SASTA OLIPHANT
SCIENCE AWARDS

Prize Winner

Programming, Apps & Robotics

Year 5-6

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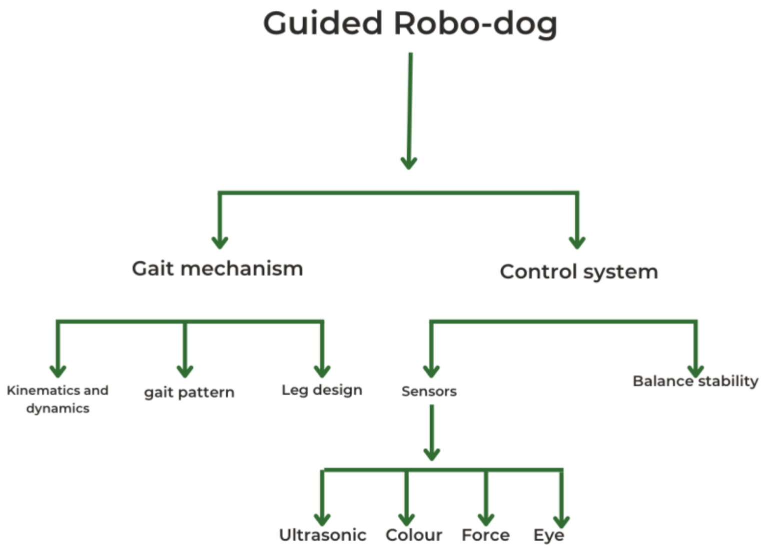
Guided Robodog

Guided Robo-dog is a four-legged robot designed to help visually impaired people to navigate through public places such as shopping centres, hospitals, parks etc. Safely and independently, similarly as companion dogs. They offer physical and mental benefits in the daily lives of people who needs assistance.

Where did the idea come from?

I recently went to the airport to drop off my grandparents and saw a visually impaired man who had a guided dog and I ask a few questions about how hard it is to have the dog while flying on a plane and being on the airport and he replied ‘travelling with a guide dog is possible but very difficult because of the quarantine and all the paperwork that you have to fill’. There it stunned me! What if I create a guided robot dogs which could solve the situation for a lifetime.

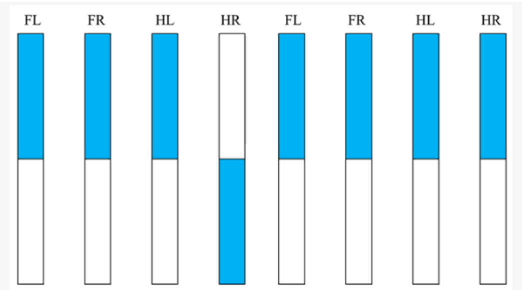
To build a Robo-dog we need to establish the connection between the gait mechanism (physics), and the control system (technology).



When the robot dog moves, it follows different foot fall movements which depends on following scientific reasons.

The gait patterns

The common gaits of bionic robots mainly include crawl, trot, pace and bound. The Crawl gait is a common gait. A robot in a crawling gait will have four legs. One leg is lifted, while the other three legs form a stable triangle area. When the robot dog switches from the front left leg to the rear right leg, the centre of gravity of the robot dog switches from one side of the support to the other side and creating strong endurability. As a result, the crawling gait has high stability at this time, the stability of the system is greatly enhanced, however at



the same time, the speed of the system. FL, FR, HL and HR represent the front left foot, front right foot, hind left, and hind right respectively. For an example If HR is lifted then FL, FR, HL forms a support for HR leg. Shown in the diagram below.

1. kinematics and dynamics

Kinematics and dynamics of robot manipulators are fundamental to its technologies. The kinematics is the science of motion that does not consider mass and moments of inertia. It refers to all of the geometrical and time-based properties of the motion. The dynamics is what represents the relationship between the joint torques and the robot motion. Both models are used widely in the simulation of motion, analysis of robot manipulator structures, and design of control algorithms.

2. Leg mechanism

Leg mechanism is a mechanical system consist of rigid links that connected with joints and joints movements which allows relative motion of the neighbouring links. The joints have different degrees of freedom, where number of freedoms is equals to the number of independent parameters. Joint movements achieved by deploying actuators.

3. Joints

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The robot dogs have 3 main joints hip, knee and ankle. Each joint contributes to one or more DoF.Each DoF corresponds to a specific type of movement like rotation, translation. The robot's leg hip joint typically includes 3 main DoF which allows legs to move forwards and backwards. There is a single DoF involved in the knee joint, allowing the leg to bend and straighten. Ankle joint consists of 2-3 DoF which permits foot to move side by side.

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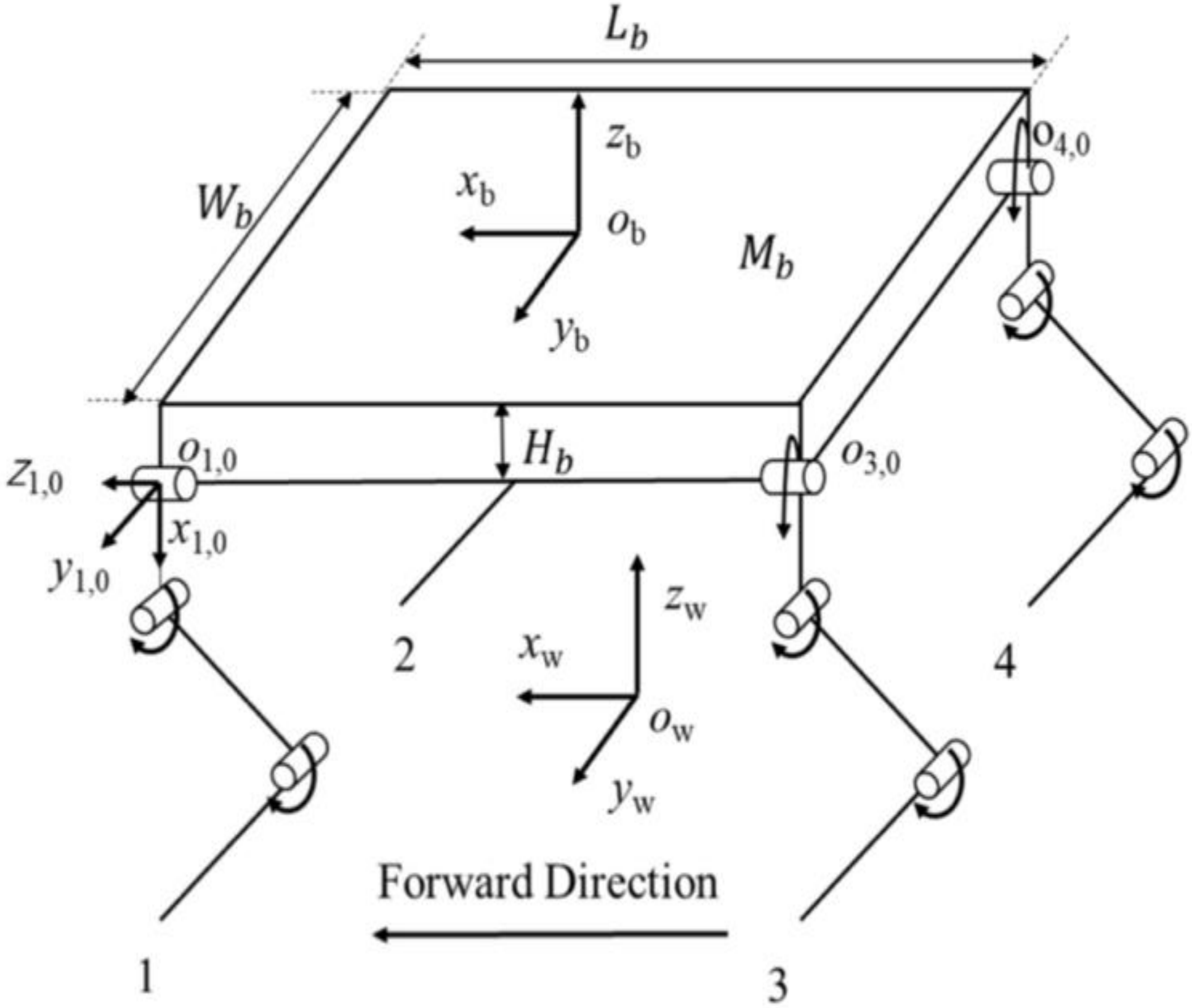

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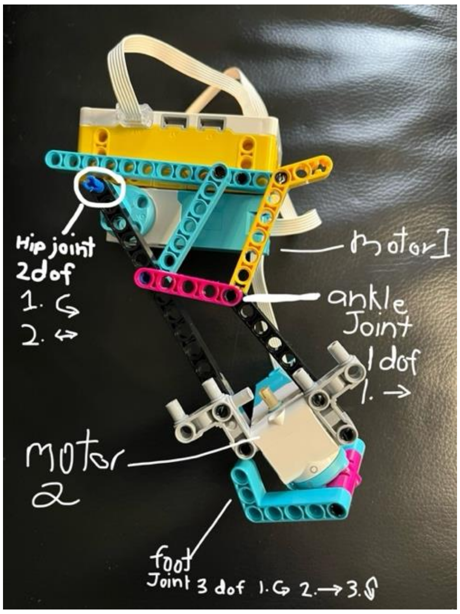
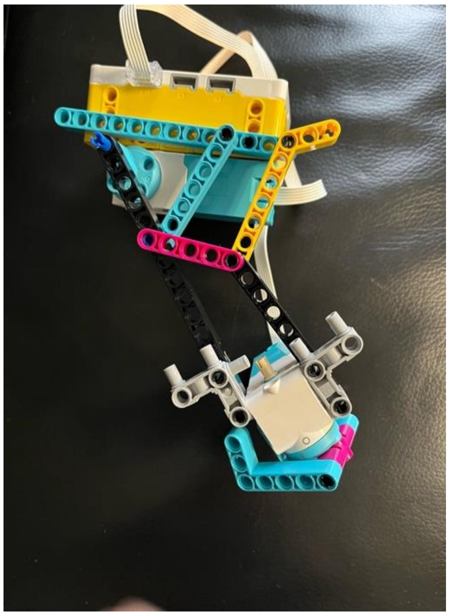
Forward Direction

Innovation in my Robo-dog





I have added an extra degree of freedom to the robot shown in the pictures.

4. **Actuators**

Now joints mechanism can be achieved by rotational actuators aligning with different axises. Actuators are devices that enable movement in the robotic dog's limbs and body. These can include electric motors, hydraulic systems, or other mechanisms that provide the necessary force and control for movement.

Control system

Control System of a robot dog is an intricate integration of hardware and software design to manage its movements, maintain balance and stability and interaction with environment.

1. **Balance and stability**

Balance and stability are achieved by combining hardware design, sensor and software.

CoG is very important factor in constructing the robot. The CoG is the point where the entire weight of the system is evenly distributed. CoG is a critical factor in gait's stability and performance. If CoG is not properly located, the robot maybe unstable and can increase the chance of tipping over creating a safety hazard. If CoG is located at the wrong height robot will reduce mobility.

2. Sensors

Robot dogs are equipped with various sensors to perceive their environment and gather information. These sensors can include cameras, microphones, touch sensors, distance sensors and colour sensors. Sensors provide data about obstacles, sounds, and other factors that influence the robot dog's behaviour.

Ultrasonic sensor

The sensor can measure the distance to an object or surface using ultrasonic technology. In addition, the sensor has a light output which, is divided into four segments that can be activated individually Ultrasonics is the science of sound waves above the limits of human audibility. I have used the sensor to detect pedestrians, trees and other object in the way of the robot dog making sure it does not bump into anything.

Force/touch sensors

Force Sensor is a physical input sensor that can be programmed to detect when the amount of force is being applied in units called Newtons. Pressing harder means more force is being applied, so the number of Newtons shown will be higher. My robot’s use of the force sensor is if the robot gets pat it will stop and say do not do that again.

Colour sensor

Colour Sensor is designed to detect and identify colours such as green grass, grey roads, allowing the robot to interact with its environment based on colour inputs. The Colour Sensor works by emitting light and measuring the intensity of light reflected back from a surface.

Eye/camera sensor

It absorbs particles of light through millions of light-sensitive pixels and converts them into electrical signal. These electrical signals are then interpreted by a computer chip, which uses them to produce an image.

Gyro sensor

The Gyroscopic Sensor is typically used to measure rotational speed, but it can also calculate rotational change. When the robot dog turns around, the Gyro Sensor can measure the robot's turn rate, in degrees per seconds. So, gyroscope can be used to measure DoF.

The Gyro Sensor detects rotational movement. If you rotate the Gyro Sensor in the direction of the arrows on the case of the sensor, the sensor can detect the rate of rotation in degrees per second. You can use the rotation rate to detect if the robot is falling over or getting knocked, in addition, the Gyro Sensor keeps track of the total rotation angle in degrees. You can use this rotation angle to see how far your robot has turned.

Challenges and how I overcame them

During the construction and coding of the guided robo-dog I've faced many challenges and those obstacles I overcame by basic physic law and power of technology. I am explaining three main challenges below.

1. My first problem was making the the robot walk straight-The robot would always drift to the right every single time. I got very frustrated but after doing some research, discussed with my teacher and parents. I found the solution; I have applied the gyroscope sensor. When it turns more than 2 degrees of yaw then the gyro sensor would bring it back to 0 degree that made the robot walk straight. However, the problem was not completely solved. The robot would still drift a tiny bit but after chatting with my parent, I realise the CoG is shifting (explained above in the gait mechanism) To achieve CoG we have added some weight on the left side. That made the robot stable in all positions. After all of that hard work, the robot finally went perfectly straight when needed.

2. My second challenge was the grip of the robot dog. When the robodog walked it was slipping over because of the less friction. After discussing with teachers and my parents I put on masking tape to make the surface rougher however it was not enough hold. Then I did some research and found that this is a very common problem and the best way to fix it is to add sandpaper creating more friction to the bottom of the robot's feet so, it would grip more, and that worked.

3. Another problem was the robot walking on grass (different surface). When the robot was walking on grass it was getting stuck. So, I realised that I needed to adjust the speed and in simple physics I have increase torque from 25% to 50%

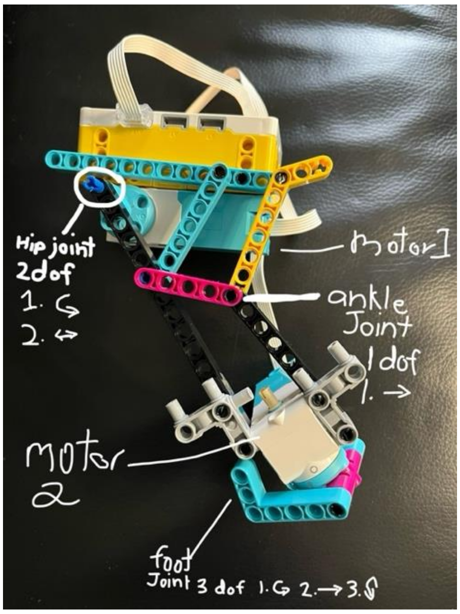
speed when the robot sensed grass through colour sensor. After having multiple experiences, I have applied different torque and speed. Through this experiment I reached to the concluded speed and torque that worked perfectly on the grass. This is very simple problem however robo-dog needs to sense different surfaces every-time it walks and needs to make the robo-dog at a constant walking speed by applying torque according to surface.

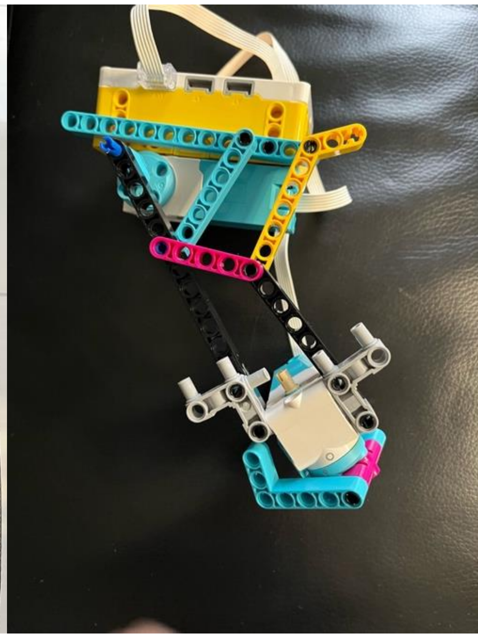
What is torque?

Torque is the measure of the force that can cause an object to rotate about an axis.

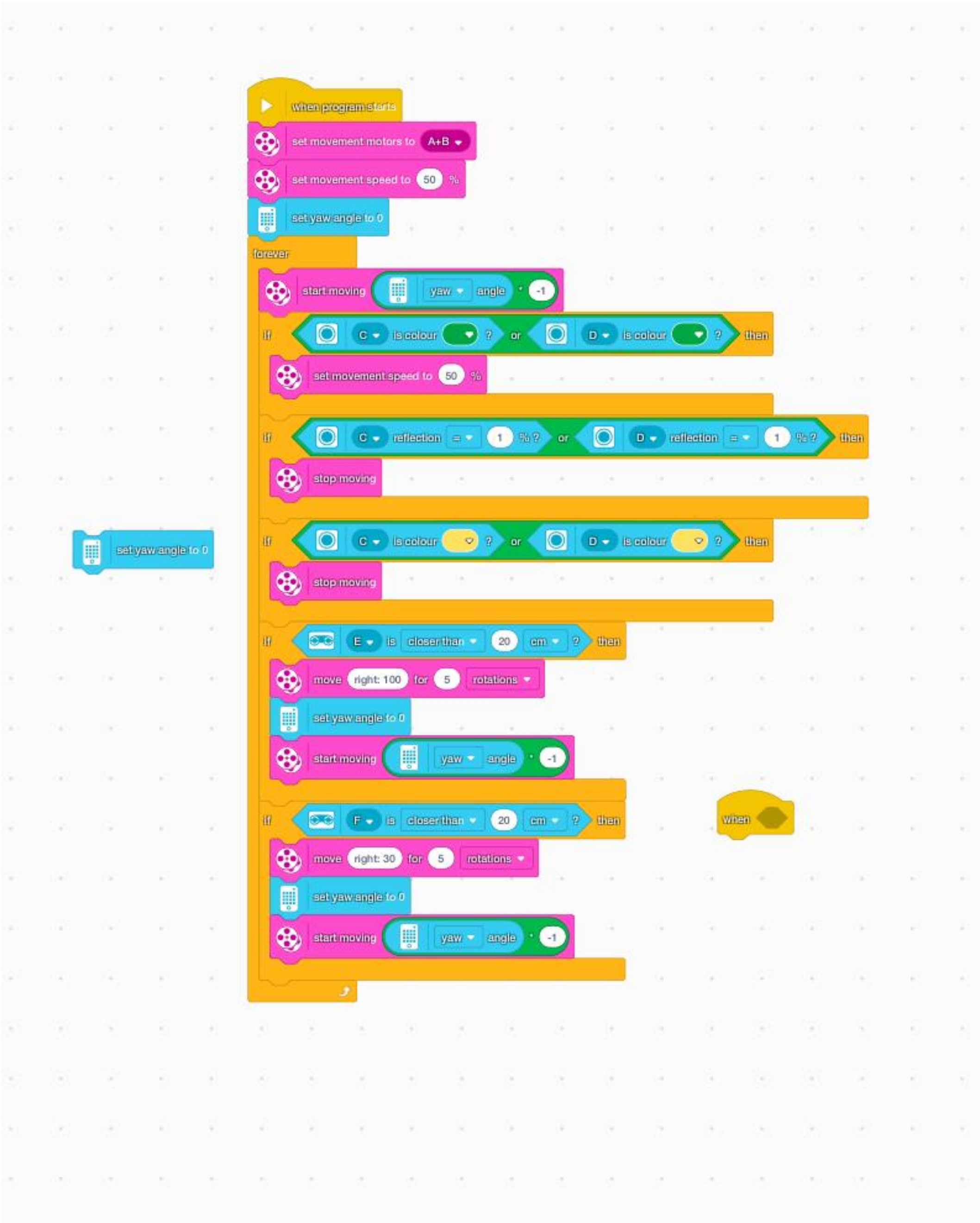
Innovation in my robo-dog project.

I have added an extra degree of freedom to the ankle joint. Traditionally ankle joint has two DoF. I have achieved an extra DoF by adding a motor link mechanism which allows ankle to rotate 360 degrees. By adding this feature, we are getting quick responsiveness and flexibility. As show below in the figure and the separate model for one leg only due to limited resources.





Programming



Applications and Benefits of Robo-Dog

- Utilising advance sensors and AI to detect potential hazard that a guided might miss such as fast moving vehical, low hanging obstacles and etc.
- By interfgrating different applications, robo-dog can provide real-time updates e.g. weather alerts, navigation and GPS.
- Providing similar companionship as traditional guided dog with the benefit of not needing to care and support to that living animal.
- A benefit of a robo-dog is, once you have programmed it you can transfer programming other robo-dogs rather than spending the same amount of time to each dog.

Future and innovation

This guided robot dog is only model but there are many steps where the robot can excel. We can add an extra degree of freedom to increase the flexibility of the dog. Also, we could add sensor for scents, taste and vision. Furthermore, is that the robot dog can easily navigate itself in indoor areas on carpets, leather and slippery surfaces.

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