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This chapter describes the history and main business activities of this company.

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Acknowledgment

Abarajithan Gnaneswaran,

Undergraduate,

Department of Electronics and Telecommunication Engineering,

University of Moratuwa.

1 Introduction to Training Establishment

1.1 Company Overview

Commonwealth Scientific and Industrial Research Organization (CSIRO) is the Australian federal government agency for scientific research and development. CSIRO has its headquarters in Canberra, Australia and several branches across the world, with over 5500 employees. CSIRO is known for the development of Wi-Fi, Atomic absorption spectrography and the polymer banknote which have changed the lives of millions of people around the world.

CSIRO consists of many parts: Agriculture and Food, Data61, Energy, Land and Water, Mineral Resources...etc with research centers in several cities of Australia. DATA61 is a part of CSIRO that aims on developing a data driven future for Australia. DATA61 consists of multiple groups: robotics and automation group (RAG), data privacy group, mobile security group, distributed sensor networks...etc.

I worked in the Pullenvale (Brisbane) branch of CSIRO. It is called the 'Robotics hub of Australia' due to the large number of robotics projects, facilities and researchers present in the Pullenvale branch. The robotics and automation group of CSIRO is known worldwide for their state-of-the-art SLAM (Simultaneous Locomotion and Mapping) algorithms.

Fig. 1.1. DATA61 logo

1.2 Company History

It was formed in 2015 by merging NICTA (National Information and Communications Technology Australia Ltd) with CSIRO's data science section.

1.3 Organization Structure and Hierarchy

1.4 Areas of Interest

1.5 Current Situation

The RAG of CSIRO was recently selected as one of the six teams worldwide for the DARPA Subterranean Challenge by United States Department of Defense. Therefore the next four years of research in Robotics in CSIRO will be more focused on developing robots that can simultaneously map and navigate underground tunnels, caves and mines without GPS or reliable communication with humans. For this task, incorporating machine learning into the workflow of algorithm development and testing is of paramount importance for all researches in RAG. I addressed this problem by developing an efficient end-to-end pipeline for this and demonstrating it through two projects.

1.6 Impacts on Sri Lankan Industry

1.7 SWOT Analysis

1.7.1 Strengths

1.7.2 Weaknesses

1.7.3 Opportunities

1.7.4 Threats

1.8 DARPA Subterranean Challenge

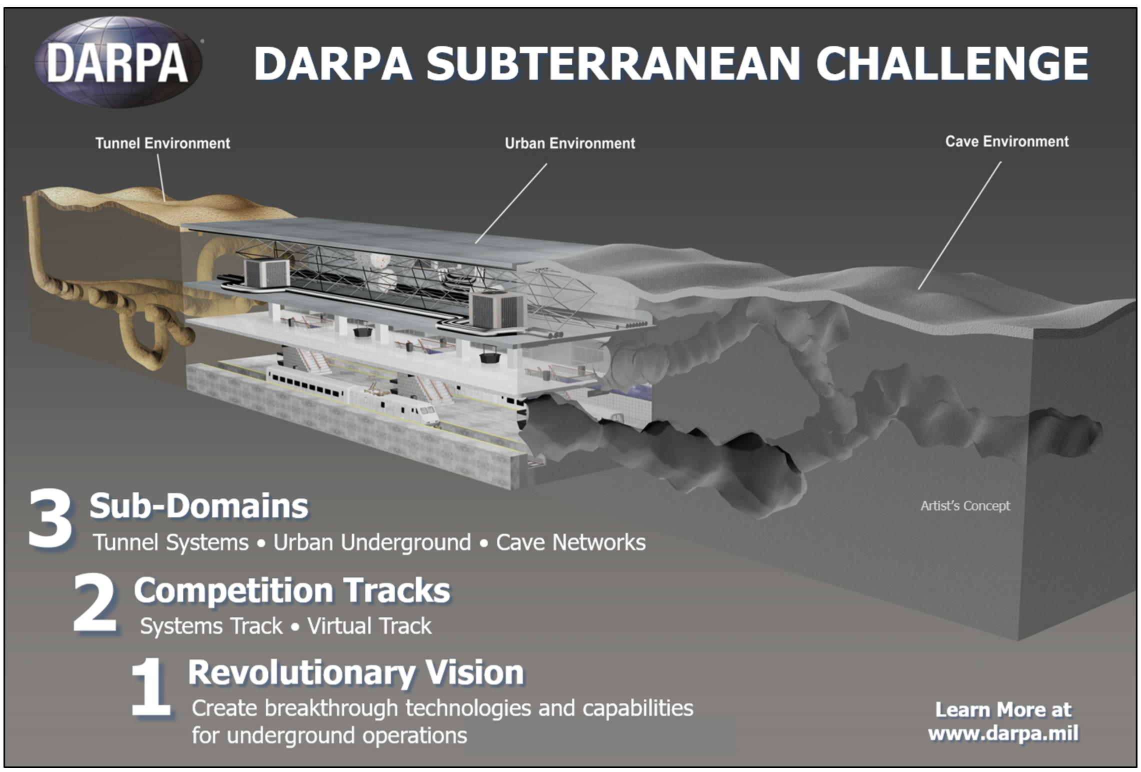

Fig. 1.2. CSIRO focuses on DARPA challenge

1.9 Usefulness to the Country

1.10 Suggestions to Improve the Company

2 Training Experience

2.1 How I got the Opportunity

After graduation, I wanted to continue doing higher studies and become an academic, rather than settling for a job at a company. Therefore, for my internship, I applied for research opportunities in universities and institutes around the world. I got positive response from two or three institutes, one of them being CSIRO. I sent my CV to Dr. Navinda Kottege from RAG, DATA61, CSIRO in February 2018, requesting a research internship opportunity. He asked me to complete a set of 3 timed tasks online to assess my skills in programming and algorithms. He then interviewed and offered me the position as research intern student in CSIRO for 6 months.

Initially I was informed that I am being assigned to the project titled "Computer vision based off-board autonomous UAV Navigation" under the supervision of Mr. Frederick Pauling, a highly capable and friendly senior engineer in DATA61. I was informed that knowledge in ROS (Robot Operating System) and Tensorflow would be necessary, so I spent few weeks learning the basics before the internship.

However, when I arrived at CSIRO, Mr. Frederick Pauling had been promoted into the Group Leader of RAG (Robotics and Autonomous systems Group), to lead the cutting edge robotics research in Australia. Therefore, I could not be assigned into the said project under his supervision. As a result, Uvindu and I was assigned under the supervision of Mr. Nicolas Hudson.

Mr. Nicolas Hudson arrived CSIRO only few weeks before us, after working as a senior roboticist in NASA's Jet Propulsion Laboratory, Boston Dynamics and Google's Machine Learning Division. In CSIRO he wanted to streamline the workflow of the RAG group and incorporate Machine Learning tools into their workflow seamlessly. He asked us to work with him in one of his experimental projects: "Learning Transfer Across RGB, Thermal and IR Modalities in CNNs". After about a week, Uvindu requested for a project that is more focused on hardware. Hence, he asked us to modify Trailnet for autonomous indoor navigation.

2.2 Trailnet: A Classification Network for Autonomous Trail Navigation

2.2.1 Trailnet: An Introduction

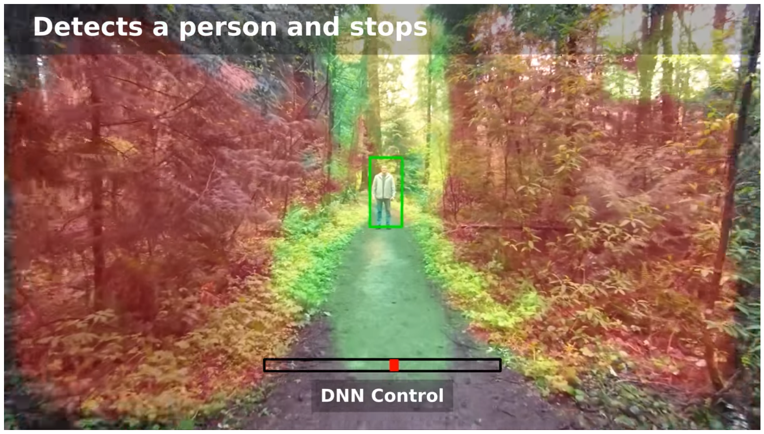

Fig. 2.1. NVIDIA's Trailnet Navigating a Drone

In 2017, four researchers published a paper titled "Toward Low-Flying Autonomous MAV Trail Navigation using Deep Neural Networks for Environmental Awareness" [3] (Trailnet paper in short) with the funding of NVIDIA. The paper describes the following:

- Merits of approaching autonomous navigation as a classification problem
- Architecture of their Trailnet CNN, a modified version of Resnet-18. [2]
- Data collection techniques for the Trailnet CNN
- Training Trailnet with a relatively small dataset
- Hardware hierarchy and the command flow between cameras, NVIDIA Jetson TX2 [1] running ROS and the flight control board.
- Usage of YOLO for obstacle detection and algorithm for obstacle avoidance.
- Results and observations after flying the quadcopter autonomously in the forest trail for several kilometers.

2.2.2 Building Trailnet from scratch

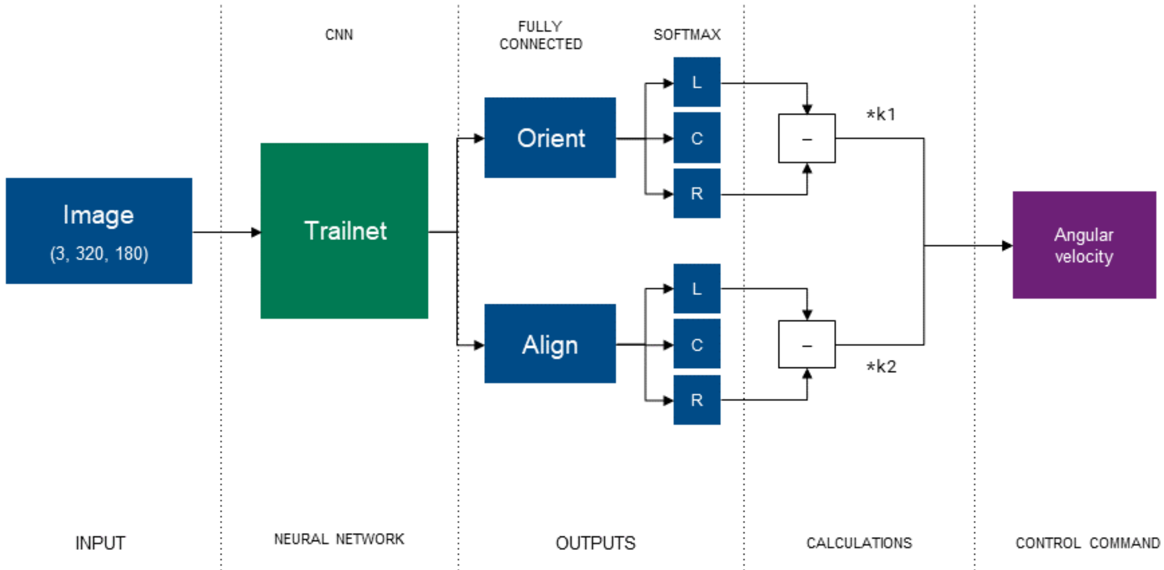

Fig. 2.2. Simplified Trailnet Architecture and Post Processing

2.2.3 Data collection and training Trailnet from scratch

Fig. 2.3. IDSIA Dataset of 40,000 images

Fig. 2.4. Hallway Dataset of 120,000 images

2.2.4 Deployment on a Robot and Testing

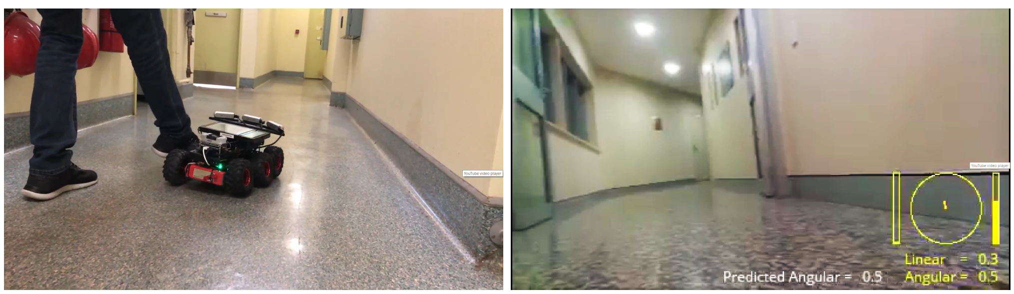

Fig. 2.5. Our indoor Trailnet CNN reacting to external disturbances

Fig. 2.6. Our CNN reacting to corners

2.3 Building Wallie: A Hardware Platform for Data Collection and Deployment

Fig. 2.7. Wallie: The Robot

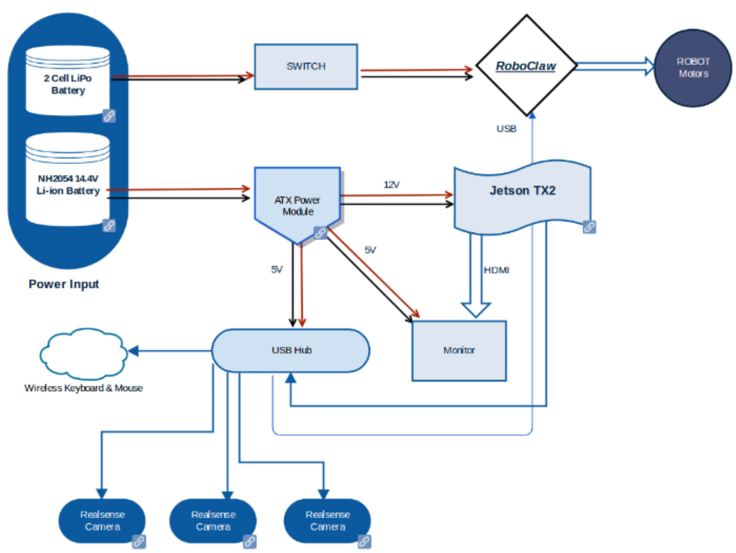

Fig. 2.8. Wallie: Hardware Hierarchy

NVIDIA Jetson TX2

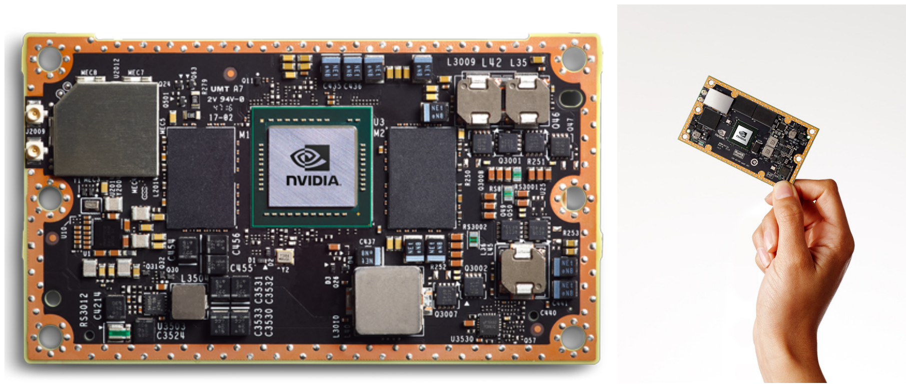

Fig. 2.9. NVIDIA Jetson TX2

Intel Realsense Depth Camera D435

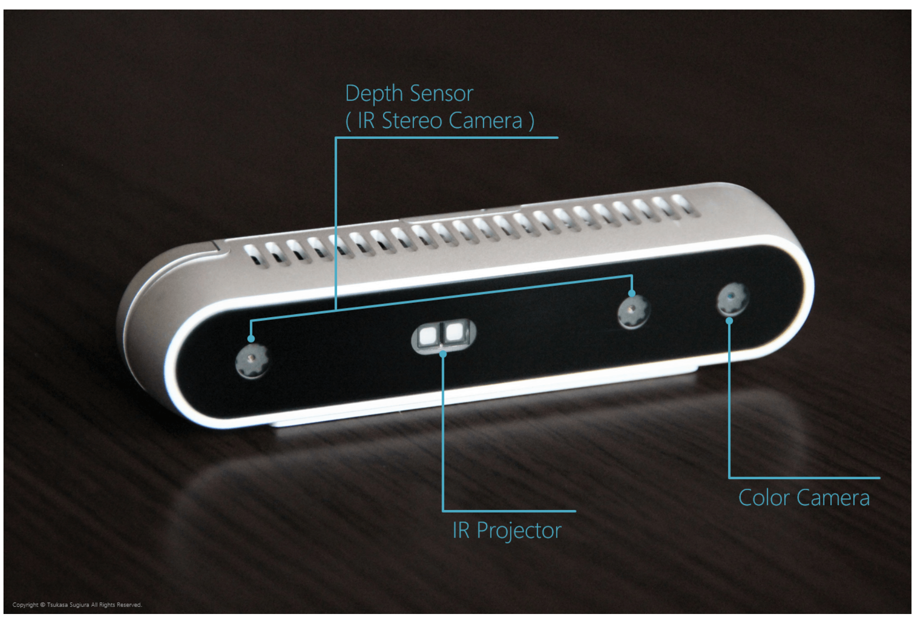

Fig. 2.10. Intel Realsense D435

Roboclaw Motor Controller

Problems Faced and Solutions

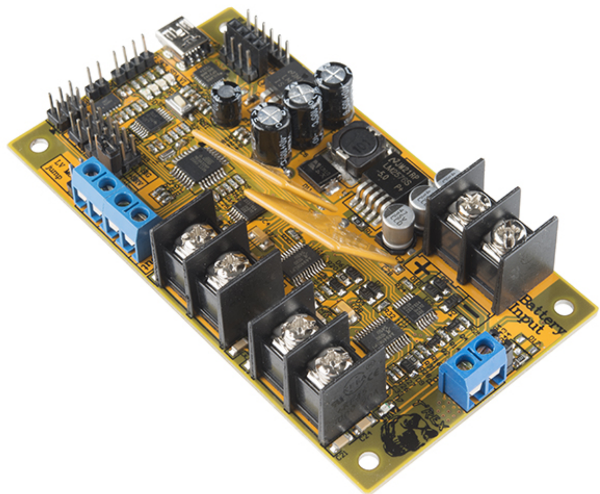

Fig. 2.11. TREX Motor Controller

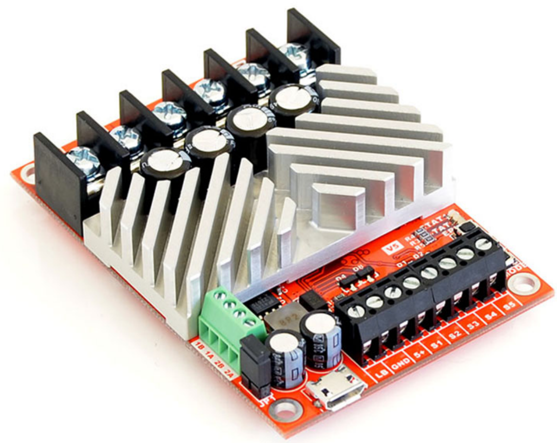

Fig. 2.12. Roboclaw Motor Controller

2.4 Designing and Implementing an Efficient End-toEnd Pipeline for Machine Learning in Robotics

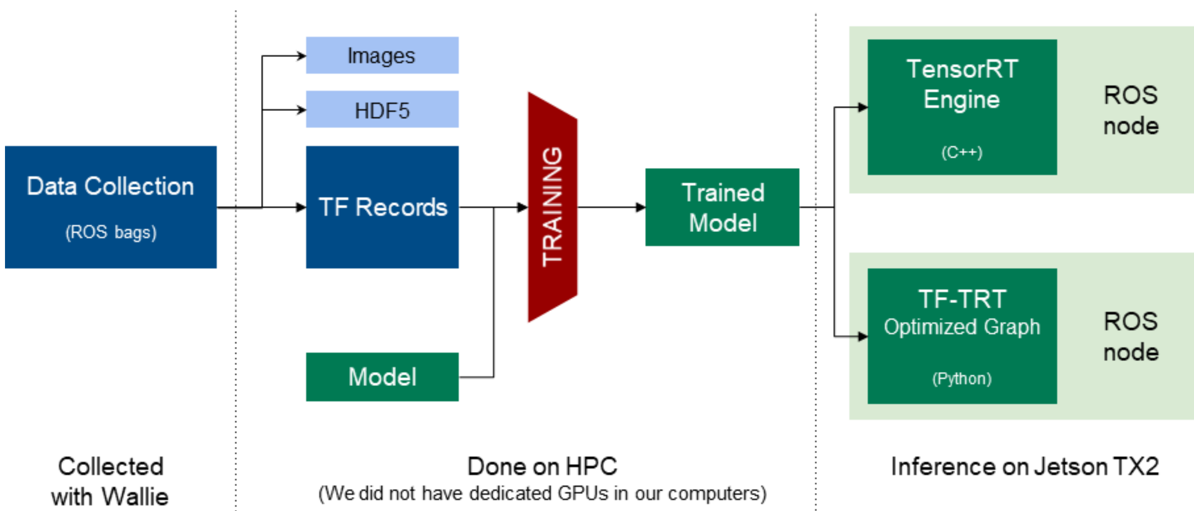

Fig. 2.13. End-to-End Pipeline

2.4.1 Training on Supercomputers

2.4.2 TF Records

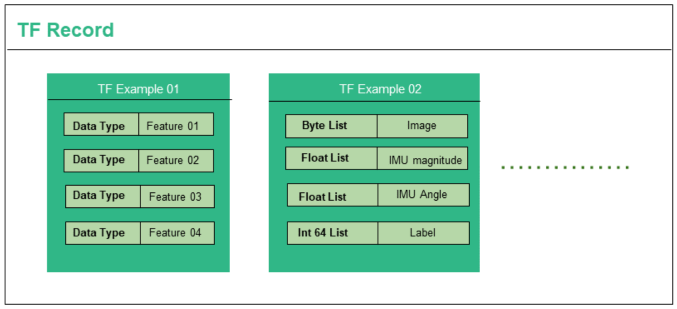

Fig. 2.14. Structure of a TF Record

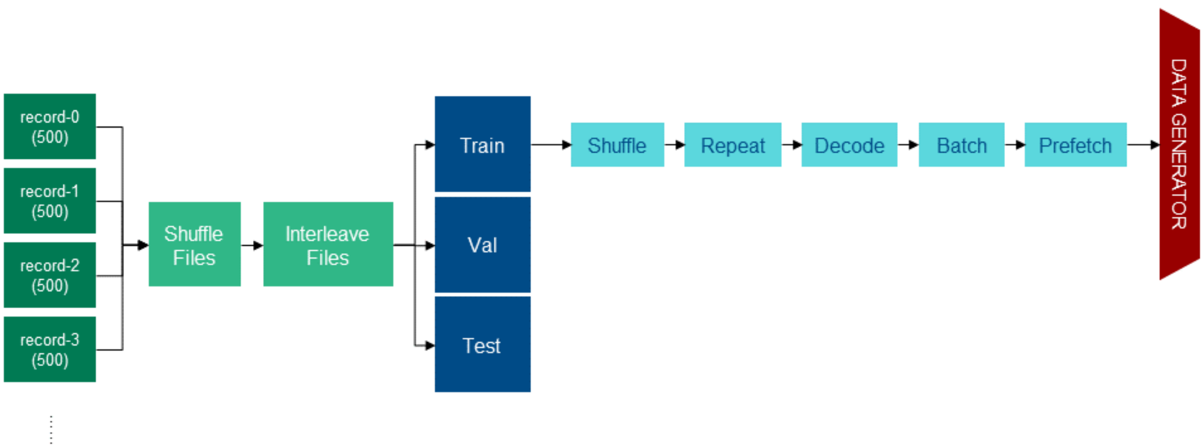

Fig. 2.15. Data Input Pipeline with TFRecords

2.4.3 TensorRT: Deployment on a low power device

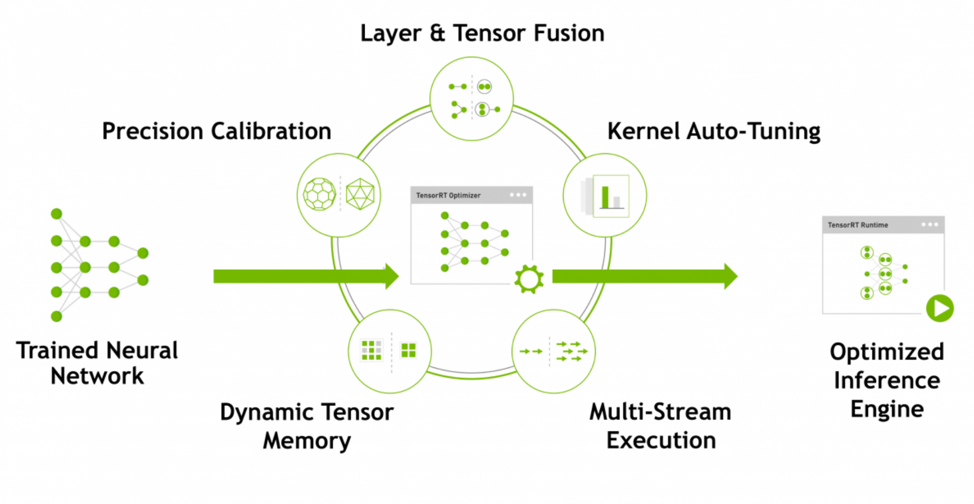

Fig. 2.16. TensorRT in a nutshell

Fig. 2.17. Deployment Pipeline: C++

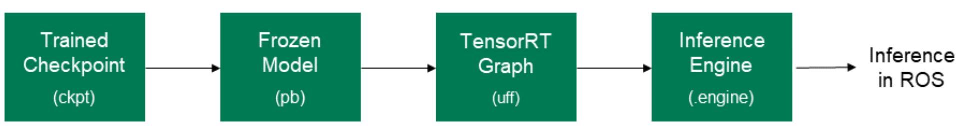

Fig. 2.18. Deployment Pipeline: Python

2.4.4 Problems Faced and Solutions

2.5 Hillnet: An Experimental Attempt at Utilizing ML for Hill Climbing

2.5.1 Preprocessing IMU and Velocity Data

2.5.2 Data Collection

Fig. 2.19. Data collection to train hillnet

2.5.3 Classification Approach

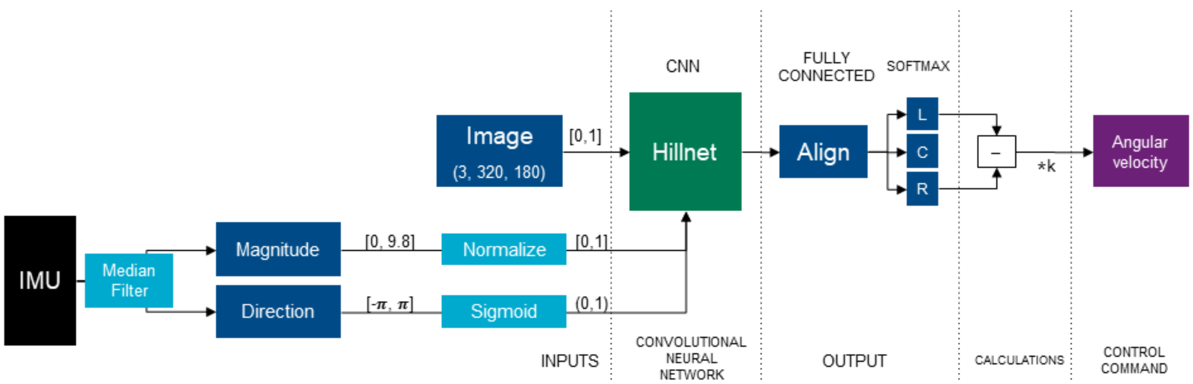

Fig. 2.20. Hillnet Classification Architecture

2.5.4 Regression Approach

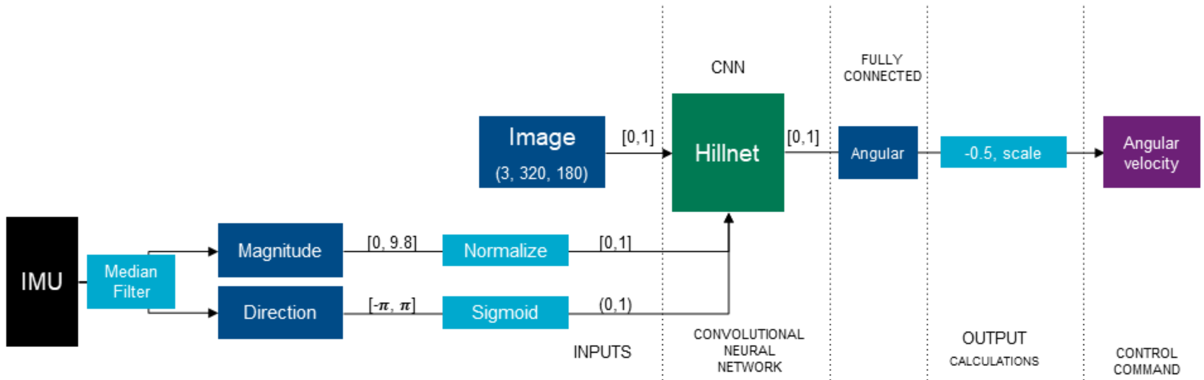

Fig. 2.21. Hillnet Regression Architecture

2.5.5 Merging Scaler and Image Inputs

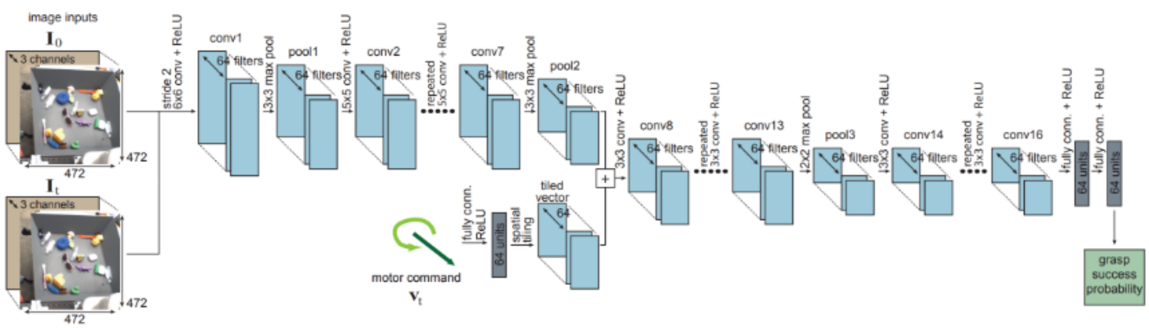

Fig. 2.22. Merging by Broadcast and Add

2.5.6 Problems Faced and Solutions

2.6 Life at CSIRO

2.6.1 Reading Groups and DATA61 Meetings

2.6.2 DATA61 Live Event

Fig. 2.23. DATA61 LIVE Event

2.7 Presenting the Pipeline at Reading Group to the Scientists

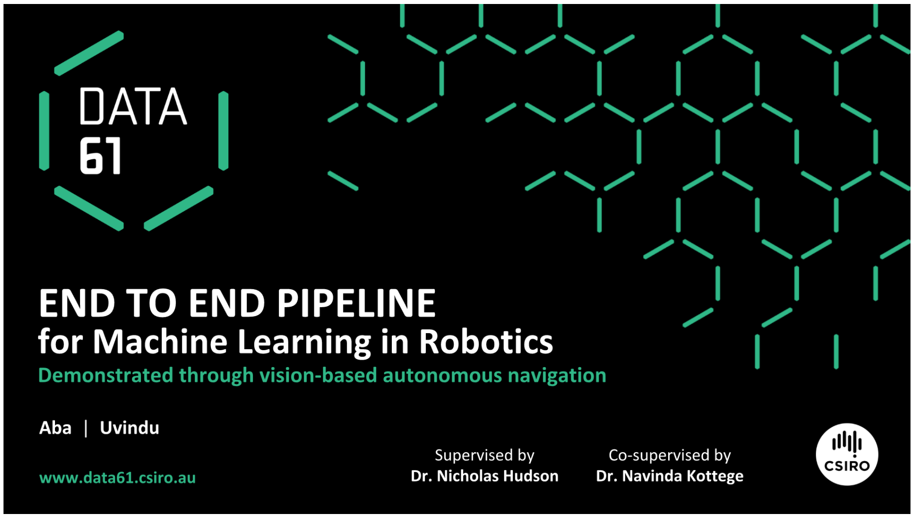

Fig. 2.24. Presenting the Pipeline

3 Conclusion

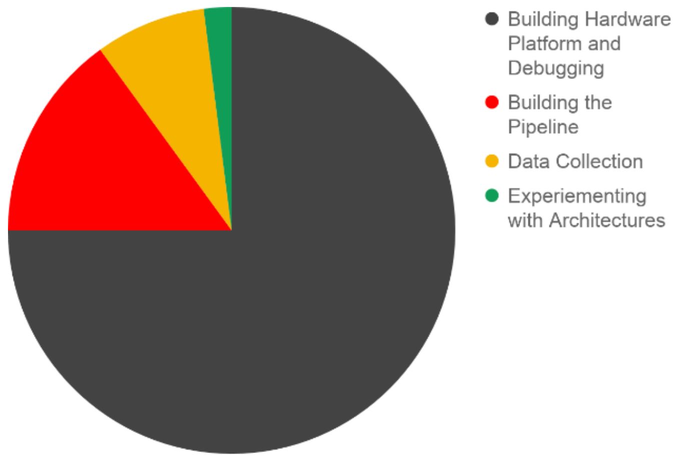

Fig. 3.1. Overview of our time spent

References

[1] Nvidia jetson tx2 module. https://developer.nvidia.com/embedded/buy/jetson-tx2. Accessed: 2018-06-28.

[2] K. He, X. Zhang, S. Ren, and J. Sun. Deep residual learning for image recognition. *CoRR*, abs/1512.03385, 2015.

[3] N. Smolyanskiy, A. Kamenev, J. Smith, and S. Birchfield. Toward low-flying autonomous mav trail navigation using deep neural networks for environmental awareness. 2017.