Netwatch Object Recognition

Project Report

by

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Abstract

This document contains an overview of the overall process experienced throughout the completion of the final year project. The general and technical issues faced are mentioned, as well as the learning outcomes of the project.

Keywords: overview, outcomes, issues

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Introduction

The aim of the project report is to provide a thorough reflection on the development process of the final year project that took place over past months.

The first part of this report will briefly describe the project that was to be completed, directly followed by the deliverables that were and were not achieved.

The following section will cover the general issues that were faced during the project, both technical and non-technical.

The next part of the report will discuss all of the learning outcomes as a consequence of completing the project, including any technical and personal skills that were developed or gained.

Lastly, this document will go over what I would have done differently if I could start the project again.

Project Description

My final year project was a sponsored project by Netwatch, where the requirements were to build an object detection model capable of detecting humans and moving vehicles using their image data.

Another primary specification was to provide Netwatch with a report on my experience using different open-source machine learning frameworks.

What Was Achieved?

The main achievements of this project were the the fine-tuning of an object detection model using Netwatch data, the implementation of web applications for the purpose of

demonstrating contextual application of object recognition on Newatch images, as well as an analysis of the machine learning frameworks used as part of the project (MLNET, PyTorch).

PyTorch Modelling

After spending some time researching, I chose a two-stage detector model called “Faster R-CNN” for its balance between detection speed and accuracy.

Initially, due to having no labelled data, using a pre-trained Faster R-CNN model out of the box offered good results, however for the purpose of the report I eventually learned to fine-tune the same pre-trained model on around 200 Netwatch images data that were manually labelled.

The output comparisons between both models were occasionally significant, and the fine tuned model would expectedly catch certain vehicles and humans that the pre-trained model wouldn’t, however the results are very dependant on both the quality of the dataset and the hyperparameters used, which unfortunately I not spend too much time exploring.

Framework Report

As Netwatch requested, I provided them with a report on both PyTorch and ML.NET frameworks, covering each of their ecosystems, setup, modelling, and training processes with a summary of my personal thoughts on each of the frameworks' learning curve and practicality.

Demonstrative Web Applications

Due to not having any complete technical deliverable specification as part of my project, it was difficult to come up with something to develop to include more practical aspects. However, eventually I decided to implement demonstrative web applications for each

machine learning framework being used, which ended up complete for their demonstrative purposes.

Flask Web App Home Page

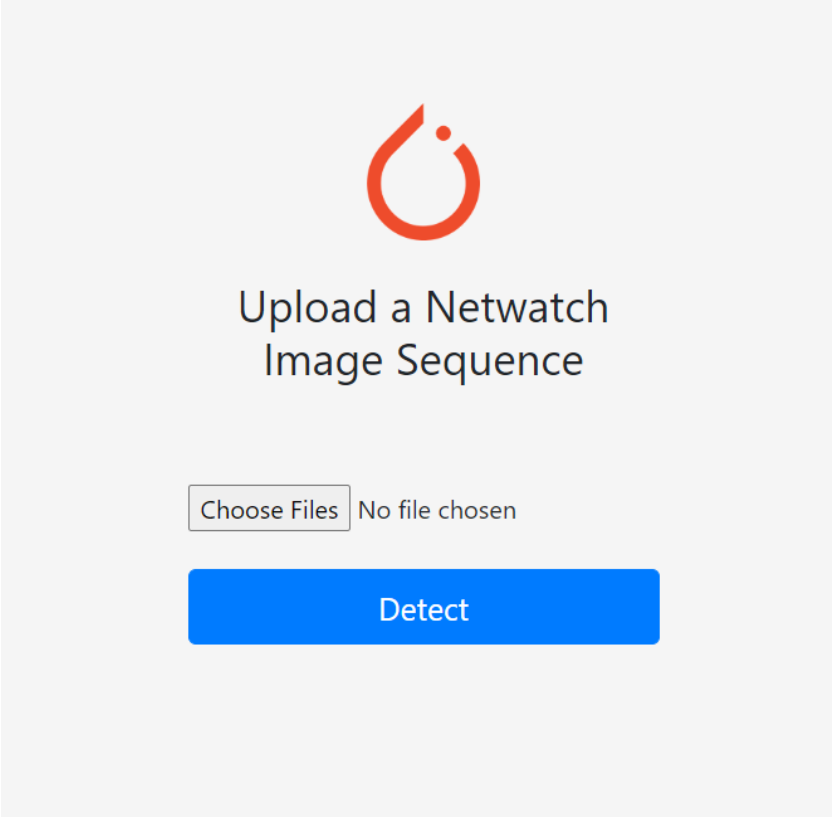

Figure 1 (Tremblay, 2022)

Flask Web App Results Page

Figure 2 (Tremblay, 2022)

Blazor Web App Home Page

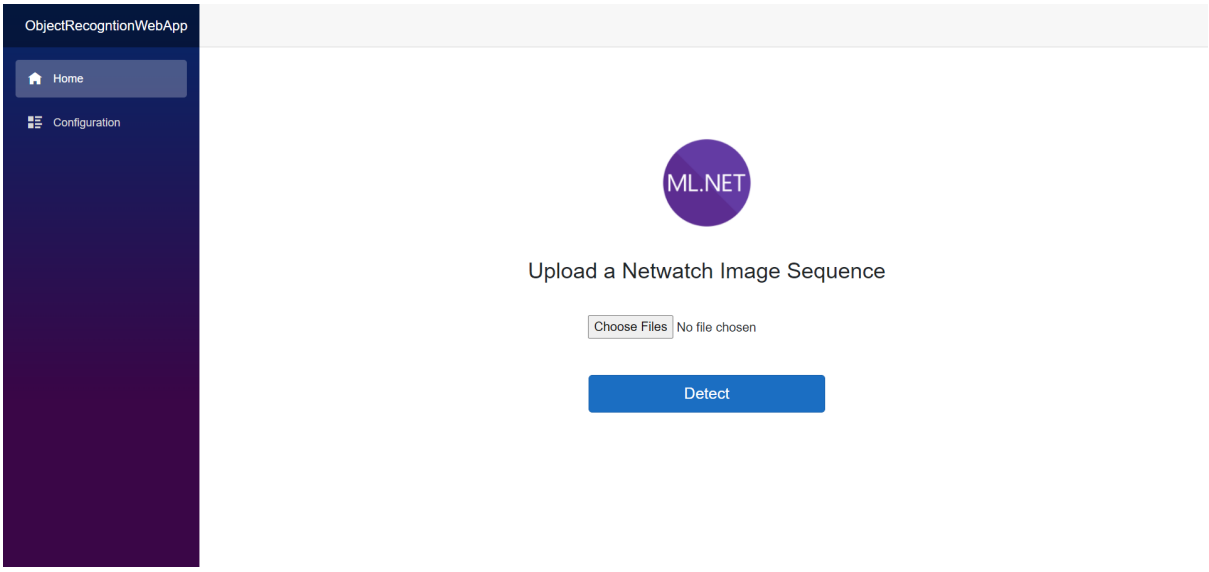

Figure 3 (Tremblay, 2022)

Blazor Web App Results Page

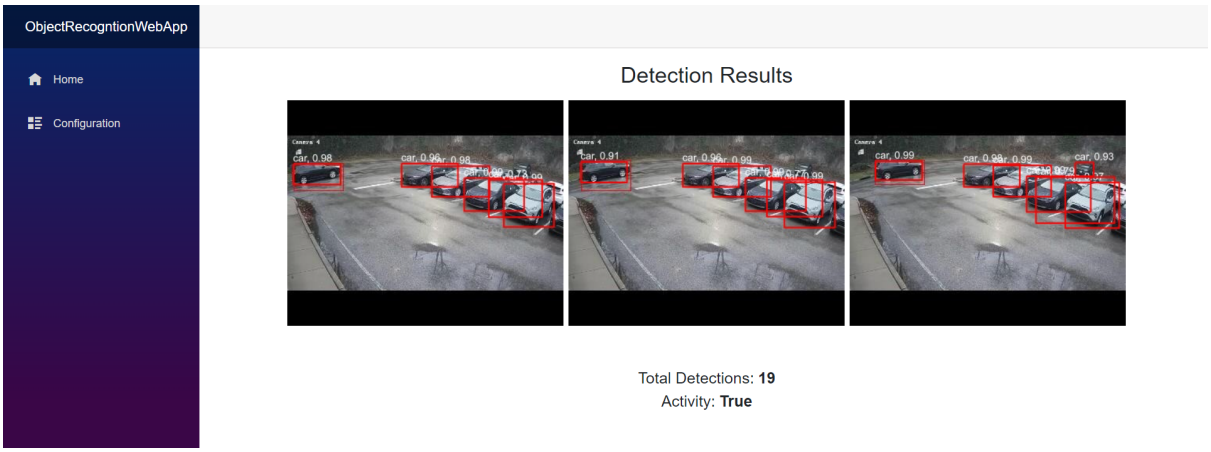

Figure 4 (Tremblay, 2022)

Blazor Web App Configuration Page

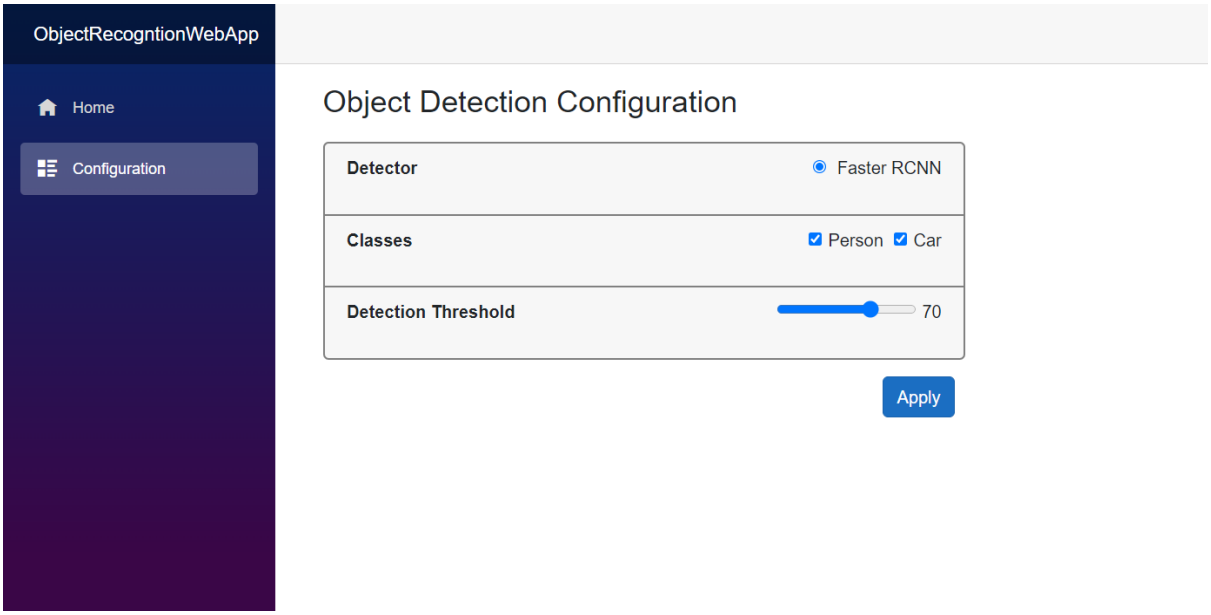

Figure 5 (Tremblay, 2022)

What Was Not Achieved?

Moving Car Detection

A secondary specification of the project was to develop a model capable of detecting moving vehicles/cars from their image sequences, however this was not achieved due to a combination of the task's higher complexity and my lack of time to invest in that aspect of the project.

ML.NET Modelling

Although ML.NET was used to incorporate object detection within the Blazor web application, the model building itself was not achieved upon the realisation that the framework only supports cloud based object detection model training, which unfortunately requires a Microsoft Azure paid subscription.

Challenges

Communication

One of the bigger non-technical challenges I experienced throughout the final year project was communicating with an external client (Netwatch). Due to being limited to communicating remotely, and not having the ability to meet as often, a lot of aspects can be misunderstood which can potentially cause setbacks during the course of the project.

Data Understanding

Another big challenge experienced during the project was the data to be used for the modelling.

The image data that was provided, and to be used by specification, was completely unlabeled. Due to this situation, manual image labelling had to occur and by not having a great data understanding as to how the dataset should be formed for Netwatch's context (e.g. what size vehicles/persons should or should not be annotated), I found the model tuning to be limited in the sense that model performance will only be as good as the generated dataset.

Direction

The last challenge I faced was the lack of direction as a result of not having concrete technical specifications, other than model training. I was constantly left questioning the direction of the project in its technical aspect, and even after the final implementation outcome I am still left with uncertainty in its scale.

Learning Outcomes

As the depth and expectations of final year projects are high, a lot of new technologies are to be learned and used throughout the development process, as well as personal skills that are inevitably refined. This section will discuss both the technical and personal abilities gained as a consequence of completing this project.

Technical

The biggest technical learning outcomes from the project stemmed from both the machine learning modelling and use of machine learning models. Knowledge about creating

a dataset for specifically training an object detection model was gained, including image labelling and exporting into specific formats. Experience on the use of transfer learning on existing models, as well as the general boilerplate code structure to be used for the integration of object detection models in applications were also gained.

Due to the Netwatch's specification of using Microsoft's open source machine learning framework ML.NET, a lot of technical knowledge was obtained related to the .NET developer environment. I gained experience using the C# programming language, Visual Studio IDE, and Blazor framework for building client-side web applications.

Due to also using PyTorch as part of the project, experience using the more pythonic machine learning framework was attained, as well as insight on the technical differences and similarities between both frameworks. Although I had prior knowledge of the Python language, I learned quite a bit about the popular web framework Flask from building a separate demonstrative web application for the PyTorch models.

Personal

This project was by far the biggest personal challenge that had to be faced throughout my academic journey, however personal experience and skills were definitely obtained from it.

The main personal skill that has drastically improved over the course of this assessment is my ability to navigate through information efficiently. Performing proper research and learning about new topics or technologies was a huge stepping stone in this project, and as a developer that used to be uncomfortable with the unknown, I now feel much less intimidated when introduced to new concepts.

The value of practical work compared to theoretical knowledge, and the agile methodology have also become more evident to me. Having learned this the hard way, putting things into practice is often much more difficult than it seems, and oftentimes the outcome of learning through practical trial and error is better than attempting to learn everything in advance.

Lastly, I personally have learned that time management is one of the most important aspects involved in the success of a project, and that although my time management ability is nowhere near a desirable level, the importance of this assessment has inevitably forced me to refine the skill and understand its importance firsthand throughout the year.

What Would I Do Differently?

If starting over from scratch, there are a few things I would change as part of my development journey in hopes of positively affecting the outcome of the project.

To start off, I would prioritise communication with the client as early as possible rather than hold onto assumptions that will present debt later on. This would minimise the amount of set-backs caused by misunderstandings and provide a clearer direction as a developer.

Another thing I would do differently would be to spend less time with the overall initial theoretical research, and start implementing as early as possible whether that involves tutorials or my own code. A lot of machine learning concepts, while important, were not crucial to my particular project and in turn cost me some development time.

Conclusion

To conclude, my overall experience working on my final year project taught me a lot when it comes to new technologies and personal skills, and while I personally believe to have faced many challenges, most primary requirements of the project were fulfilled even though I still believe the technical scale could have been larger.