THE DESIGN AND DEVELOPMENT OF A

Robotic Hexapod Platform

(PART B)

Christopher Lane
BE Network&SE (Hons)
U3170162@UNI.CANBERRA.EDU.AU

Bryce Cronin
BE Network&SE (Hons)
U3173916@UNI.CANBERRA.EDU.AU

UNIVERSITY OF CANBERRA

WE WOULD LIKE TO THANK EVERYONE WHO HAS CONTRIBUTED TO THIS PROJECT. INCLUDING DR. DAMITH HERATH, DAVID HINWOOD, CHARLES RAFFAELE, JEDIDIAH HODSON, AND DYLAN MORLEY.

The robotic hexapod platform (pictured) **was created in response to the University of Canberra (UC) seeking practical teaching resources for the newly created robotics classes being offered. Our robot hexapod design provides a powerful platform for future upgrades, developments, and research to take place. All code and physical components were designed so that they can be easily modified by students to assist with their understanding of robotics concepts. In addition to creating a platform, code was also developed to perform simple actions such as walking and waving in order to provide a starting-point for students to develop their own code.**

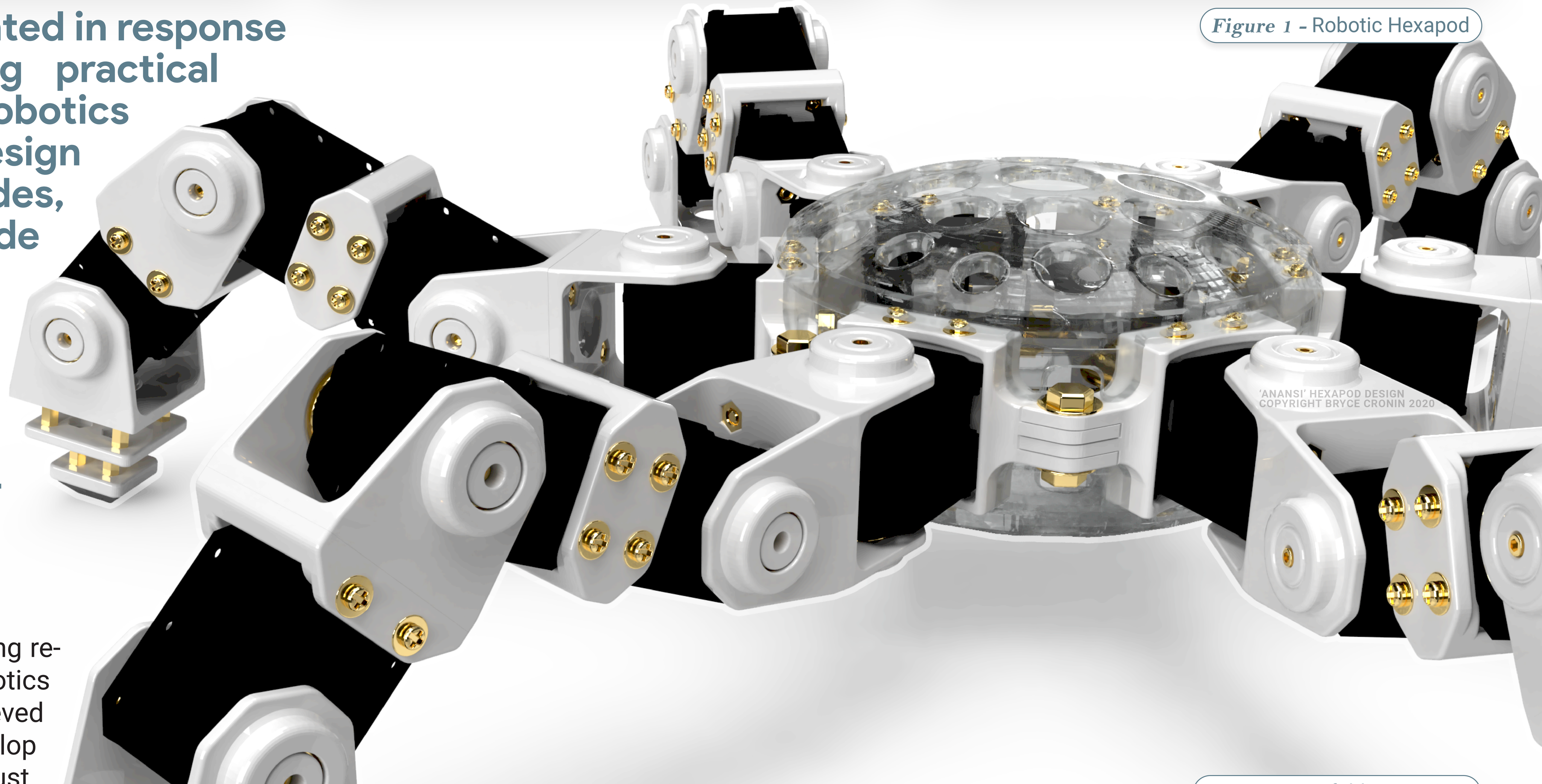

Figure 1 - Robotic Hexapod

Background

UC approached us to design, manufacture, and program a practical teaching resource for use in the 'Foundations of Robotics (11370)' and 'Advanced Robotics (11479)' units. We had the freedom to choose any form of robot that we believed would be beneficial for our fellow students. We ultimately decided to develop a hexapod - a robot with six legs. The only condition was that our robot must provide a platform for future upgrades and developments to easily take place.

A hexapod was chosen over a more traditional robot design as it caters for both introductory robotics concepts found in the 11370 unit, as well as advanced robotics concepts found in the 11479 unit. The inclusion of six legs also provides a lot of flexibility, especially in navigating uneven terrain or continuing to operate even if some legs become disabled.

Design

We've designed our robotic hexapod to be an excellent starting point for future developments, upgrades, and research to take place. Creating a design that is extremely modular and intuitive was essential in achieving this. All major components were designed to be easy to edit using the Fusion 360 Computer-Aided Design (CAD) software, as well as easy to 3D-print. For example, by rearranging the order of components you can extend, shorten, or even completely relocate the joints in each leg. The radially symmetrical design also allows for additional legs to be added, or for legs to be removed.

The internal electronics components were designed in such a way that allows for additional electronics to be added in the future that can communicate with existing electronic components This allows for future additions to be easily added, as seen in [Figure 5]. Up to 2kg of additional sensors and equipment can be supported by the hexapod. Rigorous testing of 3D-printed components was required to ensure that every individual component was up to this strenuous task.

Components

Where possible, parts were designed in CAD and 3D-printed. This allowed us to forgo purchasing expensive off-the-shelf robotics components. Polylactic Acid (PLA) plastic was chosen for 3D-printing due to its low cost, high strength, and ease. Where it wasn't possible to 3D-print, high-end hobbyist components were selected for use. A breakdown of selected electronic components and associated wiring diagram can be found below.

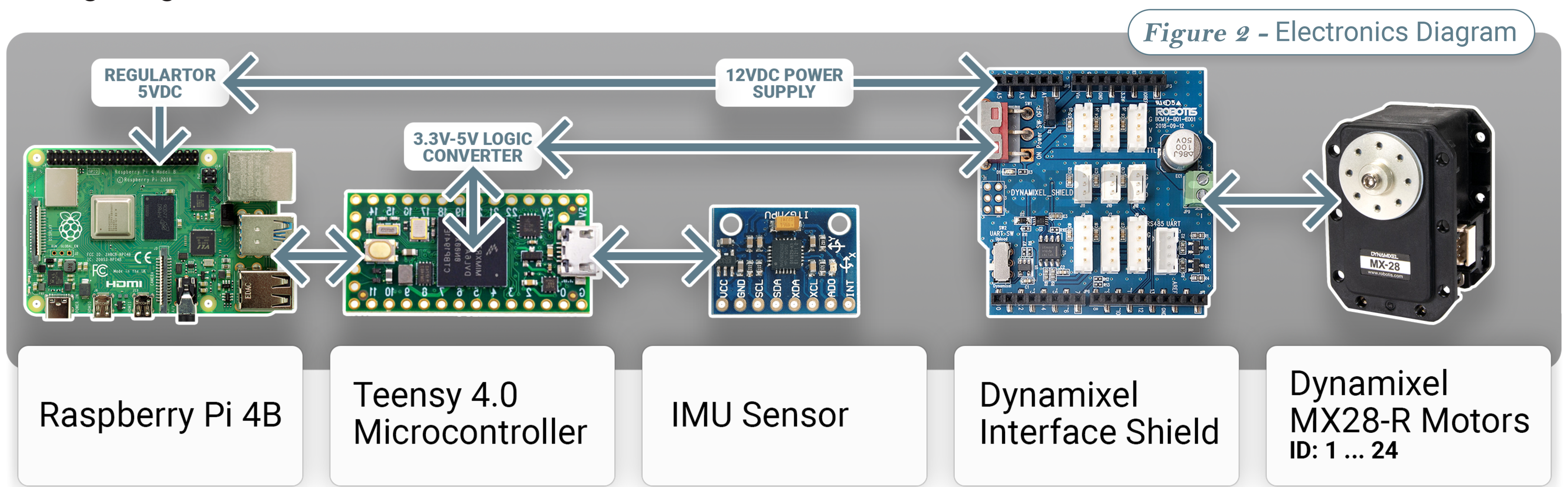

Figure 2 - Electronics Diagram

- **Raspberry Pi 4B:** This is used as the "brain" of the hexapod, co-ordinating power and messaging to the Teensy microcontroller and Dynamixel shield.
- **Teensy 4.0 Microcontroller:** Acts as the traffic controller for sending messages between electronic components. It manages sending motor commands to the Dynamixel shield and receiving sensor data from IMU sensor and the 24 Dynamixel motors, which is sent to the Raspberry Pi for processing.
- **IMU Sensor (x2):** Sends accelerometer, gyroscope, and compass sensor data to the Raspberry Pi, allowing for multi-axis motion tracking of the hexapod.
- **Dynamixel Interface Shield:** This is the hub for the Dynamixel motors. This shield is connected to our custom made "Control-inator" board, which allows for the addition of extra motors or other electronic devices.
- **Dynamixel MX28-R (x24):** These high-end motors are fast, strong, and accurate motors, especially considering their small size. They have low latency and provide high-precision feedback.
- **Logic Converter:** Due to varying voltage requirements, this component is able to convert 3.3V to 5V and vice versa so that all components receive their correct input voltage.
- **Power Supply:** Converts 240VAC to 12VDC 26.8A, allowing all components of the hexapod to be powered to the point of their maximum energy draw.

Development

Our hexapod has been developed with flexibility of movement in mind, allowing it to traverse uneven terrain and be used in gesture-based communication for Human Robot Interaction (HRI) experimentation. Unlike traditional hexapod designs that usually have two or three Degrees of Freedom (DoF) in each limb, ours has four DoF in each limb. This allows for our hexapod to perform a wide variety of programmed actions, such as those seen in [Figure 3] and [Figure 4].

Figure 3 - Unfolding Motion

The software architecture of the hexapod is built upon the commonly used open source software known as ROS (Robotic Operating System). ROS is a simple and flexible middleware that allows for high speed synchronous control of the robot's motors and sensors. The advantage of building our system architecture with ROS is that it is capable of integrating a huge collection of libraries and tools making future upgrades easier and better integrated.

Walking

Hexapods can walk in a variety of ways depending on requirements for speed and stability. Our hexapod currently moves in a tripod gait, meaning that it will alternate three legs on the ground and an opposing three legs in the air at any time in its movement (see [Figure 4]), this provides a combination of speed and stability that is only possible with a hexapod design. With future upgrades made possibly by ROS, the hexapod will be able to have a dynamic gait. This means that it will be able to change its footing and posture based on the terrain beneath it, achieving better balance and natural movement.

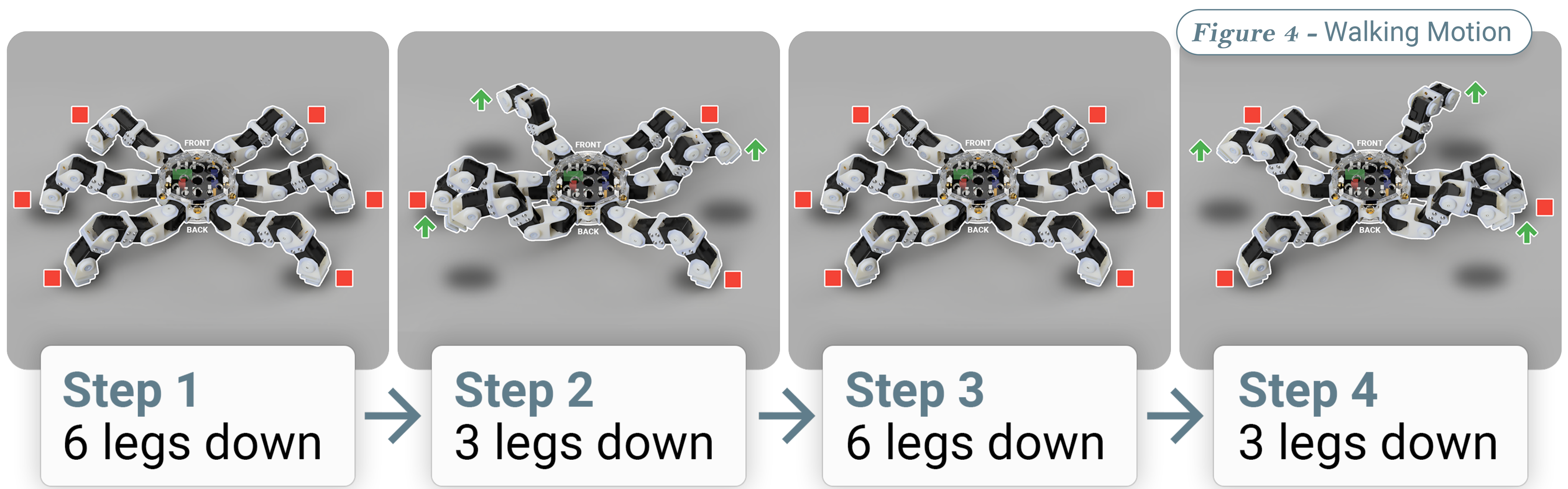

Figure 4 - Walking Motion

Other Movements

- Fold and unfold itself from a tight ring into its standing position, see [Figure 3].
- Adjust it's posture and centre of gravity on uneven terrain, giving it better static stability.
- Flip itself over and continue to perform actions (such as walking) while upside down.
- Gesture and pose to human collaborators giving it a method of expression intention and communication to non-technical personnel in the field. (waving, tapping, beckoning, etc.)

Conclusion

Based on test results and sponsor feedback, we're confident that we've created a powerful platform for many years to come that will assist students understand robotics concepts. Our hexapod and its potential applications in HRC was also presented to the Engineers Australia undergraduate project presentation competition, achieving 2nd place overall. We're extremely proud that our hexapod has already made a positive impact at the University of Canberra and hope that it will continue to do so through future upgrades and research, such as those proposed in [Figure 5].

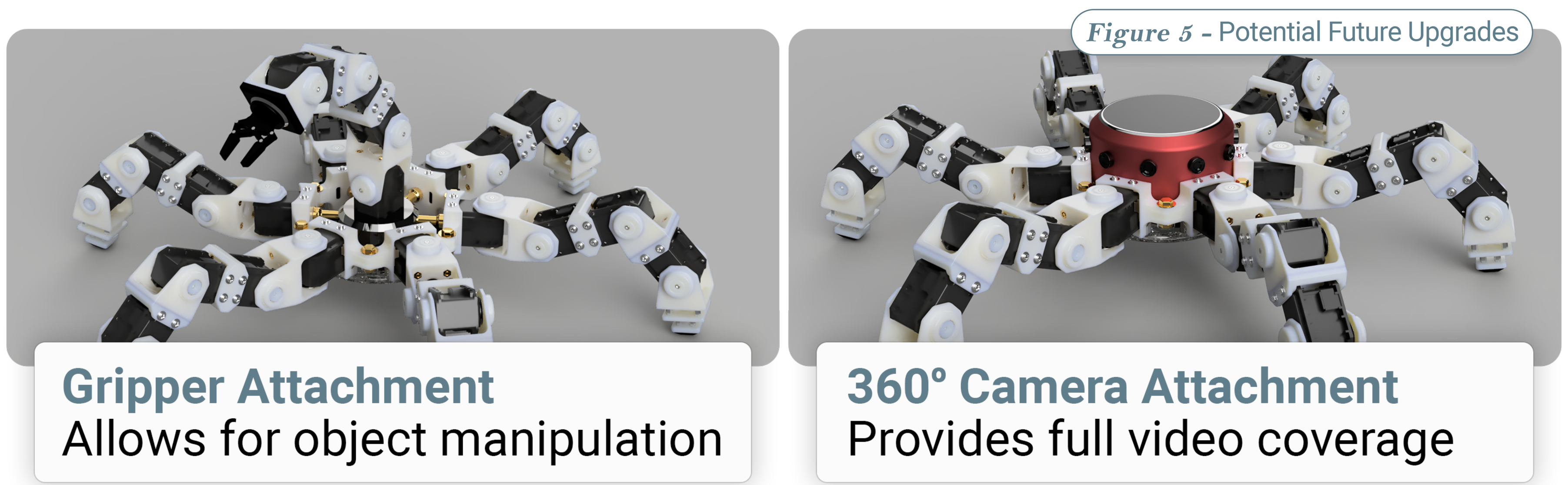

Figure 5 - Potential Future Upgrades