >

2.1.2.1 Description & Priority

Key element to the end functionality of the product, the information gathered from the camera will be processed and the results will be printed in either physical or digital form to the user.

2.1.2.2 Use Case

1A

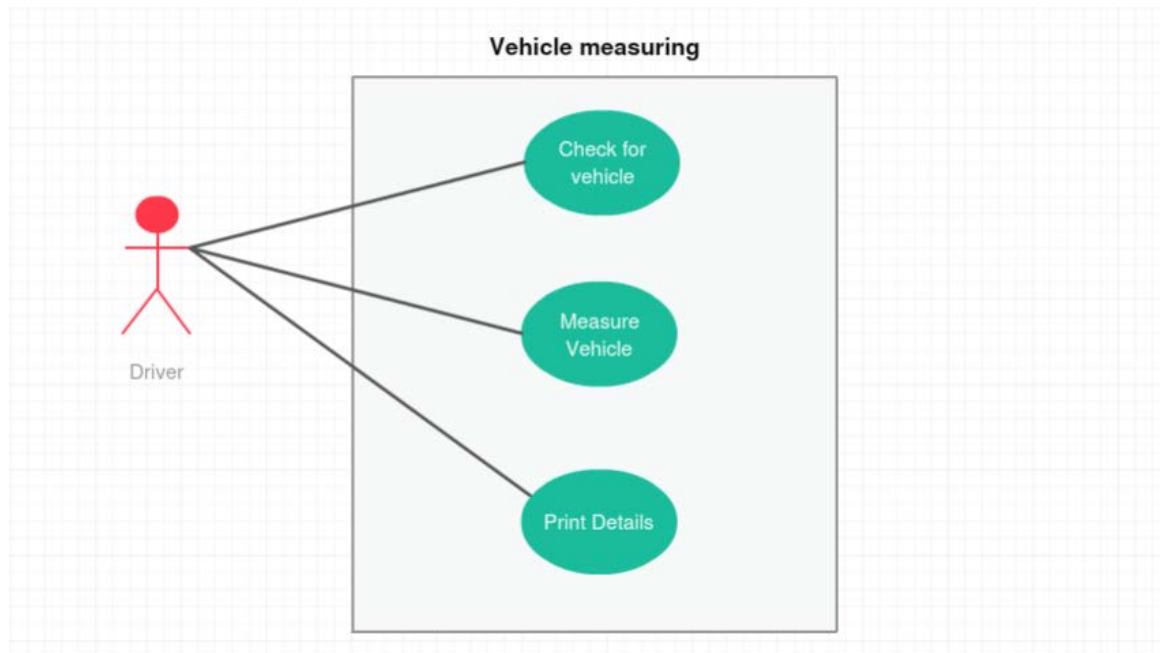
Scope

The scope of this use case is to display the core function of the system.

Description

This use case describes the initial interaction of the user with the system.

Use Case Diagram



Flow Description

Precondition

The system is in initialisation mode awaiting the arrival of a vehicle.

Activation

This use case starts when a <Driver> enters the designated area and the camera recognises as much.

Main flow

1. The system identifies the vehicle as an object to be measured.
2. The <Driver> Awaits instruction (See a1).
3. The system measures and prints the details.
4. The <Driver>records the height of their vehicle.

Alternate flow

A1 : <title of 1A>

1. The system fails to recognise the vehicle.
2. The <Driver> repositions themselves to the correct position.
3. The use case continues at position 3 of the main flow

Exceptional flow

E1 : <title of E1>

4. The system fails to print ticket.
5. The <Driver> notes their vehicle height from display.
6. The use case continues at position 4 of the main flow

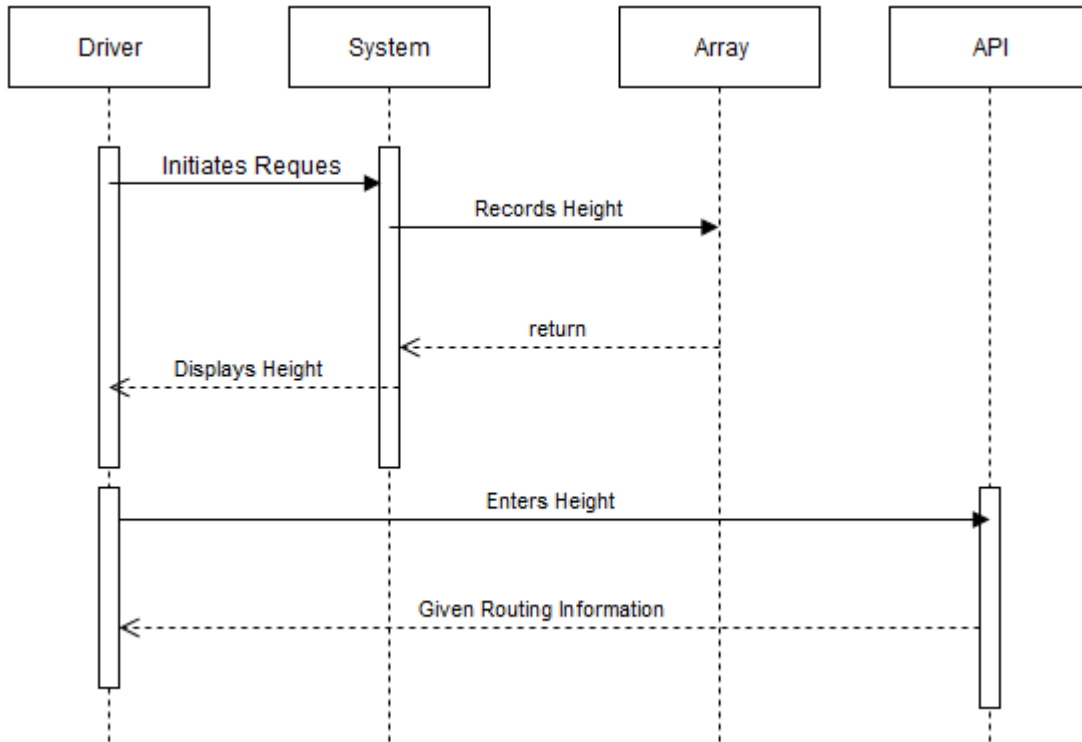
Termination

The system presents the height of the vehicle correctly.

Post condition

The system goes into a wait state for the next driver to arrive.

2.1.3 Sequence Diagram



2.1.4 Functional requirements

Read from camera to print.

Accurately record the height of the vehicle.

Map the most efficient and safe route for the driver.

Update this route with live traffic and incident reports.

2.1.5 Data requirements

The data that will be collected will not need to be warehoused or stored digitally. Information such as height, once received by the user, can be disregarded unless statistical analysis techniques will be undertaken in the future. In the possible event that statistical analysis will become pertinent it will be a requirement that this data adheres strictly to the three main pillars of information security namely Confidentiality, Integrity and Availability. With this in mind, even though the data being stored may seem arbitrary, it will be necessary to rely on strong encryption techniques and a method for retrieving this information from the self-contained unit of operation. Geolocation data will be handled and stored, as per user request confirmation, by the Mapping API.

2.1.6 User requirements

As the systems scope is quite narrow the users of said system require an accurate reading of the height of their HGVs with an acceptable margin of error. Due to the critical nature of the information being processed this information must be secure and free from unnecessary errors or alterations, as such it is a requirement that the system be securely coded and that all aspects of the inner workings be inaccessible from anyone other than the system developers. This should create peace of mind for both the operators and end users of the system in the authenticity of the information they have been provided with.

2.1.7 Environmental requirements

The system environment, as per user suggestion, will be minimal. All things being successful the system could be run from a self-contained box which would house a small computer, Raspberry Pi, a camera and a switch to activate the automated process and a screen to present the results. For the user to avail of the more advanced mapping mechanisms a web enabled device will be needed to input their data and receive the appropriate routing information.

2.1.8 Usability requirements

For the system to receive high rates of adoption it must be extremely easy to use, as simple as ensuring the vehicle is in the correct place and clicking a button. With the results of this first step the user can then benefit from the mapping system which will run from within a web browser akin to normal satnav technology.

Confidentiality: The system should not leak or reveal any sensitive data and should only be accessible by those who have the correct permissions.

Integrity: The system ensures that there is no unintended data manipulation of any sort, if data is miscalculated or distorted in any fashion it may have highly negative effects and cause accidents for which the application was designed to avoid.

Availability: Once installed and relied upon the system should be available for use twenty four hours a day and will require minimal maintenance and calibration.

Learnability: The system should be relatively self-explanatory and require minimal computer knowledge to operate once installed.

Responsivity: The system should behave normally within an acceptable time frame.

2.1.9 Maintainability Requirement

Any expected downtime in regards the maintenance of the system will be kept to times when the system is normally out of hours thus minimising any effect maintenance may have on the operation of the facility in question. Both minor and major adjustments will require an onsite visit by authorised technicians due to the systems design constraints.

2.1.10 Portability Requirements

Due to the systems design and language it will allow for installation on a variety of host systems; however any host must be non-networked to adhere to its security principles.

2.1.11 Reusability Requirements

As the system has been implemented in Python nearly all of the base code may be reused no matter what host system is employed, once the host system can handle Python and OpenCV the only aspect of the code which will need to be altered is the call to the specific camera hardware being used at that given time.

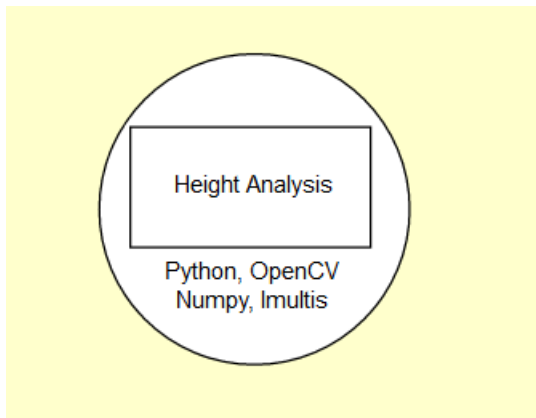
2.1.12 Security Requirements

Addressing security of the application was one of the first concerns of the project as the information being processed could have devastating effects if it was to be tampered with. The solution in this regard was to design the system in such a way that tampering of the application would require physical access to the system itself, this was achieved by designing the architecture in a non-networked manner meaning that the system would remain a self-contained closed circuit system for which there would only be one input method and one output. This in turn does have some drawbacks as it would require any updates to be performed in person by an authorised technician and wouldn't allow for updates or changes to be performed OTA. If the system is seen to be a success and adoption rates increase this is one of the key areas that will need to be revisited, a possible solution to this problem would be for the system to operate only over a VPN whereby all communications between hosts and command would be encrypted preventing would be attackers from garnering any relevant information through network snooping.

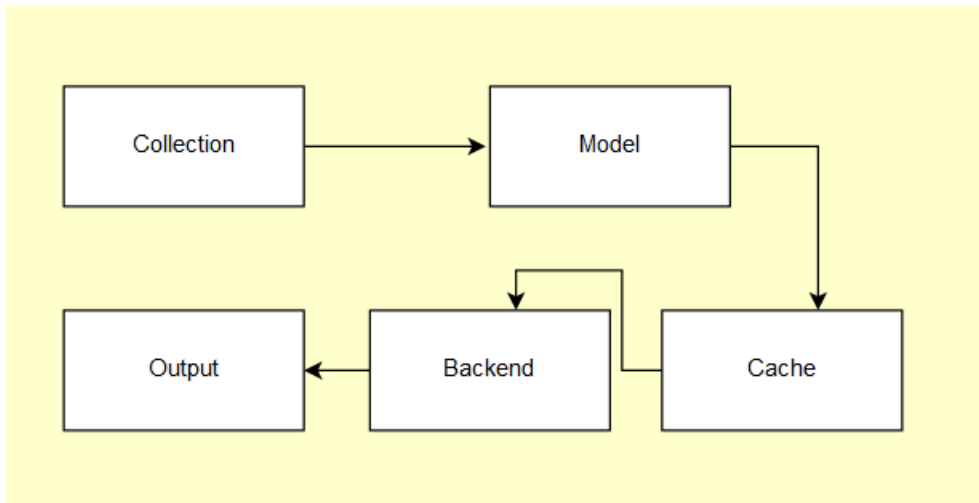
2.2 Design and Architecture

The entire application will be hosted in a non-distributed manner with no network connectivity. All of the application layers can be stored in a single .py script and can be launched from any Python and OpenCV enabled machine once the libraries have been setup correctly.

The system as a whole may seem complex but when broken down into a sequence of steps it begins to look clearer. Firstly the image must be loaded into the system for analysis, this can be achieved by taking a snapshot from the connected webcam. After loading the image OpenCV allows for the ordering of objects within that image. To achieve this, the image must first be converted to greyscale. From here an edge detection method called canny edge is used to roughly define the outer lines of the objects within the image, this is then further refined by dilating and eroding these lines to create an image which looks like a simple line drawing of the originally imported image.



With this now basic image the lines can be extracted with the findContours function which iterates through the lines and contours and extrapolates this data for sorting through the function order_points, this clockwise detection and ordering allows for easier implementation of measurement analysis at a later stage.



The measuring procedure relies on a pixel per metric ratio operation, this requires the image to contain at least one constant of which its dimensions must be know. From that constant the dimensions of objects within the image can be determined. For my final implementation a simple QR code or expanding box would remain onsite beside the vehicles rest point in the process.

2.3 Implementation

First step is to load and read the image. The following snippet of code loads the image and converts it to a greyscale version.

```
image = cv2.imread("example.png")
gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
gray = cv2.GaussianBlur(gray, (7, 7), 0)
```

Next the image needs to be cleaned and further defined so that it is easier to work with. To do this the next piece of code will find the edges of the objects in the image and fill in the gaps where necessary.

```
edged = cv2.Canny(gray, 50, 100)
edged = cv2.dilate(edged, None, iterations=1)
edged = cv2.erode(edged, None, iterations=1)
```

From here the image begins to look something like an x-ray of the original image.

```
def sort_contours(cnts, method="left-to-right"):
    reverse = False
    i = 0

    if method == "top-to-bottom" or method == "bottom-to-top":
        i = 1
    boundingBoxes = [cv2.boundingRect(c) for c in cnts]
    (cnts, boundingBoxes) = zip(*sorted(zip(cnts, boundingBoxes),
    key=lambda b:b[1][i], reverse=reverse))

    return (cnts, boundingBoxes)
```

This phase requires the extraction of the contours in a computer friendly mapped format, it then puts each object in a bounding box to allow for easy cycling through each one. Having a constant known object allows for the relational computation of the sizes of the other objects in the image resulting in the recording of the height of the object of interest, in this case the HGV. It is necessary for the objects to be documented and cycled from a specific point to another so that the known object can be recognised for comparison.

2.4 Graphical User Interface (GUI) Layout

For the core of the project there should be no need for a GUI but there will be a need for minimal interfacing. With optimum performance and development success the system will be implemented with a simple switch/button configuration that will initiate the process and produce the readings. For mapping/routing options a simple webpage with an adaption for a vehicle height input field will be fed from the Mapping API system.

2.5 Testing

Simply put if the system does not accurately record the height of the objects it will fail to be of any use. Testing in lab will begin with pictures taken of a variety of objects to work out any initial bugs or quirks. From here in lab testing will work by using a live feed from the webcam and either take a snapshot for analysis or work consecutively with the live image for rendering. Depending on results from these tests preferred method of image capturing will be chosen and on site testing can begin.

Testing has proven to be one of the most difficult and time consuming parts of the project, initial testing within the Java environment was positive up until the point where no further progress could be made and the decision was then made to migrate to Python. Since beginning code implementation in Python several hurdles have been overcome but there remain many more before presentation day. The hope was to have had many examples of successful tests at this point and to be able to do unit testing on the working code in question but as all of the kinks have yet to be worked out this is currently not possible as the errors in the code prevent proper unit testing from taking place. There are several plugins for the Spyder IDE to assist in unit testing which have been installed but as of yet have not been fully implemented.

2.6 Customer testing

As with unit testing customer testing has been held back due to the constraints placed on the project when switching development languages and environments.

2.7 Evaluation

System evaluation will depend entirely on the systems performance when completed. The system performance can be broken down into two main parts: the validity of the information being processed and the time it takes for the system to complete its analysis. Early tests concluded that the information was accurate within a small margin of error and processing time was fast but as this was performed only on a section of the application which had yet to be completed the results may vary as the application is further fleshed out. True system evaluation will come with interactions with prospective users and or buyers who will have a large degree of input as to where the application should go from there.

3 Conclusions

The advantages of an application such as the one I have developed are evident from its conception. If drivers of HGVs are made aware of their vehicles heights and are given planned safe routes to travel the number of bridge strikes in the capital should be greatly reduced, granted this will only be the case if the drivers adhere to these suggestions, and countless man hours will be saved in the process. Limits which might be encountered could be a lack of interest from prospective buyers or by the drivers themselves disregarding the newly available options. In developing this project I have come to realise my own limitations and difficulties with certain aspects of coding. At times during the course of the year I wished that I had chosen one of the predetermined projects set out by our tutors, as if I had done so I would have been staying within my comfort zone and sphere of influence, but I wanted to develop an application which might actually make a difference in people's everyday lives and thus I am happy to have undertaken this course of action. None of the technologies that I have used in the creation of this project are new or ground-breaking but the combination of these technologies had not been used to perform the tasks which I had set out for it before.

Difficulties arose at nearly every step of the projects code implementation. At first the hardest part was merely getting Java and OpenCV to communicate properly with each other, once this had been achieved the next few steps were relatively easy until I hit a wall where I could not implement custom libraries as desired. From there I was resolved to using Python to get the job done, as this is a language which I am unfamiliar with this posed a tough challenge to overcome. With more time and more experience using Python I believe this project would be of relative ease, especially to someone who was experienced with Python and OpenCV. This experience has taught me that I am capable of learning, or at least implementing, a new language in a short period of time. It is the skills I have learned in my time in college which have allowed me this ability and ones which I hope to carry with me into my career.

4 Further development or research

With more time and data the application could be rolled out on a countrywide basis. This would require a massive undertaking by a state body to accurately record the heights of all bridges on all roads in the country, this is something currently being done in the UK by Ordnance Survey. If the application can perform from a live camera feed it would allow for the creation of an early warning system to warn drivers of tall vehicles, approaching low bridges, to find an alternative route before it is too late. The creation of a database to record all of the parameters, including routes taken, would allow for analysis of the most regularly used roads. This information in turn would assist city and town planners to implement traffic calming measures and to best facilitate both the drivers and the people who live on or near these routes.

As I am invested in the outcome of this project whether or not this application is picked up or adopted by a third party I feel I will continue to work on it in my free time and, with a high degree of success, release it to the open source community so that any possible positives that can be achieved from its implementation will be realised in the future. As the system is now primarily designed and implemented in Python with a few tweaks it could be developed for use on a Raspberry Pi, in particular Jessie which integrates well with Python and camera technologies such as OpenCV. This development would make for an extremely cost effective way of distributing the technology to all sectors of public works from car parks to drive through and with an open source project it could be implemented in places in the world where funding for such initiatives are low or non-existent but where a need for such a service is still of importance.

5 References

5.1 References

Codingbite.org. (2017). *Intro and loading Images – OpenCV with Python for Image and Video Analysis 1 | Coding Bite*. [online] Available at: <http://www.codingbite.org/intro-and-loading-images-opencv-with-python-for-image-and-video-analysis-1/> [Accessed 2 Apr. 2017].

Cs.indiana.edu. (2017). *OpenCV: Image Processing and Computer Vision Reference Manual*. [online] Available at: https://www.cs.indiana.edu/cgi-pub/oleykin/website/OpenCVHelp/ref/OpenCVRef_Cv.htm [Accessed 5 Apr. 2017].

Docs.opencv.org. (2016). *OpenCV: Shape Distance and Matching*. [online] Available at: http://docs.opencv.org/3.1.0/d1/d85/group__shape.html [Accessed 3 Dec. 2016].

Gouillart, E. and Varoquaux, G. (2017). 2.6. *Image manipulation and processing using Numpy and Scipy — Scipy lecture notes*. [online] Scipy-lectures.org. Available at: http://www.scipy-lectures.org/advanced/image_processing/ [Accessed 5 Apr. 2017].

Heesch., D. (2016). *OpenCV: Introduction*. [online] Docs.opencv.org. Available at: <http://docs.opencv.org/3.1.0/d1/dfb/intro.html> [Accessed 9 Nov. 2016].

Lelis Baggio, D. (2015). *OpenCV 3.0 computer vision with Java*. 1st ed. Birmingham, UK: Packt Publishing Limited.

MapQuest API Documentation. (2017). *Directions API - Overview*. [online] Available at: <https://developer.mapquest.com/documentation/directions-api/#output> [Accessed 4 Apr. 2017].

Maps, C. (2017). *Custom routes/paths/roads on Google Maps*. [online] Stackoverflow.com. Available at: <https://stackoverflow.com/questions/2741808/custom-routes-paths-roads-on-google-maps> [Accessed 6 Apr. 2017].

Mordvintsev, A. and K., A. (2017). *Image Processing in OpenCV — OpenCV-Python Tutorials 1 documentation*. [online] Opencv-python-tutroals.readthedocs.io. Available at: https://opencv-python-tutroals.readthedocs.io/en/latest/py_tutorials/py_imgproc/py_table_of_contents_imgproc/py_table_of_contents_imgproc.html [Accessed 5 Apr. 2017].

points, G. (2017). *Google API (directions) - creating routes that avoid certain points*. [online] Stackoverflow.com. Available at: <https://stackoverflow.com/questions/19144100/google-api-directions-creating-routes-that-avoid-certain-points> [Accessed 9 Apr. 2017].

Programering.com. (2016). *[OpenCV] Gauss mixed background modeling*. [online] Available at: <http://www.programering.com/a/MDMxUjMwATQ.html> [Accessed 3 Dec. 2016].

Pythonvision.org. (2017). *Tutorial*. [online] Available at: <http://pythonvision.org/basic-tutorial/> [Accessed 5 Apr. 2017].

Rosebrock, A. (2017). *OpenCV shape detection - PyImageSearch*. [online] PyImageSearch. Available at: <http://www.pyimagesearch.com/2016/02/08/opencv-shape-detection/> [Accessed 2 Mar. 2017].

Rosebrock, A. (2016). *Measuring size of objects in an image with OpenCV - PyImageSearch*. [online] PyImageSearch. Available at: <http://www.pyimagesearch.com/2016/03/28/measuring-size-of-objects-in-an-image-with-opencv/> [Accessed 1 Dec. 2016].

Rosebrock, A. (2016). *Ordering coordinates clockwise with Python and OpenCV - PyImageSearch*. [online] PyImageSearch. Available at: <http://www.pyimagesearch.com/2016/03/21/ordering-coordinates-clockwise-with-python-and-opencv/> [Accessed 1 Dec. 2016].

Shel, M. (2014). *An introduction to Python for scientific computing*. 1st ed. [ebook] California: University of California, Santa Barbara. Available at: <https://engineering.ucsb.edu/~shell/che210d/python.pdf> [Accessed 6 Apr. 2017].

Technostarry. (2017). *How to Create Custom Routes in Google Maps*. [online] Available at: <http://www.technostarry.com/create-custom-google-maps/> [Accessed 4 Mar. 2017].

6 Appendix

6.1 *Project Proposal*

Project Proposal

Heavy Goods Height Analysis

Conor Berkery, 12741829, Conor.Berkery1@student.ncirl.ie

BSc (Hons) in Computing

Cybersecurity

13/10/2016

7 1. Objectives

I propose to undertake the development of a closed system that accurately determines the height of heavy goods vehicles (HGVs) as they leave Dublin Port. The system to be employed will determine the maximum height of the HGV and print this information so that the driver can be made aware of the maximum clearance height required to pass under bridges positioned near the city. The application should require very little input from the user once initial installation has been completed and not add any unnecessary time constraints to drivers who work very tight schedules. Drivers are already required to check in and out of the Port as they enter and leave so this operation would ideally take place at checkout as they are already required to halt their vehicle and thus no additional delay would be introduced as well as allowing for measurements while the vehicle is under load which would impact the vehicles height.

The system offers room for scope widening if time constraints are met or if after the project is submitted that it has a viable entry point to the marketplace. Some possible additions to the project could be a route planner which would advise drivers of HGVs as to what routes they can take quickly and safely. Another area of potential development would be the design and implementation of an early warning system at bridge strike blackspots which would alert vehicles which exceed the maximum height for an upcoming bridge and allow them an exit before reaching said bridge. This would act like currently employed live speed signs which advise drivers to slow down when necessary. Apart from the obvious security implementations, the camera systems could be updated, where privacy laws allow, to increase their data gathering capabilities and provide valuable information to city and port authorities for future planning.

8 2. Background

The idea for this project was inspired by recent events around the city of Dublin. Startling statistics released by CIE revealed that the number of bridge strikes, eighty-five, that had occurred in the six months up until that point had already exceeded the number for the entire year previous to that. Twenty-five of these strikes happened on commuter rail lines. Each one of these strikes represents countless lost hours for commuters who have to wait for engineers to inspect the bridges and ensure that it is safe for trains to continue to use them. CIE have placed the blame squarely on the drivers and haulage companies that operate these vehicles. It is perplexing to think that professional drivers could be unaware of the height of their vehicles and how this situation could occur.

Since presenting this topic to the panel of lecturers on the October 5th the issue of bridge strikes has been in the news again but this time in Britain. The BBC published an article on the October 19th outlining that Ordnance Survey, the UK government agency responsible for the official, definitive topographic **survey** and mapping of Great Britain, were undertaking the creation of a database that would determine the height of all bridges along a two hundred thousand mile stretch of roadways across the UK. This dataset would then become available at a price to Satnav makers so that routes could be planned by their users. For their system to work though it requires that the driver of the HGV already knows the height of their vehicle and this is not always as straightforward as one might think as drivers are often in different vehicles from day to day and the max height can vary depending on its loading.

9 3. Technical Approach

Having presented my project to the panel the main concern I was met with was that the idea would be too difficult to achieve within the time allocated. This meant that I had to begin analysing the technical requirements necessary to develop such a project earlier than expected. Initial research garnered some positive results with the topic having been approached by some students and professionals alike, luckily none had thought to implement it as I have done. While none of the research that I encountered dealt directly with measuring the height of vehicles much of it dealt with smaller objects such as coins, tablets et cetera.

Thus far I have only researched enough to convince myself that the project is implementable. The next step is to continue my research in a more in-depth manner and begin to select the most viable options for completing the task. Since this project deals directly with public safety it will be imperative that my calculations are very accurate and leave little room for error. There are several research papers and tutorials which I have collected and begun to go through which will be an invaluable resource as the project progresses. Due to the nature of the project it is important that the technical requirements be firmly laid out before coding commences, this will guide the project and prevent it from scope creeping. For the project to be implemented correctly extensive field testing must take place, this will involve initial lab testing which will over time move outside to field testing.

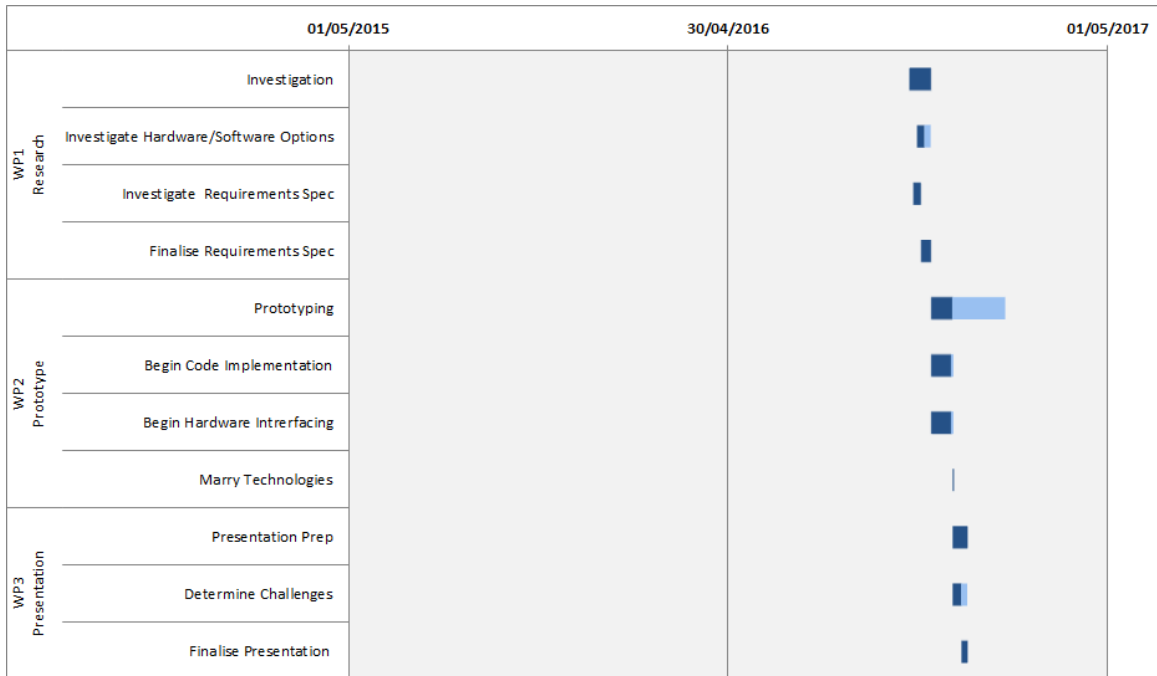
10 4. Special resources required

Possible special resources which may be required:

- o Raspberry Pi
- o Webcam
- o Kinect Camera
- o DSLR
- o Lasers (Distance capabilities)
- o Smart Phone

11 5. Project Plan

Work Package	Task	Start Date	Finish Date	Days	Contingency
WP1 Research	Investigation	22/10/2016	11/11/2016	20	0
	Investigate Hardware/Software Options	29/10/2016	05/11/2016	7	6
	Investigate Requirements Spec	25/10/2016	01/11/2016	7	0
	Finalise Requirements Spec	01/11/2016	11/11/2016	10	0
WP2 Prototype	Prototyping	11/11/2016	02/12/2016	21	50
	Begin Code Implementation	11/11/2016	30/11/2016	19	3
	Begin Hardware Interfacing	11/11/2016	30/11/2016	19	3
	Marry Technologies	01/12/2016	02/12/2016	1	0
WP3 Presentation	Presentation Prep	02/12/2016	16/12/2016	14	0
	Determine Challenges	02/12/2016	10/12/2016	8	6
	Finalise Presentation	10/12/2016	16/12/2016	6	0



12 6. Technical Details

The two main programming languages I will investigate are Python and Java as they both interface well with OpenCV which allows for real time computer vision. As the information I hope to provide will be of a critical nature the system will be required to be securely coded and closed to ensure against unauthorized data manipulation.

13.7. Evaluation

System testing will play an integral role in whether or not my project is a success. I hope to begin by testing the initial prototype on smaller objects within the lab and move on to cars/vans/trucks as testing improves. For the project to meet market standards further onsite testing would have to be carried out in liaison with potential customers. Requirements at this point may need to be altered to suit specific environments but if designed properly from the start it should work as a plug and play type application. The impact of such a system could only be completely evaluated after a year of full integration to existing traffic management systems and the statics of bridge strikes collected after integration.

Conor Berkery 21/10/16

Signature of student and date

13.1 Project Plan

Included in proposal.

13.2 Monthly Journals

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: September

My Achievements

This month, I was able to ... Formulate my project idea, create a high level conceptual framework for the system and attempt to narrow its scope so that it could be an attainable goal for 4th year.

My contributions to the projects included ... The creation of two basic ppt slides to outline my project and what I hope to achieve over the course of the semester.

My Reflection

I felt, it worked well to Put my ideas down on paper, to look at why and how my project should be implemented, who it would benefit the most and who if anyone might pay to use the service. I briefly looked into the technologies which I may use to realise my ambitions.

However, I was not successful in ... Convincing the panel of judges for my presentation, not that my idea was poor or unrelated but that it may be too difficult to succeed in or too difficult to realise to its full potential. Initially I felt that my project may be rejected as it wouldn't have enough meat to it but as it turned out my fears were reversed and I need to prove that it is something I can do.

Intended Changes

Next month, I will try to ... Research thoroughly all technological capabilities that may assist me in convincing the board that my project I doable and that I can attain a good grade while doing so.

I realised that I need to ... Explore all the avenues available, possible tech implementations and speak to my supervisors as to where I go next. I hope to receive approval for my project so that I can make something worthwhile that will also hopefully make a difference to the lives of the people living in my city and others like it.

Supervisor Meetings

Date of Meeting: 5/10/16

Items discussed: Project Proposal

Action Items: Discussion of project proposal and where to go next.

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: October

My Achievements

This month, I was able to Continue researching and gathering requirements and possible viable technologies which could be employed by me to undertake my project.

My contributions to the projects included ... creation of a preliminary requirements document, creation of preliminary use case diagram, research including both collegial and media related information.

My Reflection

I felt, it worked well to To read around my subject matter, investigate further how my project could be implemented and where best an initial launch would have most success. I discovered Ordnance Survey England are undertaking the creation of a dataset to record the height of all of the bridges along the most used roadways in Britain, this data would be combined with existing SatNav to create safe and convenient routes for the drivers of HGVs. This undertaking is good news for a project like mine as the drivers will still need an accurate reading of the height of their vehicle to input into their SatNav to avail of the new routing system.

However, I was not successful in ... Completing all of the tasks I had set out for myself, I hoped to have finished both my requirements documentation and use case diagrams but there is still some work to do before they can be handed in .

Intended Changes

Next month, I will try to ... Complete my next round of documentation so as to begin properly implementing code and experimenting with hardware options.

I realised that I need to ... Set tighter deadlines for myself to ensure I have all of my required information in on time and completed to a high standard so that I can push on with developing my project thoroughly. I need to experiment with camera technologies to ensure I have chosen the one that is best suited to my needs and can be implemented in a timely fashion.

Supervisor Meetings

Date of Meeting: TBC

Items discussed: TBC

Action Items: TBC

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: November

My Achievements

This month, I was able to Work on final documentation for the mid-point presentation, create a power point presentation to help convey my ideas and how they've developed since its conception. Unfortunately, due to the difficulty in learning a new programming language compiled with all of my other coursework I have been unable to achieve much coding.

My Reflection

I felt, it worked well to Meet with my supervisor and talk to my other lecturers about my project. It was also helpful, while not successful, to begin coding my project. Beginning coding allowed me to begin to understand the architecture, class structuring and algorithms that I will need to implement for my project to be a success.

However, I was not successful in ... Completing all of the tasks I had set out for myself, I hoped to have finished my technical report at this stage but know that I will be working on it into Sunday evening. I am still uncertain as to which programming language will best suit my project depending on its final form, OpenCV is the only certainty at this point.

Intended Changes

Next month, I will try to ... Finalise languages and structuring.

I realised that I need to ... Flesh out my ideas to bolster the project and increase its complexity.

Supervisor Meetings

Date of Meeting: 8/12/16 Very successful, Eugene was a great help in that he guided me as to where I should go next, where I needed to make changes and what information I should include for the presentation.

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: December

My Achievements

This month, I was able to ... Successfully present my findings and work thus far to my supervisor(Eugene) and Sam Cogan the other panellist.

My contributions to the projects included ... Further research and code implementations and the creation of a Prezi slideshow to present for the midpoint examination. I used Prezi online presentation tool to help make my project stand out and to provide a break from the usual PowerPoint presentation format.

My Reflection

I felt, it worked well to Stick to my project plan and not to allow myself to deviate too far from my milestones.

However, I was not successful in ... Getting much work completed as I had hoped to as Christmas and exam prep has taken over most of my allotted time. With four exams to study for my study plan had to expand into the time I had previously boxed off for project work. Last exam is on Thursday the 12th so I will attempt to catch up to where I should be as soon as I'm finished.

Intended Changes

Next month, I will try to ... Get through the main code functionality/implementation and begin testing.

I realised that I need to ... Concentrate on hitting the milestones I have set out in my project plan to ensure that the system is ready on time for the end of year presentation. While this was very difficult to achieve over the last month it should be a little easier to manage next month with new classes starting and a short break beforehand where I can catch up.

Supervisor Meetings

No supervisor meeting other than midpoint over the Christmas break.

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: January

My Achievements

This month, I was able to ... Begin focusing my attentions on how I might go about implementing a traffic/routing system.

My contributions to the projects included ... Researching Google Maps Api and other mapping solutions to see which would best suit and be capable of doing what I need it to do.

My Reflection

I felt, it worked well to Explore as many options as I could in relation to mapping solutions as each of them has their own benefits and drawbacks, finding the one that's a good fit is proving difficult.

However, I was not successful in ... Determining as of yet which of these options will provide the services I need and how to properly implement them.

Intended Changes

Next month, I will try to ... Finalise the mapping solution and begin making test cases to ensure its feasibility.

I realised that I need to ... Get back into the full swing of things after my exams as it has proved more difficult than I thought to pick up where I left off after presentations.

Supervisor Meetings

No supervisor meeting

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: February

My Achievements

This month, I was able to ... Start implementing my code into some form of working application.

My contributions to the projects included ... Separate from further mapping research I was able to implement the basic code structure that will form the basis for my entire project.

My Reflection

I felt, it worked well to Implement a basic swing gui to assist in the photo analysis but simply setting up the environment proved to be more difficult than I had anticipated, integrating Java with OpenCV within NetBeans was not straight forward and calling on appropriate functions and libraries is more time consuming than I had anticipated.

However, I was not successful in ... Completing as much work as I had initially set out in my project plan, while I have fallen back in this regard now that I have the foundations set in place I should be able to catch up back on schedule.

Intended Changes

Next month, I will try to ... Progress with the coding of the photo analysis and begin testing my solution.

I realised that I need to ... Familiarise myself with the wealth of options that OpenCV offers and implement them where appropriate, I also realised that Google Maps API may not be the best solution to my mapping procedures as it does not allow for the creation of custom roadblocks as is necessary.

Supervisor Meetings

Having met with Eugene we discussed where I was having difficulties and where I should focus more of my efforts in the final months, I find these meetings helpful as the help me to concert my time and prevent me from falling back on my project plan.

Reflective Journal

Student name: Conor Bekery

Programme (BSc in Computing):

Month: March

My Achievements

This month, I was able to ... Start finalising my code and routing solutions and design my poster for the project.

My contributions to the projects included ... Further development of the code base which I had been working on previously and experimentation with various forms of mapping solutions which may be of assistance.

My Reflection

I felt, it worked well to To continue to focus my time on the actual code itself rather than how I may go about things to actually attempt to achieve these goals by trial and error within NetBeans.

However, I was not successful in ... Achieving the desired results in regards to the photo analysis techniques I need to implement for my project to be deemed a success.

Intended Changes

Next month, I will try to ... Fix my code base to correctly estimate the height of the objects in the photos I'm analysing.

I realised that I need to ... Look into implementing custom libraries on top of the OpenCV library to assist in the project goals.

Supervisor Meetings

I discussed with Eugene the issues I was having with NetBeans and some possible solutions as well as the mapping issues I encountered earlier, we are both still confident that I will be able to achieve a positive result by projects end.