University of BRISTOL
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Mechanical Engineering
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Design of a Humanoid Robot

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3rd Year Individual Project

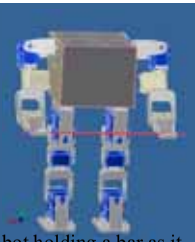
Summary

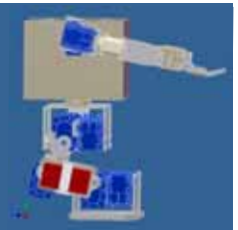
This project aimed to research and design a humanoid robot based on Commercial off the Shelf (COTS) parts to compete in the FIRA HuroCup robotics competition. This project summarises the research required for acquisition of the COTS parts and design for bespoke parts not commercially available, focusing on the legs and body. The robot's arms and hands were designed outside of this project. The competition requires the robot to complete eight tasks without alteration with the accumulated scores deciding the overall winner.

The main research and design areas in this project were the bracket design and configuration of the leg, design of the body and exploration and lowering of the robot's centre of mass. Further work included establishing a method to convert AutoDesk CAD assembly files to Matlab and Simulink files to simulate the robot to assist future programming.


Crouch position with battery holder on the leg


Side view with arms out


Robot holding a bar as it would in the weight lifting


Side view of robot with bent legs with arm out

Introduction

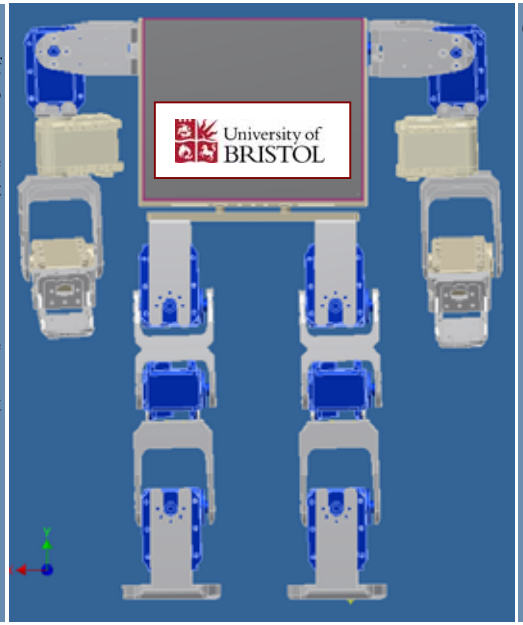
This project researched and designed a humanoid robot based on Commercial off the Shelf (COTS) parts to compete in the FIRA HuroCup. The robot is versatile and designed to compete in a series of tasks without modification.

FIRA hold the all round HuroCup annually for humanoid robots, where this robot will be entered in the all round division. The all round division consists of eight in dependant tasks which are accumulated to choose a winner.

The tasks that the robot will be asked to perform are;

- Sprint - a short distance test of speed
- Penalty kick - to approach a ball and kick it into a goal defended by a competitor
- Obstacle run - to negotiate obstacles on a path by moving around of over the obstacle
- Lift and carry - to carry a load over an un-even terrain
- Weight lifting - to lift a load to waist height, walk then lift to head height and walk
- Marathon - to walk a long distance in the shortest time
- Basket ball - to walk forwards, pick up a ball and throw it in a hoop
- Climbing - to climb a wall using blocks mounted either side to push up from its hands and feet

This robot will be entered in the small category and measures 359 mm.



Conclusion

This project was successful as:

- The specification for the whole robot and the specification for the body have been met
- Any brackets not commercially available have been designed
- The body has been designed to house the circuit boards, the battery and an extra servo to actuate the hand
- All parts to be made are ready to be manufactured
- A design for a lower centre of mass has been developed
- Once the parts are manufactured the robot can be built
- When built, the robot assembly CAD file that has been converted to a Matlab file can be used to assist with simulation and programming of the robot

Overall this has been a successful project but is only the first step in the process of preparing the robot for competition. There will be much more work to do in programming the robot after it is built to refine the control for the tasks but the Simulink files generated for this project will greatly help this work.

Research Conducted

- The FIRA HuroCup competition
- Similar competitions
- Other competitors in the HuroCup
- Robot servos / motors
- Manufacturing techniques available
- Effect of centre of mass on stability, below

Robotis Bioloid and bespoke parts were used with Dynamixel RX-28 servos.

If the robot has a lower centre of mass it will fall after a greater toppling angle (blue).

Leg Design


Foot bracket to be manufactured


FEA of the bracket


Left, proposed leg configuration built with bought and manufactured parts

The leg is made of servos with interlinking brackets, some were acquire as a set, and some, shown left were designed in AutoDesk

Body Design

A requirement tree and design specification were drawn up for the body, this resulted in in a body that had:

- Removable covers
- Removable circuit board mountings (pink)
- The fewest fixings for ease of access without compromising function


Inside: AX-12 servo (yellow) and circuit boards (red and blue flats)


Exploded view of the body, RX-28 shoulder motors (dark blue) and battery (red) on the right

Lowering the Centre of Mass

To lower the centre of mass a design was developed for a leg mounted battery holder.

Design development is shown below.

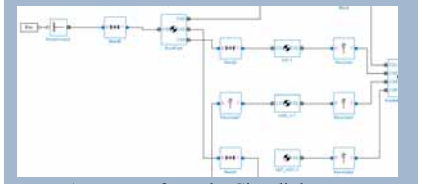
	Centre of mass (mm from floor)	Robot Mass (g)
No batteries	224.1	2340
One battery, in body	225.8	2410
One battery on leg	219.9	2410
2 batteries on leg	215.9	2480

Total height of robot = 359 mm

Further Work

The robot must be programmed to complete the competition tasks.

Programming is outside the scope, however a Simulink file allowing Matlab manipulation of the CAD model has been built to assist further work.


An extract from the Simulink representation of the leg