25/4/2017

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Final Report

Professional practice SOC09108

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# Introduction

The purpose of this report is to describe and critically evaluate the work produced during the 180-hour placement that was undertaken at Edinburgh Napier University. The report provides an overview of the research topic and its relation to the current computing industry. Next, it presents a skill audit which demonstrate the skills and techniques and skills that were learned, used and developed throughout the project. This is followed by the project artefact sections which will further provide evidence of the work undertaken. The penultimate section of this report contains a critical evaluation of the placement and the appendices will form the last section of this report.

# Context

The project undertaken was a research topic regarding facial recognition with an emphasis on jaw movement. There were constraints on the project which involved it being developed in the Unity engine and using the OpenCv (Open Computer Vision) library. Furthermore, documentation regarding the project and what has been researched was to be produced and handed in at the end of the placement. The client for the research project was Gregory Leplatre, a lecturer at Edinburgh Napier University. Although the project specified Jaw tracking I was given near full control of the project if there was valid justification behind the approach.

Due to the nature of the research project, following the 180-hour work plan was not feasible as it was difficult to estimate how long each stage of the project would take. Thus, this plan was modified and has been supplied along with the original work plan that was submitted. Further information of this is provided in the project artefact section.

The duties as a research student included:

* Documenting research done.
* Provide sample solutions.
* Weekly meeting with client to discuss work.
* Recording potential future work.
* Testing performance and feasibility.

# Skills Audit

The core skill that I brought to this placement which helped me to undertake this research topic was my knowledge in computer graphics and post-processing effects. As the entire project revolved around image manipulation it was essential in knowing how to use image techniques such as grey-scale and Gaussian blur. Furthermore, it meant when researching I could quickly able to interpret the terminology. An example of requiring this information is face-detection. Before the computer can try to recognise potential face patterns it requires the image to be in a grey-scale format.

Another important skill that was beneficial to this project was my understanding of code complexity and data structures. This was important as performance was important, due to this being a real-time application. I was also able to identify where there were performance issues in the code. For example, in one of the initial applications I created as part of this project, the method used to convert an image into a suitable data-structures for OpenCvSharp involved nested for loops. This is not a good practise as the larger the image being processed, the more detrimental to performance it is. Identifying this early resulted in a more appropriate technique being used which involved condensing images to arrays then converting images using the byte array. My understanding of algorithms was proven useful when I was researching how the face detection worked in the OpenCv library. Due to my understanding after researching the algorithm I could determine the limitations that the method improved, such as the approach being rotation-invariant, thus detecting faces that are not correctly aligned could not be detected.

A strategy that I used throughout the entirety of the placement was the agile software development methodology. I implemented this into my work by assigning a weekly sprint. In a sprint, I would set out a series of goal which are categorised as: must have, should have and would like to have This is like the MoSCoW prioritisation technique which I adapted this from. The reason I adapted it was to make it more streamlined and simpler to follow.

When I start an agile sprint the first stage is to work out the aims of the sprint and what should be the result of it. After that has been worked out I follow it up with the correct research that is needed to progress with the project. Once the research has been sufficiently done then an implementation was attempted. Regardless of the result of the implementation stage I would conclude the work by writing it up into document that is for the client. I also tidy up the code and ensure that correct coding stands are adhered to. For example, correct indentation, meaningful variable names, sufficient comments regarding variables and functions. This is standard for the industry as other people will also being looking/ using the code.

Before any coding is undertaken, the algorithm needs to be planned. The standard approach which I followed was writing down the pseudo-code for the algorithm. This is simple notation which is used in program design and resembles a simple programming language. The benefits of writing down this notation was it would identify programming features such as loops or conditional statements.

I had a basic understanding of the Game Engine selected before the placement started. The game engine that was requested was Unity. Although most of the development was done in C# scripts I still had to configure the Unity project. When the project was displayed, I had to decide on a way to present the resulting image produced. Early in the project I used the external OpenCv window that could be initialised. This provided a smooth output however this did not meet the criteria that was specified at the start of the project. Therefore, about half way into the placement I rewrote the output so it displays onto a GUI texture within Unity. This has performance issues which I have been trying to resolve but it meets the criteria of the placement.

Towards the end of the project I put an emphasis on the optimising the project. Although I reduced program complexity throughout the entire placement there was still performance issues regarding image conversion, I recognised that the issue was the image was being calculated on the CPU instead of the GPU. Due to time constraints, I was unable to apply the changes to the application but in the documentation, I made a note explaining how to improve the performance.

For the documentation, I condensed the research done into sections and split up the sections into small part that can be read independently. Furthermore, I hyper-link the sections

Effective communication between the Client and I was essentially throughout the entire placement. Therefore, we would have a meeting at 1pm every Wednesday. Before this meeting takes place, I would ensure I would have everything the work done prepared and write down any questions I would have. In this meeting, I would also answer any questions that the Client would have. If the meeting was unable to take place at the scheduled an email was sent to the client as soon as possible to alert him to the situation and to request if the meeting could be moved to another time that was suitable for the both of us.

My knowledge of how to use repositories (cloud-based version control) would have been useful for this project as it would have provided me the different versions of the project as it evolved over time. At the start of this project I had set up a repository so that the Client could see what how the project was progressing, rather than waiting to see me each week.

# Project artefacts

One of the most important artefact that was produced in this placement was the research document which recorded the finalised notes on the project. Several iterations of this produced was produced as the project progressed. Artefact 1 show the outcome of this document that was created. When I initially started the document, I asked the Client how he wanted to documented to be formatted/Structured. I was asked a simple word documents with headings so he could easily navigate to the sections he would like to read.

There were also some small sample applications created during the research topic. Each of the sample applications tested, and demonstrated a potential way of tracking facial features. The sample applications were created as a Unity project that the Client can load and experiment with. An example of what the result of these sample applications can be found at appendix 3,4 and 5.

As the project progressed a weekly log book was recorded This can be seen at appendix 9. The purpose of this documents was to keep track of the work done throughout the entirety of this project. I structured the log book in weekly bullet points which were kept concise. Originally I intended to use the STARL format. However, this proven to be quite difficult for several weeks due to the nature of the project hence why I kept to the simple bullet point formula.

I utilised my whiteboard a lot throughout this placement. This was where I wrote down initial thoughts and pseudocode, after I was done I would take a photo of the board before removing the work and starting again. Unfortunately, the photographs that were taken were lost before I uploaded them to my computer, therefore I only have photos of white-board towards the end of this project.

# Log Book

At the start of the placement a work plan was created per the original specification that was agreed with the client. As the placement progressed the aims and expectations of the project gradually changed. To reflect the changes a new work plan was created and adapted to suit the requirements of the project.

* Original one
* New one
* Why changes were made.

# Evaluation

One skill that I have managed to improve upon at the start of this project was my ability to work independently, which is an important skill to have in this industry. At the start, I found it difficult to prioritise what should be done first and when it should be done for. As the weeks progressed I could formulate a weekly plan which was structured around a small MOSCOW plan.

Another skill that has been further developed during this placement was my research and documentation skills. Although I had basic researching skills I found that this topic was quiet a small niche and therefore, there was not a lot of documentation on the internet to help me. I learned how to adapt my searches to find something similar then using my problem-solving skills and programming techniques to progress my work. Unfortunately, this took longer than I would have liked and most of the progress has come towards the end of the project, rather than consistently throughout the placement. However, this have provided me with more experience that will be useful for future projects. Leading on from this, consistency was another issue that I noticed during my project, and even the Client mentioned it in the feedback. This is something that I need to rectify as it is important in the industry to always be showing advancement in your project.

At the start of this placement I created a repository to keep a track of my work as the project progressed. However, I neglected to keep regular commits like I intended to. As the use of repositories is an industry standard I need to ensure that I keep regular commits on my repositories in the future. As it was only I who was working on this project, it did not affect the outcome of the project but having access to previous versions of the project would have been beneficial.

I created a repository for this project however I rarely uploaded to it, this is something that I need to improve upon as well as improving the comment and description of the commit.

As I mentioned in the previous paragraph, due to an issue with my phone I lost a series of artefact evidence due to my mistake in not backing up the work. This did effect my work for the documentation and would have not occurred if I was using the repository as I originally intended to do. This is a mistake that I have learned from and will not be making the same mistake again.

One of the skills that I developed well throughout this project was my problem-solving skills. I could provide some possibilities to a rather difficult project which I am proud off.

# Appendices

7.1 Appendix 1

The document created as part of this project contains all the vital information of the research undertaken. It includes information such as the context of project; installation of two different libraries; the pro and cons of the project

7.2 Appendix 2

This is a small sample of the DLL files that need to be implemented for EmguCv to be integrated into a Unity project.

7.3 Appendix 3

This is a small sample of the DLL files that need to be implemented for OpenCvSharp to be integrated into a Unity project.

7.4 Appendix 4

(Face Detection OpenCvSharp)

7.5 Appendix 5

(Edge Detection OpenCvSharp)

7.6 Appendix 6

(Combined EmguCv)

I used the research and implementation done in the previous weeks and combined them into a single project. This was done using the second wrapper as it provided slightly improved performance gain. Below is the image which shows a detected face and the contours drawn in that area.

7.7 Appendix 7

(Grab Cut EmguCv)

As seen in the image provided, while the results work the performance shows that it is not a suitable solution, Ideally the minimum frames per second (FPS) should be 24. This approach which averages about 0.9 FPS indicates that it will not work. But the idea behind it is quite useful as it could be used in another manner.

7.8 Appendix 8

(Original plan)

After initial discussions with the Client I drafted up a work plan that coincided with the project specifications that was provided, however as the project evolved from its original design this plan became outdated and needed to be re-written.

7.9 Appendix 9

(New Plan)

As the project aims changed the work plan that was being followed was constantly changed. This is the result that was produced due to these constant changes.

7.10 Appendix 10

(Log book)

At the end of each week I bullet pointed the work that was under-taken and any important information that was discussed during the client meetings. As there is no non-disclosure agreement it was acceptable to take notes during meetings.