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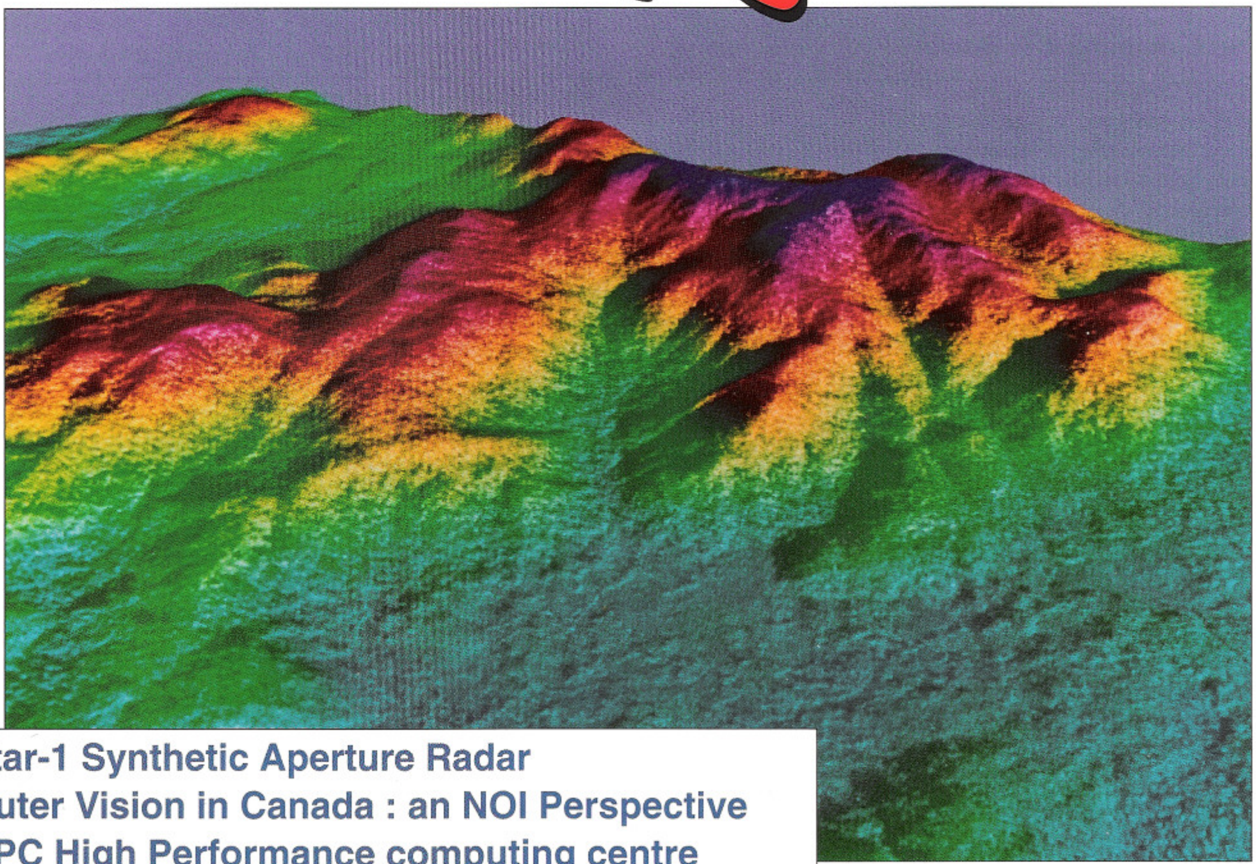

- The Star-1 Synthetic Aperture Radar
- Computer Vision in Canada : an NOI Perspective
- The HPC High Performance computing centre
- The development of Power System Analysis Tools in Canada

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IEEE Canadian Review General Information

The ***IEEE Canadian Review*** is published three times per year as follows: Winter (to appear in early March); Spring/Summer (to appear in early July); Fall (to appear in early November).The ***IEEE Canadian Review's*** principal objective is to project an **image** of the Canadian electrical, electronics, communications and computer engineering professions and their associated academic and business communities to :

(i) Canadian members of IEEE;
(ii) Canadian members of the profession and community who are non-members of IEEE;
(iii) the associated academic (i.e. universities, colleges, secondary schools), government and business communities in Canada.

To ensure that the ***IEEE Canadian Review*** has the desired breadth and depth, Associate Editors are responsible for identifying issues and screening articles submitted to the ***IEEE Canadian Review*** according to the following general themes :

1- National Affairs
2- International Affairs
3- Industry
4- Education
5- Power
6- Communications
7- Computers

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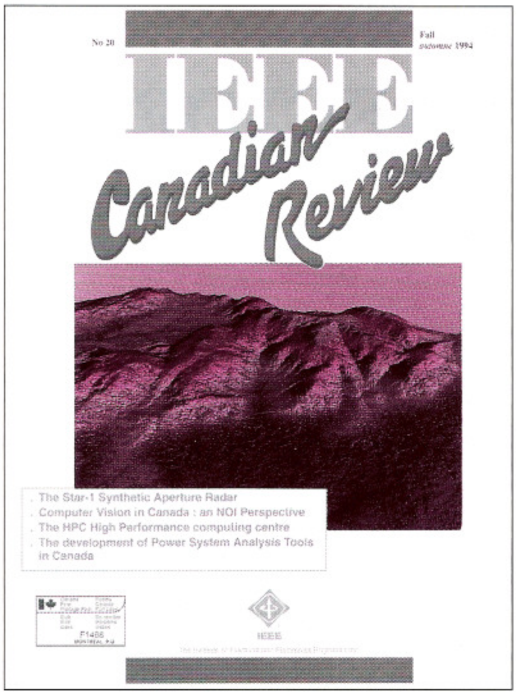
Cover picture

This perspective view of Oban, Nigeria, was generated from stereo radar data by overlaying an ortho-rectified image on a Digital Elevation Map and generating a perspective view using PCI's «FLY» software. The data was collected in March 1993 for the Commission of European Communities, DG VIII-D5, Belgium.

Tableau couverture

Ce plan en perspective de l'Oban au Nigérie a été créé à partir de données d'un radar stéréographique par la superposition d'une image ortho-rectifiée sur une carte d'élévation numérique, grâce au logiciel «FLY» de PCI. Les données ont été saisies en mars 1993 pour le compte de la Commission des communautés européenes, DG VIII-D5, Belgique.



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DIRECTOR'S REPORT

Jacek Chrostowski's hard work and dedication has resulted in plans to establish a Canadian electronic mail network for IEEE Canada members. He has decided on eight regional centres to cover most members in Canada with a local phone call. This is one of the great things about my job as your Director. I keep running into tremendously dedicated, enthusiastic volunteers who don't know the meaning of the phrase "It can t be done". They do it in spite of all odds, and, incidentally our Region is way out in front of everyone else in getting connectivity for its constituents.

Adam Skorek is another dedicated volunteer. He is using his energies to help solve the problem of providing Continuing Education services for Electrical Engineers in Canada. In his first effort, Adam has targeted the power utilities, negotiating a grant to help develop the services needed. Adam has also put together an ambitious program with the help of the Education Department at IEEE Headquarters, to inform IEEE Canada members about what is available. If you would like more information about this, or would like to be involved, please contact Adam at a.skorek@ieee.org.

The question of Section boundaries has plagued us for years. Some members have been assigned to Sections remote from their homes, for example those members who live in Hull belong to the Montréal Section. There are two ways to solve this dilemma: to invite this large group of members to form their own Section (it takes the signatures of 50 members to petition for the formation of a Section). Eric Holdrinet (Montréal Section Chair) and Ibrahim Gedeon (Ottawa Section Chair) have pledged to help Hull follow this route. The second approach is to try to address the problem on a rational basis by postal codes. Ibrahim has undertaken to build some software to do this. He will be testing it with the help of the Montréal Section's cooperation this fall. We hope to implement it across Canada by spring, 1995.

Plans are under way already to hold a celebration of our newly merged IEEE Canada at the Regional Conference in Montréal next September. Notice will shortly be coming in a call for papers for the conference. The Halifax conference was very well received by those attending, and attracted the attention of both provincial governments and the federal government. Bob Baird and Euan Strachan, along with a formidable team from the Maritimes and Newfoundland, helped to put the conference together.

Approval was given at the last Board meeting to proceed with plans for the merger with CSECE. We expect final approval for the merger to be given at the November Board meeting, contingent upon a favourable vote from Canadian members in the referendum circulated with the ballots for the election. If you have not already done so, please return your ballots now: exercise your franchise to choose the next governing body of IEEE. Make your wishes known about the merger, as well.

The IEEE Board of Directors has announced that the first meeting of '95 will be held in Calgary from 28 February to 6 March. We believe this would be an appropriate occasion to welcome the Board again to our Region so that members of the Board could help us to celebrate the founding of IEEE Canada. I have asked the IEEE Management whether it would be possible to help us to plan a reception for the Board, to be hosted by the Executive Committee for IEEE Canada, in cooperation with IEEE Headquarters.

by Ray Findlay
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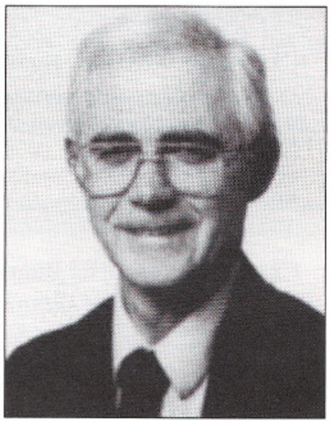

I have had several people ask me when I intend to have a new Region Office. Part of the problem with the Region Office as previously constituted was that it was supported solely from Region funds. There was no support from Headquarters. Hence, for example, Headquarters charged us full member price on Standards. We could not supply them to our customers at a reasonable price, hence lost a lot of money on them. Had the Office been an arm of the IEEE Offices, instead of wholly a Regional Office, the problems could have been solved. I have had preliminary discussions with staff on the feasibility of an IEEE Office to be located in Canada. This would be an advantage to both IEEE and us because it would circumvent Customs problems as well as difficulties we have in getting GST credits. The Region could be a partner in such an Office. I will keep you posted as I pursue this idea.

Finally ...

We come to difficulties with Customer Service. The entire process of member record keeping, order processing, membership renewal, etc. is being restructured in a new relational data base. During the changeover, there may be some difficulties in communicating with headquarters, getting applications processed, etc. However, I would like to track the process to establish that our members are getting the service they pay for. To help me do that I need members to keep records whenever they deal with Headquarters. Keep records for orders, keep a copy of your renewal notice, date of return, etc. When you sponsor an applicant for membership, take a photocopy of the application form and note the date of mailing, payment process, etc. If you have any troubles please let me know. Send me a copy of the documentation. I will help you solve the problem.

IEEE is a member-driven society. It's your society. Let me know your wishes. If you have something you want to tell me, send me an email for preference, or a FAX. Or phone me if you need to talk to me personally.

RAPPORT DU DIRECTEUR

Les efforts et le dévouement de Jacek Chrostwoski ont permis de mettre sur pied un réseau canadien de courrier électronique pour les membres d'IEEE Canada. Il a établi huit centres régionaux regroupant ainsi la plupart des membres par un simple appel téléphonique local.

Ça, c'est un des aspects magnifiques de mon travail en tant que directeur d'IEEE Canada. Continuellement, je rencontre dans cette organisation des volontaires enthousiastes et dévoués qui ne connaissent pas la signification du mot «impossible». En dépit des embûches, ils y arrivent. Or, notre région est loin devant quant à fournir une telle connexité de ses membres.

Adam Skorek est un autre bénévole hors pair. Présentement, il concentre toute son énergie à trouver une solution au problème de la formation continue pour les ingénieurs en génie électrique du Canada. Dans un premier temps, Adam s'est consacré à la négociation d'une subvention afin de développer les services nécessaires à ce projet. Avec l'aide du service d'éducation du bureau chef d'IEEE, Adam a mis sur pied un ambitieux programme afin d'informer les membres d'IEEE Canada de ce qui est disponible. Si vous désirez plus d'information ou si vous souhaitez vous impliquer dans ce projet, veuillez le contacter à : a.skorek@ieee.org.

La délimitation des frontières des sections nous a préoccupés depuis de nombreuses années. Par exemple, des membres demeurant à Hull se voient rattachés à la section de Montréal. Il existe deux approches pour régler ce dilemme. La première serait d'inviter les membres de la région de Hull à former leur propre section (une pétition comprenant 50 signatures est requise pour former une section). Eric Holdfrinet (président de la section de Montréal) et Ibrahim Gedeon (président de la section d'Ottawa) se sont engagés à aider les membres de la région de Hull à réaliser cette option. La seconde serait de délimiter les sections selon les codes postaux correspondants. Pour ce faire, Ibrahim a déjà entrepris de mettre au point un logiciel. Il fera les premiers essais avec la collaboration de la section de Montréal cet automne. Nous souhaitons pouvoir l'implanter à travers le Canada au printemps prochain.

Déjà, nous travaillons à l'organisation d'une célébration pour notre nouvelle fusion lors du congrès canadien à Montréal en septembre prochain. Prochainement, une annonce d'appel aux communications pour ce congrès sera publiée. Le dernier congrès qui se tenait à Halifax a été très apprécié des participants. Il a même réussi à attirer l'attention de nos deux palliers de gouvernement. J'aimerais souligner le beau travail de Euan Strachan et Bob Baird avec l'équipe des maritimes et de Terre-Neuve.

Le conseil d'administration a donné son accord lors de sa première rencontre pour continuer les démarches en vue de la fusion avec le CSECE. L'accord final pour cette fusion devrait être donné lors de la rencontre du conseil en novembre. Par contre, cette fusion est conditionnelle à un vote favorable des membres canadiens au référendum circulant présentement. Si vous ne l'avez déjà fait, veuillez nous faire parvenir votre bulletin de vote dès que possible. Profitez du droit qui vous revient d'élire vos prochains dirigeants et faites-nous connaître votre choix quant à la fusion avec le CSECE.

Le conseil d'administration d'IEEE a annoncé que sa première rencontre de 1995 aura lieu à Calgary, du 28 février au 6 mars. Cela nous semble une belle opportunité d'accueillir de nouveau les membres du conseil dans notre région et de profiter de leur passage pour célébrer avec nous la fondation d'IEEE Canada. J'ai demandé à la direction d'IEEE si nous pouvions compter sur leur collaboration pour organiser une réception dont le comité exécutif d'IEEE Canada serait l'hôte.

Quelques personnes m'ont demandé si j'avais l'intention de mettre sur pied un bureau régional. Comme déjà mentionné, le problème avec un bureau régional, c'est que les dépenses sont supportées par les fonds de la région uniquement. Il n'y a aucun support du bureau chef. Désormais, par exemple, le bureau chef nous chargera le plein tarif membre pour les publications portant sur les normes. Ainsi, nous n'avons pas pu les distribuer à nos clients à un prix raisonnable et nous avons perdu de l'argent. Si ce bureau était soutenu par IEEE au lieu de l'organisation régionale, ce problème pourrait être évité. J'ai déjà entamé des discussions avec IEEE quant à la possibilité d'établir une succursale au Canada. Cette option serait avantageuse pour IEEE parce qu'elle contournerait les problèmes de douanes et les difficultés rencontrées pour obtenir les crédits de TPS. La région pourrit être partenaire d'un tel bureau. Je vous tiendrai au courant des développements en ce sens.

Finalement ...

Nous en arrivons aux difficultés éprouvées avec le service à la clientèle. La restructuration des procédures concernant les inscriptions, les commandes, les renouvellements, etc. est présentement en cours de réalisation dans une nouvelle base de données. Pendant cette transition, il se peut que vous éprouviez des problèmes de communication avec le bureau chef, ou dans le traitement des demandes, etc. Cependant, je compte suivre cette opération afin de m'assurer que chaque membre reçoit le service pour lequel il paie. Pour m'aider dans cette tâche, il faut que vous gardiez toute pièce justificative lors de vos communications avec le bureau chef. Si vous parrainez un nouveau membre, faites une photocopie de l'application, notez la date d'envoi et le mode de paiement. Si une anomalie se présente, dites-le moi. Envoyez-moi une copie des documents et je pourrai ainsi vous aider.

IEEE est une société dirigée par ses membres. C'est votre société. Faites-moi savoir vos souhaits. Si vous avez un message à me transmettre, faites-le, de préférence par courrier électronique ou par télécopieur. Si vous désirez me parler personnellement, n'hésitez pas à me joindre par téléphone.

The STAR-1
Synthetic Aperture Radar

by R. T. Lowry, M. D. Thompson and J. B. Mercer
Intera Information Technologies, Calgary

«STAR-1» is a Synthetic Aperture Radar (SAR) system that was developed by Intera Technologies for commercial remote sensing. Introduced in late 1983 as the world's first fully digital, real time commercial SAR system, it has since become the basis for applications around the world in areas such as geological exploration and tropical forest management. This paper describes the STAR-1 system and the business that is based on the imagery it generates. It is the second in a series describing ongoing Canadian work in the area of radar remote sensing.

«STAR-1», un système de radar d'aperture synthétitique, a été développé par Intera Technologies pour des applications de télédétection commerciale. Mis en service en 1983 comme premier système numérique et temps réel au monde, STAR-1 est depuis à la base des applications mondiales dans des domaines tels que l'exploration géologique et la gestion de forêt tropicale. Cet article présente STAR-1 et ses capacités d'imagerie, ainsi que les activités commerciales qui en découlent. Ceci constitue le deuxième article dans une série consacrée à la télédétection au Canada.

Radar - an all-weather day/night sensor - has been used since World War II for a wide variety of surveillance and reconnaissance applications. Radar detects 'targets' by transmitting a pulse of radio waves toward them, and detecting the reflected energy. The range, or distance to the target is calculated from the return transit time of pulses (range) which have been focused in one direction by an antenna, hence the acronym, RADAR from RAdio Detection And Ranging. Imaging radars use the movement of a platform, with the antenna pointed perpendicular to the direction of motion, to provide a second dimension (azimuth), and thereby build up a two-dimensional strip image. These images, which represent the radar reflectivity of the terrain being imaged, are from 10 to 100 km wide, and may be several hundred kilometres in length. Imaging radars (called SLAR for Side Looking Airborne Radar) were developed in the 1960s and 1970s as military reconnaissance tools. As these technologies were declassified, they quickly attracted civilian users, based in large part on their ability to provide information in an image format essentially independently of cloud and sunlight conditions. An advanced signal processing version of these radars, known as Synthetic Aperture Radar (SAR), produces imagery with resolution that is independent of range. In 1983, Intera introduced a new fully digital SAR service to the world, called STAR-1. For the first time, it was possible to obtain very fine resolution digital radar imagery, in real time, from a commercial operator. This system was immediately engaged in providing close tactical support to the oil exploration activities in the ice-covered waters of the Beaufort Sea. Since that time STAR-1 has been developed by Intera into a comprehensive radar remote sensing system, with a global clientele for a wide variety of services.

Intera is a publicly held company, with its head office in Calgary and offices throughout the world, specializing in providing geographical information solutions to a wide variety of commercial and government clients. Intera has been involved in remote sensing since its start in 1974, and is currently one of the world's largest non-governmental suppliers of data to the remote sensing community. In its Image Mapping Services Division, Intera operates airborne imaging radar systems, processes and analyzes data from airborne and spaceborne sensors, and using these data sources, delivers information as custom-tailored maps to its clients.

This article describes the development of the STAR-1 radar, its specifications, the evolution of the system over the last decade, and the global applications-related business developed using the system. This article is part of a series in the IEEE Canadian Review dealing with the ongoing work in Canada in the area of SAR technology and applications. In this and the next three issues of the IEEE Canadian Review, some of the work in Canadian government and industrial organizations will be described. (See No. 19, Spring Summer, 1994.).Topics to be covered include the current research and development focusing on multi-band and multi-polarized SAR with the Canada Centre for Remote Sensing's (CCRS) SAR-580, Canada's RADARSAT program, and research and development within the Department of National Defence on Spotlight SAR.

STAR-1 Development and System Description

STAR-1 was designed and developed to meet a perceived need for fine quality, reliable information on ice conditions and geology. It was the first such system in the world to be built entirely without government funding, and was designed to be supported exclusively on the revenue from data sales. The cost of the data from the system needed to be kept relatively low to ensure data sales could support the system. Thus the capital and operating costs of the system both had to be low. The system also needed to produce a very fine, commercial product.

The development of the STAR-1 SAR was a study in compromise between the requirements for quality imagery, low cost, small size, light weight, and high reliability. It was also an excellent example of the productivity of a cooperative relationship between government and industry. The SURSAT program (VanKoughnett et al.1980), which was funded by government, brought together a large number of industrial users of radar data with a research effort aimed at developing the criteria for a Canadian radar reconnaissance system which has become known as RADARSAT. As the RADARSAT launch was many years in the future, this created a unique opportunity for industry to develop a commercial SAR. The result was STAR-1.

The system design for STAR-1 was carried out by Intera, based on SURSAT results and specific experiments designed to optimize the system for commercial remote sensing (Lowry and Hengeveld, 1980).

The hardware design of STAR-1 was carried out by ERIM (Nichols et al., 1986), based in large part on the availability of the real-time processor (RTP) developed by the Vancouver firm, MDA for the Canada Centre for Remote Sensing (CCRS) radar. STAR-1 operates at X-Band (3.2 cm wavelength) with a horizontally polarized antenna system. The imagery consists of a continuous strip map of 4096 pixels (either 6 or 12 metres, user selectable with the lines spaced 4.2 metres apart). The effective resolution of the system is approximately 8 metres in range (across-track) and 6 metres in azimuth (along-track). Image quality is kept very high by using a high degree of coherent fading or speckle reduction (7 looks).

STAR-1 is installed in a small executive-class turbo-prop (Cessna Conquest), an airframe with low operating costs but high altitude and long range performance. The system has been upgraded regularly since 1983 and consistently produces imagery of excellent quality.

STAR-1 and Ice Reconnaissance

In the fall of 1993, STAR-1 entered service and was immediately engaged to support late season drilling operations in the Beaufort Sea. The availability of fine resolution imagery via a real time downlink with a range in excess of 300 km made STAR-1 both a technical and commercial success. Marine operators came to rely on the availability of timely radar imagery, delivered to the bridge of the ship, and timely STAR-1 imagery became part of the operational requirements for a number of marine operators. For the first few years, the data rates involved (2-4 Gbytes of data per mission) dictated the use of direct film recorders. More recently, Intera's softcopy workstations, STAR-VUE, have been deployed on both land and ships to store and exploit the real time SAR imagery for marine navigation.

Three factors led to the cessation of ice activities for STAR-1. First, Intera developed a second system dedicated to ice reconnaissance, called STAR-2 (Mercer, 1989). This system, under contract to the Canadian government, was capable of covering the whole of the Arctic in a relatively short period of time, and thus could provide the needed ice reconnaissance. Second, changes in world oil prices and Canadian oil policy led to a decrease in the intensity of drilling activities in ice-infested waters. Third, Intera began to develop other markets for STAR-1, including geology mapping, cartographic mapping, and tropical forest monitoring.

STAR-MAP: Topographic Mapping Products from SAR

The provision of accurate, up-to-date topographic information is one of the most critical aspects of land-based mapping programs. Topography affects and is affected by all earth surface operations and land cover; digital topographic information has become even more important with the increase in use of geographic information systems and remote sensing image analysis in mapping and monitoring programs. Traditionally, aerial photography has provided the source data for topographic mapping. However in certain areas, particularly in the tropics, cloud cover has inhibited mapping from aerial photography or from optical satellite sources. Because of its cloud penetrating capability, radar offers an obvious alternative. The development of STARMAP, Intera's SAR-based topographic mapping process, has allowed topographic mapping to be carried out in these areas in a rapid, cost-effective manner as compared to traditional means.

In its current form, STARMAP is an all-digital system hosted on a single high-performance stereo-viewing workstation (Mercer and Griffiths 1993). Input to STARMAP includes overlapping digital STAR-1 image strips, differentially-processed GPS[1] data for precise flight-track recovery, and certain motion compensation parameters. Output products include ortho-rectified image maps[2], dams[3], elevation contours and other derived products. Output presentations appear both in GIS-formatted digital form and in analogue form at typical mapping scales of 1:25,000 to1:100,000. Geometric accuracy and image resolution preclude larger presentation scales, which remain in the domain of aerial photography. (By comparison, Canada's national topographic map series are presented at scales of 1:50,000 and 1:250,000).

Development of STARMAP has been on-going over several years in order to improve quality and production rate. Where feasible, automation has been introduced, but because of radar-specific problems operator interaction is required in many of the processes. The aim in these instances has been to provide the operators with the appropriate digital tools and procedures. At this stage STARMAP is considered fully operational although development will continue.

Several commercial mapping projects, ranging in size from 2,000 to 100,000 square km have now been completed. In one early program for example (Granath et al. 1991), STARMAP products were used in support of a successful oil exploration program in a very rugged mountain area of Irian Jaya, Indonesia. The radar imagery were used for geological interpretation, the radar image map for general base map applications such as logistical support, and the DEM was used in a geophysical "balanced cross-section" process which ultimately determined location and target depth of the exploration wells.

More recently in order to satisfy increased capacity requirements, the single workstation has been increased to ten with modular functionality being distributed among them. Resources are shared through a local area network (Ethernet) which connects the UNIX workstations (Kubota Pacific Titans and SPARC 10/30 and 10/40 platforms) and PC's. Because of the large image files, about 20 GB of disk is distributed among the systems.

Geologic Mapping

SAR data constitute a uniquely valuable information source for geologic mapping and for its applications in hydrocarbon and mineral exploration. They enhance surface terrain features and can acquire information in the cloud-covered tropical regions in which intensive exploration for hydrocarbons and minerals is taking place. STAR-1 has carried out data acquisition programs for large oil and gas and mineral lease areas in Indonesia, Malaysia, Papua New Guinea. the Congo, Equatorial Guinea, Colombia, Brazil, Venezuela, Cameroon, and other tropical countries, in addition to large regions of the United States and Canada (Thompson et al.1993).

The United States Geologic Survey has an ongoing program for 1:250,000 scale SAR image map coverage of the entire United States, most of which has been acquired and processed by Intera. Other programs have been carried out for international oil and gas and mineral companies,

1. The Global Positioning Satellite System (GPS) consists of a suite of 24 satellites. Using data from these satellites, a GPS receiver can calculate its position to an accuracy on the order of 30-100 metres in all three dimensions. By using a ground based receiver at a known location, as a reference, it is possible to improve the positional accuracy in locating an aircraft to 1-3 metres accuracy. This so called differential GPS or D-GPS is used by Intera to geo-reference imagery from its radars for precision cartography.
2. An Ortho-Rectified Image map is a 2-dimensional mosaic of individual image strips which have been rectified (i.e. adjusted to improve geometric fidelity), referenced to a map projection and presented in a 'parallax-free' or ortho-morphia view.
3. A DEM (Digital Elevation Model) or DTM (Digital Terrain Model) is a mathematical description of the Earth's surface usually presented as a two-dimensional grid of elevation values from which contours, perspective views, etc. can be derived.

and for national geologic survey and mapping agencies. In tropical areas, several success stories have resulted from the use of SAR data for geologic mapping and exploration. Two of the largest oil discoveries in the tropics in recent years are directly attributable to the availability and interpretation of radar data provided by the STAR-1 system. The very successful Chevron (Nuigini Gulf) oil wells in Papua New Guinea were drilled on locations selected primarily from SAR data. Integration of SAR data with other types of digital data with relevance for exploration (geophysical (magnetics, gravity), geochemical, seismic) is now an operational technique.

Forest Cover Mapping

SAR as a tool for forest cover mapping and forest depletion monitoring has developed from research to operational status over the past decade (Thompson et al. 1993). Although airborne radar was recognized during the 1970s as having potential for land cover and forest mapping and monitoring, it was not until about 1986 that SAR began to be used routinely for monitoring forest resources in cloud-covered tropical areas. Operational programs have been carried out using STAR-1 in many tropical areas. Figure 1 provides an example of forest land use change monitoring using high resolution SAR data from 1989 and 1991 from a southeast Asian peatswamp forest area. Changes in selective logging using rail lines, agricultural patterns, road infrastructure, and particularly large-scale clearing of the forest for a sago plantation are very evident in these images.

Foresters using these data in the more recent programs require digital SAR, DEMs, and thematic forestry and land use layers for use in the increasingly prevalent Geographic Information Systems[1] (GIS) used by the forestry community. Recent mapping programs in Indonesia and West Africa (six countries) have generated 1:50,000 scale STARMAP topographic maps and forest cover maps. SAR is now being used routinely in operational forest management systems in areas of persistent cloud cover.

Land Use Mapping

Commercial studies using STAR data for tropical land use mapping and monitoring have to date covered relatively extensive areas, usually carried out as part of a multi-purpose program (Thompson et al. 1993). Permanent and shifting agriculture, some individual crops (banana, indian cane, tapioca, cocoa, rice, pepper, lowland rice, upland maize/rice, clove plantations, village coconut, coconut plantations), pasture, wetland, cropland, agricultural settlements, and various urban classes) have been mapped using STAR-1 data. In one area in Indonesia where aerial photographs were of inadequate quality for mapping and satellite images were unavailable, STAR-1 was used to map land units at 1:250,000 scale. A current program is producing SAR-based 1:100,000 scale land use maps for all of the Malaysian State of Sabah.

Future of STAR-1 Commercial SAR Remote Sensing

Over the last decade, a series of applications based on STAR-1 data have been developed from concept to commercial reality. Canadian technology that was developed with close cooperation between government and industry has led to a strong commercial base which has played a major international role in radar remote sensing. The world today, however, is much different from that of a decade ago and the market for SAR services has evolved. Other nations are now developing SAR systems for a wide variety of applications. There are now two operating SAR satellite systems: one launched by the European Space Agency (ERS-1), and one by the Japanese government (JERS-1). Canada's RADARSAT will be launched in August 1995, and ERS-2 in late 1994. There are also several airborne SAR systems that have been developed by a variety of research institutes, a number of which are venturing into the commercial domain.

While the radar applications knowledge base of the SAR user community has broadened, there have been concurrent developments of SAR systems with finer resolution, better terrain height measurement, polarimetric capabilities and multiple frequencies, all of which are still in the pre-operational phases. SAR systems with spatial resolution in the 1-3 metres range provide more detailed information for interpretation (although usually at the expense of area coverage efficiency). Direct measurement of terrain height is now being accomplished using a two-antenna interferometric system (three-dimensional SAR); such systems offer superior vertical accuracy to the two-pass stereo system used in STARMAP. Polarimetric radar systems more fully map the polarimetric response of targets, thus enhancing the capability to discriminate amongst subtle target identification parameters. Simultaneous acquisition of microwave frequencies other than the standard operational X-band and C-band--ranging from P Band (75 cm wavelength) to K Band (8 mm wavelength)--in multi-frequency radar systems also provides valuable additional information for target discrimination. Global coverage from the newer SAR satellite systems at modest resolutions has helped to stimulate the user community interest in SAR for a wide variety of applications.

The complementarity of spaceborne and airborne SAR systems for mapping and monitoring of topography, forest resources, land use and ice conditions has recently been recognized (Thompson et al. 1994). Establishment of a baseline map data set based on the finer resolution and shallower viewing geometry of the airborne radar systems can be efficiently carried out over local areas. Satellite SARs provide global or regional coverage with a steep viewing geometry, which is useful for broad-scale resource or topographic mapping, land use/land cover map updating, and monitoring applications such as oceanography and ice reconnaissance. Complementary use of the airborne and spaceborne SAR systems thus provides resource managers with cost-effective mapping.

The future for Intera's commercial SAR operations is thus both challenging and exciting. The rapidly evolving and expanding market for SAR products and services will continue to be served by Intera's operational airborne systems and by involvement in the satellite user product/service market. Intera will continue its leading role in the operationalization of commercial radar remote sensing through development of upgraded airborne radar products and services (e.g., finer resolution SAR data), of interferometric SAR capability, and of satellite SAR products and services involving training, geometric processing and topographic and thematic mapping products. These developments are currently in progress, based in large part on the technology to be described in future articles in this series.

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1. A Geographic Information System is a digital system used to store, present, and manipulate data layers with spatially-related attributes. A simple example in this context would consist of a 2-dimensional image-map upon which forest-type attributes, drainage, road infrastructure, and elevation contours were all overlayed in the form of vector (points, lines and polygons) and raster (image) data. An important virtue lies in the ability to organize, visualize and model the data layers.

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About the authors

With a background in Electrical Engineering from the University of Saskatchewan (B.Sc. 1967), and Imperial College, London (DIC and PhD 1971), *Ray Lowry*,s work has been in radar and related remote sensing areas initially as a government scientist at DREO and CCRS in Ottawa. Since 1978 he has been an industrial scientist with Intera Technologies of Calgary, developing new applications for SAR, upgrades to existing systems, and the development of new capabilities within the company.

With Intera since 1974, *Diane Thompson* is currently responsible for Intera's Geo-Information Services' programs in remote sensing/GIS consulting, thematic mapping and training/technology transfer business, in Canada, Southeast Asia, Africa, Latin America and Europe. She has been involved in development of new operational applications of remote sensing tools and geographic information systems (GIS), including environmental monitoring (global, national and local), tropical forest monitoring, tropical agriculture/land use mapping and geologic mapping, as well as user-based mission specifications for a proposed environmental monitoring small satellite.

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The IEEE Canada Conference Advisory Committee

There are a significant number of technical meetings held each year under the auspices of the IEEE. These meetings, whether large or small, entail a great deal of effort on the part of the organizing team of the conference or symposium. Some technical meetings are annual affairs with a long-standing organizational history, others are infrequent or one-time events that have no pre-established structure or routine to fall back on.

Most organizing committees, involved in either long-standing or infrequent conferences, consist of new people who may be inexperienced and may require some information, guidelines or tips for running a successful conference. The IEEE Canada Conference Advisory Committee (CONAC) provides such a service to its membership (Sections and Chapters). CONAC is an Operating Committee of the IEEE, reporting to the IEEE Canada Board of Directors, with a specific mandate to facilitate conference organization.

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COMPUTER VISION IN CANADA: An NOI Perspective

by Denis Boulanger and Denis Gingras
National Optics Institute

Computer vision systems are being used more and more in many industries. The North American market for computer vision is forecast to reach $660 million by 1996. Over the years, Canada has become one of the most active countries in the field of computer vision, and has gained a worldwide reputation among the industrialized countries. This article reviews Canadian activities in that field and also describes some of the contribution of the National Optics Institute in the development of this industry.

La vision par ordinateur est utilisée de plus en plus dans le domaine industriel. Le marché Nord-Américain est prévu d'atteindre un chiffre d'affaire de $660 millions en 1996. Le Canada est devenu au cours des années un des pays les plus actifs dans le domaine de la vision par ordinateur. Cet article révise les activités canadiennes dans ce domaine et décrit sommairement quelques unes des contribution de l'Institut National d'Optique dans le développement de cette industrie.

Vision perception plays an essential role in animals as well as human beings. Flies use their visual system in order to detect motion, in that way avoiding certain death from a newspaper swat. For humans, the vast majority of the knowledge that we acquire from our surrounding world comes from our visual system. In recent years, a lot of research has been oriented to try to explain and understand the mechanism of visual perception. Some problems, such as depth and motion perception, have been studied at a psychological as well as a biological level. Machine vision or computer vision, to a certain extent, tries to give machines this faculty of "seeing" and "understanding" their surroundings.

In the last thirty years, research in the field of visual perception has attracted many scientists. Their research has led to a growing number of industrial applications. The development of computer vision based systems has proven to be effective in numerous tasks such as:

- Identification and localization of objects in a cluttered environment, in order to pick them up and manipulate them.
- Inspection or gauging of an object, either to ensure that its components are present or to measure and compare parts of an object against specifications.
- Vehicle navigation and localization, in order for a robot to determine its position relative to a map of its world.

Each of these tasks requires the solution of recognition and object localization problems; a robot uses the information collected by its sensors to determine "what" objects are in its surrounding and "where" they are located.

A computer vision system is essentially made up of sensors for acquisition interfaced to a computing unit used for data processing and recognition tasks (see Figure 1). Controlled lighting systems can be used in order to enhance important features of objects and simplify the processing scheme.

Vision systems are divided into three different categories depending on the type of sensor technology used. 1-D and 2-D vision systems rely on linear and arrays of photosensitive devices such as Charge Couple Devices (CCDs) or photodiodes. These systems primarily acquire the ambient light intensity as inputs. An example of such a device is the video camera. This type of sensor can cover a broad range of the light spectrum, going from visible to infrared.

3-D vision systems extract distance information from points on an object relative to the camera or an origin point. There are a variety of range sensor technologies that accomplish this task using both passive and active methods; passive methods use only the incoming light in order to extract range data, whereas active sensors use the projection of a light pattern usually from a coherent laser source.

There are a number of passive methods used in 3-D vision systems. Stereoscopic pair matching combines two video cameras with a known separation looking at a scene. The range information is then computed from triangulation using common features, such as edges, extracted from both images. This kind of system is based on the understanding of how people perceive their world with their eyes. There are also a series of photometric methods, called "shape from shading, or texture etc.", which extract range information from a single picture using only indirect information such as shading or texture, etc. Such passive methods suffer from their sensitivity to acquisition noise and to variations in the ambient illumination. They also require complex segmentation algorithms which make them difficult to implement in real-time applications.

Active methods are better suited for industrial and robotic applications because of their precision and because they do not rely on feature extraction algorithms. There are a variety of such optical technologies that have been developed over the years. Some systems look at the deformation of a structured light pattern, such as lines or a grid of points, projected onto an object. Others use the time taken by a pulse of light or of ultra-sound to hit a point on an object and bounce back to the sensor in order to compute the distance (time-of-flight techniques). Other systems use a triangulation scheme based on lasers to precisely extract profiles of an object.

There are also a wide variety of technologies available for data processing. One of the major problems in computer vision concerns the huge amount of data that has to be processed. While some applications can use simple computers such as PCs, many industrial or robotic applications however require more processing power in order to obtain

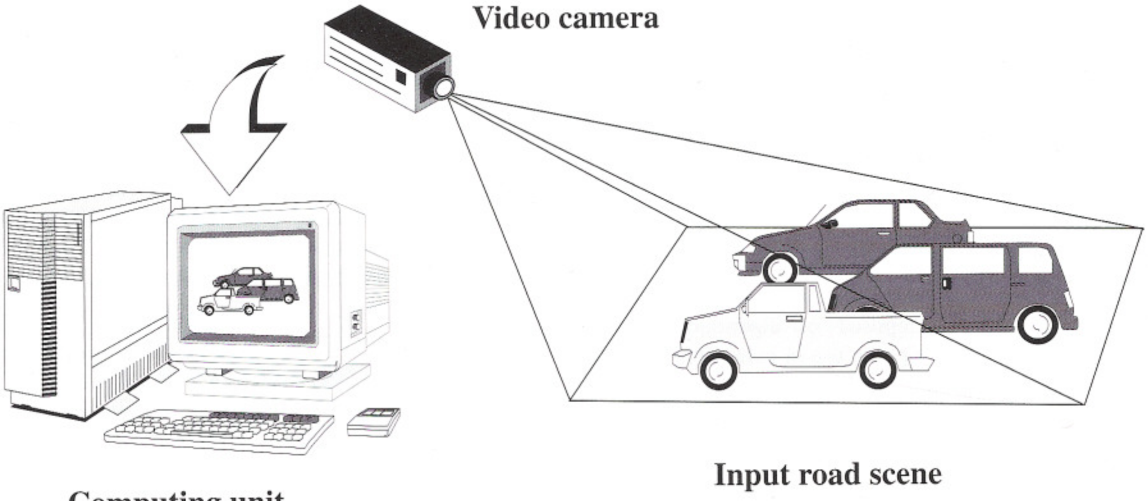

Figure 1: Example of computer vision system: A computer vision system is essentially made up of sensors for acquisition, such as video cameras, interfaced to a computing unit used for data processing and recognition tasks. This schematic represent an automatic road surveillance system under development at NOI.

reasonable real time performance. In such cases, specialized processors such as Digital Signal Processors (DSPs) are often used. For applications requiring heavy processing, some systems use parallel computer architectures, where the processing is distributed among many processors.

Optical computing has become another alternative to the data processing problem in the past few years. Such systems use optical components such as lenses, lasers, and liquid crystal displays, to implement certain functions (such as a 2-D Fourier transform) with greater speed and efficiency than conventional electronic hardware. Optical correlators can use such 2-D Fourier transform techniques to quickly find patterns such as lines or circles in the input field. Such optical devices, connected to a computer system, can be very powerful tools for solving pattern recognition problems in real time. The development of these systems is still at an experimental level but will be available in the near future in the marketplace.

A detailed description of even a small fraction of the total activities in computer vision on the Canadian scene would be beyond the scope of this paper. We will therefore limit ourselves to give a brief overview of the actual status of computer vision research and industrial involvement in Canada.

This is the fourth in a series of articles about robotics and computer vision, of which the first was "Robotics in the 1990s" by Paul Freedman (Winter '93), the second was "Robotics and Automation in Mining" by Ahmad Hemami (Fall '93) and the third was "Robotics in Canadian Forestry" by Jean Courteau (Winter '94).

Computer vision in Canada

Amazingly, if one considers all of the research activities and industries involved in computer vision, Canada, for its relatively small population, has become one of the most active countries in the field and has gained a worldwide reputation among the industrialized countries.

Several universities in Canada, such as Laval, McGill, Toronto, York, Waterloo, University of British Colombia, and Simon Fraser have extensive research programs in computer vision. Many others are also involved in computer vision research to some extent. Research topics include the development of new computer vision algorithms, sensors for tele-operated or mobile robots, integrated vision systems (smart-sensors), signature and character recognition, and non destructive evaluation, such as defect detection, using thermography.

Research is also being done in public research centers such as the National Research Council (NRC). The NRC is involved in the development of high resolution and very fast laser range finders. This unique technology, which has been licensed and marketed by several firms, puts Canada among the world leaders in three-dimensional sensing. It is currently used in many applications such as mobile robots, on-line industrial monitoring, museum artifact archives, and reverse engineering systems.

The program "Strategic Technologies in Automation and Robotics" (STEAR) is a component of the overall activities of the Canadian Space Agency. STEAR funds the development of advanced technologies in the general area of intelligent systems and has had a number of initiatives related to computer vision and relating sensing devices.

Military applications of computer vision, such as automatic target recognition systems or underwater inspection systems, are being developed in places such as the Defence Research Establishment in Valcartier (DREV).

Hydro-Quebec, at its research center in Varennes, is also involved in computer vision systems research for tele-operation of robots involved in hazardous tasks such as changing ceramic insulators on high voltage wires. They have also developed a system for inspecting cracks in hydroelectric dams.

The National Optics Institute

The NOI is a private non-profit research and development center whose national mandate is to promote and stimulate the Canadian economy expansion by assisting companies and industry in their efforts to improve their competitiveness via photonics and optics-related technologies. The

NOI has five sectors of activity: optical systems and components, photonic materials and processes, photonics and guided optics, lasers, and information processing. The last sector is a group composed of about 20 scientists involved in three areas of activities: optical processing, digital signal and image processing, and machine vision. The sector works in collaboration with many industries, research centers such as the Centre for Industrial Research of Quebec (CRIQ) and the NRC, universities, and several other agencies. NOI is also a modest member of the IRIS-2 (PRECARN) network.

The NOI is actively involved in the design and development of computer vision systems. Such systems comprised of algorithms, support processing, and sensing hardware are put to use in industrial inspection and quality control applications.

Over thirty companies exist in Canada offering services and systems for industrial applications. Their applications are mostly aimed at part inspection and gauging, industrial robotics, and optical character recognition. SAMI in Windsor, PLV in Toronto, or Shape Technology in Vancouver, try to offer custom products and evaluate the best technology to use in each application. MVS in Montréal and Servo-Robot in Boucherville are two companies who have commercialized the laser range finder technology developed at the Institut for Information Technology at NRC. This technology is used in applications such as robotic welding; Hymark in Ottawa has commercialized the same technology for inspection and gauging. Laser Inspeck in Quebec City has also recently introduced a 3-D vision system based on a non-coherent Moiré technique. Other companies, such as DALSA in Ontario, specialize in the manufacturing of sensors; they are presently a world leader in the development of CCD camera technologies. There are also a number of companies, such as Coreco in Ville St-Laurent, Matrox in Dorval, DiPix and Applied Silicon, both in Ottawa, oriented mainly in the development of specialized image processing boards. Many more companies exist, only a few have been mentioned here.

University and company partnerships

There are several joint programs, funded by both the government and industry in Canada, dedicated to research and development in the field of computer vision. These consortia bring together the very best researchers and engineers across Canada to participate in the development of well defined projects. This kind of activity helps to focus Canada's research, making industries more competitive in the world market. This also helps to increase the interaction between Canadian universities and industries.

PRECARN is an example of such an industrial research consortium in the field of intelligent systems. Its goal is to improve the capacity of Canadian industry to understand, use, and exploit intelligent systems technologies (see: "Robotics in the 1990s" by Paul Freedman in the Winter '93 edition of this magazine).

OPCOM, a $20 million, five year, pre-competitive research consortium funded by both its members and Industry Canada, is working towards the development of a parallel optoelectronic processor and aims to demonstrate applications in real-time pattern recognition.. The technical goal of OPCOM is to advance photonic technologies in the computer environment in order to reduce the bottlenecks associated with the conventional electronic processing. Started in 1994, the OPCOM consortium is composed of the following members: Andrew Engineering, DEC Canada, Dynatek, Optoelectronic Inc., NOI, NRC, and Spar.

In the next section, a description of the major trends in computer vision research will be given using some examples of the current technological developments in the field of computer vision in Canada.

Future trends

In recent years, research in computer vision has lead to the development of a series of new technologies which has put Canada among the leaders in this field.

Among the active fields of research, new sensor technologies development is playing a major role in building Canada's worldwide reputation. These new technologies include: 3-D sensing, smart-sensing, and multi-spectral sensing.

In 3-D sensing, the NRC has developed a series of high resolution cameras capable of digitizing the surface as well as the color of an object or a scene. In collaboration with NRC, NOI has also participated in the development of a new generation of range finders. This technology is being used, for example, for the profiling of road surfaces and the detection of ruts.

At a component level, NOI is also involved in the design and fabrication of diffractive optical elements which are used for generating structured coherent light patterns such as lines, grids, or dot matrices. These elements are an essential part of 3-D vision systems based on laser triangulation which do not require moving parts.

Smart-sensors are also a new trend in vision systems. Smart-sensors integrate analog or digital VLSI (Very Large Scale Integration) processing circuits with each sensing element, providing the computational speed needed for robotic applications. An example of such technology is the MAR system (Multi-ports Access photo-Receptors) under development at Laval University. This system integrates, in only a few VLSI chips, the sensing and computing devices for applications of edge detection, image processing, or stereo-vision.

In the past few years, NOI has been developing various vision systems based on special sensors such as polarization meters or multi-spectral sensors. An example is a system based on a multi-spectral sensor which is able to classify rapidly oak wood according to its color and darkness. Another example can be found in a system under development for the automatic sorting of recyclable plastic. The system uses a neural network classifier and vision algorithms to discriminate between various kinds of transparent plastics as well as sorting opaque colored plastic objects.

Another field of Canadian expertise is in the area of computing technologies. The increasing amount of data throughput from new sensor technologies or from multiple-sensor systems and the development of new complex algorithms such as neural network classifiers has lead to the requirement of such powerful computing technologies for real-time applications. Three major trends of computer technologies have emerged over the years: new DSP boards dedicated to computer vision applications, multi-processor computers, and opto-electronic computer systems.

Many of the industries mentioned earlier are specialized in the development of DSP and multi-processor technology. The combination of optical components with electronic systems has also shown very interesting computing capabilities. For example, NOI is currently pursuing the development of opto-electronic computer systems for real-time automatic target recognition. Automatic target recognition consists of detecting and classifying objects using a series of images obtained from one or several sensors in the infrared and visible spectra. The system recognizes objects, such as vehicles, belonging to different classes under various geometric transformations such as translation, in and out of plane rotation, and scaling. The system merges the power of electronic and optical computing to perform the task of image processing and segmentation, object detection, feature extraction, data fusion, and classification. These research efforts are supported in part by DREV for their applications in automatic target recognition.

Conclusion

As of yet, there is no general solution to the problem of computer vision. Every problem has a different approach which has to be customized to take into account the surroundings and physical constraints, the manufacturing process, and the economic context. More and more industries now use computer vision systems because the notion of quality control and automatization is imperative in a world of free trades and total quality. Also, because of the evolution of technology in sensors and computers, complex vision systems implementing more demanding tasks are now becoming more affordable. Vision systems are now widely used in many industries such as semiconductors and electronics, automobile manufacturing, space technology, medical applications, pharmaceuticals, food industries, military applications, logging industries, computer graphics, and museums and arts.

The North American market for machine vision systems was estimated at $593 million this year and is forecast to reach $660 million by 1996 with the largest current user industries being semiconductors and electronics manufacturing .

This paper presented an overview of the computer vision research and development industry in Canada. Research in Canadian industries and agencies has led to a number of break through which have put Canada among the leaders in the world of computer vision. An increasing number of small companies, of which only a few have been mentioned in this paper, are now emerging in the Canadian market. These companies try to offer a broad range of services and products to help industries improve their quality control process. Vision systems are now widely used in many industries and will become more imperative in a worldwide competitive market.

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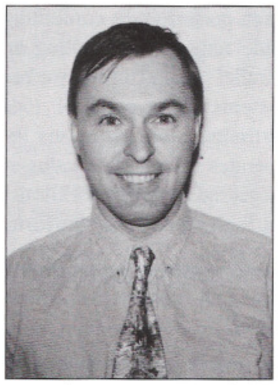
Denis Gingras



He received his B.Sc. and M.Sc. degrees in Electrical Engineering from Laval University in 1980 and 1984 respectively, and his Dr. S. in 1989 from the Ruhr-Universität Bochum, Germany, in 1989. His work has been on signal and image processing. From 1989 to 1990, he was a STA fellowship award recipient as a guest researcher at the Communication Research Laboratory in Tokyo, Japan. Since 1990, he has been involved in the set-up and management of the Information Processing Group at the National Optics Institute in Quebec City, Canada. Dr. Gingras is also Adjunct Professor at Laval University in the Department of Electrical Engineering. His current research interests cover fields in information processing such as signal and image processing, neural networks, vision, and optical implementation of processing systems for real-time applications. Dr. Gingras is a member of IEEE, INNS, EURASIP, and SPIE. Tel: (418) 657-7006, e-mail: gingras@ino.qc.ca

THE HPC HIGH PERFORMANCE COMPUTING CENTRE:

Specialized Computing Cycles for Canada Scientific and Engineering Community

Until very recently the lack of access to adequate, competitively priced, high-performance computing (hpc) cycles via high performance networks (hpn) has been one of the challenges facing Canada's scientific and engineering community. The HPC High Performance Computing Centre (HPCC) is currently the only centre in Canada whose sole focus is to provide high performance computing resources and expertise to any user on a full-time business basis.

by Pat Comer
HPC High Performance Computing Centre

The HPC High Performance Computing Centre (HPCC), Canada's only publicly available supercomputing centre, has been operational for just over a year. One hundred-eighty industrial and research clients have successfully used the Centre's resources. With a new CEO and new direction, HPCC is focused on satisfying client requirements for technology and service. HPCC is dedicated to delivering state-of-the-art, commercially viable computing resources and services to Canada's scientific and engineering community. This article gives a brief overview of what high performance computing is all about, discusses the Centre's facilities, some experiences from its first year of operations, as well as its plans for the future.

Le centre de «calcul haute performance» HPCC est le seul au Canada accessible au grand public et cela, depuis un an. Jusqu'à ce jour, cent quatre-vingt clients des milieux de la recherche et de lindustrie ont fait appel à ses services. Avec un nouveau PDG et une nouvelle direction, HPCC s'est engagé à répondre aux besoins des communautés de génie et de sciences, en fournissant du matériel et des services à la fine pointe de la technologie. Dans cet article, nous allons tout d'abord préciser ce que veut dire «calcul haute performance» et par la suite, le Centre sera présenté. L'article se terminera avec un regard sur les orientations en perspective.

High Performance Computing Defined

High performance computing replaces the older term, "supercomputing", in referring to robust systems which have very fast central processing units (CPUs), very high memory bandwidth and high speed input/output (i/o) capability. These systems have been used to solve computationally intensive numerical problems such as scientific and engineering simulations and modelling.

Automobile design, aeronautical engineering, computational chemistry and hydrocarbon exploration are all disciplines which have made use of hpc technologies for years. More recently, hpc has been found useful in non-traditional fields including macro-economic forecasting, financial modelling and applications using large-scale databases.

Types of High Performance Computing Systems

High performance computing refers to a class of systems which cover a wide range of computing architectures. In the past, scalar, vector and parallel architectures have been recognizable categories of systems. Scalar systems are typical of today's desktop personal computers. System instructions are processed individually and sequentially. One instruction operates on one data value at a time. The speed of these systems can be measured in MIPS (Millions of Instructions Per Second). Typical values for high speed scalar performance today range from 60-80 MIPS.

Vector systems allow data to move through machine instructions in a pipelined manner, something like water flowing through a garden hose. Parallel systems contain a number of CPUs which work together in parallel by various topologies. There are a wide variety of architectural implementations which have been used in current parallel systems, making this type of system arguably the most interesting as well as perhaps the most confusing to the layman. And finally, there are researchers beginning to use clusters of workstations (sometimes referred to as "farms") for solving computational problems.

The current trend in system architecture is for designers to combine these technologies in search of optimum performance. For example, some vector CPUs e.g. Fujitsu contain parallel arithmetic pipelines to increase fine grained parallelism. Some massively parallel systems have added vector CPUs to their scalar CPU's e.g. Meiko, Thinking Machines. Other manufacturers e.g. Cray Research have introduced moderately parallel systems with combined vector/scalar CPUs. Vendors of traditionally scalar systems are incorporating pipelining and parallelism into both chip design and system architecture e.g. IBM SP2, SGI, Sun. Virtually all hardware vendors today rely on a combination of technologies to improve performance.

Perhaps it is easier to examine hpc systems according to Flynn's taxonomy of parallel processing, which includes SIMD and MIMD machines. SIMD (Single Instruction working on Multiple Data) systems include vector supercomputers such as those from Fujitsu, Cray and NEC, as well as massively parallel systems as those supplied by Thinking Machines. MIMD stands for Many Instructions, Multiple Data. Parallel systems split up instructions and data across CPUs. SIMD and MIMD systems can generate many results from one machine instruction and therefore have their performance measured in MFLOPS (megaflops - Millions of Floating Point Operations per Second) or GFLOPS (gigaflops - Billions of FLOPS).

The Canadian Environment

There have been a number of academic/government and industrial computing initiatives undertaken in Canada over the past ten years. Examples include the Universities of Calgary and Toronto, which installed Control Data and Cray Research vector supercomputers at their respective sites in the mid 1980's. Smaller centres were also initiated in several provinces, including Nova Scotia, Québec, and B.C. Many university computing science and computing service departments have installed smaller parallel systems or workstation clusters for research work.

Atmospheric Environment Services, in Dorval, Québec, is perhaps the longest running Canadian hpc site, originally housing Control Data equipment, followed by Cray and now NEC vector supercomputing technology. Within Canada, industry initiatives have been limited to private centres. For example, centres with hpc capability have been set up in several major integrated oil and gas companies (e.g. Shell Canada, Amoco Canada) and seismic processing organizations (e.g. Geco-Prakla, Geo-Ex, Veritas). None of these projects has attempted to create a business venture to offer publicly accessible hpc for Canada.

The HPC High Performance Computing Centre

The Centre's mission is to create and maintain a commercially viable, state-of-the-art, heterogeneous environment of high performance computing and high performance network services for use by industry, government and research communities. HPCC is a not-for-profit company, with original funding from the Province of Alberta, Western Economic Development and support from Fujitsu. The Centre's mandate is to become self supporting, with all profits to pay for operations and expansion.

HPCC began operations a little over one year ago in June 1993. The initial year was a time of learning and building, not only of hardware, but also networks, software, peripherals, staffing and support services. A small team of technical support and sales staff was formed to bring the systems and services on-line and to initiate client support.

HPCC has integrated its services and is focusing directly on client needs. HPC Centre services include access to robust computer systems, well maintained software (including operating systems, compilers, and application software), state-of-the-art networks and technical knowledge. HPCC believes that these components prove useful only through the efforts of competent marketing, technical, and support staff. A new CEO/President, Paul Davis, and a recently hired salesperson bring valuable expertise in technical support, marketing/sales and executive experience to the HPCC organization. The technical support team includes a core staff with UNIX, programming and optimization expertise as well as a community of consultants who provide project management, algorithm and discipline specific knowledge to the group.

In its first year of operation, HPCC has been successful in attracting 180 users to the system from industry as well as academia. Industrial production clients include companies such as Pulsonic Geophysical Ltd. of Calgary, a medium-sized seismic processing company, which has made HPCC the major compute node of their Calgary-based distributed processing centre. Industrial researchers come from companies such as Travis Chemicals, a small Calgary-based company specializing in chemicals for the drilling industry. Travis has accessed HPCC via support from the National Research Council's support program for small technology firms, IRAP (Industrial Research Assistance Program).

Academic users include researchers from the University of Calgary, which has signed a long term agreement with the Centre, as well as scholarship holders among others. The purpose of the HPCC scholarship program is to promote excellence in computational science and engineering research and is open to all graduate students attending Canadian universities. Scholarship holders are given grants measured in system resource units, as well as technical support to assist them in making efficient use of the Centre.

HPCC Hardware Environment

The Centre's original hardware focus has centered around a Fujitsu VPX240/10 vector supercomputer named "Titan" by Centre staff. This vector/scalar system has a theoretical vector peak performance of 2.5 Gflops. Currently, it is configured with one vector and one scalar processor and is upgradable to two vector and four scalar processors with a peak vector performance of 5.0 GFlops.

Soon after bringing the Fujitsu on-line, a SPARCstation 10/41 system, called "Stampede", was added as a front-end. The SPARCstation 10 acts as the definitions gateway for interactive access and is responsible for running the robust logical security system for the Centre. It is also used for a number of housekeeping, accounting and job monitoring tasks, as well as interactive file editing and some computational work. Stampede also provides some longer-term disk storage space, accessible directly by Titan.

Figure 1 outlines the current HPC Centre hardware and network configuration. Stampede and Titan are linked via a 100 Mbits/second FDDI ring. This ring also connects to the outside networks including OilNET, WurcNet (described later) and the Internet.

HPCC has contracted SHL Systemhouse Ltd. to provide 24 hour a day, 365 days per year facilities management services for systems and network components. SHL operates the hardware in a secure, environmentally protected computer room equipped with air and power conditioning. A 150 KVA motor generator-set enables the HPCC equipment to ride through any power fluctuations.

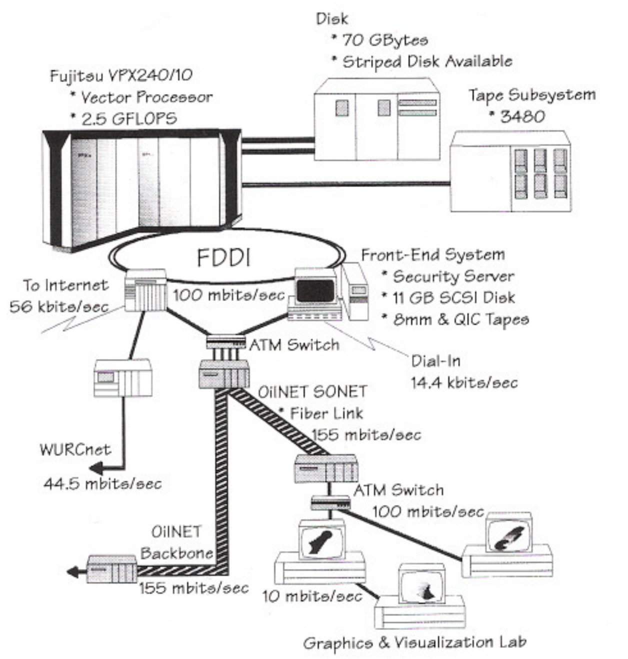


Figure 1: HPCC hardware and network configuration

Visualization Centre

One of the challenges faced by researchers is manipulating and interpreting the tremendous amounts of data produced by their applications. Today, high-performance computing facilities require a convenient means with which to visualize data and results. The HPCC visualization centre consists of several SGI systems combined with a variety of graphics and visualization software. A T3 (44.5 Mbits/sec) OilNET connection to the supercomputer allows for transmission of large volumes of data at high speed (more will be said about OilNET later in this article).

Software - Compilers, Tools, Applications

Both Titan and Stampede run versions of SUN O/S UNIX as their operating systems. This means that it is very easy for users familiar with current workstations to use the HPC Centre with little additional training.

Titan has proven suitable for highly vectorizable programs such as seismic processing, computational chemistry, and a variety of other scientific and engineering applications. Many standard software packages are available for the system. Additionally, researchers from across Canada have ported and optimized code for a wide variety of applications, from ship design to theoretical physics.

The wide range of hybrid technologies within the high performance computing class of computers points to a challenge in porting and optimizing software for any specific system. Tools and techniques are available to minimize the impact of changing technologies. Compiler technology has become quite sophisticated over the past decade, with virtually all vendors, including Fujitsu, offering automatic vectorizing/parallelizing Fortran and C compilers. Performance measuring tools assist programmers in determining where CPU and input/output (i/o) bottlenecks exist within their code. Use of vectorized standard FORTRAN or C-callable mathematical and statistical subroutines such as the NAG (Numerical Algorithm Group) routines makes for easy porting of applications to the Fujitsu.

High Performance Networking - The Canadian Meta-Centre Concept

Access to high performance computing is essential to academic, government and industry users across the country. Unlike the national priority funded US Supercomputing program, Canada must manage its Science and Technology assets in support of Canadian socioeconomic goals. We will need to create centres of excellence interconnected by high bandwidth communications networks. The emphasis is on bringing the best minds together without relocation. Regional and national centres can acquire technology, and more importantly, build expertise, focussed through efficient service organizations. Without high performance networking, regional or national centres in Canada are doomed to failure.

With high performance networking (hpn), users can have access to a variety of centres which can each offer complementary technologies and/or services. Geographically dispersed colleagues might be served by one centre, eliminating costly duplication of technologies and support personnel. This concept of a nation-wide high performance network joining hpc centres and users has been called the Canadian Meta-Centre concept, and is a modified version of the US initiative currently underway.

The federal government is addressing the problem of increasing communication bandwidth at a national level through CANARIE, the Canadian Network for the Advancement of Research, Industry and Education. CANet, the Canadian Internet backbone, has been upgraded to T1 (1.5 Mbits/sec) speeds over the past year. CANARIE also funds the CANARIE National Testbed Network, which is composed of national links joining regional test networks. These links are currently T3 (44.5 Mbits/sec), with plans to upgrade to OC3 (155 Mbits/sec) beginning in 1995/96. CANARIE is also responsible for funding regional test network infrastructure and application development based on the network.

Regional initiatives include both test and commercial projects building municipal and private networks as "on-ramps" to national super-highway infrastructure. HPCC is both a destination and a service provider to travellers on the Canadian Super-Highway. HPCC is a founding member of both OilNET and WurcNET projects as a means of providing high speed access to the supercomputer and technical services. We describe them now.

OilNET is a Calgary-based fiber network utilizing SVC (Switch Virtual Circuit) architecture using ATM at T3 speeds and SONET (Synchronous Optical Network) technologies currently running at OC3. This high speed network enables customers to run distributed applications at the Centre while accessing information maintained at their own site. OilNET is the tool that allows clients access to a powerful compute server directly from their own LANs (local area network).

The Western Universities Research Consortium in high-performance computing and high-performance networking (WurcNet) is in the process of implementing a testbed ATM/SONET network (Wnet), joining member organizations throughout the western provinces. HPCC is currently connected via T3 links to the network members.

Ongoing Growth and Diversification

Successfully achieving HPCC s goals of self-sufficiency and technology renewal requires an ongoing effort to evaluate and incorporate new systems, software, and expertise. HPCC plans to add capability in response to its clients needs. An increase in scalar power is a priority, and may be accomplished with the addition of another scalar CPU on the Fujitsu, high speed scientific workstations, and a multipurpose parallel engine. Network improvements continue, as does the installation and porting of relevant software, including both applications and tools.

It is clear that the HPC Centre will be moving forward, offering an affordable computing environment for Canada s scientists and engineers to solve their most challenging and complex problems.

About the author

Pat Comer is a principal of Force 10 Consulting, a company specializing in both computer systems and renewable energy consulting. Her career has focused on scientific high-performance computing, particularly in the petroleum industry, for the past 15 years. She has been involved with technical client support, user services, marketing and sales.Pat has worked for industry users, vendors and academic institutions. She was directly involved in the support and operations of the Cyber 205 supercomputing project at The University of Calgary in the late 1980 s.Pat is currently under contract to the HPC High Performance Computing Centre as a Technical Support - Consultant, responsible for client liaison and project management.

The Development of Power System Analysis Tools in Canada

by D. A. Woodford
Manitoba HVDC Research Centre

Canadian engineering expertise in the power system study area is known and respected internationally. This paper provides a brief overview of the development of power system analysis tools in Canada. The tools discussed include the phasor based traditional analysis programs of load flow and stability as well as the derivative programs for short circuit, motor starting, harmonic analysis, eigenvalue analysis, etc. In addition, the electromagnetic transients analysis programs and analog or digital/analog hybrid transient network analysis simulators are also discussed. Advanced power system analysis tools developed in Canada are commercially developed and are having an impact on the international market.

L'expertise canadienne en ingénierie dans le domaine de la puissance est reconnue internationalement. Ce document donne un bref survol de développements des outils d'analyse de systèmes de puissance au Canada. Les outils discutés incluent les logiciels d'analyse par phaseur pour le transfert de charge et la stabilité, logiciel de dérive pour les court-circuit, démarrage de moteur, analyse d'harmonique, analyse de valeur propre, etc. De plus, les logiciels d'analyse transitoire d'ondes électromagnétiques et les simulateurs d'analyse de réseaux analogiques ou hybrides (analogique/digital) sont aussi aborde. Le développement canadien des outils d'analyse de systèmes de puissance avancés sont commercialisés et ont un impact sur les marchés internationaux.

Canadian engineers are world leaders in electric power system analysis, both in the development of analytical tools and methods as well as in their use and application. The geography of the country with its vast distances between abundant energy resources and load centres has forced pioneering developments in electrical power transmission systems. By necessity, power system analysis tools and methods have been and continue to be developed to advanced standards.

Electric power in Canada is purchased at the cheapest prices in the world and it is delivered with a high degree of reliability, notwithstanding the harsh climate, difficult terrain and long distances. Access to and use of advanced analysis tools and methods by expert engineers has contributed significantly to the success of Canadian electric power systems and the essential service rendered by electric utilities across the country.

For a while at least, the age of pioneering in the electric utility industry in Canada has dramatically shifted focus. The great electric power projects with their formidable engineering, environmental and socio-political challenges have been delayed or indefinitely postponed (with the possible exception of the Great Whale Project still on the books in Quebec). There are new challenges such as the corporate restructuring of utilities, the threat of privatization, demand side management, and the operations and rehabilitation of existing generation, transmission and distribution facilities. Engineering experts who were once centre stage, may be encouraged to accept early retirement packages. Their expertise so essential in a past decade is still expected to be applied with less manpower and less time to do the work.

There is a greater requirement for power system engineering experts to utilize the best and most efficient of analytical tools. What are these tools and what part have Canadians played in their development?

The Analytical Tools

The analytical tools in question are not confined to a single package or institution but are inherent across the nation in utilities, research establishments, universities and commercial enterprises. Some analytical tools have been developed to commercial readiness and are being exploited on the international market. This is a desirable outcome and one which must be encouraged.

Some leading analytical tools which have been developed for commercial distribution are summarized. By these examples, it is hoped others will be encouraged to pursue development, perhaps with assistance from the Canadian Electrical Association (CEA) or through one of the research institutes in Canada. CEA or any other research institute would have to very carefully consider funding any development of an analytical tool if one already exists on the market in Canada of similar capability and at a reasonable purchase price.

Power System Computer Programs

Both Hydro Quebec and Ontario Hydro and their research establishments have developed power system computer programs to solve load flow and power system stability solutions and related problems such as distribution feeder analysis, harmonics analysis and eigen-analysis. These packages of analytical programs from both utilities have been commercially developed and are being improved and exploited by third parties for the international market.

Cyme International from St. Bruno, Quebec are successfully marketing the power system analysis software originating from Hydro Quebec with some initial funding from CEA. Their software runs on personal computers and they have over 1000 users in 70 countries.

Power system analysis software developed at Ontario Hydro was prepared commercially with substantial financial support from the U.S. based Electric Power Research Institute (EPRI). With the recent corporate restructuring at Ontario Hydro, experts under Dr. Prabha Kundar left the corporation and re-established themselves at Powertech Labs, Inc., which is a BC Hydro subsidiary. Through appropriate licensing, they are now marketing Ontario Hydro/EPRI's power system analysis software under the name of Power System Analysis Package (PSAPA) and Dynamic Security Analysis (DSA) programs. There is no published information on sales outside the member utilities of EPRI.

EPRI is a research arm of largely US utilities who subscribe to some or all of its research and development programs. It is significant that BC Hydro is now a member of EPRI and is the first Canadian utility to join. EPRI and CEA have jointly funded some projects. One such collaboration involves the Development Coordination Group (DCG) established for the development of the EMTP electromagnetic transients program.

An important feature of any power system analysis software is its ability to allow the user to create individual and unique control system models. One such feature known as User Defined Controls or "UDC" was developed for EPRI by the Manitoba HVDC Research Centre through Dr. Doug Chapman of Manitoba Hydro. UDC is incorporated in Ontario Hydro/EPRI's power system analysis software.

Electromagnetic Transients Programs

Electromagnetic transients analysis (emtp) makes it possible to study the power system network with differential equations instead of algebraic equations as in the case with load flow and stability and related analysis programs. Canada is a foremost leader in emtp development. At the University of British Columbia, Dr. Hermann Dommel pioneered emtp development and was recently appointed to a Chair in Power System Analysis. He also works with Dr Jose Marti in emtp development. Other universities with significant emtp developments to their credit include the University of Toronto with Dr. Adam Semlyn and Dr. Reza Iravani, the University of Manitoba with Dr. Ani Gole, Concordia University with Dr. Vijay Sood (also of IREQ) and École Polytechnique with Dr Serge Lefebvre (also of IREQ). The University of Waterloo has examined merging emtp with power system stability software with Dr. John Reeve. The University of Western Ontario was the first to develop special hardware to run emtp transmission line models in real time under Dr. Mohan Mathur. Dr. Atef Morched and Dr. Luis Marti of Ontario Hydro have also been influential EMTP developers.

As mentioned above, EPRI and CEA and other contributors from around the world have jointly financed the development of the version of emtp known as "EMTP". It is available at little or no charge to Canadian utilities who are members of CEA. Hydro Quebec and Ontario Hydro have contributed specialized developments for EMTP including static var compensator and dc link models and also ac system equivalencing methods.

Manitoba Hydro, the Manitoba HVDC Research Centre and the University of Manitoba have participated in the development of PSCAD/EMTDC which is a Power System Computer Aided Design package with the ElectroMagnetic Transients program for ac and DC systems. It is a commercial and completely graphically driven emtp well suited for simulating electric power systems, power electronic systems and complex controls and protections. The graphics significantly increase the productivity of set-up and analysis of electromagnetic transients studies. PSCAD/EMTDC is licensed at over 100 sites around the world.

A personal computer version of emtp has been licensed from the University of British Columbia by Microtran Power System Analysis Corporation. It is available commercially under the name of "Microtran". Also at the University of British Columbia, Dr. Martin Wedepohl is developing a frequency domain electromagnetic analysis program. This provides precise transmission line representation over a wide range of frequencies and offers a good way to check emtp transmission line models.

Real Time Simulators

Real time simulators make it possible to study the behavior of electric power system networks through models of transmission lines, transformers, generators, circuit breakers, dc links, etc. Their tremendous advantage is in the connection of actual controls and protection equipment for design, testing, training and study purposes. Unfortunately, few real time simulators have existed and in Canada one such simulator was built 20 years ago at the Hydro Quebec Institute of Research (IREQ).

The IREQ simulator is one of the largest in the world and is built from actual component or analog models as well as complete digital models of some components. This analog/digital hybrid simulator was described in detail in the Spring/Summer 1994 edition of the IEEE Canadian Review pp 6-9.

Recently, the first real time digital simulators (RTDS) have been developed in Canada at the Manitoba HVDC Research Centre and licensed to RTDS Technologies Inc. for further development and commercialization. Manitoba Hydro, Ontario Hydro and the University of Manitoba now have real time digital simulators which can represent every type of component in the electric power system using the same mathematical algorithm as in emtp. Real time digital simulators essentially simulate everything that a component based analog simulator can with much smaller dimensions and less cost. Protective relays and controllers can be tested by interfacing directly to the real time digital simulator through analog and digital ports. With the power system modelled on the real time digital simulator, closed loop connection of relays and controllers is possible as with the component based analog simulators. Because of compactness, it is even possible to transport the real time digital simulator to site in order to minimize outage duration of station based equipment to be tested. With a real time simulator, testing of relays and controls can be more stringent and demanding than can ever be under taken through commissioning tests directly on the system or with traditional benchtop or portable test units. Eleven RTDS systems have been sold commercially in Canada, Europe and Asia.

A second type of real time digital simulator has been developed at the University of British Columbia. Based on one of the fastest of single workstation computers now available, small ac networks can be modelled with the emtp solution algorithm and solved in real time. With real time input/output interfacing hardware added to the workstation, it can function quite acceptably as a relay tester. Workstation single processor computing power is expected to quadruple by the end of this decade. Such workstations used for real time digital simulation will then be able to expand the size of the simulated electric network with eventual inclusion of detailed synchronous machine and frequency dependent line models.

The real time simulators described above usually represent the ac power system in three phases with reasonable accuracy over a frequency range of 0 to 2000 Hz. The load flow and stability programs are a completely different class of analysis tool since they are just a phasor based positive sequence representation of the power system. Consequently, frequencies up to only 5 Hz are adequately represented which is suitable for study of load flow and electromechanical oscillations. Powertech Labs, Inc for example, have demonstrated the running in real time of a 1000 bus model on the EPRI mid-term stability program on a modern workstation computer. Such a high speed stability solution will enhance and change study procedures because multi-run techniques can be adopted.

Is Real Time Essential?

It is a subject for debate as to whether real time and in particular, electromagnetic simulation of electric power systems is required.

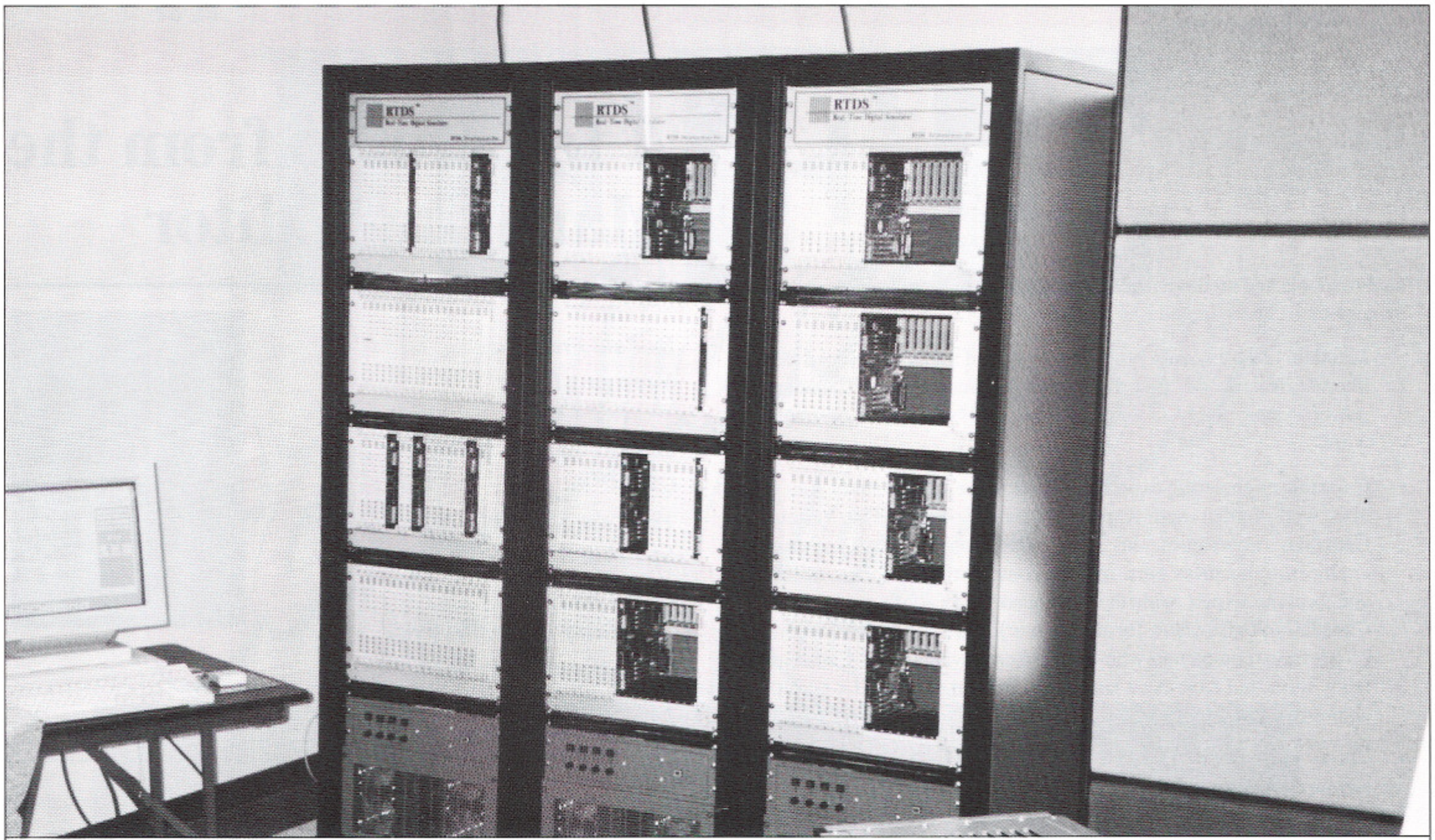


Figure 1: Large real time digital simulator under construction by RTDS Technologies Inc. of Winnipeg for shipment to Japan. This is a parallel processing supercomputer simulator with 432 parallel digital signal processors.

Certainly and most importantly, equipment testing requires real time. But what of "playback" systems? Playback systems utilize pre-recorded current and voltage signals required for the equipment under test. Having been previously recorded into a computer file, these signals are played back in real time in exactly the same way as a digital record of music. The voltage and current signals required as input to the equipment under test can be amplified to the required levels to fully emulate the effect of the actual system. The pre-recording can be made from digital recordings of an event captured off the real system or, from the output out of a non real time emtp simulation. The playback test method is quite satisfactory only so long as the equipment under test does not need to be connected in closed loop, and provided that an adequate number of test recordings have been prepared.

A power system stabilizer for example, requires connection and testing in closed loop because the response of the network with its generators is directly affected by the response of the stabilizer. Some relay tests also require closed loop connection with the simulator. The trip signal and the subsequent opening of the associated circuit breaker in the simulator may cause a power system electromechanical swing or transient coupling effect to other transmission lines with possibility for secondary impact on this or other protection devices and controls. When closed loop testing is desired or essential, real time simulation is required. It may also be required if the assembly of pre-recordings for testing is laborious or requires observation of some tests before remaining tests can be completely formulated.

From a studies perspective not involving testing, there are three main considerations. These are:

- The data and models must be trusted and be faithful to the system under study.
- The speed and ease of assembly, running and analyzing the results is most important.
- Power electronic equipment and their control systems need to be represented with sufficient precision to enable the simulation results to be realistic.

These three considerations can be accommodated with modern computer simulation programs having advanced graphical user interfaces running on modern powerful workstation computers. Where real time or near real time is most advantageous is when many repetitive cases must be undertaken to search for worst or best overvoltages or the best settings of a many parameter control system of a fast acting device in a non-linear system.

In short, real time is essential for testing actual equipment in closed loop or to undertake studies when actual controllers or relays are utilized with the real time simulator. If, on the other hand, actual equipment testing is not the purpose of the study and if essential controls are modelled in precision on the simulator model, real time is not essential.

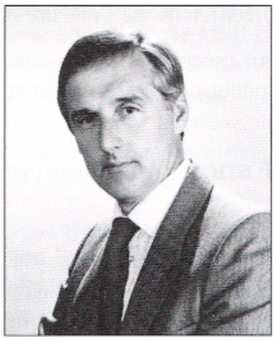
An exception is when simulation of a power system is being used for training. The real time simulator is a valuable training tool in this regard.

Future Developments

Canadian engineers have participated in the development and use of the most advanced power system analysis tools available. The home grown simulators and simulation programs of various kinds, both real time and non real time are sold or used internationally. Most real time simulators being supplied to the international market today are built in Canada. Of 15 known real time simulators purchased throughout the world in the past 2 years, 13 have been supplied from Canada. In order to maintain or increase the recognition and use of Canadian leadership in power system analysis tools and methods, there are a number of points which should not be neglected. These include:

- Maintain a high quality in all simulation tools developed for international use so that the reputation and trust of Canadian power system analysis and methods will become a household word.
- Canadian engineering expertise in the power system study area is also well known and respected internationally. The various Canadian companies in the international power system engineering business must make a conscientious effort to utilize and become expert with the advanced study tools available in Canada (and elsewhere for that matter). Already there is record of overseas companies who have taken advantage of Canadian study tools and have been successful in being awarded a project against Canadian competition.
- Those in Canada who are involved in the development of advanced power system study tools and methods must not be deterred by the low growth of the electric utility industry and lack of power system projects in Canada at this time. Instead, engineers and companies should aim for the international market where demand is high. In so doing, there is need to listen to what the international customer has need of and act to meet that requirement by exerting extraordinary effort and produce exceptional services and quality of simulation tools.
- A related area requiring further attention is the processing of on-line logging of system, station and unit status. On-line status information of the power system can be processed with advanced high speed analytical tools to provide frequent dynamic risk assessment of the operating system. Intelligent on-line assessment of generation and transmission stations will inform operators as to the health of the plant in those stations. On-line monitoring if units such as transformers, circuit breakers and generators can identify and predict requirements for maintenance.

About the author



Dennis Woodford graduated from the University of Melbourne in 1967 and from the University of Manitoba in 1973 with an M.Sc. degree.

From 1967 to 1970, he worked with the English Electric Company in Australia and the U.K. In 1972, he joined Manitoba Hydro and worked as Special Studies Engineer in Transmission Planning. In 1986, he joined the Manitoba HVDC Research Centre as Executive Director. He is a member of IEEE, CIGRE and the Canadian Electrical Association. He is an Adjunct Professor with the University of Manitoba and a registered professional engineer with the Province of Manitoba.

Perspective / *Perspectives*

A few words from the Managing Editor

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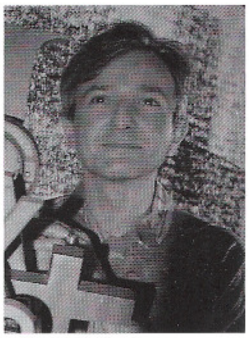

This issue marks the mid-way point in my two-year mandate as Managing Editor of the *IEEE Canadian Review*. As such, it seems appropriate to dwell for a moment or two on what has happened over the last year and what lies ahead. More than anything else, I have tried to encourage a more technical slant to the magazine articles and a more balanced thematic distribution of topics, to better reflect the distribution of IEEE membership interests. While Canada continues to be a world leader in power generation, transmission and research, I have tried to target Canadian «success stories» in other domains such as IMAX and SAR to name just two. In addition, many articles are now appearing as part of a continuing series on a related theme, and this helps build continuity into the magazine.

With new fully-electronic desktop publishing, I have reduced the magazine layout time and more importantly, reduced magazine preparation costs. And thanks to CRIM, I also have full Internet access which makes it possible to respond to people more quickly, whether they be Associate Editors, prospective authors, or simply curious readers. As Ray Findlay points out in his Director's Report, IEEE Canada is working hard to make Internet access a reality for all of our members.

Et afin de rappeler à tout le monde que la société IEEE Canada valorise également ses lecteurs francophones, j'ai instauré la traduction du rapport du directeur.

Unfortunately, amid all this good news, advertising remains a problem and will become my top priority over the coming year. The key, of course, is a regular publishing schedule and I am also proud of that achievement (I remind the reader that publishing dates are listed on the inside front cover of each issue).

In closing, I must thank my Associate Editors who work away behind the scenes; they all deserve much credit for their efforts. And a special thanks goes out to my assistant Francine Riel here at CRIM who has learned much more about electronic desktop publishing than she ever thought she would.