University of Cape Town

EEE3000X

EEE3000X Report - ECE

Author:
Dylan Trowsdale

Student Number:
TRWDYL001

March 31, 2024

Contents

1 African Robotics Unit

2 September - 13 September
16 November - 29 December

1.1 Introduction

During the mid-term vac in September 2023 and during the December holidays I completed 6 weeks of Vacation work at the African Robotics Unit at UCT. The African Robotics unit is a group of robotics researchers at the University of Cape Town who study problems that we as Africans are uniquely positioned to solve. I was hired by the African Robotics unit as a Research Assistant for one of their current projects that involves the study of the biomechanics of cheetahs for bio-inspired robotics. The specific project that I worked on was their 'Cheetah-Bakkie' project where cheetahs at the Ann van Dyk Cheetah Center were filmed in the back of a bakkie using multiple high frame-rate cameras to collect data on how cheetahs use their tails to balance themselves via tail movements and flicks.

2 Objectives, Implementation and Results

2.1 Flick Isolation and frame Synchronization

The first objective that I was given was to analyze high frame-rate videos of the cheetahs from three different angles to find moments in the videos where tail flicks are observed. I was then tasked with trimming the short clips of the videos where the tail flicks were observed and synchronizing these tail flick clips between the different cameras. To time synchronize the three cameras, a blinking LED was positioned in the back of the Bakkie that all three cameras could observe. Using Adobe Premier video editing software, the tail flicks were then trimmed from the high frame-rate footage and synchronized from the closest LED blink before and after the tail flick.

2.2 Camera Calibration

The next objective was to obtain camera calibration data from the cameras for each session of recordings that were performed at the Ann van Dyk Cheetah Center. To perform camera calibrations, videos of a checkerboard of black and white squares of known sizes are recorded with the checkerboard being visible by at least two cameras at the same time. With the use of a Matlab program and the Matlab camera calibration and stereo calibration tool, the intrinsic and extrinsic calibration data was attained so that accurate 3D reconstructions of the cheetahs could be made possible in the future.

2.3 DeepLabCut deeplearning model

The primary objective of this project was to create a DeepLabCut model capable of analyzing cheetah tail flicks from video clips.

DeepLabCut is a cutting-edge method that employs deep neural networks and transfer learning for markerless 2D and 3D pose estimation. This technique allows for accurate tracking and analysis of body movements without the need for physical markers, making it a powerful tool for various applications, including animal behavior studies.

Firstly my objective was to create the DeepLabCut project and label frames from the tail flick clips that were created. Using the DeepLabcut graphical user interface (GUI), I meticulously labeled frames from all three camera angles. Particular attention was given to encompassing a diverse range of poses, videos, and individual cheetahs during the labeling process.

Once a substantial number of frames were labeled, a new training data set was created. The model was then trained on this dataset, initially using Google Collab's Data Center GPUs and later also the powerful Mechatronics server PC situated in a server room at the University of Cape Town. After the training process, the model's performance was evaluated, and then I tested it by analysing novel videos on the model and then creating labeled videos from the analysis. This initial analysis revealed that the model struggled to generalize well to unseen poses and different individuals, necessitating further refinement.

This became a very iterative process. I manually reviewed the labeled videos that were created using the DeepLabCut model. I refined the model by extracting outlier frames from the analyzed novel videos, then labeling the outlier frames, creating a new training dataset, and finally re-training the model.

Training the DeepLabCut model was a very iterative and tedious process that required me to refine the model many times until the desired accuracies and results were attained.

3 Equipment and Principles Involved

Over the six weeks of vac work at the ARU, I gained valuable experience using different software programs, coding languages, and computer systems. When completing the first objective, I used Adobe Premier which is a very popular video editing software. Because the footage was filmed at 120fps a specialised video editing software like Adobe Premier proved to be a very handy tool. To perform the camera calibration, I used Matlab in addition to the Camera calibration and Stereo calibration

Matlab add-ons. To create the deep learning model for the pose estimation of the cheetahs, I used DeepLabCut's software package. While I was creating the model, I was exposed to working with different platforms and computer systems. I used the DeepLabCut GUI to label frames on my PC, I was exposed to using cloud computing as I used a Python notebook in Google Collab to perform expensive computations that working with a deep learning model requires and I also worked with the powerful, headless, Linux server PC that the ARU has based at UCT which was also used for expensive computations and training.

4 Conclusion

During my time spent at the ARU, I was exposed to many different software and hardware systems. I gained valuable experience with Machine Learning tasks and I trained multiple deep neural networks. I was required to learn how to use different software packages and I gained experience working with computationally expensive tasks on different platforms including remote cloud computing and working on a powerful remote server. In conclusion, I believe that I gained very useful experience and knowledge from my vac work at the ARU and I was able to apply much of what I have learned in my ECE course material to the objectives of my lacework. I believe that this experience has taught me a lot and has made me a better engineer.

A/Prof. Amir Patel 04/04/2024