GuRoo: Humanoid Robot Project

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Abstract. This paper describes the design and implementation of The GuRoo, a humanoid robot. The GuRoo has 23 degrees of freedom, with limb proportions based on anthropomorphic data, and is used as a platform for research into learning systems for humanoid gait and balance.

1. Introduction

This paper outlines the GuRoo project, first started in 2001 at the University of Queensland. Twelve months of research, design and simulation was undertaken before the 1.2m tall robot was constructed. The GuRoo will be used as a platform for further research into learning algorithms for humanoid movement in unstructured environments.

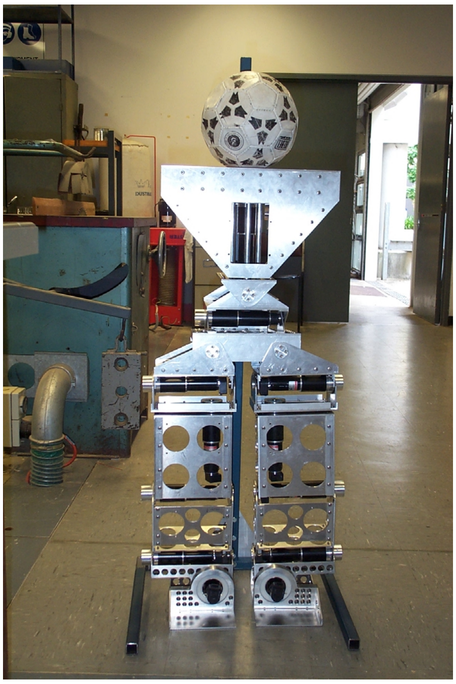

Fig. 1. The GuRoo under construction

2. Electro-mechanical

The robot is actuated by a combination of brushed DC and servo motors. 15 DC motors control the legs and spine, with the remaining DoF controlled by eight common RC servo motors.

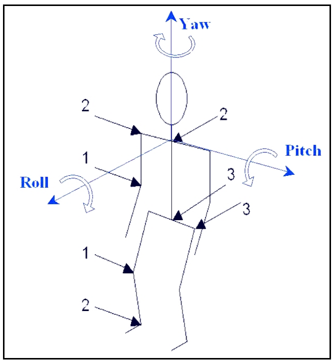

Fig. 2. The Degrees of freedom and axis of rotation for each joint[1]

The DC motors coupled with a 156:1 3 stage planetary gear head is able to provide a continuous 10Nm, with short intermittent peaks of 20Nm. A pair of torsion springs are located in parallel with the roll axis hip actuators to provide additional torque when the robot is supported by only one leg. The servo motors can provide 1.4Nm and are used to actuate the arms and head.

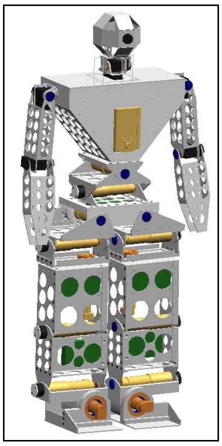

Fig. 3. SolidEdge model of the GuRoo

SolidEdge, a solid modeling program, was used to design the mechanical structure of the GuRoo. By assigning appropriate material properties to each component, it was possible to obtain a precise measure of the mass distribution of the robot via a series of inertia tensors for each limb. This provided an accurate physical model of the robot for use in the simulator, long before the physical robot was built.

3. Electronics

Six control boards are located within the robot, five of which each control three DC motors, and the final board controlling the eight servo motors. Located on each board is a Texas Instruments TMS320F243 DSP, which provides local control loops and joint monitoring. Quadrature encoders provide feedback from the 500 counts per revolution encoders situated on each DC motor. The temperature and current consumption of each joint is also measured and logged. The servo motors rely on their internal potentiometer for control.

A Compaq IPAQ pocket PC provides a user interface as well as generating the joint velocities for each actuator. A USB to CAN bridge provides the link to the CAN bus.

Vision information is obtained via a monocular CMOS camera, with image processing being handled by a dedicated Hitachi SH4 board.

Additional instrumentation amplifiers are included on each board to accommodate various sensors such as gyroscopes, inertial navigation systems and force sensors.

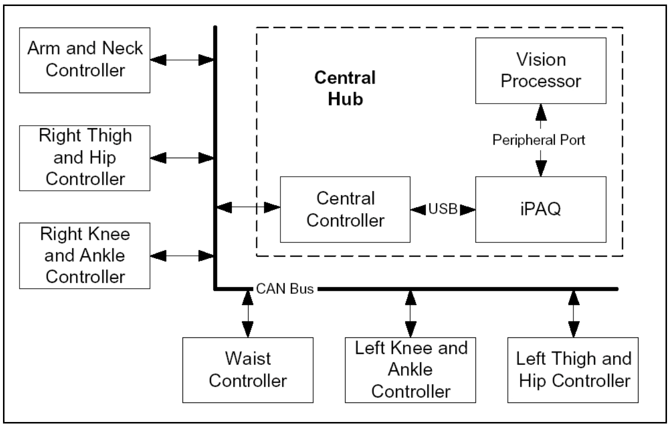

Fig. 4. Block diagram of distributed control system[2]

4. Software

Each control board and the IPAQ are connected in a multi-master Controller Area Network (CAN) configuration. Each node on the network has the ability to send and receive messages, with the CAN protocol determining message priority.

DynaMechs[3], a high fidelity dynamic simulator, is used to simulate various humanoid movement including crouching, standing on one leg and walking. An accurate model of the robot along with actuator characteristics obtained from the SolidEdge model is used, and the resulting forces and current requirements analysed.

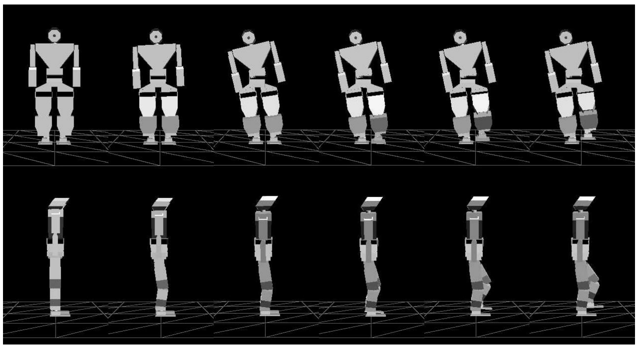

Fig. 5. Example result of a 'standing on one leg' simulation[1]

5. Conclusion

The creation of the GuRoo has shown that a through a combination of different design tools, it is possible to construct a practical autonomous humanoid robot. The robot will provide a good platform for subsequent research into humanoid robotics.

References

[1] D. Kee, Drive System Selection and Simulation for a Humanoid Robot, Undergraduate Thesis, University of Queensland, 2001

[2] G. Wyeth, D. Kee, M. Wagstaff, N. Brewer, J. Stirzaker, T. Cartwright, B. Bebel. Design of an Autonomous Humanoid Robot, Proceedings of the Australian Conference on Robotics and Automation (ACRA 2001), 14-15 November 2001, Sydney

[3] S. McMillian, Computational Dynamics for Robotic Systems on Land and Underwater, PhD Thesis, Ohio State University, 1995