UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

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To: **Faculty Council**

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Item: **Proposal to establish the Institute for Robotics and Mechatronics (IRM) in the Faculty of Applied Science and Engineering at the University of Toronto**

Background

In the Fall of 2009, a number of academics in the Faculty of Applied Science and Engineering were tasked by the Dean and Chairs of MIE and ECE to explore the possibility of the creation of an Institute for Robotics and Mechatronics in order to pull together and enhance various research and teaching activities within the Faculty focused on Mechatronics and Robotics. Discussions and consultations with a number of faculty members across the Faculty were conducted in order to establish the objectives and priorities of the Institute.

Motivation

The formation of the institute is motivated by the recent rapid development of fundamental enabling technologies such as micro electromechanical systems (MEMS) and nanotechnology, advanced techniques for signal processing and systems control, combined with new system-level principles underlying embedded systems, which together render robotic and mechatronic systems viable as consumer products. These advances have resulted in a two-fold resurgence of interest in robotics as a distinct academic area and in opening a door to the adoption of mechatronic sub-systems in a very large number of mainstream applications.

How an Institute for Robotics and Mechatronics would be positioned on the larger stage is best addressed by stepping back and examining some of the developments of the last decade. One of the key innovation engines in technology today is a triumvirate of three giants:

Communication -- Computation -- Information Technologies.

Each of these three giant players has leap-frogged off the discoveries of the next, and this has lead to a cycle of breakthroughs whose pace far exceeds that of isolated industries. The underlying medium that each of these three players manipulates is *information*.

During this period there have been developments along other fronts, largely fuelled by advances in the Basic Sciences. New players are moving to the centre of the technology stage. It is this

reality which is the central motivation for the Institute. There is, on the horizon, a new triumvirate:

Sensing -- Computation -- Actuation.

By *sensing* we mean, small devices which gather data in situ. This data can be communicated via a network, it can be locally stored on handheld devices, it can be recorded in very small memories for future analysis, it can be collected in novel and extreme environments. The technology for transmitting and processing large amounts of data is currently available. The new aspect here is the capability to gather that data. This relies on physics at very small scale, on materials science, and on chemical engineering.

Dual to sensing is *actuation*, that is, the disciplined use of information to create desired behaviours in engineering systems. This can range, on the one hand, from targeted applications such as microactuators for fine focusing of light using a multitude of mirrors placed on a single chip, to, on the other hand, very generalized applications such as micro-motors to drive any number of motion control processes. The development of actuation devices is built upon fundamental discoveries in the physics of ceramic and crystal materials, as well as more recent advances in fabrication methods and design concepts. While today these devices find applications in high end instruments such as imaging devices for medicine, in the future, the availability of low-cost, low-power actuators will lead to wide spread use of these actuators in everyday engineering systems.

Sitting between sensing and actuation is *computation*, and this takes two forms. In the form of hardware, we refer to new and efficient dedicated architectures for high speed processing. For example, GPUs and FPGAs can process vision data more effectively than general purpose microprocessors. In the form of software, a leading role is taken in recent years by real-time operating systems, signal processing algorithms, control algorithms, and reasoning algorithms.

It is clear that a coherent triumvirate exists and that all enabling elements are in place. The Institute for Robotics and Mechatronics at the University of Toronto will take advantage of novel and rapidly developing sensing, actuation and computational capabilities to enable the development of next generation mechatronic and robotic systems that will affect almost all sectors of the economy. While, for instance, robots have been largely used in manufacturing and industrial settings to perform repetitive tasks in the past, robots are expected to become consumer products and be part of the life of humans helping with everyday tasks. Various developments are also expected in, for instance, automotive and aerospace systems, where microfabricated wireless sensor arrays, using energy harvesting technology, combined with actuators, embedded microprocessors and control technology will support “Drive-by-Wire” technologies that are expected to replace most mechanical connections.

The Institute for Robotics and Mechatronics at the University of Toronto will focus on coordinating the large number of academic and research activities underway within the Faculty of Applied Science and Engineering and facilitate the development of large teaching and research initiatives in the areas of Mechatronics and Robotics. The Institute will also pursue enhancing collaborations between faculty members and industrial partners and ensuring that research and teaching programs offered by the Faculty have high visibility nationally and internationally.

While the focus area of the Institute is wide and covers technical areas with applications in various sectors of the economy (i.e. Manufacturing, Automotive, Biomedical, Aerospace), the research initiatives to be pursued will be focused and will be pursued by subgroups within the Institute.

Goals and Objectives

The main objective of such an institute is to coordinate the large number of academic and research activities underway within the Faculty of Applied Science and Engineering at the University of Toronto (UoT) and facilitate the development of large teaching and research initiatives in the areas of Mechatronics and Robotics. Specifically:

- To assemble a number of research groups in the areas of Robotics and Mechatronics in order to enhance cross-disciplinary research and lead cross-disciplinary research programs and initiatives.
- To facilitate the commercialization of technology through proper technology transfer mechanisms and industrial collaborations.
- To lead the establishment of high caliber teaching programs focused on Robotics and Mechatronics at the undergraduate and graduate levels and establish the necessary infrastructure to deliver such programs.
- To enhance the visibility of research and teaching programs within the Faculty of Applied Science and Engineering at the University of Toronto nationally and internationally.
- To provide outreach to high schools and community, so as to promote engineering and attract students to the field.

Governance

The IRM will be established as an EDU:C extra departmental unit subject to the guidelines established by the University of Toronto for such units.

Organizational structure

The institute will actively pursue involvement from all research groups within the Faculty working in the relevant areas. The Institute will be run on a daily basis by a Steering Committee made up of UoT faculty members. The Steering Committee will be headed by a Director. An Advisory Committee made up of leaders from industry, academia and national labs will provide a consulting role on all institute activities.

Steering Committee

- Made up of academics from across the Faculty of Applied Science and Engineering
- Deals with operational decisions regarding all institute activities
- Ensures that the institute pursues its objectives
- Members of the committee are selected by the Director in consultation with the Dean, Chairs and Director of the relevant programs.
- Members are responsible for all the programs of the institute.
- Members meet at least quarterly.
- Members of the committee normally serve for 3 years.

Director

To be appointed by the Dean of the Faculty of Applied Science and Engineering for a fixed term. The director is responsible for:

- Policy, administrative and financial operations

- Chairing the Steering Committee
- Providing regular reports to the Dean, Chairs and Directors.

Advisory Board

- Consists of technical leaders in the areas relevant to the centre from industry, academia and national labs.
- Board members are to be appointed by the Dean based on a recommendation from the Director.
- Provides input to the Steering Committee on centre activities and initiatives.
- Identifies valuable initiatives to members of the Institute.
- Members of the Advisory Board serve for a period of up to 3 years.
- Reviews the annual report and plan.

Measures of Success

The success of the Institute will be measured based on its ability to bring together faculty members from across the Faculty to offer the best educational programs and to enhance their research in the broad areas of Robotics and Mechatronics while raising the national and international profile of the University of Toronto and its impact on the community.

Specific measures include:

1. International recognition of the University of Toronto as a leader in Robotics and Mechatronics education and research.
2. Number of high caliber Canadian and international students and researchers attracted to study and/or enhance their careers at the University of Toronto in the areas of Robotics and Mechatronics.
3. Number of large research initiatives in emerging areas within Robotics and Mechatronics that are led by members of the Institute.
4. Number and quality of crossdisciplinary teaching and research programs that take advantage of the large expertise available across the faculty.
5. Number of quality partnerships and collaborations between members of the Institute and partners from academia, industry and the community.