IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Multiple Human-Robot Cooperation	
Project Number	**IMURA0854** Cognizant	
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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**Highlight which of the Academy's Theme(s) this project will address?** *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*	***1***	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	*Nanotechnology*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Autonomous systems have replaced humans in most simple and repetitive tasks in modern times. While recent advances in robotic systems have benefited many applications, it is increasingly felt that *only-robot* systems are limited in their capabilities and reliability. It is generally taken as granted that humans will decide/assist/be involved in crucial parts of any multi-robot operation. This follows from limited estimation and decision making capabilities in machines especially in uncertain and highly heterogeneous environments. This is true in spite of untiring and accurate actuation possible through machine interfaces. Limitations of only-robot systems are evident in autonomous and semi-autonomous car driving scenarios, UAV operations (where multitudes of human operators are required to fly unmanned vehicles), fully automatic warehouse/shopfloor management (where human overseers need to reprogram every small change), etc.

On the other hand, humans have limited physical and mental abilities. Hence, human-robot combinations are necessary in situations that are unsuitable for *only-human* operations. Examples include search and rescue in dangerous environments (buildings on fire, natural calamities, industrial accidents, etc.), jobs beyond the physical capabilities of humans (hazardous materials, moving heavy objects), time critical operations requiring computations beyond the mental abilities of human operators (extreme multiplicities of tasks, objects and data, optimal task allocation, emergency operations).

Hence in this project, we aim to build human-robot cooperative algorithms and systems, which combines the superior cognitive, estimation and decision-making capabilities of human operators with the precision and unlimited power available from robots.

Project aims

The aim of the project is to develop algorithms and perform human-robot cooperative experiments in sample environments, which mimic a limited number of real life scenarios. The specific aims are listed next:

1. Autonomous Robot operations:
    a. Indoor emergency operations – human identification & head count inventory by robot swarms*:* mission planning, coordinated navigation, obstacle avoidance, communication.
    b. Warehouse automation: inventory, shop floor management: passively aiding humans
2. Human-robot operations:
    a) Indoor emergency operations - human guided robot swarms: cooperative 3D maze solving to simulate tracing survivors inside a building in emergency situations
    b) Shopfloor automation: actively aiding humans, cooperatively moving heavy objects, machine led tasks with humans in compensatory role

The aims listed above will be achieved through the development of appropriate control and learning algorithms, and testing of those algorithms on a six-robot testbed. These robots will be highly programmable, with significant onboard computing power, capable of carrying heavy loads and simultaneous fast locomotion. The robots should have a full suite of sensors e.g. LiDAR, Camera, IR, sonars, IMU, odometers etc, and transmitters/receivers for telemetry and communication. They should also be able to pick and place objects if required. We intend to procure robots meeting these specifications directly from the open market.

Expected outcomes

1. *Algorithms for completely autonomous multi-robot operation (including task allocation, real-time communication and execution) in several test scenarios: prototypes of building emergency situations, warehouse automation scenarios etc.*
2. *Algorithms for multiple human-robot operations (including task allocation, real-time communication and execution) in test scenarios: prototypes of human-robot cooperative maze solving, examples of human-robot cooperation through kinaesthetic coupling (such as a robot-human team carrying a heavy object)*
3. *Execution and testing of the algorithms developed in (1) and (2) above on the testbed of six ground robots in the test scenarios outlined above.*

How will the project address the Goals of the above Themes?

Capabilities and Degrees Required

Desired capabilities:

1. *Embedded coding*
2. *Electronics systems*
3. *Robotic systems*
4. *ROS/ Gazebo platform*
5. *Control and instrumentation*

Degrees: Btech, Mtech, MS, BSc/MSc in Electrical, Electronics, Mechnical Instrumentation Engineering, Control Systems, Robotics.

Potential Collaborators

Professor Hoam Chung, Mechanical and Aerospace engineering department, Monash University.