# Mobile, Dexterous, Social Robots for Mobile Manipulation and Human-Robot Interaction

Cynthia Breazeal*
Michael Siegel
Matt Berlin
Jesse Gray
MIT Media Lab

Rod Grupen†
UMass Amherst

Patrick Deegan‡
DigitROBOTICS, LLC

Jeff Weber§
Meka Robotics, LLC

Kailas Narendran¶
John McBean
Xitome Design, LLC

## 1 Introduction

The Personal Robots Group at the MIT Media Lab (URL: robotic.media.mit.edu) is leading the development of a new class of robots that feature a novel combination of mobility, dexterity, and human-centric communication and interaction skills that sets a new standard for research into personal robots. We refer to this class of robots as "MDS" for Mobile-Dexterous-Social.

The purpose of this platform is to support research and education goals in human-robot interaction and mobile manipulation with applications that require the integration of these abilities. In particular, our research aims to develop personal robots that work with people as capable teammates to assist in eldercare, healthcare, domestic chores, and other physical tasks that require robots to serve as competent members of human-robot teams. The robot's small, agile design is particularly well suited to human-robot interaction and coordination in human living spaces. Our collaborators include the Laboratory for Perceptual Robotics at the University of Massachusetts at Amherst, Xitome Design, Meka Robotics, and digitROBOTICS.

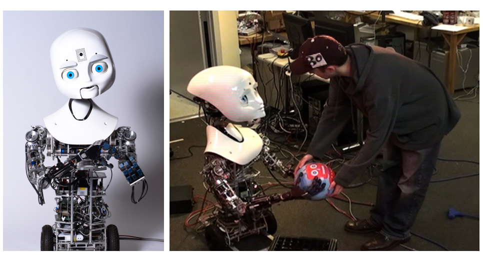

**Figure 1:** *The MDS robot (left). The MDS robot coordinating joint action with a person in a VICON space (right).*

## 2 Design Highlights

The total height of the MDS robot is approximately 48 inches, and the total weight is roughly 65 lbs (in tethered power mode). A photograph of the MDS robot with face, neck, and shoulder shells is shown in Figure 1.

The MDS mobile base builds upon the uBot-5 platform developed at the University of Massachusetts at Amherst. The uBot-5 system features two wheels and a dynamically balancing control system, as well as two arms that employ force feedback. The arm design supports a large diameter workspace, including a sizeable reach for objects on the floor and two-handed manipulation of objects. The mobile base allows the robot to turn in place and move forward and reverse at human walking speeds in indoor environments. The balancing system can overcome significant impulse forces to support stability critical behaviors such as pushing and throwing a ball. A statically stable version of the base is showcased on the MDS robot at the SIGGRAPH New Tech Demos.

In addition, the MDS robot currently has two 2 degree of freedom hands to support pointing gestures and simple object manipulation. The fingers are designed using a cast rubber technique to be resilient to falls and collisions with objects. The fingers can compliantly close around target objects using a power grasp, simplifying the control required for interaction with objects. In the next generation hand (on display at the New Tech Demo), the index finger and thumb are independently controlled to enable the robot to perform a wider range of gestures and object manipulations. A slip clutch in the wrist of the 2 degree of freedom forearm makes the wrists robust to impact forces.

A particularly distinguishing aspect of the MDS design is the robot's socially expressive 4 degree of freedom neck and a 17 degree of freedom face – including gaze, eyelids, eyebrows, and a jaw. The face and neck design supports a wide range of emotional and dialog-based expressions.

The robot has multiple on-board sensing technologies for visual, auditory, and kinesthetic feedback to allow the robot to interact in real-time with the environment and with people. A four microphone array in the head supports sound localization. A laser range finder mounted in the torso supports navigation and environment mapping. Each eye has a color firewire camera with a 6mm microlens. A real-time 3D IR depth-sensing camera is mounted in the forehead. High resolution encoders and current sensing exist on all joints. All sensors use a uniform xmlrpc based network interface.

An on-board network supports both on-board and off-board computation. Three 1GHz PC-104+ on-board computers support low level motor control, sensor management, and wireless communication. Off-board computation allows for higher-level perception, cognition, learning, and behavior. Much of the robots cognitive abilities are supported by the C5M cognitive architecture codebase developed by the Personal Robots Group. This repertoire is continuously being extended through collaboration with other research groups as part of joint research projects.

The robot can operate in either tethered power mode or on battery power. Estimated run time using battery power in the current design is 1 hour.

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*e-mail: cynthiab@media.mit.edu
†e-mail:grupen@cs.umass.edu
‡e-mail:pdeegan@digitrobotics.com
§e-mail:jaweber@mekabot.com
¶e-mail:kailas@xitome.com


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