McGill

Centre for

Intelligent Machines

September 1998

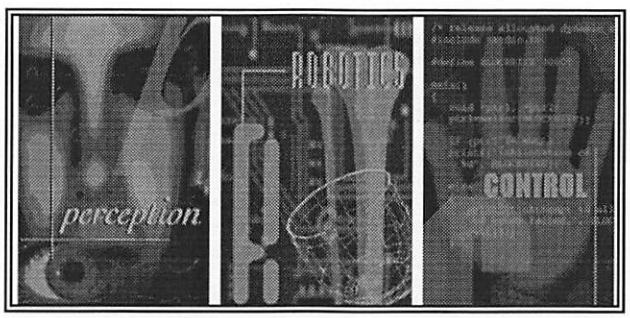
CIM – An Overview

INTRODUCTION

Summary

Well trained, highly skilled graduates in the electrical and mechanical engineering and computer fields are critical to Canada's ability to respond to the demands of a very lucrative global marketplace.

The *Centre for Intelligent Machines* (CIM) has been making a vital contribution to the mentoring and development of hundreds of graduate students in engineering and computer science for over a decade. It is also an international venue for showcasing McGill's prominent scientists and their work in intelligent systems. Ranked among the top 10 of its kind in the world, CIM is the largest centre in the Faculty of Engineering and arguably the most prestigious centre in Canada devoted to the study of intelligent systems.



As CIM moves into its second decade, the Centre is facing new challenges and fresh directions. Both internal and external factors have influenced the departure of several prominent members. There have been drastic government cutbacks in funding for research and development. Moreover, with increased urgency, granting agencies are tying research monies to industrial partnering. All of these factors have impacted CIM directly.

Responding to these challenges has become the impetus driving CIM into the millennium. Armed with a formidable team of researchers, students and dedicated staff, the Centre has seized these challenges as opportunities for renewed growth and diversification.

This document will familiarize the reader with the Centre for Intelligent Machines – its role as a centre, its people and culture, its purpose in McGill's educational mission and its contribution to the McGill community over its 13 year history.

Research Centre vs. Department

For the purpose of clarification, within McGill several distinctions exist between a research centre and a classical department. Faculties are divided into Departments plus a few specialized Schools, Institutes and Programs. These are the units that appoint Professors, grant degrees at both the undergraduate and graduate levels and have responsibility for the McGill base budget. Students must be registered in one of these units in order to be officially counted. Centres, on the other hand, have no right to hire tenure-track staff or give their own Master's or Doctoral degrees and have no access to the base-budget at McGill for funding their activities. In short, research centres at McGill must be entirely self-supporting for the direct costs of their research and staff.

Additionally, research centres within McGill are required to add an extra dimension to the research capacities and productivity of the academic staff members who join the Centre. Whereas a Department typically represents a collection of individuals with a well-defined commonality of research interests, but not necessarily a willingness to exchange or collaborate on ideas, there must exist within a Centre a strong motivation among its members to participate in joint research and contract work.

The effectiveness, and ultimately the long-term viability, of any Centre relies on its ability to transcend classical departmental boundaries, thereby creating a unique "culture" within the University's research community that emphasizes team work and cooperation.

The People and Culture of CIM

Since its official formation in 1985, CIM has carved an identity for itself as a world leader in the study of intelligent systems – robotics, automation, computer vision and systems and control theory. Spanning two faculties and several departments, and reporting to the Faculty of Engineering and the Faculty of Research and Graduate Studies, CIM has justly earned a reputation as a world class facility dedicated to the pursuit, advancement and sharing of knowledge. Launched by a core group of researchers in Electrical Engineering whose objective was to encourage interdisciplinary collaboration under the common theme of intelligent systems, CIM grew rapidly into a centre comprised of researchers from Mechanical Engineering, the School of Computer Science, Mining and Metallurgical Engineering and Biomedical Engineering. This Centre of Excellence has achieved international status entirely on its own financial merit.

CIM fulfills its mission as a research center with dedication and integrity. Over the years, the people of CIM have proudly assumed the role of ambassadors and mentors to multitudes of visiting scholars, international delegations, politicians, business leaders, government officials, youngsters and high school students. CIM's success, and longevity, can be attributed to many factors – outstanding quality of research, a spirit of teamwork and collaboration, state-of-the-art laboratories, and an extraordinary willingness on behalf of CIM's academic members to share knowledge, equipment and space.

Aforementioned qualities notwithstanding, CIM's greatest asset is, and always has been, its students. Collectively, these bright and energetic individuals form the heart and soul of CIM's very existence. As new students begin the rigors of post-graduate studies at CIM, it is remarkable to witness the bond that develops between these young engineers and the Centre's researchers, staff and fellow students.

There is commitment at every level to cultivate an environment in which each student feels welcome and special. While never losing sight of the goal to achieve excellence in research, there prevails within the Centre's framework a degree of interaction, of sharing, of taking pride in each other's accomplishments and of mutual support and respect that sets CIM apart from traditional departments. This type of nurturing plays a significant role in the personal and professional development of CIM's graduates.

CIM's culture provides many benefits to these students. Because of the emphasis on teamwork, the Centre's students develop a multi-faceted and creative approach to project management. They gain hands-on experience in giving presentations and popular lab "demos" to a diverse and challenging audience ranging from renowned scientists and high ranking corporate executives to grade school students, thus refining their leadership and interpersonal skills. They participate in an environment where, on a day-to-day basis, considerable attention is paid to coaching by supervisors and senior research engineers alike. Equally important, through interaction with industry, they develop a keen awareness of business issues and concerns. Thus, the spirit of entrepreneurship is alive and well at the Centre, as evidenced by the many spin-off companies that have been born of CIM graduates.

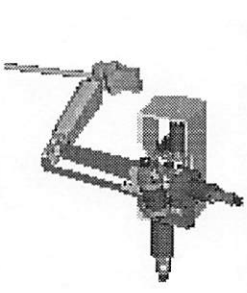
When students leave the Centre to move on to careers elsewhere, there is a genuine sense that a family member has left home. Conversely, departing students themselves often express the desire to remain at CIM as research engineers, despite the fact that industry has aggressively courted them with far more competitive salaries and attractive incentives.

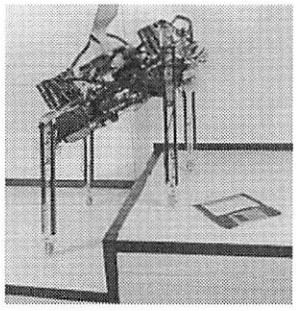
CIM – THE FIRST DECADE
1985 - 1995

Definition

What is an *Intelligent Machine*?

Artificial Intelligence (AI) has been an important area of study for over 40 years, essentially starting with the earliest computers. A significant aspect of this endeavor is research on so-called Intelligent Machines, the focus of the Centre. The simplest definition of an intelligent machine is one that governs its actions on the basis of a continual perception of its environment, linking sensory feedback with system control in a loop which is operating dynamically. This is also how humans and animals typically function. The connection between the biological and the computational is a recurring theme in the Centre's research.





The Research Team

The Centre for Intelligent Machines was founded in 1985 to provide researchers in robotics, computer vision, speech recognition, and systems and control with a context in which to pursue a common goal: the understanding and creation of systems which exhibit intelligent behaviour. At the peak of its first decade, CIM (then known as McGill Research Centre for Intelligent Machines, or McCRIM), was home to 16 academic members. These researchers formed an impressive knowledge pool working across many disciplines – the Departments of Electrical, Mechanical, Biomedical and Mining and Metallurgical Engineering and the School of Computer Science.

In addition to being world leaders in the study of intelligent systems, CIM's research teams actively participated in numerous scientific contributions in peer review journals and have developed considerable intellectual property in the form of patents and copyrighted software.

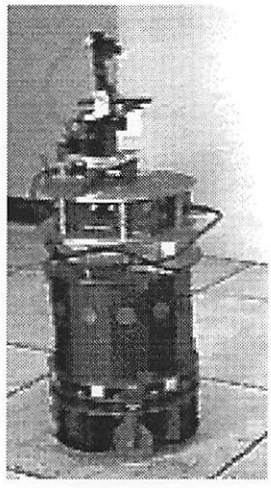
Principal Groups of Research

Between 1985 and 1995, the research team was divided into four principle groups of research in intelligent machines:

- vision
- robotics
- speech recognition
- control theory

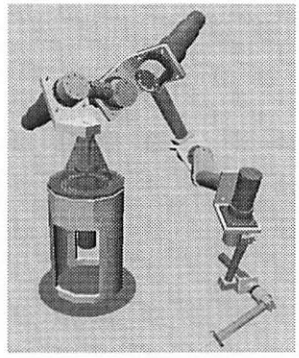
Principal Themes of Research

Research in intelligent machines involves the study of the complexities of human processes – thinking, feeling, seeing, moving, making decisions and carrying out specific tasks. As a result, CIM's research centered on three basic issues:



- perception
- cognition
- action

Perception refers to the ability of the machine to visualize, or sense, its environment and interpret the existing physical layout. **Cognition**, the "thought" processes of the machine, evaluates the results of what it visualizes and puts together an appropriate plan to carry out and control the action. **Action** deals with the physical manifestation of a task, for example, movement or manipulation.



Applications

Similar to computers, intelligent machines are powerful tools which can be, and are used beyond the capability of the human creator. With increasing efficiency, these machines are capable of adjusting to the real world in an ever-changing environment. Modern computer technologies have helped to reduce the cost and size of earlier generations, thus dramatically increasing their range of applications to the real world and improving their

impact on the quality of human life. Robotics is an important subgroup in intelligent systems. Apart from the more glamorous Mars Pathfinder, mobile and legged robots are in demand for use in extremely hostile environments such as radioactive surroundings or bomb disposal. The use of advanced robots in welding and laser welding applications significantly reduces the long term health hazards to humans caused by the carcinogenic substances present in weld fumes and dust and also reduces potential damage to the eye. Humanoid robots, such as the one developed by Honda Corporation, might eventually assist the elderly or handicapped. Other sectors have benefited from advanced technology in intelligent machines as well. For example, surgical simulators provide many exciting technical and scientific challenges in medicine. Applications are also prevalent in the defense sector and the aeronautics industry where air traffic control systems and navigation systems are employed.

Funding Sources

As outlined earlier, research centres within McGill do not have access to the University's base budget and therefore must rely on other funding sources in order to sustain operations. CIM's funding sources are listed below:

Direct

- MESS – 1985 - 1989 – Ministère de l'Enseignement supérieur et de la science du Québec
- FCAR – 1989 - present – Fonds pour la Formation de chercheurs et l'aide à la recherche

Indirect

- NCE/IRIS – 1989 - present – The federal government's Networks of Centres of Excellence program (NCE) established 15 networks in which the Institute of Robotics and Intelligent Systems (IRIS) is one. CIM researchers lead several IRIS projects, and provided CIM with valuable indirect support to increase its number of research engineers and technical staff, to augment its experimental research and to substantially upgrade its computer network.

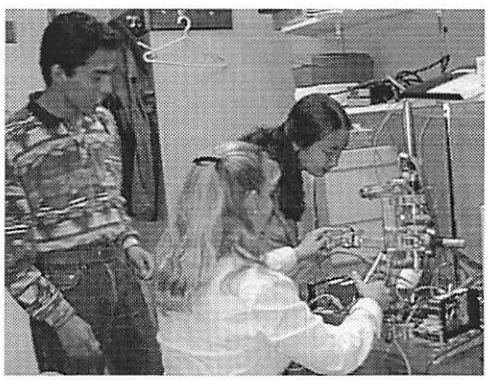
- CIAR – 1984 - 1995 – Canadian Institute of Advanced Research represented by five key members of CIM.

Students

Drawing from engineering and computer science, students of CIM are enrolled in post-graduate studies related to his or her supervisor's area of expertise. In 1993-94, the student population peaked at 151.

Date	*Ph.D's*	*Masters*	*Total*
1997-98	33	39	**72**
1996-97	48	59	**107**
1995-96	51	60	**111**
1994-95	55	88	**143**
1993-94	61	90	**151**
1992-93	52	85	**137**
1991-92	49	75	**124**
1990-91	43	61	**104**
1989-90	44	50	**94**
1988-89	53	88	**141**

As previously noted, CIM's culture provides unique advantages to its students – it exposes them to a spirit of teamwork, a high degree of collaboration, and an awareness of business issues. One consequence to this environment has been the generation of a considerable number of spin-off companies over the past decade. These companies are largely creations of former graduate students and represent measurable success at the transfer of CIM technologies.



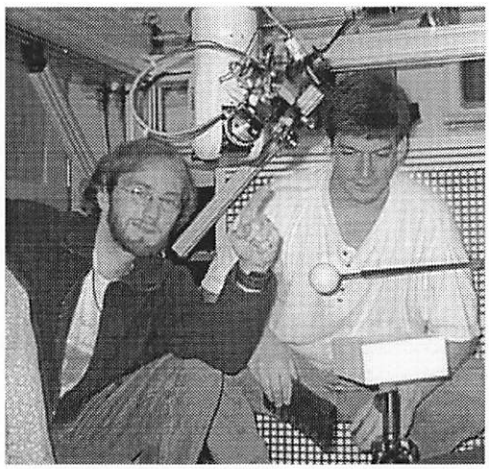
Facilities

Since its inception, the Centre for Intelligent Machines has functioned primarily on the 4th floor of the McConnell and Macdonald Engineering Buildings. Today this area houses 35 offices, nine labs, a computer machine room and a video editing room. Main laboratories include the Ambulatory Robotics Lab, the Artificial Perception Lab, the Haptics Lab, the Mobile Robotics Lab and the Robotic Mechanical Systems Lab.

CIM – THE SECOND DECADE
Strategy for the Future

New Research Initiatives

Information technology is an industrial sector moving at breakneck speed. Consequently, it can be difficult to anticipate how technology will evolve and how it will impact society.



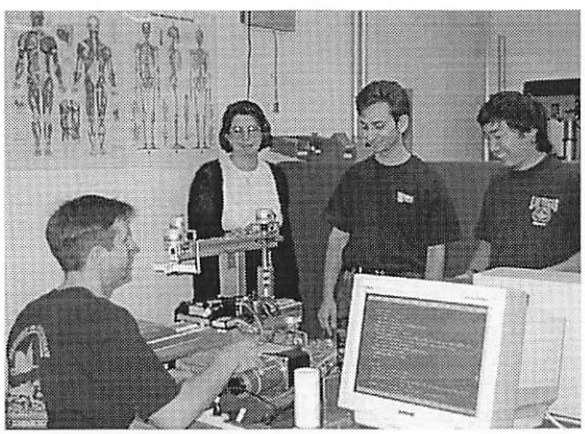
The following is a small sampling of key areas of new interest in IT research within CIM and their applications to knowledge-based industries.

Perception:

- Recent advances in optics and microelectronics (photonics) have revolutionized the capacity and design of optical sensing systems. So-called *"smart-sensors"*, incorporating both sensing and computational elements on the same silicon, have provided a means of realizing many of the earlier ideas on biological computation.

- *Intelligent environments* greatly expand the notion of an intelligent machine into an intelligence distributed across an environment, e.g. smart rooms that set their configuration according to tasks as sensed from the behaviour of it's occupant. This brings much of the Centre's expertise in artificial perception into an entirely new research area.

- The study of intelligent environments has spawned several research initiatives:



(1) Researchers are currently building a set of rooms that provide inhabitants with a rich sense of presence in a remote space, allowing physically separated individuals to share a common environment. These rooms will be interconnected by audio and video under computer control, and will configure themselves dynamically based on the activity taking place.

(2) Tools are being created for an electronic classroom so that teachers can give their lectures without having to think about how to control the technology. In addition, the classroom will automatically create a Web-based version of the lecture, both for review purposes and for those students who were unable to attend the class in person.

(3) Investigations are underway to determine how modern hospital equipment can be networked together to share time-sensitive information. This could enable medical workers to concentrate attention on their current tasks without being distracted by low-level control and monitoring of other devices.

- *Content-based image retrieval* (CBIR) systems are an effective means of using information stored in digital image databases. Software is currently being developed within CIM that is capable of being searched using object classes, such as faces, cars, seascapes and urban environments. This will provide a very useful mechanism for communicating with large image databases which are becoming extremely prevalent on the Internet.

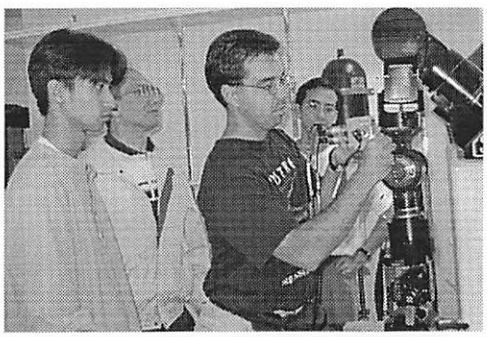
Robotics – Mobile, Ambulatory and Mechanical:

- A new project has been initiated on how groups of two or more moving robots can work together to explore the environment or search it for items of interest or hazards. This is closely tied to research on how biological organisms interact in groups. Also under investigation is how to construct realistic models of large spaces automatically using cameras and/or moving robots.

- A collaborative project is underway with multiple CIM members and institutions on the automated creation of virtual museums and exhibitions. This project will bring together skills on sensing, robotics modelling and other areas. In addition, another group in mobile robotics will be working on control problems for robots and other complex systems.

- New studies have begun in the area of novel mechanical transmissions. These include speed reduction that will replace gear trains; speed modulation intended to produce quick-return motions, for example in production of automation systems; and speed demodulation, which will compensate for geometric nonlinearities in mechatronic systems.

- Technologies are presently being developed for the control of long booms carrying a small robot at their tips for tasks such as aircraft de-icing or cleaning.



- In collaboration with the mobile robotics group, researchers within the Ambulatory Robotics group are working on the design, control and remote operation of a legged mobile robot for indoor environments. Applications include bomb disposal, surveillance and some forestry tasks.

CIMI – The CIM Incubator

For many years, industry has been sending out a clear message to universities – they want more and more involvement in the direction of research and development. Today the degree of university-industry collaboration evident in research is the critical factor in evaluating research grants. Given the fact that CIM's culture has traditionally been that of a multidisciplinary centre involved heavily in basic research, the members recognized the implications of this overwhelming trend.

To adapt its environment to better meet the needs of industry, the CIM Industrial Liaison Group Incubator was established. This is a bold and innovative move intended to increase industry linkages and to facilitate the transfer of knowledge between CIM and local and international business.

The CIM Incubator is intended to play a pivotal role in cultivating the enthusiastic and fearless nature of CIM graduate students by fostering an entrepreneurial and community spirit at the earliest stages of business development. It also serves as an effective mechanism for bringing together scientific talent with business capital and know-how.

The CIM Incubator's mandate is to:

- Encourage and cultivate an "entrepreneurial spirit" amongst CIM students and Professors
- Foster the creation and development of CIM spin-off companies
- Provide a supportive climate in which entrepreneurs have the opportunity to learn skills and access expertise which will assist them to develop new industry in Quebec, Canada and abroad
- Increase the potential for joint university–industry collaboration
- Create opportunities for accessing public and private funding sources and for generating revenue for research