Design of a Dexterous Force Controllable Humanoid

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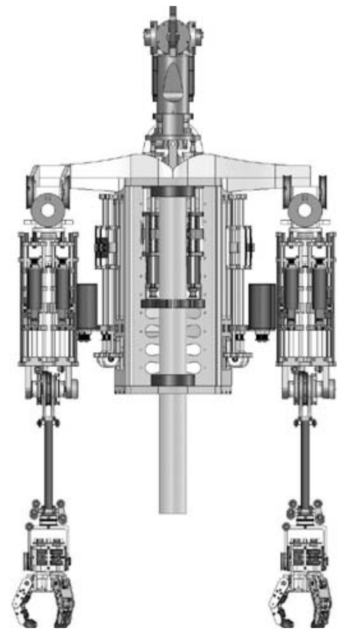

Figure 1: A new humanoid platform currently under design. This robot has two 6 degree-of-freedom (DOF) arms utilizing force controllable series elastic actuators (SEA), two 4 DOF SEA hands, a 2 DOF SEA neck, and a 6 DOF stereo active vision head.

What: We are designing a humanoid robot platform with dexterous, force controlled arms and hands, as well as a stereo active vision head. The design of this robot is focused on providing high dexterity, agility, and mobility while emphasizing compactness and modularity.

Why: Dexterous manipulation allows a humanoid robot to actively explore its world. Through exploratory acts such as touching, poking, pushing, and holding, the robot can physically ground its sensory experiences. A humanoid which is capable of manipulating its world can move from a passive sensing of the world to an active and directed perception. Developing a mechanically robust manipulator which can be force controlled will allows us explore long-term interactions with an unfamiliar environment.

How: A central pillar of our design approach is that the manipulator must be passively and actively compliant, and it must be able to directly sense and command torques at each joint. To accomplish this, we have used Series Elastic Actuators (SEA) [2]. These actuators provide passive compliance through a spring placed between the motor and the actuated limb. By sensing the deflection of the spring we can directly sense the torque at each joint.

This approach draws on the manipulator designs of the Cog Project [1] and the Whole Arm Manipulator [3]. We have developed a lightweight and agile 6 DOF cable-driven arm which exhibits kinematic and mechanical modularity, and low power consumption. We have also developed a very compact and lightweight 4 DOF SEA hand. The hand has three independently controlled fingers for gripping. One DOF controls the spread between two fingers, allowing a variety of grasps to be executed.

By utilizing a cable-drive to transmit power from the actuator to the joint, we are able to keep the mass of the actuators close to the shoulder. This allows for a lower power consumption and a higher agility. The control electronics are embedded throughout the robot, which allows for the untethered robot to be placed on a mobile platform.

Progress: We are nearing the completion of the design stage of this work. After assembly and testing of the robot, we will begin integration of the manipulators with the vision system. Our initial experiments will be with vision guided exploratory acts.

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References:

[1] Rodney A. Brooks, Cynthia Breazeal, Matthew Marjanovic, Brian Scassellati, and Matthew M. Williamson. The Cog project: Building a humanoid robot. In C. L. Nehaniv, editor, *Computation for Metaphors, Analogy and Agents*, volume 1562 of *Springer Lecture Notes in Artificial Intelligence*. Springer-Verlag, 1999.

[2] Gill A. Pratt and Matthew M. Williamson. Series elastic actuators. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS-95)*, volume 1, pages 399–406, Pittsburg, PA, July 1995.

[3] J. Kenneth Salisbury, William T. Townsend, Brian S. Eberman, and D. M. DiPietro. Preliminary design of a whole arm manipulation system (wams). In *Proc 1988 IEEE Intl Conf on Robotics and Automation*, 1988.