

MLiS II Project

Programming an Autonomous Driving Car

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1 Overview

In the past decade, driver-less cars have gone from 'impossible' to 'inevitable'. Google's self-driving car project¹ started in 2009 and now in 2024, most car manufacturers have adopted or are developing autonomous driving capabilities. The central concept behind the technology is to use trained object detection models to make principled decisions about what manoeuvres a car should make.

In this project your task is to train a deep learning algorithm to autonomously navigate a **real car** around a realistic test circuit, and make the appropriate manoeuvres where necessary. At the end of the project, you are expected to give a presentation and write a report about what you have done. Your model will be tested on the track and will compete against the models of your peers.

2 Challenge Details

In groups of 2 of 3, you will develop a deep learning model that takes an image from a camera on the car, and predicts the appropriate speed and steering angle.

2.1 Training data

We have generated training data for you to use. This is hosted on Kaggle (see next section) and consists of 13.8k images, along with the target car response (speed and steering angle). You are also free to generate additional training data yourself (see below).

2.2 Challenges

There will be two challenges:

1. A Kaggle hosted challenge. This will allow you to automate the process of model submission, and obtain an indication of performance (using a small set of test data), before we evaluate them on the final, unseen data. The Kaggle competition is hosted at <https://www.kaggle.com/competitions/machine-learning-in-science-ii-2024>. You are allowed 1 submission per day. **Please create a Kaggle account (if you do not have one) and form a team with your project partner(s).**
2. A live challenge, where your pre-trained model will be deployed to the car and tested on real circuits. This will be performed in person – we aim to make it a fun day!

¹<https://waymo.com/>

2.3 Equipment

The main body of the car is the SunFounder PiCar-V kit V2 (<https://www.sunfounder.com/smart-video-car-kit-v2-0.html>), and is equipped with a Raspberry Pi (RPi) 4. **Tensorflow v2.15** is installed on the car, so please make sure your model is capable with this version (at the time of writing, January 11, 2024, this is the default version on Colab).

The car has an **optional** Coral Edge TPU, which is a custom device to run forward-pass operations for edge computing. The machine learning runtime used to execute models on the TPU is TensorFlow Lite v2.15. If you wish to use this capability, you will need to convert your code to TensorFlow Lite using the conversion tool <https://www.tensorflow.org/lite/convert>.

Note that it isn't necessary to convert your model to TensorFlow Lite. In this case it will run using regular TensorFlow on the RPi CPU, so you should bear in mind the CPU capability when performing inference on large image sizes. Furthermore, not all operations are compatible with Tensorflow Lite. Please see the link in the resources below for more details.

2.4 Deploying Models to the Car

A standardised skeleton code will be provided to you that you should integrate your pre-trained model with, which we will then install on the car prior to the live testing.

2.5 Taking Additional Data and Performing Live Tests

The 13.8k images on Kaggle provide a good base dataset. However, you may wish to take more data with the car, and also test how your model performs in advance of live testing. We will provide an introductory session on how to use the equipment after reading week.

2.6 Training Machines

As well as Google Colab and any local resources you may have, each group will have access to either the MLiS1 or MLiS2 machines (each with 2 2080Ti GPUs) to perform training. These are accessible by ssh'ing into the machine, by typing `ssh username@mlis1.nottingham.ac.uk` or `ssh username@mlis2.nottingham.ac.uk`, where `username` is your University username. You should use your University password.

In order to install custom packages on your machine, you will need to set up a conda environment. To install conda, type the following command,

```
bash /shared/Anaconda3-2019.10-Linux-x86_64.sh
```

Once installed, you will need to add a start up script,

```
echo . ~/ . bashrc >> . profile
```

Lastly to create your conda environment use,

```
conda create --name my_env python=3.9
```

where `my_env` is the name of the environment. For more information on the usage of conda see: <https://docs.conda.io/projects/conda/en/latest/user-guide/cheatsheet.html>

2.7 Tracks

The training data was obtained on 3 tracks, as shown in Fig. 1. The live testing will also be performed on the same tracks.

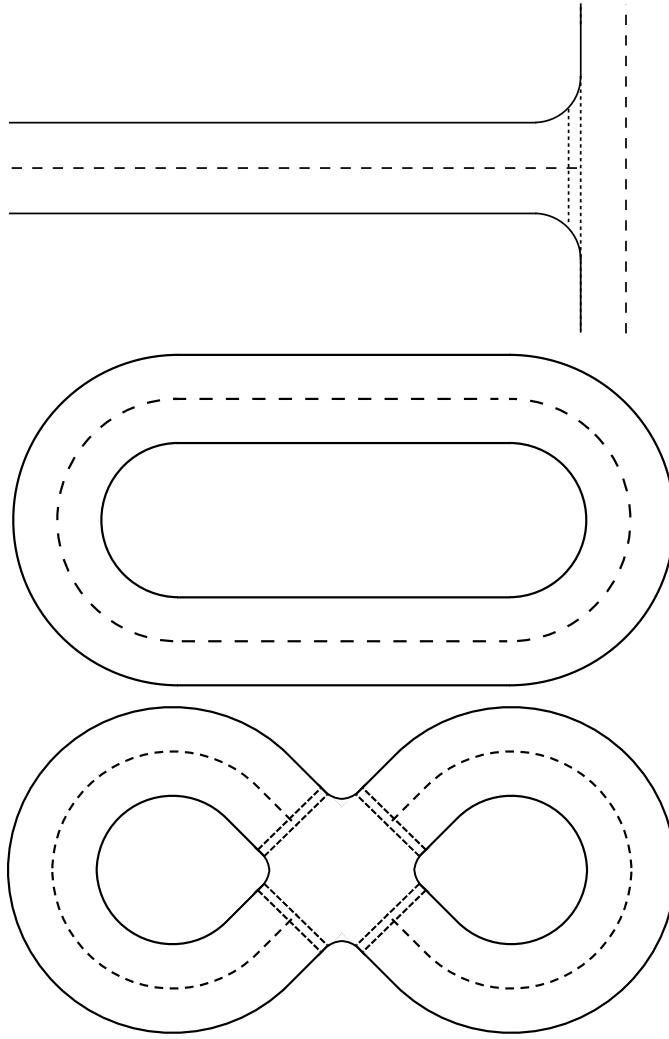


Figure 1: (Top) T-junction tracks (Middle) Oval Track (Bottom) Figure-of-eight track.

2.8 Driving Scenarios

Please refer to the MLiS2 performance marking document for details of the driving scenarios and scoring.

2.9 Prizes

The best-performing car on the live testing will win a £100 Amazon voucher for the group.

3 Assessment and Important Dates

There are several important dates:

Kaggle opens The Kaggle competition will open on **15th February 2024**.

Kaggle deadline The Kaggle deadline is **5pm on the 29th March 2024**.

Live testing model submission You should submit your model, fully implemented with the skeleton code to interface with the car, at **5pm on 7th May 2024**.

Live testing This will take place at **10am - 4pm on 8th May 2024 in CAPT A113**. The Kaggle and live testing performance will contribute **20%** towards your total mark.

Presentations These will take place on **10th May 2024, time and location TBC**. The presentations will last for 25 minutes for groups of 2, and 35 minutes for groups of 3. You will be expected to speak for approximately 10 minutes each, with 5 minutes for questions. You will be penalized if you over-run significantly. The presentation will contribute **40%** towards your total mark and the assessment criteria are available on Moodle.

Report Your completed report should be submitted via Moodle by **5pm on 17th May 2024**. This is to be completed individually and will contribute **40%** towards your total mark. The report assessment criteria are available on Moodle.

4 Teams

Please come up with a suitable team name and use this on Kaggle.

5 Resources

You may find the following resources helpful in designing your own model,

- <https://towardsdatascience.com/deeppicar-part-1-102e03c83f2c>
- <https://coral.ai/docs/edgetpu/models-intro/>

6 Tips

1. Make good use of your Kaggle submissions to test different things. You get 1 per day – don’t let them go to waste! The only submission that matters is your final one – earlier ones have no bearing on your mark, so don’t worry if the test score isn’t great. The best-performing groups last year all made many submissions.
2. Get started **early** and make a plan.
3. Some initial data exploration on the training data will help you understand it better.
4. More tips to come in the introductory session, including lessons from last year!

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