DOMO

A FORCE SENSING HUMANOID ROBOT FOR MANIPULATION RESEARCH

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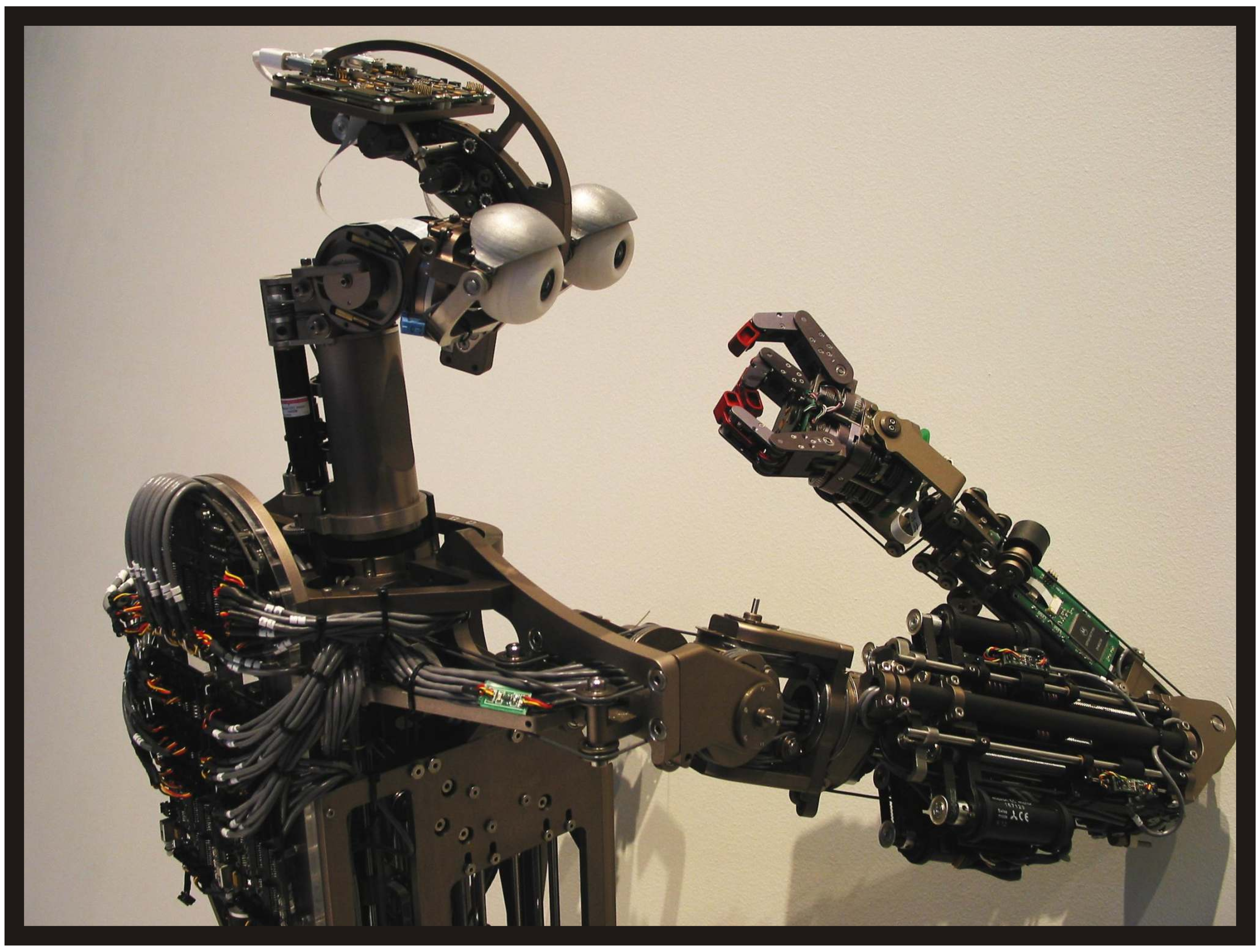
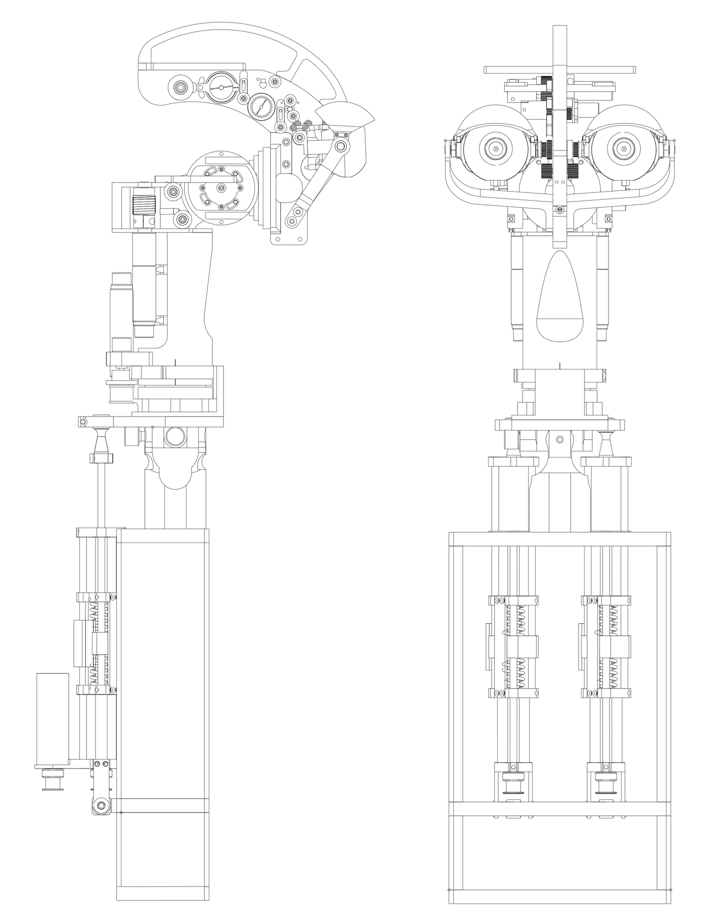
Domo is a research platform for exploring problems in general dexterous manipulation, visual perception, and sensorimotor learning.

The goal of our research is to contribute an alternative approach to humanoid robot manipulation in unstructured environments. Our approach is centered on integrating compliant and force sensitive manipulators into a behavior based architecture which incorporates anticipatory sensorimotor models.

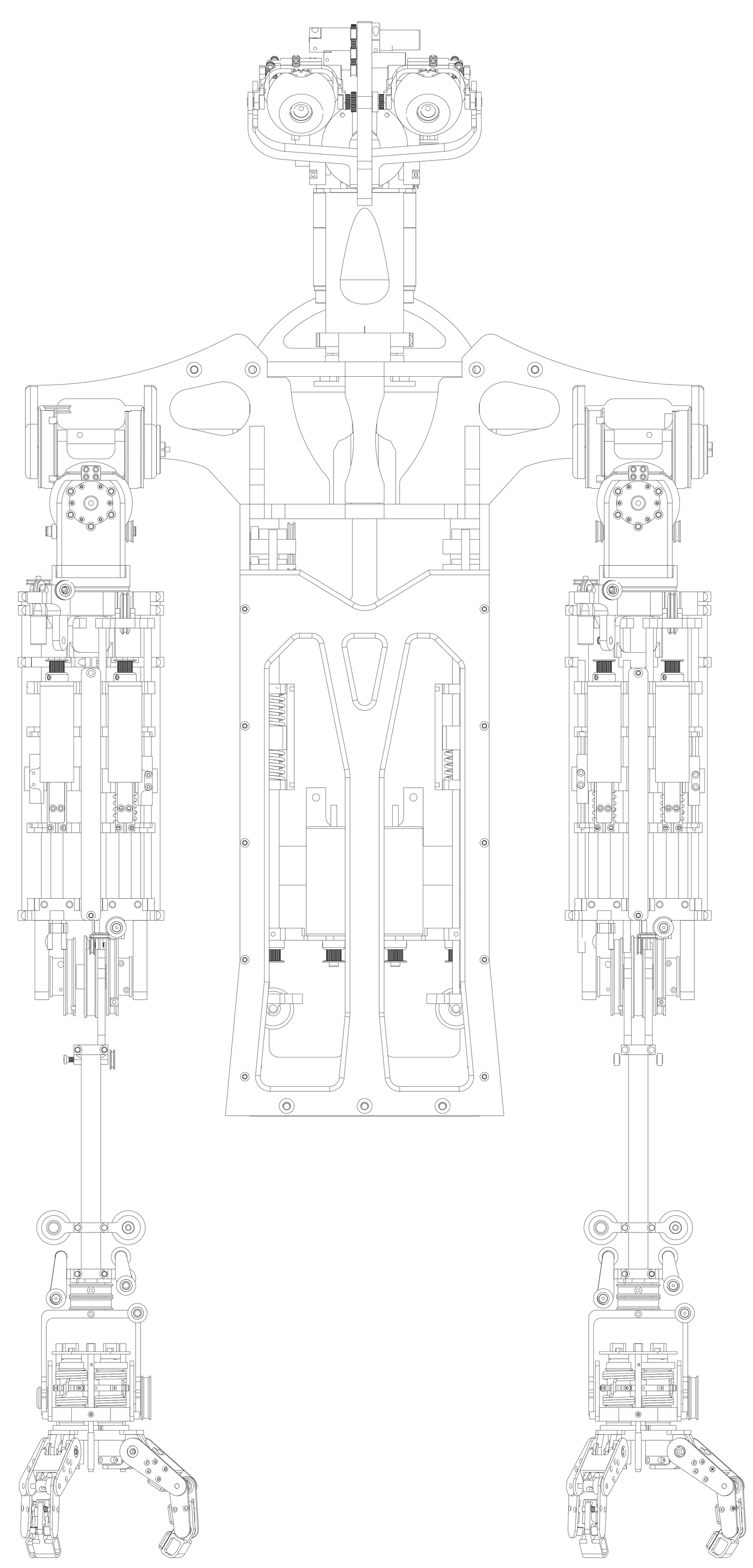
Domo has 28 degrees of freedom (DOF). Of these, 22 DOF use force controlled and compliant actuators which are fundamental to our research approach. There are two 6 DOF force controlled arms, two 4 DOF force controlled hands with tactile sensing, a 2 DOF force controlled neck, and a 6 DOF active vision head. The torso is not currently actuated. The vision system includes 2 firewire CCD cameras. The sensorimotor system is controlled by a CANbus network of DSP controllers. The cognitive system runs on a small networked cluster of Linux machines using the Yarp interprocess communication protocol.

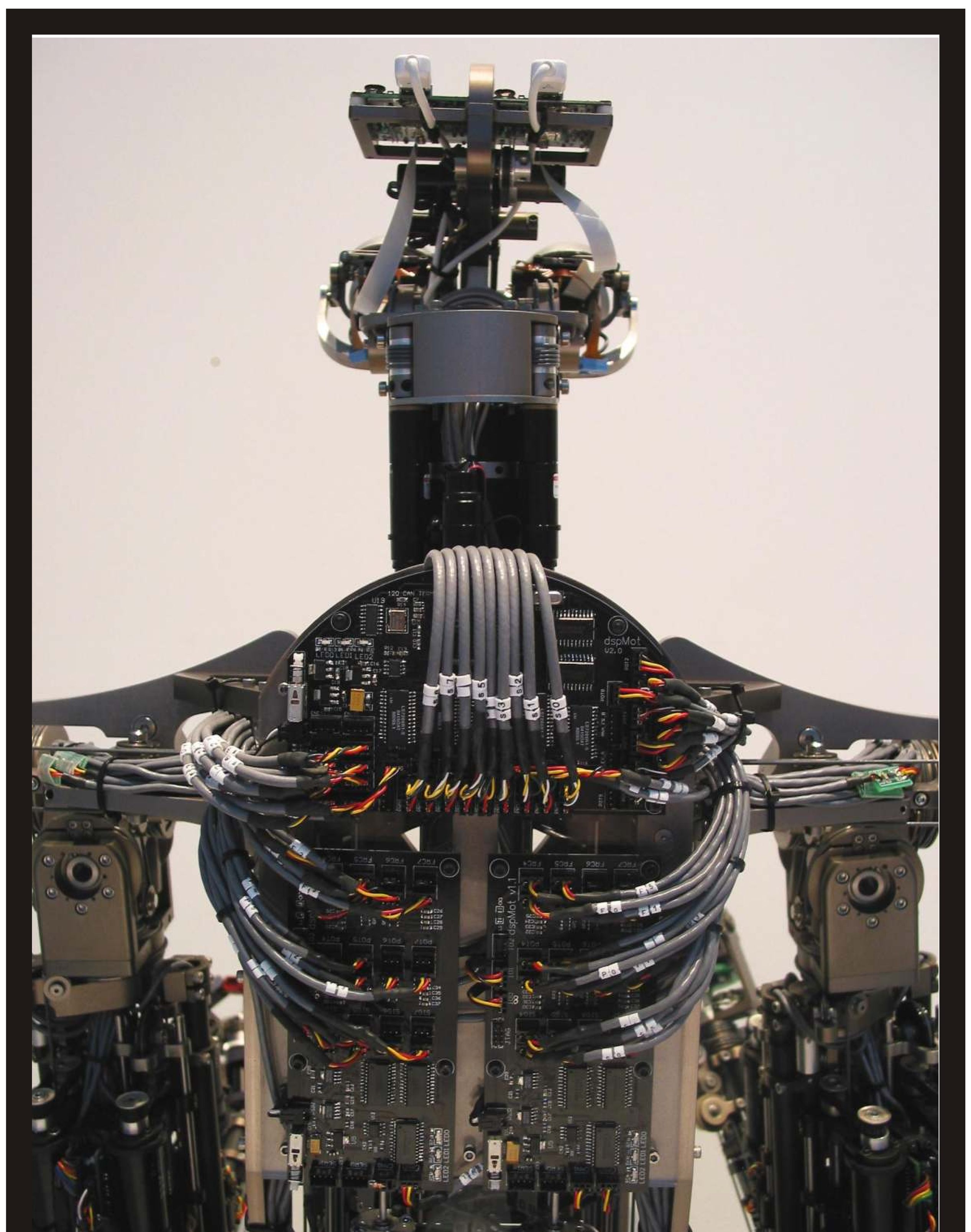




The head features seven DOF in the upper head, a two DOF force controlled neck, and a stereo pair of FireWire CCD cameras. The upper head provides roll and tilt through a compact cable-drive differential. The two cameras share a single tilt DOF and have two independent pan DOF. The head also features one DOF expressive eyelids.

The visual system runs on a set of networked linux Pcs. We are developing a set of visual feature discriminators for manipulation based on previous work conducted in our group on the robots Cog and Kismet.



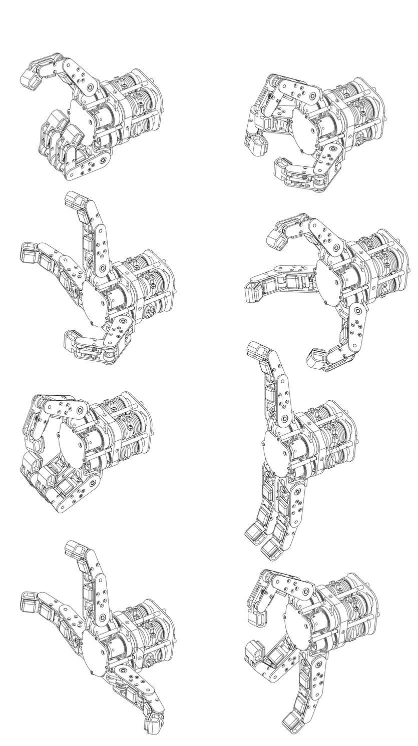


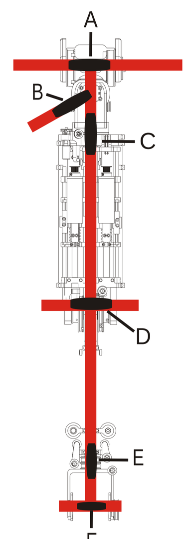
Domo's hands each contain four modular force sensing and compliant actuators acting on three fingers. One actuator controls the spread between two fingers. Three actuators independently control the top knuckle of each finger. The lower knuckles of the finger are passively coupled to the top knuckle.

The passive compliance of the Actuator is allows the finger to better conform to an object through local, fine-grained adjustments of posture.

we can create a large variety of grasps by adapting the spread between two fingers.

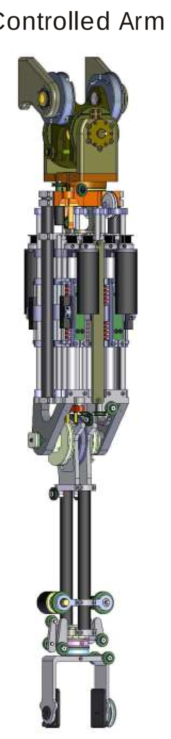
We are developing a set of grasp behaviors to generate visually guided preshaping of the robot grasp and dynamic grasp adaptation based on force cues.

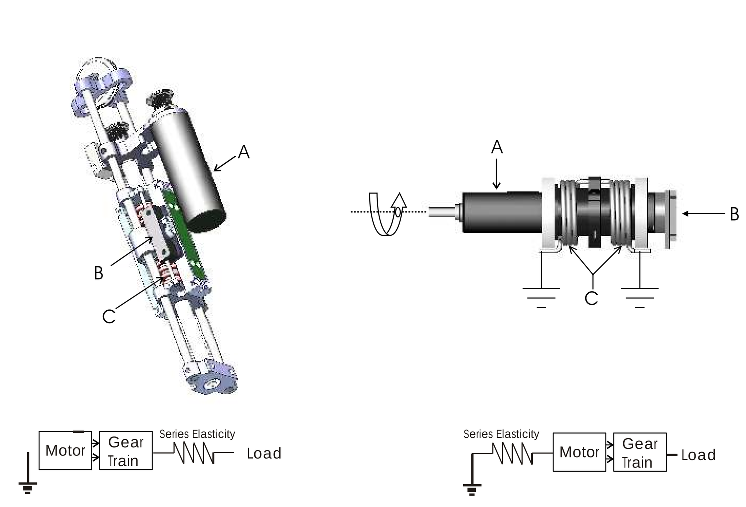




A: Shoulder Pitch
B: Shoulder Roll
C: Shoulder Yaw
D: Elbow Pitch
E: Wrist Roll
F: Wrist Pitch

6 DOF Force Controlled Arm





The 20 actuators in Domo's arms and hands and the 2 actuators in the neck utilize series elasticity to provide force sensing. We place a spring (C) inline with the motor (A) at each joint. By measuring the deflection of this spring with a potentiometer (B), we know the force output by using Hooke's law ($F=-kx$ where k is the spring constant and x is the spring displacement).

Humans are very good at controlling manipulator forces, but relatively poor at controlling joint position. The Arms and Hands of Domo have been designed to exploit the spring and damper like qualities found in the human musculature system. This provides stable and simplified control of the arms.

In the context of manipulation, compliant and force sensing manipulators can significantly modify the shape of the problem space to one that is simpler and more intuitive.

These manipulators allow a force-based decomposition of manipulation tasks, allow the robot to safely move when the location of objects in the environment are not well known, and provide a robustness to unexpected collisions.

We apply Virtual Model Control (VMC) to the control of Domo's arms. VMC represents the control problem in terms of physical metaphors that we have a good natural intuition of: springs and dampers.

The key idea of VMC is to add control in parallel with the naturaldynamics of the arm. Virtual springs and dampers are simulated between the robot and objects in the world. This allows force controlled movement of the manipulator with only a forwardkinematic model.