MIT and Robotics Industry

The Massachusetts Institute of Technology (MIT) is a leading center of research and education on topics important to robotics industries, including:

- Artificial Intelligence and Cognition
- Autonomy / Autonomous Systems and Control
- Bionics, Biomimetic Robotics
- Human-Robot Interaction
- Locomotion
- Marine Robotics
- Robotic Networks
- Sensing

Below are brief descriptions of a selection of MIT centers, departments, groups, and labs conducting research and education in these areas.

Please note that this is not a comprehensive summary of research being conducted at MIT in the topic areas listed above and that some of these groups may fit within multiple topic areas.

MIT's Industrial Liaison Program (ILP) can bring the intellectual power of MIT to your organization by providing a direct connection to the knowledge, experience and resources at MIT in these fields--giving you the ideas to stay ahead.

For more information about how the ILP can put the resources of MIT to work for you, call us at 1-617-253-2691, e-mail us at liaison@ilp.mit.edu, or visit http://ilp.mit.edu/.

ARTIFICIAL INTELLIGENCE AND COGNITION

The **Center for Brains, Minds, and Machines (CBMM)** is a multi-institutional NSF Science and Technology Center at MIT dedicated to the study of intelligence—how the brain produces intelligent behavior and how it may be able to replicate intelligence in machines.

The **Computer Science and Artificial Intelligence Laboratory (CSAIL)** researchers have been key movers in developments like time-sharing, massively parallel computers, public key encryption, the mass commercialization of robots, and much of the technology underlying the ARPANet, Internet and the World Wide Web. CSAIL's approximately 50 research groups are organized into three focus areas: artificial intelligence, systems, and theory. Research is

conducted in almost all aspects of computer science, as well as exploring revolutionary new computational methods for advancing healthcare, manufacturing, energy and human productivity.

The goal of the **Haystack** group is to make it easier for people to collect, organize, find, visualize, and share their information. Haystack is an interdisciplinary group of researchers blending approaches from human-computer interaction, social computing, databases, web infrastructure, information retrieval, artificial intelligence and the semantic web.

The **Learning and Intelligent Systems (LIS) Group** conducts interdisciplinary research aimed at discovering the principles underlying the design of artificially intelligent robots. The goal is to create robots that can perform the kinds of everyday tasks that come naturally to humans, but that are beyond the reach of current technology. The group's research brings together ideas from motion and task planning, machine learning, reinforcement learning, and computer vision to synthesize robot systems that are capable of behaving intelligently across a wide range of problem domains.

Model-based Embedded & Robotic Systems (MERS) develops "cognitive robots," robots that are able to think and act much like humans do. Toward this goal, the group has three main thrusts to its research: goal-driven interaction with robots, natural human/robot teaming, and robotic reasoning about the environment. When combined, these research topics allow the group to create cognitive robots, using model-based techniques, that can be talked to like another human, can work with a team member to finish a task, can recover from many failures without assistance, and can collaborate with a human to recover from a failure that the robot cannot solve alone.

The **Multimodal Understanding Group's** objective is to build techniques, software and hardware that enable natural interaction with information. The vision is that natural interaction implies the integration of speech, gestures and sketching to emulate a human-like dialogue. Consequently, research focuses on the following: building and testing systems that understand body- and hand-based gestures; improving, generalizing and applying sketch recognition algorithms to real-world problems; building systems that integrate speech with the gesture and sketch modalities, by leveraging speech understanding and natural language processing research at MIT CSAIL.

The **Perceptual Science Group** does research in human visual perception, machine vision, image processing, and human-computer interaction.

The **Spoken Language Systems (SLS)** group has focused its research on the creation of technology that enables humans to interact with computers using natural spoken language. Conversational interfaces will enable us to converse with machines in much the same way that we communicate with one another.

AUTONOMY /AUTONOMOUS SYSTEMS AND CONTROL

The **Aerospace Controls Laboratory (ACL)** researches topics related to autonomous systems and control design for aircraft, spacecraft, and ground vehicles. Theoretical research is pursued in areas such as: decision making under uncertainty; path planning, activity and task

assignment; estimation and navigation; sensor network design; robust control, adaptive control, and model predictive control.

The **Aerospace Robotics and Embedded Systems (ARES) Group's** mission is the development of theoretical foundations and practical algorithms for real-time control of large-scale systems of vehicles and mobile robots. Application examples range from UAVs and autonomous cars, to air traffic control, and urban mobility. The group researches advanced algorithmic approaches to control high-dimensional, fast, and uncertain dynamical systems subject to stringent safety requirements in a rapidly changing environment.

The **Field and Space Robotics Laboratory's** areas of interest focus on the dynamics, design, and control of high performance machine systems, robots, and manipulators. Sample project includes the autonomous tactile exploration of oil wells.

The **Laboratory for Information and Decision Systems (LIDS)** is committed to advancing research and education in systems and control; communications and networks; and inference and statistical data processing. LIDS research spans the full range from fundamental research and the development of new methodologies, to applications of major significance. Sample areas include: Coordination of unmanned autonomous systems; energy information systems; intelligence, surveillance, and reconnaissance (ISR) systems; network scheduling and routing; sensor networks; ultra-wideband and other emerging communications technologies.

The **Mechatronics Research Laboratory (MRL)** conducts research and development in the areas of: design and control of atomic resolution systems, design of autonomous robots for the exploration of complex and unstructured terrains, and innovates on the effective techniques to estimate and model physical systems.

The **Nonlinear Systems Laboratory** studies mathematical principles of nonlinear system stability, adaptation, and learning, and how they apply to robots and to models of biological control. The lab is particularly interested in how stability and performance constraints shape system architecture, representation, and algorithms in robots, and in whether similar constraints may in some cases lead to similar mechanisms in biological systems.

The **Robust Robotics Group** aims to build unmanned vehicles that can fly without GPS through unmapped indoor environments, robots that can drive through unmapped cities, and to build social robots that can quickly learn what people want without being annoying or intrusive. The group specifically focuses on problems of planning and control in domains with uncertain models, using optimization, statistical estimation and machine learning to learn good plans and policies from experience.

BIONICS, BIOMIMETIC ROBOTICS

The **Biomechatronics Group** works to advance the science of biomechanics and biological movement control, and to apply that knowledge to the design of human rehabilitation and augmentation technology. The mission of the group is: to restore function to individuals who have impaired mobility due to trauma or disease through research and development; and to develop technologies that augment human performance beyond what nature intends. These objectives are met by combining the scientific discipline of organismal and cellular neuromechanics with the technological discipline of bionic device design.

The MIT **Biomimetic Robotics Lab** aspires to develop a mutidisciplinary foundation of hyperdynamic robotics. Hyperdynamic robotics involves dynamic modeling, hierarchical control architecture, monolithic multi-material manufacturing, novel actuation technologies, and morphological design tool that enable the development of high performance dynamic robotic platforms.

The focus of the **Bio-Robotics group** in the **Brit and Alex d'Arbeloff Laboratory for Information Systems and Technology** is science and technology of robotic systems motivated by both practical applications and scientific interests. The researchers in the d'Arbeloff Laboratory extend the traditional bio-mimetic robotics to new frontiers of robotics science and technology for seeking effective solutions to socially and economically challenging problems, developing key enabling technologies, such as novel actuators, sensors, and communication technology, and exploring the possibility of using live cells and organelles as components of robots.

HUMAN-ROBOT INTERACTION

The **Interactive Robotics Group** is developing innovative methods for enabling fluid human-robot collaboration. The group's vision is to harness relative strengths of humans and robots to accomplish what neither can do alone. The focus is on developing robots that work in teams with people in high-intensity and safety-critical applications, including industrial manufacturing, disaster response, and space exploration.

The **Personal Robots Group** focuses on developing the principles, techniques, and technologies for personal robots. Recent work investigates the impact of long-term, personalized Human-Robot Interaction (HRI) applied to quality of life, health, creativity, communication, and educational goals. The ability of these robot systems to naturally interact, learn from, and effectively cooperate with people has been evaluated in numerous human subjects experiments, both inside the lab and in real-world environments.

LOCOMOTION

The **Robot Locomotion Group** builds machines that exploit their natural dynamics to achieve extraordinary agility and efficiency. Project examples include dynamics and control for humanoid robots, robotic manipulation, and dynamic walking over rough terrain, flight control for aggressive maneuvers in unmanned aerial vehicles, feedback control for fluid dynamics and soft robotics, and connections between perception and control.

The **Robotic Mobility Group** focuses on the modeling, design, control, motion planning, and sensing for robotic systems operating in unstructured environments. Project examples include: Human-inspired autonomous vehicle highway navigation; terramechanics for small, lightweight robots; classification and modeling of forested terrain from unmanned ground vehicles.

The **Department of Mechanical Engineering (MechE)** conducts research in a range of areas, such as mechanics, product design, manufacturing, energy, nanoengineering, ocean engineering, controls, instrumentation, robotics, and bioengineering, that are diverse and allow for rich collaboration both within the department and with other engineering and science

disciplines at MIT and beyond. These broad areas of focus and the department's commitment to multidisciplinary research results in an exciting variety of innovative projects, including among many other things the design of miniature robots for extraterrestrial exploration; the development of unmanned underwater vehicles.

MARINE ROBOTICS

The **Center for Ocean Engineering** has significant research efforts in fluid mechanics and hydrodynamics, acoustics, offshore mechanics, marine robotics and sensors, and ocean sensing and forecasting, as well as advanced graduate education on the design of naval ships and vehicles through the Naval Construction program. Center faculty and staff address a number of ocean-related activities, including: observation and exploration of the ocean; naval construction and engineering; ocean resource development; shipping and transportation; ocean energy; ocean acoustics; the role of the ocean in the global environment and in climate change; oceanographic engineering; marine robotics; and biomimetics.

The **MIT Laboratory for Autonomous Marine Sensing (LAMSS)** specializes in the development of new distributed ocean sensing concepts for oceanographic science, national defense and coastal management and protection. It continues two decades of multi-disciplinary research and development into such systems by Department of Ocean Engineering and the MIT Sea Grant AUV Laboratory. The faculty, staff, and students provide a strongly multidisciplinary team with expertise in oceanographic sensing and modeling, sonar system technology, computational underwater acoustics, and marine robotics and communication networking.

The **Marine Robotics Group**, part of CSAIL at MIT, research is fundamentally centered around the task of navigation for mobile robots in unknown environments. The group's projects are centered around the problems of navigation and mapping for autonomous mobile robots operating in underwater and terrestrial environments.

The **Multidisciplinary Simulation, Estimation, and Assimilation Systems (MSEAS)** group develops and transforms ocean modeling and data assimilation to quantify regional ocean dynamics on multiple scales. The group creates and utilizes new models and methods for multiscale modeling, uncertainty quantification, data assimilation and the guidance of autonomous vehicles. These advances are then applied to better understand physical, acoustical and biological interactions.

The **Ocean Acoustics Group's** research effort is both science and technology-development oriented. Thus, part of the research concerns improving the fundamental understanding of the propagation of sound and seismic waves in the ocean, while other research focus on the development of improved acoustic systems, e.g. for Autonomous Underwater Vehicle (AUV) communication and navigation.

The **MIT Sea Grant AUV Lab** is a leading developer of advanced unmanned marine robots, dedicated to the development and application of autonomous underwater vehicles. Because the lab's vehicles can function without tethers, cables, or remote control, they have a multitude of applications in oceanography, environmental monitoring, and underwater resource studies. The laboratory also serves as a training ground for graduate and undergraduate students, visiting engineers, and scientists, from around the world, who both learn from and contribute to the Lab's current research activities.

ROBOTIC NETWORKS

The **Distributed Robotics Laboratory (DRL)** work spans areas including modular and self-reconfiguring robots, soft robotics, distributed algorithms and systems of self-organizing robots, networks of robots and sensors for first-responders, mobile sensor networks, animals and robots, cooperative underwater robotics, desktop robotics, and forming, moving, and navigating sparse 2D and 3D structures.

SENSING

The focus of the Newman Laboratory is technology to enhance human performance. The mission of **The Eric P. and Evelyn E. Newman Laboratory for Biomechanics and Human Rehabilitation** is to: Understand and quantify key aspects of human sensorimotor performance, including mobility manipulation touch and feel; restore function to individuals impaired by disease, accident, birth defect, occupational hazard or the physical challenge of normal aging; and create new technology to enable performance beyond unaided human capability.

The **Sensing, Learning, and Inference** group focuses on the analysis of complex, high-dimensional data by combining elements of Bayesian inference, information theory, optimization, and physical sensor models to develop scalable algorithms with theoretical performance guarantees. Application areas include multi-modal data fusion, distributed inference under resource constraints, structural inference, resource management in sensor networks, and analysis of video, seismic volumes, and radar images.

The mission of the Massachusetts Institute of Technology is to advance knowledge and educate students and others in science, technology, and additional areas of scholarship. MIT is committed to generating, disseminating and preserving knowledge and to working to bring this knowledge to bear on the world's great challenges. As part of its mission, MIT maintains relationships with industrial organizations that enable the exchange of ideas in the context of real-world problems and demonstrate how principles studied at MIT are applied to generate practical benefits for industry and society. MIT's Industrial Liaison Program helps develop these relationships by facilitating industry's access to MIT and its vast resources.