Project 2 Robot Arm Research

Articulated Joints, Gears and Cogs, Power,

Control Systems and Programming

The use of articulated joints within the design and build of robotic arms is crucial to the operation of the arm. There are 5 main types of joint used: rotational, linear, twisting, orthogonal and revolving joints (Robotics Bible, 2011). These joints are used in different sections to create the necessary degrees of freedom for the robot to perform its preselected task. Rotational joints allow for “movement in a rotary motion along the axis that is vertical to the arm axes” (Robotics Bible, 2011). Linear joints are used when “translational and sliding” (Robotics Bible, 2011) movements are required. Orthogonal joints are extremely similar to linear joints, with the only difference being that “the output and input links move at right angles as opposed to vertically” (Robotics Bible, 2011). Twisting joints “make a twisting motion between the output and input link when the output link axis is vertical to the rotational axis” (Robotics Bible, 2011). The revolving joint is used to spin the output link around the input link, with the “output link axis being perpendicular to the rotational axis and the input link being parallel to the rotational axis” (Robotics Bible, 2011).

“Gears are used to transmit power from one part of a machine to another” (Woodford, C. 2019). This means that gears are used thoroughly when designing and building robotic arms. “Gears are used to transmit torque, with the teeth of the gears which mesh together being called cogs” (LSNED, 2012). The main types of gear are as follows: spur, helical, bevel, rack and pinion and worm gears (Mechanical Booster, 2019). Spur gears are the simplest type of gear and feature straight teeth, “used to transmit power between parallel shafts and is usually used to increase or decrease speed” (Mechanical Booster, 2019). Helical gears feature gears with teeth that are cut at an angle to provide smoother and quieter operation than spur gears but are usually used for the same purpose (Mechanical Booster, 2019). Both spur and helical gears are usually found within gearboxes. Bevel gears are used to change the direction of torque by “transferring power between two non-parallel shafts” (Mechanical Booster, 2019). These gears are usually used within differentials. Rack and pinion gears are usually used for steering and are made up of a straight-line gear (rack) and circular gear (pinion) that mesh together to transmit torque (Mechanical Booster, 2019). Worm gears consist of a gear that is in the form of a screw (worm screw) and a straight cut gear, similar to a spur gear (worm wheel). These gears are commonly used when “large gear reductions are required” (Nice, K. 2019). The design of the screw and wheel also means that the gear can act as a brake, as it is unable to spin backwards. This makes this system well suited to conveyor systems and also the Torsen differential (Nice, K, 2019).

Robot arms can be powered in a multitude of different ways, most commonly through the use of a mains socket or through batteries. Rechargeable batteries are an extremely good choice to use to power robots, as they allow the robot to be mobile and do not require replacing, which in the long run is more efficient than standard batteries (Learning About Electronics, 2019). It is crucial that certain arms use battery power because they are required to be mobile to be used in places in which mains power is not available. Examples of mains powered robots are most “six axis robot arms and collaborative robots” (Engineer Live, 2018). These robots use mains power due to their fixed locations, as this provides a constant power source and doesn’t affect the function of these types of robot, as their bases are not required to move when they are in operation. The electricity that is received from the power source is used to power all of the components inside of the robot, from the microprocessor to the servomotors.

Robotic arms use mapping processes in order to perform their job. When programming the robot to do its required job, the robot will be manually controlled. This is so that the exact instructions that the robot will need to adhere to can be given and the robot can then learn these instructions. After the learning process, the robot will be able to perform the tasks that were once controlled autonomously, using the mapping process to remember exact coordinates and movements that the arm needs to move to (Maxwell, R. 2013). This process of mapping is similar to Simultaneous Localisation and Mapping (SLAM) robots, which use “a multitude of computations, algorithms and sensory inputs” (Maxwell, R. 2013) to create a virtual map of its surroundings. The robots then use this map to navigate areas that were previously unknown to it and it will have a clear image of its position and what its surroundings are.

To control a robotic arm, a microprocessor unit is used. A microprocessor is “a component that performs the tasks involved in computer processing, executing and managing the logical instructions passed to it” (Techopedia, 2019). These microprocessors are often used in single board computers such as the Raspberry Pi 4 and Braccio Shield V4, which is the single board computer used to control the Braccio T05000 TinkerKit Braccio Robotic Arm. Microprocessors are built on silicon chips, with silicon being used because of its “abundance and semi-conductive properties” (Templeton, G. 2015).

Microprocessor chips are programmed with code written in programming languages such as C++, Python, Java, etc. (Weinberger, M. 2015). This type of language is called a “high level language” (Dev, R. 2012) because it consists of mostly English words, some of which are misspelt, but allows humans to understand the code easier. Once the code is written in a high level language, it will be translated into a low level machine language, written in binary. This allows the machine that the code has been written for to understand the instructions that it has been given (Dev, R. 2012). There are also mid-level languages such as C, which “contains aspects from both high level and low level languages” (Dev, R. 2012), being a mixture of words and binary.

“Wireless communication is used to transfer information or control a robot with an external controller (handheld controller, phone, tablet, etc.) without a physical connection” (Robot Platform, 2019). The communication can be made using many different systems. These include infrared light, radio frequency, Wi-Fi and Bluetooth (Robot Platform, 2019). Infrared light is a simple way to control a robot, with the controller transmitting a beam of infrared light and the robot receiving the transmission, which is then decoded by the microcontroller (Robot Platform, 2019). Infrared light is not the best form of transmission, as it requires direct line of sight with the receiver on the robot to function (Robot Platform, 2019).

Another way to control the robot is by using radio waves. This technology is usually used in remote control vehicles (planes, boats, cars, etc.) and works in a similar way to infrared communication. A radio wave is sent from the controller and is detected by the receiver, which is then decoded by the microcontroller (Robot Platform, 2019). Wi-fi allows robots to be controlled through an internet connection between the controller (usually a phone or a tablet) and the robot. This is done by the controller converting digital signals to radio signals through a wireless network adapter before sending these signals to another network adapter inside of the robot, which then converts the radio signals back to digital signals. These signals can then be decoded by the microprocessor (Robot Platform, 2019). Bluetooth is used in mobile phones to transfer data from one device to another but can also be used to control robots by installing a Bluetooth receiver. This system can then be used to “transfer large amounts of data from the controller to the robot” (Robot Platform, 2019). The microprocessor can then decode these signals.

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