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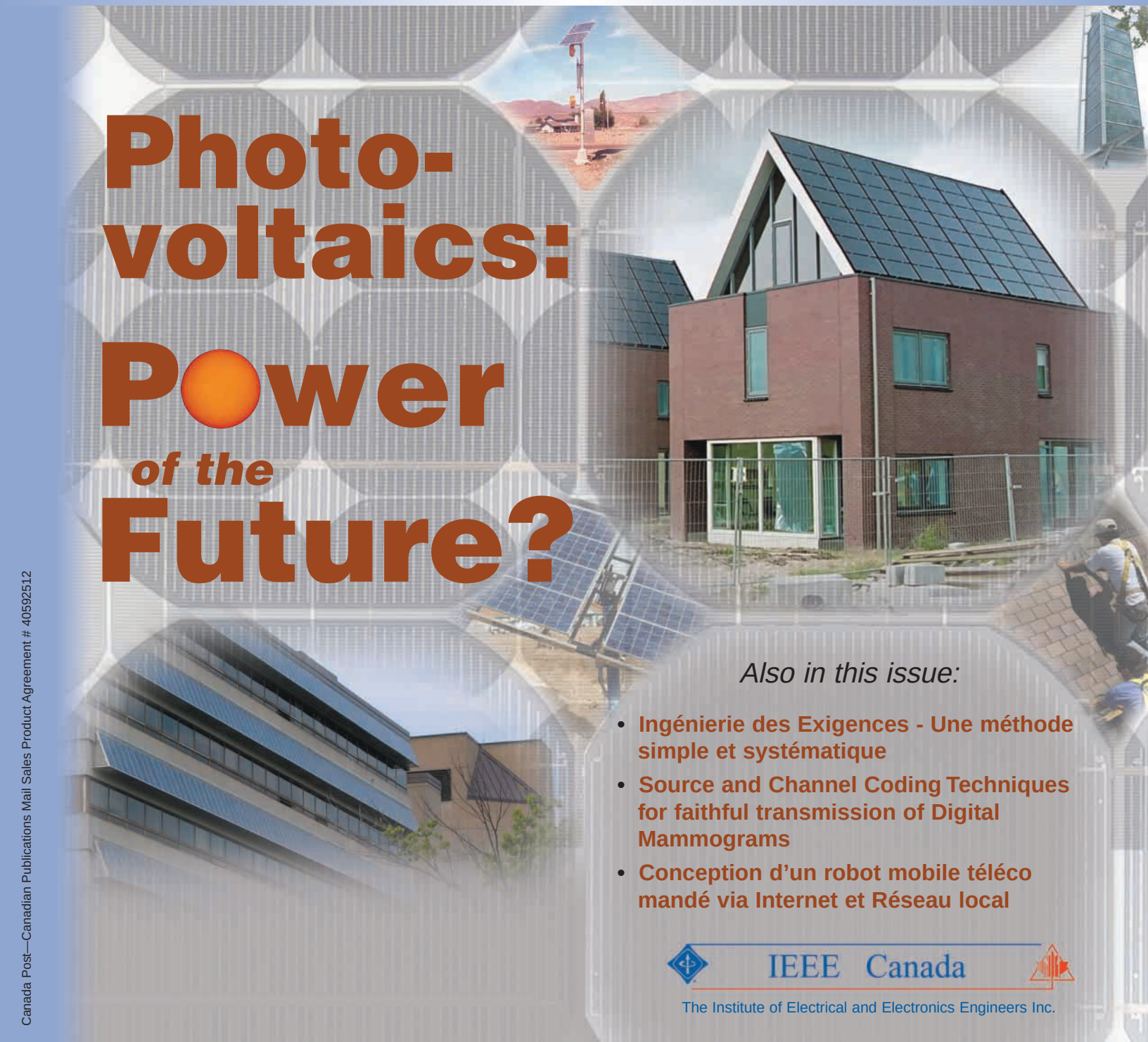

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- Source and Channel Coding Techniques for faithful transmission of Digital Mammograms
- Conception d'un robot mobile téléco mandé via Internet et Réseau local

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IEEE Canadian Review General Information

The ***IEEE Canadian Review*** is published 3 times/year as follows: Winter (to appear in April); Spring/Summer (to appear in August); Fall (to appear in December). Its 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 Canadian academic (i.e. universities, colleges, secondary schools), government and business communities.

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

1- National Affairs	4- Education	7- Computers
2- International Affairs	5- Power	8 - Electronics
3- Industry	6- Communications	

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IEEE related events and news of a topical nature may be published in the **IEEE Canada** email/fax Newsletter. Submissions should be emailed to the Editor Aby Gupta (a.gupta@ieee.org). The Internet home page address of **IEEE Canada** is:

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Quelques mots du rédacteur en chef

Vijay K. Sood, Hydro-Québec

Cet été en fut un des plus occupés. On n'a qu'à penser aux Olympiques, un événement tellement intéressant à suivre sur le petit écran. J'espère que vous avez eu la chance de regarder ces Olympiades et avez été enthousiasmé par l'énergie de la jeunesse mondiale.

De ce coté-ci de l'Atlantique, je suis heureux de vous annoncer qu'enfin nous recevons des articles dans l'une ou l'autre des deux langues de la Revue canadienne (RC). Ce numéro contient deux articles en français et deux en anglais. C'est un fait digne de mention. Les articles sont très variés, traitant des processus industriels, des techniques d'imagerie, de la robotique et des cellules photovoltaïques. Je crois que vous allez apprécier ce numéro. Mes félicitations à tous les auteurs.

Après le succès sans précédent de CCGEI2004 à Niagara Falls, la prochaine conférence canadienne se déroulera à Saskatoon, Saskatchewan (voir les pages 31 et 32 de ce numéro). Motivé par le succès de CCGEI2004, le comité organisateur de la prochaine conférence a redoublé d'efforts et est en train de préparer un programme varié et intéressant. Une visite des installations pour la recherche du *Canadian Light Source* de l'Université de Saskatoon sera un incontournable (voir photo ci-bas/à gauche). Même si plusieurs membres n'ont pas encore eu la chance de visiter Saskatoon, je suis certain que l'accueil chaleureux offert par les gens de cette belle ville sise sur le bord de la rivière du Sud de la Sakatchewan saura charmer tous ceux qui la visiteront. Les date limites approchent rapidement en ce qui a trait à l'appel de communications. Alors, vous êtes invités à participer avec nous à cette expérience unique de l'Ouest canadien.

Finalement, la progression de la RC se poursuit sans relâche, et j'aimerais inviter tout spécialement les membres à se joindre à nous et à contribuer par le biais d'articles et autres au 50ème numéro de la RC qui paraîtra au printemps 2005. J'espère en faire un numéro célébrant l'histoire et les accomplissements de la RC. Je vais contacter la plupart des personnalités qui ont participé au lancement de ce magazine au début des années 90, qui l'ont fait grandir au cours des années et finalement qui l'ont propulsé à l'avant-garde au Canada. J'attends vos commentaires et suggestions. Si vous avez des items d'intérêt, n'hésitez pas à me contacter.

The University of Saskatchewan is home of the Canadian Light Source, a unique national research facility for science and technology.

18th Annual Canadian Conference on Electrical & Computer Engineering
May 1-4, 2005, Saskatoon Inn
Saskatoon, Saskatchewan. Canada

Cover picture / *Photo de couverture*

Photovoltaic cells are steadily making their way into our modern architecture and power systems designs. Featured on the cover: One of a series of grid-connected solar-roof homes in the Netherlands (top right) and a 20 kW grid-connected installation at Queen's University that also provides summer shading (bottom left). Other "thumbnail" photos include: solar-powered stop light (top-left diamond), automatically tracked panels (bottom-left diamond), PV roof shingles (bottom-right diamond), solar-panel tower installation (top-right diamond).

A few words from the Managing Editor

This summer was quite eventful as the Olympics were such a fascinating event to watch. I hope that you all had an opportunity to watch this Olympiad and were enthused by the energies displayed by the world's youth.

At home, I am pleased to report that we are at last getting authors submitting their articles to the Canadian Review (CR) in the language of their choice. This issue of the CR has two articles each in English and French. This is a noteworthy first milestone. The articles are quite varied dealing with industrial processes, imaging techniques, robotics and photo voltaic cells. I hope that you will enjoy reading them. My personal congratulations to all the authors concerned.

After the record breaking success of the CCECE'04 in Niagara Falls, the next Canadian conference will be held in Saskatoon, Saskatchewan (see pages 31-32 of this issue). Inspired by the success of CCECE'04, next year's organizing committee has redoubled its efforts and is assembling a delightfully varied and interesting program; a "must-see" will certainly be the Canadian Light Source research facility at the University of Saskatoon (see photo below/left). Although Saskatoon is a venue that many members have not yet had the pleasure of visiting, I am sure the warm hospitality offered by this beautiful river-side city will quickly make fans of all who attend. The deadlines are fast approaching for the call for papers, so do come along and share this unique experience of western Canada with us.

Finally, the progress at the CR continues unabated, and I am making a special appeal to all members to join in and submit items for the forthcoming milestone **50th issue** of the CR which will be the Spring 2005 issue. I hope to make this a celebration issue and focus on the history and the past achievements of the CR. I will contact most of the personalities who were involved in starting this magazine in the early 1990s, maintaining and nurturing it over the years, and finally ending at the present time with pushing this magazine to the forefront in Canada. I look forward to your comments and suggestions. If you have items of interest, do not hesitate to contact me.

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Canadian Newslog / Coupures de presse Canadienne

Newslog Editor

Rédacteur des Coupures de presse

Alexandre Abecassis is a patent agent trainee in Montreal at Ogilvy Renault, Lawyers and Patent and Trade-mark Agents.

Alexandre Abecassis travaille à Montréal chez Ogilvy Renault, Avocats et agents de brevets et de marques de commerce, comme agent de brevets en formation.

Send any news clippings you would like to contribute via e-mail to alexandre.abecassis@ieee.org

Veuillez faire parvenir les coupures de presse proposées par e-mail à alexandre.abecassis@ieee.org

CALGARY, AB, June 9, 2004. Psi-Naptic Inc has announced the availability of CMatos Jini Network Technology for CSR (Cambridge Silicon Radio) BlueCore2(TM) chip. CMatos-BlueCore2 is a 32kbyte implementation of CMatos that executes on the BlueCore2 chip an all-CMOS, single-chip architecture. CMatos-BlueCore2 makes possible a whole new aspect of embedded design for the CSR BlueCore Bluetooth products. CMatos combined with BlueCore2 enables single chip embedded devices such as sensors and actuators, to have their own self-contained Jini lookup service, and offer their intrinsic services and attributes as a Java object to other Jini clients to execute, independent of wider area network availability.

WINNIPEG, MB, June 21, 2004. Novra Technologies Inc. has announce that Rikei Corporation, headquartered in Tokyo, Japan, has been appointed as Reseller of Novra S75, IPE400 series, and NovraLink Digital Signage products and solutions. As part of the reseller agreement, Novra will work with the Network Solutions Department of Rikei to market and sell Novra product and solutions in Japan.

VANCOUVER, BC, June 28, 2004. Nicer Canada Corp., a provider of Voice over Internet Protocol (VoIP) solutions and network infrastructure services, has announced an expansion of its global distributor/reseller network with the appointment of SolarTcom S.A. de C.V. of Mexico. SolarTcom S.A. de C.V. has been appointed the exclusive distributor for Mexico.

MISSISSAUGA, ON, July 13, 2004. Hewlett-Packard (Canada) Co. and TD Bank Financial Group (TD), have announced an initiative that will have HP upgrade and manage TD's national automated bank machine (ABM) network and point-of-sale (POS) transaction infrastructure. The process will include a business transformation initiative to enhance the Green Machine (TM) experience for TD customers. The seven-year outsourcing agreement is valued at CDN$420 million.

OTTAWA, ON, July 29, 2004. Protus IP Solutions has announced its new MyFax Affiliate Program, designed to further expand its presence within the Internet-based messaging marketplace. The MyFax Affiliate Program offers qualified partners the opportunity to earn up to $20 for each new subscriber referred to MyFax.com. For the first three months of enrollment in the program, MyFax Affiliate Partners will receive a double commission of $20 for every referred MyFax subscriber. Following this limited time offer, the referral will be based at $10 per subscriber.

MILTON, ON, Aug. 3, 2004. Systems Xcellence Inc., a provider of healthcare information technology solutions throughout the pharmaceutical supply chain, has announced the sale of its RxPORTAL (TM) web interface to three of its pharmacy benefit manager (PBM) and two of its managed care (MCO) customers. The five agreements have a collective value of approximately $700,000, which will be earned over a three-year period.

QUEBEC CITY, QC, Aug. 4, 2004. Labcal Technologies Inc., a company specializing in fingerprint-based biometrics, smart card and Public Key Cryptography identification and authentication solutions, has been awarded a contract by Melaka Islamic College of Technology, to supply 100 SmartPrint TruBlue(TM) readers and 1300 smart cards to secure and manage the computer room used by the students.

VANCOUVER, BC, Aug. 4, 2004. Imagis Technologies Inc. has announced that it has entered into an agreement with Centrom Limited of the United Kingdom to form a jointly owned subsidiary company Imagis Technologies UK Limited, which will be the exclusive distributor of Imagis' software products in the UK and a non-exclusive distributor on a world-wide basis.

MONTREAL, QC, Aug. 5, 2005. Nstein Technologies Inc. has announced the details of a contract previously announced on April 29, 2004, signed with Computer Sciences Corporation to develop the world's largest educational database, the Educational Resources Information Center (ERIC), a project funded by the U.S. Department of Education. Established in 1966, ERIC is composed of more than one million bibliographic records. Its goal is to give educators, researchers and the general public ready access to high-quality, education-related materials through the Internet.

SHEDIAC, NB, Aug. 5, 2004. InteliSys Aviation Systems of America Inc. has announced that it has secured a strategic alliance with Skyplan International Inc., which broadens the functionality offering delivered by the Company's suite of aviation modules, marketed under the trade name amelia. The alliance will integrate flight planning, weather and dispatch operations into the amelia. OPS module.

TORONTO, ON, Aug. 9, 2004. Celestica Inc. has announced the expansion of its integrated services, with the introduction of the EMS industry's first end-to-end Green Services offering. Celestica's Green Services offering will help original equipment manufacturers (OEMs) to achieve rapid and cost-effective compliance with pending global environmental protection initiatives, including the European Union's (EU's) Restriction of Hazardous Substances (RoHS) legislation, which will require the removal of a number of hazardous substances, including lead, from electronic components by July 1,2006.

MONTREAL, QC, Aug. 9, 2004. Japan Airlines International, has purchased a CAE-built Boeing 777-200ER full-flight simulator, giving CAE its fifth full-flight simulator sale so far this fiscal year. At list price, the contract is valued at $16 million, and the simulator is to be delivered in spring 2006. This device is the seventh CAE-built full-flight simulator to be sold to Japan Airlines International.

The editor acknowledges the support of Alexandra Daoud, Patent Agent at Ogilvy Renault in the preparation of this column.

Summer is on the wane and Fall is just around the corner. With Fall comes a new year of IEEE activities. In September, the ExCom will meet in Fredericton to discuss the plans and objectives along the budget for 2005 for Region 7. A lot has been accomplished this year and a lot is left to do.

For the first time in a long while, the ExCom will meet concurrent with the Student Workshop. As members we need to stay in contact with and nurture the students to continue their membership after they have completed their studies. In today's marketplace, most students entering the workforce will have many employers and many career changes. To be sure, most will remain and become good engineers and technologists, but their careers will change. Wherever they go, IEEE will be there to assist them. IEEE is the technical constant the students, and even you as members, can count on to maintain and increase your technical knowledge and competence.

The second of three training workshops for incoming Section Executives will be held in Fredericton. Training of Section Executives was identified by Section Chairs as needed for a successful Section.

One of my major objectives for the rest of this year, and into 2005, is to make the provincial licensing bodies aware of the benefits IEEE can provide their members through a variety of ways. These include Journals, Distinguished Lecturers, self-study courses and seminars by IEEE members. For those of us who are required by law to maintain and increase our competency, preparing and giving a talk or seminar under the auspices of the local Section is a great way to introduce others to IEEE and maintain your professional development requirements. It's also a great way to increase your Section's membership. Membership in IEEE counts towards your professional development hours and that in itself helps sell IEEE.

At the Fall Region Committee Meeting in Calgary, the Region Committee will deal with a revised governance model. This model is now in its final stages will see some major changes in the way IEEE Canada operates. It is designed to have more input from the Section Chairs and make a stronger link between the Committee Chairs and their counterparts. Hopefully it will result in a stronger IEEE Canada.

I have just returned from Halifax where I participated in a panel session on the deregulated electric industry. Three provinces are deregulated Alberta, Ontario and New Brunswick. Nova Scotia is evaluating deregulation. While I was in Halifax, I had a lengthy discussion with the past president on some of my thoughts on the future of Region 7.

After a great summer, I'm looking forward to getting IEEE Canada underway for another great year of technical activities.

W.O. (Bill) Kennedy, P.Eng., FEIC
IEEE Canada & Region 7 - Director/Président,
Calgary, AB
w.kennedy@ieee.org

L'été touche à sa fin et l'automne approche à grands pas. L'automne marque le début des activités de IEEE pour la prochaine année. En septembre, le Comité Exécutif se réunira à Fredericton pour discuter plans et objectifs, ainsi que du budget pour 2005 pour la région 7. Beaucoup de travail a été accompli cette année mais il nous reste encore beaucoup à faire.

Pour la première fois depuis fort longtemps, la rencontre du Comité Exécutif aura lieu en même temps que l'Atelier pour Étudiants. En tant que membre, nous nous devons de rester en contact et inspirer les étudiants à rester membres après la fin de leurs études. Dans le monde d'aujourd'hui, la majorité des étudiants entrant le marché du travail auront, lors de leur vie professionnelle, plusieurs changements d'employeurs et de carrière. La majorité resteront et deviendront de bons ingénieurs ou technologistes, mais on peut s'attendre à ce que leurs carrières changent au fil des ans. Où qu'ils aillent, IEEE sera là pour les aider. IEEE est la constante d'ordre technique que les étudiants et vous aussi, en tant que membres pouvez compter sur pour maintenir et améliorer vos compétences et vos connaissances techniques.

Le second de trois ateliers pour les nouveaux exécutifs de Sections se tiendra à Fredericton. L'entraînement des exécutifs de Sections fût identifié par les directeurs de Sections comme un besoin important à combler pour obtenir une Section efficace.

Un de mes principaux objectifs pour la balance de l'année et pour 2005 est de réitérer auprès des Ordres provinciaux les différents bénéfices qu'apporte IEEE à leurs membres. Ces bénéfices incluent journaux, lectures présentées par des sommités dans leurs domaines, cours d'auto éducation individuel et séminaires présentés par des membres de IEEE. Pour ceux d'entre nous qui se doivent, par réglementation, de maintenir et d'améliorer nos compétences, préparer et donné une lecture ou un séminaire sous la gouverne d'une Section locale est l'occasion d'introduire IEEE à une nouvelle audience et de satisfaire les demandes de votre développement professionnel. C'est aussi un bon moyen d'augmenter le nombre de membres de votre Section. Participer en tant que membre de IEEE compte comme temps de développement professionnel, et ceci, en lui-même, aide à vendre IEEE.

À la réunion automnale du Comité Régional à Calgary, le Comité Régional se concentrera sur un nouveau modèle de gouvernance. Ce modèle, dans sa phase finale, verra quelques changements importants dans la gestion de IEEE Canada. Il est remodelé pour donner une voix plus importante aux directeurs de Sections et établir un lien plus fort entre les directeurs de comités et leurs contreparties. J'espère que ces changements résulteront en un IEEE Canada renforcé.

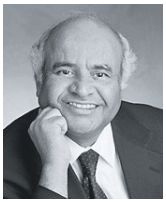
Au moment d'écrire ces lignes, je reviens de Halifax, où j'ai participé à une rencontre sur l'industrie électrique déréglementée. Trois provinces sont déréglementées – Alberta, Ontario et Nouveau-Brunswick. La Nouvelle-Écosse évalue la déréglementation. Lors de ma visite à Halifax, j'ai aussi eu une longue discussion avec notre ancien président concernant certaines de mes idées pour le futur de la Région 7.

Après un bon été, c'est avec joie que je vois IEEE Canada repartir pour une autre année d'activités techniques.

The Royal Society of Canada
THE CANADIAN ACADEMY OF THE SCIENCES AND HUMANITIES

OTTAWA — **The Royal Society of Canada**, the Canadian Academy of the Sciences and Humanities, is presenting medals and awards to twelve Canadians for extraordinary achievement in the social sciences, humanities, and pure and applied sciences. These awards come as a culmination of a lengthy nomination and selection process and are a tribute to the outstanding contributions being made by Canadians in all areas of research and scholarship. All medals and awards are funded and/or administered by the Royal Society of Canada.

"**Vijay K. Bhargava** has been awarded the 2004 Thomas W. Eadie Medal By the Royal Society of Canada in recognition of major contributions to Engineering with an impact on communications. The award is funded by Bell Canada in recognition of the increasingly important role of Applied Science to the quality of life in Canada".



The Thomas W. Eadie Medal, in recognition of major contributions to Engineering of Applied Science, with preference given to those having an impact on communications, is awarded thanks to the generous financial support of Bell Canada. The award consists of a bronze Medal and a cash award of $3,000.

The awards will be presented at the Society's Awards Banquet on the evening of Saturday, November 20, 2004, following the Induction Ceremony of newly elected Fellows.

Further information and recipients' citations in both official languages can be obtained by contacting The Royal Society of Canada or visiting their Web site at www.rsc.ca

Ingénierie des Exigences - Une méthode simple et systématique

par René Bujold,
Hydro-Québec, Montréal, QC

Abstract

Enabling the interface between the customer and the supplier, Requirements Engineering (RE) is a very important part of the supply and acquisition process. However, RE is often overlooked, with emphasis being placed on the implementation. Hence, several needs of the customer are never understood by the supplier or are done only after delivery. This results in major problems of costs and product/service quality. In 2001, Hydro-Québec developed a simple and systematic method to solve these problems. Based on international standards, this method relies on six main rules aiming at (1) diminishing the cost of RE, (2) facilitating the comprehension of the requirements, and (3) specifying requirements that are exact, complete, coherent and that can be validated. For example, the first rule consists of establishing a hierarchy of requirements. The method also relies on the use of supporting tools, such as "GenSpec" developed at Hydro-Québec.

Sommaire

Faisant le lien entre le client et le fournisseur, l'ingénierie des exigences est une activité très importante du processus de fourniture et d'acquisition. Or, elle est souvent négligée, l'accent étant mis sur la réalisation. De ce fait, plusieurs besoins du client ne sont jamais compris par le fournisseur ou ne le sont qu'après la livraison. Il en découle des problèmes majeurs de coûts et de qualité de produit / service. Pour résoudre ces problèmes, Hydro-Québec a développé une méthode simple et systématique en 2001. Rigoureusement basée sur des normes internationales, cette méthode repose principalement sur six règles simples visant (1) à diminuer le coût de l'ingénierie des exigences, (2) à faciliter la compréhension des exigences et (3) à spécifier des exigences correctes, à savoir exactes, complètes, cohérentes et validables. À titre d'exemple, la première règle est de structurer les exigences de façon hiérarchique. Cette méthode repose aussi, mais optionnellement, sur l'utilisation d'un outil de support, tel "GenSpec" développé à Hydro-Québec.

1.0 Introduction

Cet article présente une méthode d'ingénierie des exigences, développée à Hydro-Québec. Il présente plus précisément:

- Le domaine de l'ingénierie des exigences (Section 2.0),
- Les problèmes les plus souvent rencontrés dans ce domaine (Section 3.0),
- Une solution à ces problèmes: la méthode (Section 4.0),
- L'optimisation de cette solution (Section 5.0).

Cet article s'adresse à toute personne concernée par l'élaboration des exigences d'un produit / service. Par produit, on entend tout système ou sous-système tel qu'une installation, un équipement, un appareil, un composant matériel ou un composant logiciel.

2.0 Domaine

Cette section présente le domaine de l'ingénierie des exigences:

2.1 Contexte

L'ingénierie des exigences est une activité du processus de fourniture et d'acquisition. Elle fait le lien entre le client et le fournisseur. Ses intrants sont les exigences brutes ou besoins spécifiés par le client. Ses extrants sont les documents d'exigences: norme, appel d'offres, contrat, devis, cahier de charges, spécification, etc.

2.2 Contenu

L'ingénierie des exigences inclut:

a) La collecte, l'analyse, la filtration, la complémentation, la caractérisation, la structuration et la documentation des exigences,
b) La négociation des exigences avec le client et le fournisseur,
c) L'implantation et le suivi de la traçabilité des exigences,
d) La gestion des modifications d'exigences.

2.3 Importance

L'ingénierie des exigences est une activité très importante du processus de fourniture et d'acquisition. À tel point que, si elle est négligée, plusieurs besoins du client ne sont jamais compris par le fournisseur ou ne le sont qu'après la livraison. Il en découle les problèmes majeurs suivants:

a) Augmentation des coûts et délais de réalisation: la compréhension d'un besoin après la livraison implique souvent de recommencer la réalisation, au moins en partie,
b) Diminution de la qualité: l'incompréhension d'un besoin implique que le produit / service ne répondra pas à ce besoin; et la compréhension d'un besoin après la livraison implique souvent que le produit / service ne répondra pas à ce besoin ou ne sera que sommairement corrigé pour y répondre le mieux possible.

L'ingénierie des exigences est une activité non seulement importante mais aussi essentielle à la fourniture et à l'acquisition. En effet, les exigences sont la base de l'entente client-fournisseur. De surcroît, elles sont la base de la fourniture et de l'acquisition: base de réalisation; base de validation / d'acceptation par le client; base de documentation.

2.4 Notions de base

Les notions de base de l'ingénierie des exigences se retrouvent dans multiples documents de référence, dont les normes 1233 [1] et 830 [2] de IEEE. Les plus importantes sont les suivantes:

2.4.1 Généralités:

a) Exigences de boîte noire: les exigences doivent être spécifiées d'un point de vue extérieur au produit / service, donc en faisant abstraction des moyens de réalisation,
b) Exigences pour clients et fournisseurs: les exigences doivent être spécifiées de façon à être compréhensibles autant par le client que par le fournisseur,
c) Exigences structurées: les exigences doivent être structurées de façon à faciliter leur compréhension et modification, et éviter leur répétition ou contradiction,
d) Exigences simples: les exigences doivent être simples, claires et concises,
e) Exigences identifiables: chacune des exigences doit être identifiable par un code ou un numéro de référence unique,
f) Exigences retraçables: la source de chacune des exigences doit être identifiée,
g) Exigences priorisées: chacune des exigences doit être priorisée par rapport aux autres.

2.4.2 Interfaces externes: les exigences des interfaces externes doivent se limiter aux suivantes:

a) Les exigences d'intrants / extrants externes du produit / service, se limitant à spécifier les données requises en entrée, les données requises en sortie, ainsi que leur but, provenance et destination,
b) Les exigences de format des données échangées, intrants / extrants externes, incluant leur unité et précision,
c) Les exigences de synchronisation de ces échanges.

2.4.3 Fonctions: les exigences fonctionnelles doivent se limiter aux relations requises entre les intrants externes et les extrants externes du produit / service.

2.5 Notions logicielles

Dans le domaine de la théorie du développement logiciel apparaît souvent une figure semblable à la Figure 1. Elle illustre le modèle en "V" du processus de développement logiciel [3]. En effet, ce processus commence par la SES, suivi des SEI, SEL, etc, et se termine par le CES. Ce dernier est lié à la SES, son objectif étant de valider la réponse aux exigences de la SES.

La réalisation des SEL doit se faire selon les mêmes notions de base applicables à la SES (2.4): les exigences logicielles, d'un sous-système logiciel, doivent être, elles aussi, des exigences de boîte noire [2]. Ainsi, d'un point de vue de l'ingénierie des exigences, les sous-systèmes sont vus comme des boîtes noires contenues dans la boîte noire système, tels qu'illustrés à la Figure 2.

3.0 Problèmes

Cette section présente les problèmes les plus souvent rencontrés en ingénierie des exigences:

3.1 Exigences coûteuses

L'ingénierie des exigences est une activité souvent coûteuse, pour les raisons suivantes:

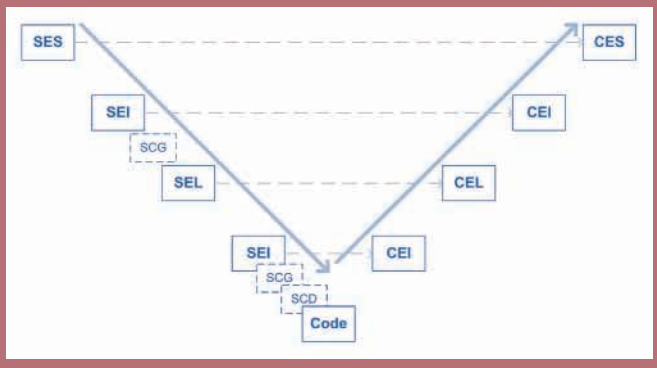
3.1.1 Budget sous-évalué: trop souvent le budget initial alloué à l'ingénierie des exigences est largement dépassé et le final, jugé trop élevé.

Note - Les Tableaux 1 et 2, présentés à la fin de cet article, relient les problèmes avec la solution.

3.1.2 Exigences incluant moyens de réalisation: les exigences ne font pas abstraction des moyens de réalisation. Lorsque survient un changement de ces moyens, l'ingénierie des exigences doit être recommencée. Cela occasionne des coûts supplémentaires importants, en particulier lors d'un changement de technologie.

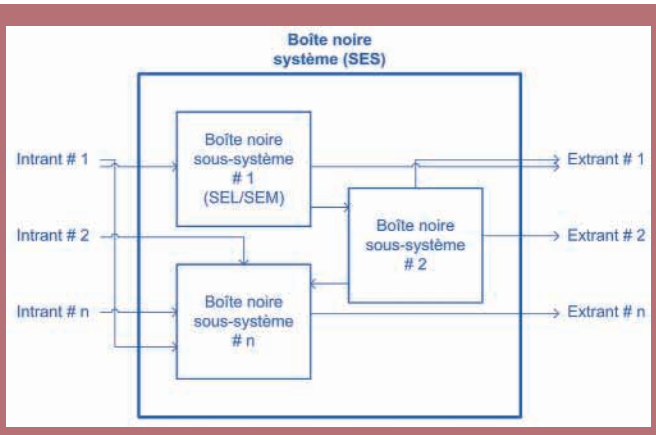
Exemple - En 1990, un système est développé et l'ingénierie des exigences ne fait pas abstraction des moyens de réalisation. En 2000, les technologies utilisées sont obsolètes. Pour pallier ce problème, un nouveau système répondant aux mêmes besoins est développé, nouvelles technologies, nouvelle architecture. L'ingénierie des exigences est alors recommencée, une charge de travail de plusieurs personnes-années; pourtant, les besoins n'ont pas changé, sauf exceptions.

3.1.3 Exigences mal structurées: les exigences ne sont pas bien structurées. Lorsque survient le moment de modifier une exigence, cela a des répercussions sur plusieurs autres exigences non clairement identifiées. Cela exige de revoir l'ensemble des exigences.



SES - Spécification d'Exigences de Système
SEI - Spécification d'Exigences d'Interface
SCG - Spécification de Conception Générale
SEL - Spécification d'Exigences de Logiciel
SCD - Spécification de Conception Détaillée
CEI - Cahier d'Essais d'Interface
CEL - Cahier d'Essais de Logiciel
CES - Cahier d'Essais de Système

Figure 1: Diagramme "V" logiciel



SEM - Spécification d'Exigences de Matériel

Figure 2: Boites noires imbriquées

3.1.4 Exigences d'interfaces instables: les exigences spécifiques aux interfaces externes varient continuellement. En effet, elles sont les plus instables, notamment celles variant le plus selon la technologie. Cela exige de revoir continuellement ces exigences.

3.1.5 Formatage manuel non normalisé: le format de présentation de chacune des exigences n'est pas automatique ou formellement normalisé. Lorsque survient une modification de format d'une exigence, il faut revoir le format des autres, afin d'assurer l'uniformité et faciliter la lecture.

3.1.6 Exigences difficiles à comprendre ou incorrectes: les exigences sont difficiles à comprendre ou incorrectes du point de vue du client ou du fournisseur. Cela exige de revoir les exigences à plusieurs reprises, constituant en effet une autre raison pour laquelle l'ingénierie des exigences est une activité souvent coûteuse.

3.2 Exigences difficiles à comprendre

Les exigences sont souvent difficiles à comprendre, pour les raisons suivantes:

3.2.1 Exigences mal structurées:

a) Mal regroupées: certaines exigences semblent regroupées de façon arbitraire,
b) Non graduelles: plusieurs exigences ne sont pas présentées de façon graduelle, de la vue d'ensemble à la vue détaillée,
c) Cachées: plusieurs exigences sont "cachées" dans un même paragraphe, parmi d'autres informations complémentaires: elles ne sont pas clairement identifiées par un code, un numéro ou l'utilisation d'un verbe d'exigence tel "devoir". Conséquemment, des exigences sont escamotées lors de la réalisation ou de la validation.

3.2.2 Exigences ambiguës: elles ont plusieurs interprétations possibles. Elles peuvent être claires pour le client mais ambiguës pour le fournisseur, ou inversement, le contexte du client étant différent de celui du fournisseur.

Exemple - "Le système doit permettre la télécommande." Pour le client Hydro-Québec, dans le contexte d'un poste électrique, "télécommande" désigne une télécommande d'un appareil du poste effectuée de l'extérieur du poste. Pour le fournisseur, cela peut désigner en plus une télécommande de cet appareil effectuée de l'intérieur du poste.

3.2.3 Exigences difficilement retraçables: il est difficile voire impossible de trouver l'exigence source de laquelle elles découlent, en particulier lorsque cette exigence source est spécifiée dans un autre document.

3.3 Exigences incorrectes

Les exigences sont souvent incorrectes, pour les raisons suivantes:

3.3.1 Exigences inexactes: le produit / service n'a pas à répondre à ces exigences du point de vue du client et du fournisseur. Elles proviennent

généralement d'une incompréhension du besoin ou d'un problème de gestion des modifications d'exigences.

3.3.2 Exigences incomplètes: elles ne couvrent pas tous les intrants / extrants requis, toutes les fonctions requises ou toutes autres caractéristiques, telles les performances requises; ou elles ne sont pas priorisées, ne fournissement pas toutes les informations nécessaires à leur compréhension ou comportent l'expression "à déterminer".

3.3.3 Exigences incohérentes: elles se contredisent ou utilisent des mots différents pour traiter des mêmes sujets.

3.3.4 Exigences invalidables: il n'existe aucune procédure acceptable permettant de les valider. Elles utilisent souvent des intrants / extrants internes ou des mots imprécis tels que "habituel", "rapide" ou "convivial".

Exemple - L'exigence suivante "Le système doit faire la somme des puissances consommées." n'est pas validable si son extrant, cette somme, n'est pas disponible sur une interface externe tel un écran.

4.0 Solution

Cette section présente une solution développée à Hydro-Québec:

4.1 Base de développement

Pour résoudre ces problèmes, Hydro-Québec a développé une solution en 2001, notamment à partir de:

a) Normes internationales [1,2,4,5,6],
b) Théories sur le développement de système [7],
c) Documents de la NASA [8,9] et de la Défense des États-Unis d'Amérique [10,11],
d) Guides de rédaction de lois [12], les exigences étant souvent contractuelles, assujetties à une interprétation légale.

En particulier, la norme 12207 de ISO/CEI/IEEE [5], un document de très haute qualité, a été utilisée comme "modèle" de document d'exigences.

4.2 Allocation d'un budget suffisant

La solution consiste d'abord à s'assurer de l'allocation d'un budget suffisant à l'ingénierie des exigences, respectant la théorie: dans le cas d'un développement logiciel, le budget alloué à l'ingénierie des exigences représente généralement 20% du budget total de développement, excluant la maintenance [7].

4.3 Adoption d'une méthode simple et systématique

La solution consiste ensuite à adopter une méthode simple et systématique. Outre les notions de base (Section 2.4), cette méthode consiste à suivre les règles suivantes:

4.3.1 Structurer les exigences de façon hiérarchique:

a) Spécifier l'ensemble des exigences sous la forme d'un arbre hiérarchique: les exigences "enfant" sous les exigences "parent", les unes découlant des autres,
b) Spécifier les exigences parent de façon à ce que chacune d'elles soit la synthèse de ses enfants. Cela aide à présenter les exigences de façon graduelle, systématiquement de la vue d'ensemble à la vue détaillée,
c) Ordonner les exigences de façon à ce que les informations nécessaires à leur compréhension soient contenues dans l'exigence ou dans celles qui la précèdent.

Exemple - "Exigence 1 - TDT doit permettre de produire un document. Exigence 1.1 - TDT doit permettre d'imprimer le document. Exigence 1.1.1 - TDT doit offrir les choix suivants: a) Imprimer par une imprimante; b) Imprimer dans un fichier". Pour des exemples complets, voir les spécifications de la NASA [9] ou de la Défense des États-Unis d'Amérique [11] accessibles par Internet.

4.3.2 Limiter chacune des exigences à un paragraphe:

a) Utiliser un seul paragraphe par exigence, si l'exigence peut être spécifiée dans un seul paragraphe simple, clair et concis,
b) Sinon, diviser l'exigence en plusieurs exigences "validables", d'un seul paragraphe, si elle peut être ainsi divisée,
c) Sinon, référer à une annexe décrivant l'exigence.

Exemple - Voir la norme 12207 de ISO/CEI/IEEE [5].

Note - (1) La rédaction anglaise traditionnelle voulait même que l'exigence se compose d'une seule phrase [12]. (2) En plus d'être basées sur des normes internationales, les deux premières règles sont recommandées par une conférence de la NASA [8] et un article de la Défense des États-Unis d'Amérique [10].

4.3.3 Référer aux exigences sources: lorsqu'une exigence découle directement d'une autre spécifiée dans un autre document, y référer. Référer non seulement au document mais aussi au paragraphe spécifiant l'exigence. Cet autre document peut être une spécification, un courriel, un compte-rendu de réunion, etc.

4.3.4 Utiliser des renvois plutôt que la redondance: utiliser des renvois plutôt que la redondance d'informations si cette redondance est faite manuellement. Cela réduit le risque d'incohérences. En effet, une incohérence est souvent introduite dans un texte lors d'une modification d'une information redondante: la modification n'est pas effectuée partout où l'information apparaît.

4.3.5 Relier les exigences: par des renvois, relier les exigences ayant des liens logiques, les exigences devant potentiellement être modifiées si l'une d'elles est modifiée. Cela exclut les liens parent-enfant, puisqu'ils sont déjà présents dans la structure des exigences (voir 4.3.1). Dans tous les cas, spécifier la raison du renvoi. Cependant, dans tous les cas, faire un usage parcimonieux des renvois: les renvois internes multiples sont inutiles dans un texte de structure logique [12]; au besoin, restructurer.

Ainsi structurées, les exigences peuvent être vues comme un simple empilement de briques interreliées, tel qu'illustré à la Figure 3. Assurément, cela facilite l'ajout, le retrait et la modification d'exigences. De surcroît, cela réduit le risque d'incohérences.

4.3.6 Respecter les règles de rédaction: respecter les règles fondamentales de rédaction technique [4], principalement les suivantes:

a) Utiliser le langage courant et n'utiliser des mots techniques que si la précision l'exige,
b) Faire des phrases simples, claires et concises,
c) Uniformiser les exigences: rédiger de façon analogue des exigences analogues et de façon identique des exigences identiques.

Cela implique notamment de (1) ne pas utiliser de synonymes, même pour les mots de liaison; et (2) utiliser systématiquement le même verbe pour spécifier une exigence, tel "devoir".

4.4 Utilisation d'un outil de support

La méthode consiste aussi, mais optionnellement, à utiliser un outil de support. En effet, la méthode ci-dessus décrite est simple. Cependant, son application peut être ardue sans le support d'un outil logiciel autre qu'un simple traitement de texte: il est généralement ardu de structurer les exigences avec un logiciel de traitement de texte, de les uniformiser et, en particulier, d'utiliser des renvois. Il convient alors d'utiliser un outil de support, commercial ou maison.

Il existe plusieurs outils commerciaux de support à l'ingénierie des exigences: System Architect, IRqA, Rational RequisitePro, etc. Ces outils

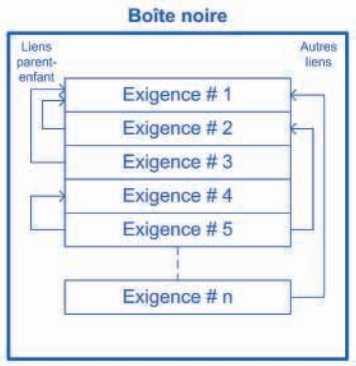


Figure 3: Exigences interreliées

sont puissants. Ils offrent notamment des facilités de traçabilité des exigences, de conception et même de génération de code logiciel. Par contre, de façon générale:

a) Ils sont complexes: ils exigent tous une formation de plusieurs jours, voire plusieurs semaines. Ils exigent, de surcroît, plusieurs mois de pratique pour les maîtriser,
b) Ils offrent peu de flexibilité quant au format des documents générés: ils ne respectent pas le gabarit et même la langue des documents de l'entreprise,
c) Ils ne sont pas axés sur la méthode présentée dans cet article: il y est ardu de structurer les exigences, de les uniformiser et d'utiliser des renvois.

Hydro-Québec a développé son propre outil d'ingénierie des exigences: GenSpec. Ce dernier n'offre aucune facilité de conception ni de génération de code logiciel. Par contre, il est simple, offre beaucoup de flexibilité quant au format des documents générés et est spécifiquement axé sur la méthode présentée dans cet article.

5.0 Optimisation

Cette section présente une optimisation de la solution:

5.1 Amélioration selon les normes IEEE

La méthode peut être améliorée en y ajoutant les règles suivantes, basées sur des recommandations tirées spécifiquement des normes 1233 [1] ou 830 [2] de IEEE:

5.1.1 Spécifier les interfaces avant les fonctions: spécifier les exigences des interfaces externes avant les exigences fonctionnelles, pour les raisons suivantes: (1) il est naturel de présenter l'extérieur du produit / service (interfaces externes) avant d'entrer à l'intérieur (fonctions) et (2) les exigences des interfaces externes remplissent aussi le rôle de glossaire, définissant des termes, les intrants / extrants, qui n'auront pas à être redéfinis aux exigences fonctionnelles. Faire attention à spécifier ces exigences de façon graduelle, comme lors d'une présentation du produit / service pour la première fois.

5.1.2 Relier les fonctions avec les interfaces: par des renvois, relier les exigences fonctionnelles aux exigences d'intrants / extrants concernés, et inversement. Cela aide (1) à couvrir toutes les exigences des interfaces externes et toutes les exigences fonctionnelles, et (2) à spécifier des exigences fonctionnelles validables, faisant abstraction des moyens de réalisation, étant reliées à des intrants / extrants externes, telles qu'illustrées à la Figure 4.

Note - (1) Tout extrant à une interface externe peut être affecté par plusieurs exigences fonctionnelles et (2) tout extrant à une interface externe peut être utilisé comme intrant à une exigence fonctionnelle.

5.1.3 Placer judicieusement les exigences: lorsqu'une exigence peut être placée dans deux sections distinctes, section "sujet # 1" ou section "sujet # 2", parce qu'elle traite à la fois du sujet # 1 et du sujet # 2, la placer dans la section ayant la plus grande probabilité d'être supprimée; cela réduit le risque d'incohérences advenant la suppression de cette section.

Exemple - L'exigence suivante "Si le système bascule en état Maintenance, il doit cesser la simulation" peut être placée dans deux sections distinctes, parce qu'elle traite à la fois de la maintenance et de la simulation: (1) dans une section "Maintenance" ou (2) dans une section "Simulation". Si la probabilité de supprimer la section "Simulation" est plus élevée, cette exigence devrait être plutôt placée dans "Simulation". Ainsi, advenant la suppression de "Simulation", il n'est pas requis de modifier la section "Maintenance".

Dans le cas contraire, c'est-à-dire si cette exigence était plutôt placée dans la section "Maintenance", il y aurait risque d'incohérences: oublier de retirer cette exigence de "Maintenance" advenant la suppression de "Simulation".

5.2 Optimisation selon d'autres normes ou guides

La méthode peut être optimisée en y ajoutant les règles suivantes, basées sur des recommandations tirées d'autres normes ou guides:

5.2.1 Ajouter des exigences de validation: ajouter des exigences facilitant la validation [6], tout en faisant abstraction des moyens de réalisation. Cela facilite, de surcroît, la simplification des exigences. En effet, lorsqu'une exigence est complexe, il suffit de (1) la séparer en deux exigences simples dont l'une utilise l'extrant de l'autre, et (2) ajouter une exigence de cet extrant sur une interface externe, pour faire, de toutes ces exigences, des exigences validables. Ainsi, cette dernière exigence ajoutée facilite-t-elle non seulement la validation mais aussi la simplification de l'exigence complexe.

5.2.2 Spécifier les interfaces dans des documents dédiés: sauf s'il y a peu d'exigences, spécifier les exigences spécifiques aux interfaces externes, celles variant le plus selon la technologie, dans des documents dédiés. Cela facilite la modification des exigences.

5.2.3 Spécifier distinctement les fonctionnements anormaux: spécifier les exigences associées à un fonctionnement anormal dans une section distincte, pour les raisons suivantes: (1) une exigence ne traitant pas tous les cas est plus simple et (2) le lecteur, dans un premier temps, ne s'intéresse pas aux cas de fonctionnement anormal.

5.2.4 Ajouter des notes d'informations complémentaires: si nécessaire, ajouter une note à une exigence, une courte remarque ou une annotation apportant un commentaire ou un éclaircissement sur le texte. Cette note ne doit, par contre, contenir aucune exigence, sauf dans le cas d'une note de figure ou de tableau [4]. Dans tous les cas, faire un usage parcimonieux des notes.

5.2.5 Ajouter des notes de simplification: si, par souci de simplification, de clarté, une exigence ne tient pas compte d'un détail, utiliser une note pour indiquer le détail en question et renvoyer aux exigences traitant de ce détail.

Exemple - "Note - Les exigences suivantes sont spécifiées en considérant que le système est en mode Exploitation. Dans le cas contraire, voir réf. interne ci-après identifiée."

5.2.6 Lister les événements en annexe: si le produit / service peut signaler une grande variété d'événements, les lister en annexe et y spécifier, pour chacun d'eux, les conditions déclenchant leur apparition / disparition; aux exigences des interfaces externes et aux exigences fonctionnelles, référer à cette annexe.

5.2.7 Limiter les énumérations: limiter à dix la quantité d'éléments de toute énumération, y compris la quantité de sections ou de paragraphes d'un document ou d'une section; au besoin, restructurer.

5.2.8 Indiquer les exigences non applicables: si une exigence normalement applicable au produit / service (ex: selon une norme) est non applicable, conserver son code, numéro de référence ou titre et indiquer "Non applicable", assurant au lecteur que cette exigence n'a pas été oubliée. Sous une exigence non applicable, omettre les exigences qui, normalement, en découlent.

6.0 Conclusion

Plusieurs problèmes importants sont rencontrés en ingénierie des exigences: plus d'une douzaine identifiée à 3.0. Compte tenu de l'importance de cette activité, de ses impacts majeurs sur les coûts et la qualité des produits / services, il est hautement souhaitable qu'ils soient résolus.

La méthode présentée dans cet article apporte une solution simple et systématique à tous ces problèmes, tel que montré par le Tableau 1.

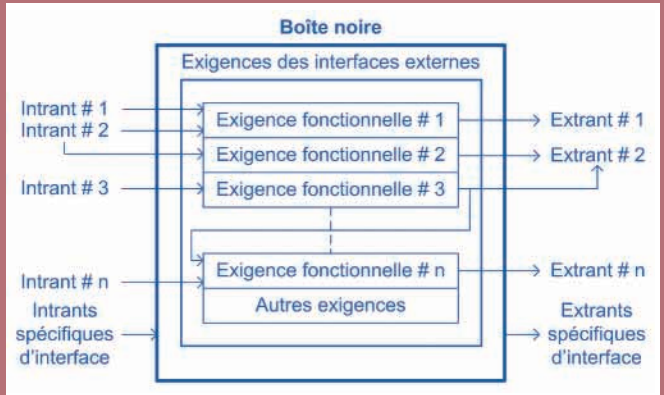


Figure 4: Exigences validables

Assurément, elle impose la rigueur nécessaire à cette ingénierie et augmente la qualité des documents d'exigences.

Pour ces raisons, depuis 2002, il est formellement convenu à la direction Expertise d'Hydro-Québec Équipement d'utiliser cette méthode pour l'ingénierie des exigences de tous ses automatismes. De surcroît, il est en voie d'y être convenu d'utiliser cette méthode pour l'ingénierie des exigences contenues dans toutes ses spécifications normalisées et dans tous ses devis d'équipement le moindrement d'envergure.

7.0 Références

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8.0 Remerciements

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René Bujold est ingénieur à la direction Expertise d'Hydro-Québec Équipement. Depuis l'obtention de son diplôme, en 1988, il a oeuvré dans tous les aspects du développement de système: étude, ingénierie des exigences, conception matérielle et logicielle, implémentation, validation, etc. Graduellement, il a concentré ses efforts dans l'activité fondamentale et la plus problématique du processus de développement: l'ingénierie des exigences. Il est à l'origine et le responsable du développement de la méthode présentée dans cet article

Tableau 1: Problème / Solution

Problème	Solution
3.1.1	4.2
3.1.2	2.4.1a); 5.1.2
3.1.3	4.3.1; 4.3.5; 5.1.2; 5.1.3
3.1.4	5.2.2
3.1.5	4.4
3.1.6	4.3.1; 4.3.2; 4.3.3; 4.3.4; 4.3.5; 4.3.6; 5.1.1; 5.1.2; 5.1.3; 5.2.1; 5.2.3; 5.2.4; 5.2.5; 5.2.6; 5.2.7; 5.2.8
3.2.1	4.3.1; 4.3.2; 5.1.1; 5.2.1; 5.2.3; 5.2.4; 5.2.5; 5.2.6; 5.2.7; 5.2.8
3.2.2	4.3.6
3.2.3	4.3.1; 4.3.3
3.3.1	4.3.3
3.3.2	4.3.3; 5.1.2; 5.2.1
3.3.3	4.3.4; 4.3.5; 4.3.6; 5.1.3
3.3.4	4.3.6; 5.1.2

Tableau 2: Solution / Problème

Solution	Problème
2.4.1a)	3.1.2
4.2	5.1.1
4.3.1	3.1.3 ; 3.1.6; 3.2.1; 3.2.3
4.3.2	3.1.6; 3.2.1
4.3.3	3.1.6; 3.2.3; 3.3.1; 3.3.2
4.3.4.	3.1.6; 3.3.3
4.3.5	3.1.3; 3.1.6; 3.3.3
4.3.6	3.1.6; 3.2.2; 3.3.3; 3.3.4
4.4	3.1.5
5.1.1	3.1.6 ; 3.2.1
5.1.2	3.1.2; 3.1.3; 3.1.6; 3.3.2; 3.3.4
5.1.3	3.1.3 ; 3.1.6; 3.3.3
5.2.1	3.1.6; 3.2.1; 3.3.2
5.2.2	3.1.4
5.2.3	3.1.6; 3.2.1
5.2.4	3.1.6; 3.2.1
5.2.5	3.1.6; 3.2.1
5.2.6	3.1.6; 3.2.1
5.2.7	3.1.6; 3.2.1
5.2.8	3.1.6; 3.2.1

Source and Channel Coding Techniques for faithful transmission of Digital Mammograms

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Abstract

This paper examines source and channel coding techniques that are necessary for reliable transfer of digital mammograms over a wireless AWGN channel. First, in order to maximize bandwidth efficiency while maintaining the input signal's entirety, lossless source compression techniques are investigated. Particular attention is paid to compressors that produce the highest degree of compression. Second, to ensure reliable data transfer over a noisy wireless channel, error correction and detection mechanisms are discussed focusing on schemes that achieve the lowest bit error rates. Specifically, for experimental purposes, digitized mammograms saved as Portable Grey Maps (PGM) were used. Prior to choosing the optimal coding arrangement, the implications of the source and channel coding algorithms on PDAs and computers will be examined. Major concerns are computational complexity and encoding and decoding delays.

Sommaire

Cet article examine les techniques de codage source et de canal qui sont nécessaires pour le transfert fiable des mammographies numériques sur un canal sans fil à bruit additif blanc gaussien (AWGN). D'abord, afin de maximiser l'utilisation de la bande passante tout en maintenant l'intégralité du signal d'entrée, des techniques de compression source sans perte sont étudiées. Une attention particulière est prêtée aux compresseurs assurant le taux de compression le plus élevé. En second lieu, pour assurer un transfert fiable de données à travers un canal sans fil affecté de bruit, la correction d'erreurs et les mécanismes de détection sont discutés en focalisant sur des configurations de codage réalisant les plus bas taux d'erreurs sur les bits. Spécifiquement, pour des fins expérimentales, des mammographies numérisées et sauvées sous format PGM ont été utilisées. Avant de choisir la configuration optimale de codage, les implications des algorithmes de codage source et de canal sur les assistants numériques personnels (PDAs) et des ordinateurs seront étudiées. L'objet principal de l'étude sera la complexité du calcul et les retards dans le codage et le décodage.

1.0 Introduction

Telemedicine is a fairly new and emerging field of engineering that is dedicated to providing hi-tech technologies to the medical profession. This paper seeks the most favorable method in which digital mammograms can be prepared for transfer over a wireless link. This transfer could be over a radio channel and may be between two computers or from a computer to a piece of mobile equipment.

The intended beneficiaries of this research are professionals who may need to transfer sensitive, medical information; in particular medical images (i.e. digitized x-rays) and physiological signals for an expert referral, and in emergency ambulatory situations.

The mobile unit of choice that is under investigation is the Personal Digital Assistant (PDA), which is easy to use, portable and is a powerful computing device with a high definition display. As a result, this research will consider the operability of any channel or source coding technique on these types of devices.

The reliability of data transmission will be simulated with real-world medical mammograms (x-ray images of the breast). The images investigated are from the MIAS database, which contains numerous mammograms that are normal, benign or malignant (Figure 1).

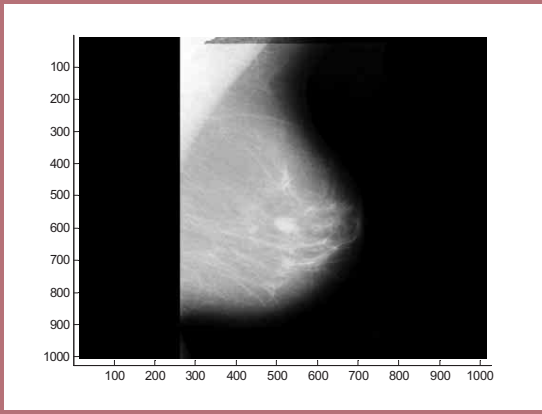

Figure 1: PGM sample of digitized mammogram (benign case)

2.0 Source Compression

Since the mammograms in question are to be later interpreted by a diagnosing physician, it is important to retain the image's accuracy and therefore lossless compression schemes will be investigated. An optimal lossless compression scheme will reduce the input image size significantly. By doing so, it will compensate for the additional redundant bits inserted by the channel encoder. Additional considerations such as computational complexity, encoding delays, transmission overhead and whether these compression techniques are practical for various computing devices will be investigated prior to deeming a source encoder favorable.

2.1 Source Description

When deciding which compression scheme is optimal for a desired application, it is first necessary to characterize and understand the unique features of the source. Identifying the source characteristics will allow an appropriate source encoder to exploit those qualities. Sources may be grouped into two categories:

1) Memoryless Source - a source that emits symbols that are statistically independent of one another.
2) Memory Source - a source that emits symbols that are dependant on any number of its previously emitted symbols.

When considering a digital image, it is highly unlikely that adjacent pixels are going to be perfectly independent of one another. This is because regions in a digital image are usually concentrated with one color and gradually blend into another. Therefore, it is concluded that each pixel exhibits a high degree of correlation with its neighbor pixel, and as a result, the digital image inputs can be modeled as a source with memory.

After some investigation, it was found that digital images prove to be exceptionally correlated with their immediate neighbors [1]. This leads to the deduction that a first order Markov model would be an accurate description of the source.

2.2 Adaptive Huffman

The adaptive Huffman compressor is a modification of the conventional Huffman algorithm. Instead of gathering symbol statistics first, the encoder and decoder use a dynamic tree that counts the probability of occurrence and assigns a codeword to each symbol, in real time. This is one of the major advantages of any adaptive Huffman scheme. It does not need to first scan the entire file to gain knowledge of the input file's characteristics, which significantly reduces the total encoding time for large files. Therefore, the only delay arises from the computational complexity of the algorithm. For the Faller, Gallager, and Knuth (FGK) algorithm, D.E Knuth has proved the complexity to be O(l) where l is the current length of the codeword [2].

Additionally, both the encoder and decoder manage their own information about the input message and do not require a look up table, unlike static Huffman codes. As a result no additional information needs to be transmitted with the encoded symbols allowing for maximum bandwidth utilization.

A downfall of any Huffman compressor is due to the fact that maximum compression is achieved when the symbol probabilities are a power of 1/2 [3].

2.3 Arithmetic Coding

Arithmetic compressors are composed of two parts: the arithmetic coder and the Markovian data model. The arithmetic coder assigns a floating point interval between 0 and 1 for each symbol. The interval endpoints are allocated by dividing the original encoding interval according to a specific algorithm that depends on the source probability distribution, which is described by a Markovian model.

Arithmetic coders are ideal for large symbol sets as the floating point interval can be divided as many times as the computing processor allows. Another advantage of arithmetic compression arises from the fact that the Markovian model takes into consideration the correlation between symbols, thus allowing for higher compression.

A major disadvantage of any arithmetic coder is its computational complexity. Some scholars say that for arithmetic coders that incorporate a Markovian data model, the complexity is at least O(n3), where n is the length of the codeword [4]. Furthermore, because a probability model is required, the input file must be scanned twice to be encoded and the symbol mapping scheme must also be transmitted along with the codewords. As a result, delay and transmission overhead are introduced.

2.4 Lempel-Ziv Welch (LZW) Coding

LZW compression is achieved using a dictionary based approach. As input symbols arrive, the encoder checks the dictionary. If the symbol can be located within the dictionary, the related codeword is assigned and transmitted. Otherwise, the new symbol is added to the dictionary and is assigned a unique codeword. Since codewords are appointed to a given symbol only if it is found in the dictionary, LZW codes rely heavily on repeating patterns. This can be good or bad depending on the application. If the input data is highly correlated, LZW compressors will find a large number of repeating patterns which will produce a high degree of compression. However, if there are only a few recurring patterns, the dictionary will be indefinitely long and the achieved compression will not be significant.

Similar to adaptive Huffman schemes, prior to encoding, LZW codes do not require any knowledge of the symbol's statistical characteristics and both the encoder and decoder maintain their own dictionaries. As a result, encoding only requires one scan of the file and delays are caused primarily as a consequence of computational complexity. If a message of length u is compressed to a length of n, when considering a pattern of length m, to find all R occurrences of this pattern in the message takes O(2m+mn+Rmlog(m)) time for the worst case scenario. On average, the worst case drops to O(2m+(n+R)log(m)), which will still reach especially high values for long message and pattern lengths [5].

2.5 Experimental Results

To test the performance of various lossless source encoders, several digital mammograms supplied by the MIAS database were used as input messages. In particular, the source coding algorithms that were experimented with were adaptive Huffman codes, LZW codes with 12 bit and 15 bit dictionaries and arithmetic coders with order-0 and order-1 probability models. A coder with an order-n probability model assumes that the present symbol is statistically dependant on the previous n symbols emitted from the source. As previously discussed, the images in question were found to exhibit exceptional correlation with their immediate neighbour, so the data model need not be higher than an order-1. A desktop computer with a 1.4 GHz processor was the computing device where all tests were conducted.

Average compression ratios for 30 mammograms (in bits per pixel) can be found in Figure 2.

The average first order Markov entropy over all images was found to be 1.5381 bits/pixel and was calculated by

$$H(x) = \sum_{x \in X} P(x) \sum_{y \in Y} P(y \mid x) \log_2 \left[\frac{1}{P(y \mid x)} \right] \qquad (1)$$

Where:

x and y are the present and past integer pixel values respectively.

Using the found entropy results, the efficiency for the previously listed source coders was easily found and are illustrated in Figure 3.

Upon examination of Figures 2 and 3, arithmetic coding with a first order probability model gave rise to the lowest compression ratio and

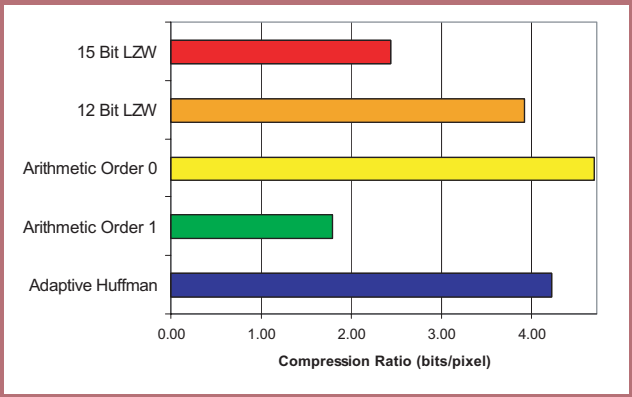

Figure 2: Average compression ratios in bits/pixel

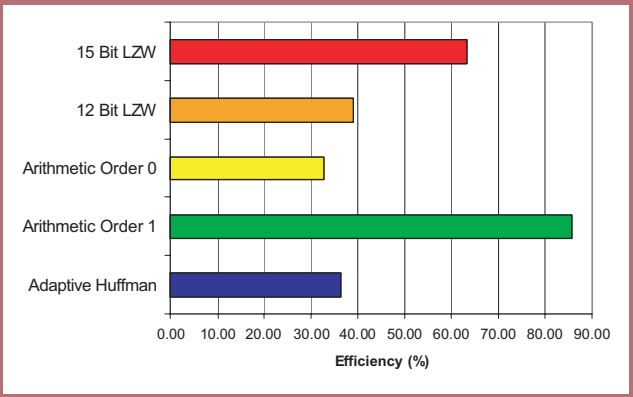

Figure 3: Efficiency results

the highest efficiency. LZW with a 15 bit dictionary also produced desirable compression and efficiency results, even though they did not supersede the results produced by the arithmetic order-1 compressor. However, as previously stated, there are many other concerns that must be considered when choosing the optimal source compression scheme for any application. Such considerations include computational complexity, encoding and decoding speed and whether it is possible to execute these compressors on different devices.

The adaptive Huffman compressor is not a very complex algorithm O(n)) and does not require a probability model. For these reasons, the encoding and decoding delay was minimal and was noted to be in the order of milliseconds. Although this was confirmed using a 1.4 GHz processor, it is very easy to deduce that because of the small number of computations required and the need for only a single file scan, similar results could be reproduced on a PDA that uses a 400 MHz processor. Additionally, adaptive Huffman codes do not transmit the symbol mapping scheme along with the encoded symbols, which permits for maximum bandwidth utilization.

Although adaptive Huffman codes performed exceptionally well in all other aspects, the compression it achieved was very poor. Its heavy reliance on symbols that occur statistically in powers of 1/2 is the reason for the inadequate compression results.

Arithmetic coders are a versatile compressor as they can account for a Markovian data model and therefore data correlation. The advantages are visible from the results shown in Figures 2 and 3. Since the digital images have been found to exhibit correlation in a first order Markov fashion, the immense benefits of considering a Markovian data model can be seen when comparing the exceptional compression characteristics of an arithmetic order-1 coder with the poor results of an arithmetic coder using a order-0 probability model.

Arithmetic coding is also a flexible compression scheme because it can handle large symbol sets. This is true because the symbol mapping scheme is dependent on a floating point interval and how many times it can be divided, which relies on the precision of the computing device. For computers and PDAs, which have processors that can maintain the precision of a number within 64 and 32 bits, respectively, large symbol sets are easily supported. The precision that these devices sustain also allows interval end points to be rather insensitive to truncation and rounding errors.

The major downfall of arithmetic coding is its complexity. As stated before, when an arithmetic coder considers a Markovian model for the source, which requires two scans of the input file, complexity is at least $O(n^3)$. This was confirmed experimentally by observing the encoding and decoding delays. Because arithmetic order-0 did not use a memory source model, it encoded and decoded rather quickly, whereas even on a 1.4 GHz processor, arithmetic order-1 took a few seconds. Since the arithmetic order-1 compressor gave rise to the most desirable results, its complexity is a major concern. For PDAs that operate at 400 MHz, there may be a longer delay than that which was found for the desktop computer. For a real time application, this delay may not be desired.

Because the LZW algorithm is based on finding repeating patterns, it can be very effective when compressing files that are highly correlated. In order to achieve high compression ratios, two things need to be satisfied: the input file must be large enough to be able to find a significant amount of pattern repetitions and the maximum buffer length in the dictionary must be longer than the period of the longer repeating patterns. For both LZW 12 and 15 bit, the message size was large enough, but for LZW 12 bit, the maximum buffer length was not long enough to realize the longer patterns. This was concluded upon observation of the fact that LZW 12 bit performed poorly with respect to LZW 15 bit. In fact, LZW 15 bit offered almost as good compression results as those of arithmetic order-1.

Although LZW 15 bit provided good results, it suffered from a noticeable encoding and decoding delay. As mentioned before, delays in the compression and expansion process is due to the average time O(2m+(n+R)log(m))) taken to find R patterns of length m, to result in a compressed file of size n. For large message sizes, which is the case here, and for patterns that are a maximum length of 2^{15} (for LZW 15 bit), this computational complexity becomes extremely high. When LZW was tested on a 1.4 GHz processor, the entire encoding and decoding process took a couple of seconds longer than that of arithmetic order1. Although LZW codes are computed in real-time and only require one scan of the file, the decoding delay may be more noticeable slower processors, like those of a PDA. When considering source compression schemes, one needs to decide whether the delay is worth the amount of compression that is achieved. Such a delay may be undesirable.

3.0 Channel Codes

There are many types of channel encoding schemes that can be used in digital communication systems such as convolutional codes, linear block codes (LBC), and various types of hamming codes. The performance of two of these techniques, convolutional codes and LBC, were investigated and tested in the transmission of digital mammograms in all white Gaussian noise (AWGN) channel.

3.1 Choosing a Channel Coder

Convolutional and linear block codes (LBC) were chosen because they can combat many types of channel impairments including AWGN. However, it will be demonstrated that convolutional codes have several distinct advantages over LBC, and because of this, convolutional codes are the focus of this section.

Convolutional encoders are simple to design and operate at very high speeds because they are composed of simple logic circuits. Also, convolutional codes can be designed with much more ease than LBC codes because no systematic procedure exists to aid in the design of LBC codes [6]. Additionally, efficient low rate convolution codes are widely used in many applications such as the Global System for Mobile Communication (GSM), IEEE 802.11x standards for wireless local area networks (WLAN) and NASA's deep space communication. This demonstrates that convolutional codes can operate on a variety of platforms including PDAs.

3.2 Convolutional Encoding

In general, any convolutional encoder can be described by the three parameters: n, k and K, where n is the number of output bits, k is the number of input bits per output set and K is the constraint length of the encoder which is equal to the number of memory location in the register. This is shown in Figure 4.

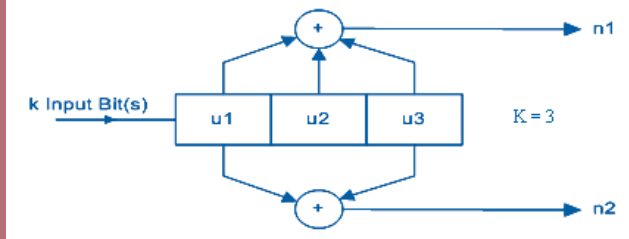

Figure 4: Convolutional encoder with encoding polynomials 7,5 (in octal), rate k/n and constraint length (K =3)

The rate or efficiency of the encoder is the ratio of the input bits to the output bits per sample time shown below:

$$Rate = Efficiency \quad (\eta) = \frac{input\ \ bits}{output\ \ bits} = \frac{k}{n} \qquad (2)$$

The encoding rate affects the bandwidth of the transmitted message significantly. For example, if k=1, then the rate (or efficiency) is equal to 1/n, which means that the encoder output is n-times the input. This is the primary reason that source compressors are often used in conjunction with convolutional coders as they compensate for the increase in file size. To reduce bandwidth requirements only encoding rates of 1/2 and 1/3 were considered. Furthermore, to significantly reduce the decoding complexity (memory as well as computations) only rate 1/n encoders were considered.

3.3 Viterbi Decoding

Although encoding is very fast and simple for any given set of specifi cations, convolutional decoders are considerably more complex. low constraint length (K) encoders, Viterbi decoding can drastically reduce complexity and can operate as fast as 100 Mbits/s [6]. In fact, because of its simplicity, Viterbi decoding is one the main advantages of convolutional encoding. Simplifications offered by Viterbi decoding include the use of hamming or Euclidean distances to measure error the received codeword, as well as reducing the memory requirements half via the introduction of survivor paths as is demonstrated in [8]. The main parameter that requires attention, in Viterbi decoding is decoding depth (D). The decoding depth determines the amount of error that can be corrected by the decoder. It also establishes the mem ory requirements of the decoder and can be expressed by

$$memory = D \times 2^{K} \tag{3}$$

Because Viterbi decoding relies on maximum likelihood probabilities, small values of D will produce poor Bit Error Rate (BER) results while large values of D will produce the best BER results. However, for large values of D, the decoder complexity increases significantly. Experimental results will determine the best decoding depth to be used for each encoder polynomial set. Furthermore, decoding complexity depends on the constraint length (K). We can see from equation 3 that decoder complexity and memory requirements grow proportional to 2K. Therefore, Viterbi decoding becomes impractical for large values of K (K>10) and in practice K is often kept small for this reason [6]. To minimize the decoder complexity, the encoder constraint length (K) was kept to below five.

3.4 Channel Simulation

The performance of convolution encoder polynomials are difficult to predict. To aid in the design and experimental process, a Viterbi decoder was designed with a built-in AWGN channel simulator so that BER results for any rate 1/n encoder could be calculated.

In order to calculate BER, prior to transmission into the AWGN channel, the simulator first performs polar-NRZ line coding techniques on the binary data. Polar-NRZ line coding techniques map binary 1 to +1 and binary 0 to -1, as can be seen in Figure 5. Upon reception, it is then the decoder's job to decode the noisy output from the channel. After doing so, the performance of the encoding polynomial can be measured based on decoded bit error rates. Assuming polar-NRZ line coding has been used prior to transmission; the theoretical BER of the received message can be calculated by

$$BER_{\ Polar\ -\ NRZ} = erfc\left(\frac{\sqrt{SNR}}{2}\right) \tag{4}$$

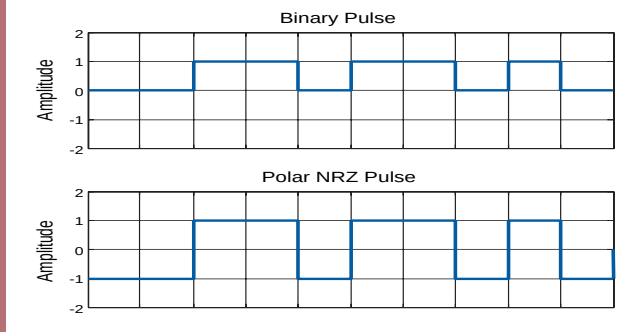

Figure 5: Binary waveform and its corresponding polar-NRZ waveform

3.5 Experimental Results

By limiting the encoder rate to 1/2 and 1/3 as well as limiting the con straint length (K) of the encoder to below five (as discussed earlier), there was a significant reduction in the memory requirements of the decoder, while simultaneously reducing the number of computations per decoded bit.

Many polynomial sets were tested and their performance was measured using the simulator. From these polynomial sets, the best rate 1/2 and polynomials were chosen for the final design. These polynomials and their characteristics are shown in Table 1, and their performance charac teristics are shown in Figure 6 for the case of 1/2 convolutional encoder after Viterbi decoding and for varying decoding depths (D). Figure accurately depicts two things: Signal Noise Ratio (SNR) versus BER improvement and also that longer decoding depths do not provide sig nificant BER improvement. Since Figure 6 does not provide sufficient comparative faetures, this figure is repeated as Figure 7 but without the uncoded channel.

Table 1: Convolutional encoder characteristics

Rate	Constraint Length	Polynomial 1	Polynomial 2	Polynomial 3
1/2	3	$x^2 + x + 1$	$x^2 + 1$	-
1/3	4	x^3	$x + 1$	1

We can see from Figures 7 and 8 that the chosen polynomials provide a significant BER improvement when compared with the uncoded message, which can also be seen on the same figures. Furthermore, while achieving this BER performance, the algorithms can still be implemented on both hand held and larger computers because of the significant reduction in complexity as discussed.

Lastly, it was found that longer decoding depths also improved BER performance of the decoder. However, from Figures 7 and 8 it can be seen that decoding depths of approximately 5K-7K produce comparable results to decoding depths of 50K for the rate 1/2 polynomial set. Similar results can also be seen for the rate 1/3 polynomial set. However, smaller decoding depths significantly decrease the memory requirements of the decoder and hence are preferred.

4.0 Conclusion

To prepare a digital mammogram for reliable transmission through a wireless channel, the image must first be compressed to minimize bandwidth usage and then a method of error detection and correction must be For the mammogram images tested, two compression schemes, arithmetic order-1 and LZW (with a 15 bit dictionary) produced the highest

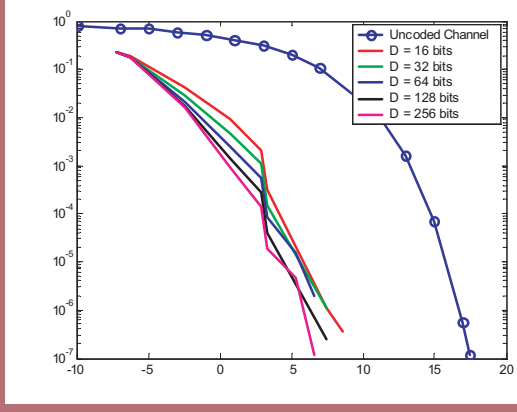

Figure 6: SNR vs. BER results for the rate 1/2 convolutional encoder after Viterbi decoding and for varying decoding depths (D)

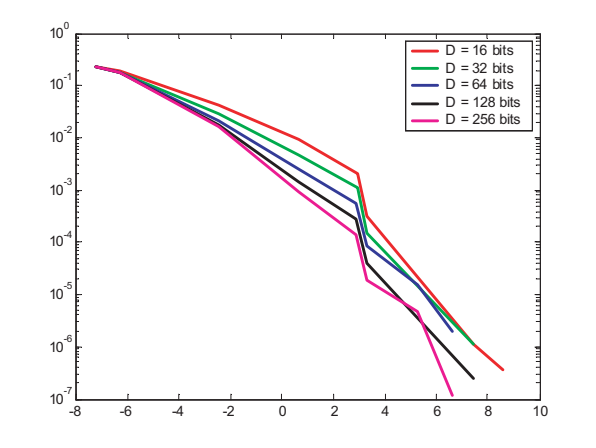

Figure7: SNR vs. BER results for the rate 1/2 convolutional encoder after Viterbi decoding and for varying decoding depths (D)

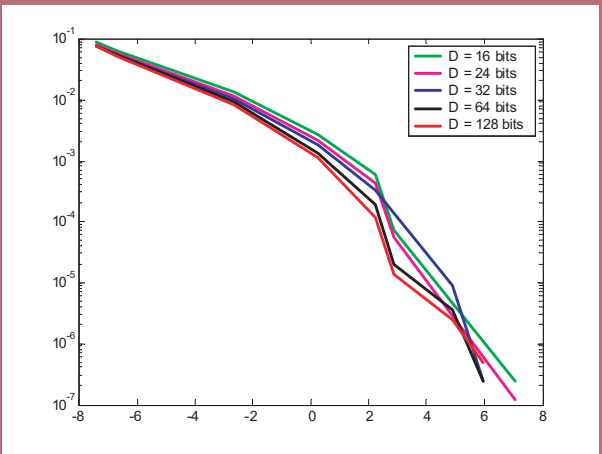

Figure 8: SNR vs. BER results for the rate 1/3 convolutional encoder after Viterbi decoder and for varying decoding depths (D)

compression results. Of the two, arithmetic order-1 achieved the highest compression ratio because it uses a Markovian data model which exploits the correlation between adjacent pixels. This exploitation increases the computational complexity which translates into longer encoding and decoding delay with respect to LZW (with a 15 bit dictionary) which operates in real-time. Arithmetic order-1 will also be less bandwidth efficient than LZW (with a 15 bit dictionary) because the receiver needs the encoder's data model, thus creating transmission overhead. Although an arithmetic order-1 compressor may be less bandwidth efficient and introduces longer encoding and decoding delays, it is still well warranted for image transmission as more compression will allow for better error correction and detection.

After image compression, a channel coding scheme must be used to ensure reliable data transfer. Convolutional codes were chosen as the channel coding technique because of their ability to correct various types of channel impairments and also because efficient low rate convolutional coders are widely being used today in many technologies. To further reduce computational complexity, only rate 1/2 and 1/3 encoders were considered with constraint lengths of less than five which enables easy Viterbi decoding. These simplifications allow for the decoder to operate on a variety of platforms.

Viterbi decoding was chosen because it is widely used for convolution codes and because of its simplicity. The optimal decoding depth (D) was found to be 5K-7K, where K is the encoder constraint length.

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Conception d'un robot mobile télécommandé via Internet et Réseau local

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Abstract

In this paper, the design and the realization of a mobile robot controlled via Internet and local network are presented. The specifications used for this realization and the various modules necessary to the good working of the mobile robot are presented and detailed. Some tests have been successfully completed locally in Moncton and via Internet directly from Fribourg in Switzerland. The recommendations for the complete system improvement will be given at the end of the paper.

Sommaire

L'article est destiné à la conception et la réalisation d'un robot mobile commandé via Internet et réseau local. La description du cahier des charges utilisées pour cette réalisation et les divers modules nécessaires au bon fonctionnement est présentée. Des testes ont été complétés avec succès localement à Moncton et à distance à partir de Fribourg en Suisse. Les conclusions et les recommandations seront données pour l'amélioration du système.

1.0 Introduction

Depuis plusieurs décennies, le robot mobile suscite beaucoup d'intérêts et trouve son emploi dans diverses disciplines ou activités de la vie moderne (robots industriels, robots destinés à l'exploration de l'univers, robots policiers, etc..). Il pose, par contre, plusieurs problèmes et soulève divers défis relatifs à l'autonomie du déplacement dans un environnement non prédéfini ou changeant et à l'exécution de tâches spécifiques demandées. À présent, il est possible de classifier le besoin de l'homme pour les robots en deux catégories:

- ***Besoin de substitution:*** Le robot doit se substituer totalement à l'homme dans l'exécution d'une tâche. Le rôle de l'homme se limite donc à ordonner le départ de l'exécution de la tâche. Ces types de robots sont utilisés principalement pour la production (robots industriels).
- ***Besoin de coopération:*** L'aide du robot permet à l'homme d'exécuter des tâches impossibles ou dangereuses à mains nues, comme par exemple la maintenance d'appareils placés dans des environnements hostiles (radioactifs ou chimiquement contaminés) ou l'exploration et l'étude de lieux inaccessibles (inspection de canalisations souterraines, l'exploration des planètes etc.).

De plus, la conception d'un robot mobile est de nature multidisciplinaire et nécessite, souvent, beaucoup d'imagination et de créativité. Cette nature multidisciplinaire s'observe dans l'exploitation de l'électronique, l'électronique de puissance, l'instrumentation et l'acquisition des données, les moteurs et la conversion de l'énergie, la commande en temps réel, l'acquisition et la transmission d'images et du son, la programmation, les télécommunications sans oublier la conception mécanique du châssis et de ses composantes. L'utilisation de la conception d'un robot mobile dans la formation des nouveaux ingénieurs s'avèrent donc très enrichissante et apporte beaucoup dans les laboratoires d'enseignement. Elle permet d'exploiter au maximum les diverses connaissances acquises par l'étudiant et facilite la compréhension approfondie des notions théoriques et pratiques. La conception d'un robot dans le cadre de la formation nécessite par contre, la complicité et l'organisation des membres d'un même groupe pour pouvoir atteindre les objectifs fixés. La gestion de projets s'impose et doit être révisée tout le long de la réalisation.

2.0 Cahier des charges

Le cahier des charges établi pour assurer la conception du robot envisagé et les plus importantes étapes de conception de ses différentes parties sont présentés comme suit:

- La conception d'un support mobile qui permettra au robot de se déplacer sur un plan horizontal.
- La conception d'un système d'acquisition des données tels que l'image vidéo, l'audio, les signaux analogiques et numériques.
- La conception d'un système d'émission et de réception de données par un réseau local ou via Internet.
- La conception d'une interface graphique facilitant la commande du robot.
- L'assemblage des différentes parties afin d'obtenir un système global entièrement fonctionnel.

Il faut signaler que le poids du robot, les caractéristiques de son déplacement, la communication avec le robot à distance et l'autonomie énergétique sont les principales contraintes de ce projet. Par ailleurs, le prototype réalisé sera une base pour des travaux futurs qui seront destinées à l'amélioration des performances du robot et de la fonctionnalité de ses diverses parties.

3.0 Modélisation de l'environnement

La figure 1 montre les entités présentes dans l'environnement du robot. Le robot prend le nom de *M.R.R.C-1.0* (*Mobile Robot with Remote Control version 1.0*) mais, en considération de sa forme finale, le robot sera appelé plus simplement *Nessie.* L'utilisateur, par l'intermédiaire du *Client*, décide comment *Nessie* doit se déplacer, tout en ayant la possibilité

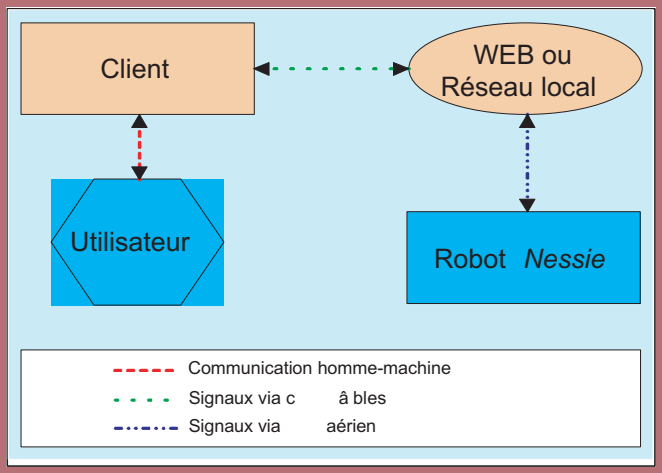

Figure 1: Entités liées au robot

de recevoir des informations sur son état. Le *Client* est la liaison entre l'utilisateur et *Nessie*. Il présente deux tâches fondamentales: la gestion de la communication depuis et vers le robot ainsi que la gestion d'une interface permettant à l'utilisateur de commander *Nessie* de façon optimale. L'interface est du type visuel (GUI) et elle présente les caractéristiques suivantes:

- L'affichage des images vidéo et la reproduction du son capté par le robot,
- La prise en charge des commandes données par l'utilisateur,
- L'affichage des différentes caractéristiques dynamiques du robot.

Le robot, *Nessie*, est capable de:

- Recevoir et interpréter les commandes envoyées par l'utilisateur,
- Se déplacer sur un plan horizontal selon les commandes reçues,
- Acquérir des informations (audio, vidéo et présence d'objets) sur l'environnement dans lequel il est placé,
- Envoyer les informations acquises et ses caractéristiques dynamiques (sa vitesse) au *Client*.

Le mouvement de *Nessie* est contrôlé par l'utilisateur, cependant dans certains cas il peut influencer son propre mouvement:

- S'il détecte un objet sur son chemin, il modifiera sa trajectoire de façon à éviter la collision,
- Lorsqu'il se déplace en ligne droite, il contrôlera le bloc moteur afin de maintenir la même trajectoire.

4.0 Conception et choix des composants du robot

La figure 2 illustre la structure du système électrique et électronique du robot. On peut distinguer:

4.1 L'ordinateur embarqué (choix et spécifications)

Les deux principales options envisageables pour répondre aux besoins du robot *Nessie* sont l'utilisation d'un microcontrôleur ou d'un ordinateur embarqué (*OE*). Afin de choisir l'option qui puisse le mieux s'adapter à notre application il faut considérer les tâches que le robot devrait exécuter:

- Gestion du multimédia (images vidéo et son),
- Gestion de plusieurs canaux d'entrées et de sorties,
- Gestion des algorithmes de contrôle des autres blocs,
- Gestion du protocole *UDP/IP*.

Un exemple d'application pour le robot *Nessie* pourrait être l'implémentation de la vision artificielle, comme la reconnaissance d'objets ou de visages.

Un microcontrôleur peut bien répondre aux besoins de gestion des canaux d'entrée et de sortie, des algorithmes de contrôle et du protocole *UDP/IP*. Cependant, il aura sûrement des problèmes lors de la gestion du multimédia et de l'implémentation de la vision artificielle. L'utilisation d'un microcontrôleur ne satisfait donc pas les besoins de notre application qui se veut être élargie et diversifiée.

L'architecture d'un *OE* est très semblable à celle d'un ordinateur de bureau (*OB*). Les différences entre les deux sont surtout:

- Les différents formats des *bus* de connexion: Pour les *OE* on parle de *PC104*, *PC104+* et *CompactPCI*, pour les *OB* de *PCI* et *ISA*,
- Les dimensions: les *OE* sont très compacts et ils présentent sur la même carte tous les composants de base d'un *OB*,
- Le coût: à parité de prestation un *OE* coûte beaucoup plus cher qu'un *OB*.

Après ces considérations on a choisit d'utiliser un *OB* comme un *OE*, c'est à dire que notre *OE* sera composé d'une classique carte mère mais de petit format.

Le modèle choisi est de marque *MK20N* de *Shuttle qui a pour* caractéristiques:

- Format *MicroATX* (très compact, grandeur de la plaque 244 mm x 200 mm),
- Cartes vidéo et de son et prise réseau intégrées,
- Un port sériel, un port parallèle et deux ports *USB* (avec possibilité d'expansion),
- Un *bus ISA* et 3 *PCI*.

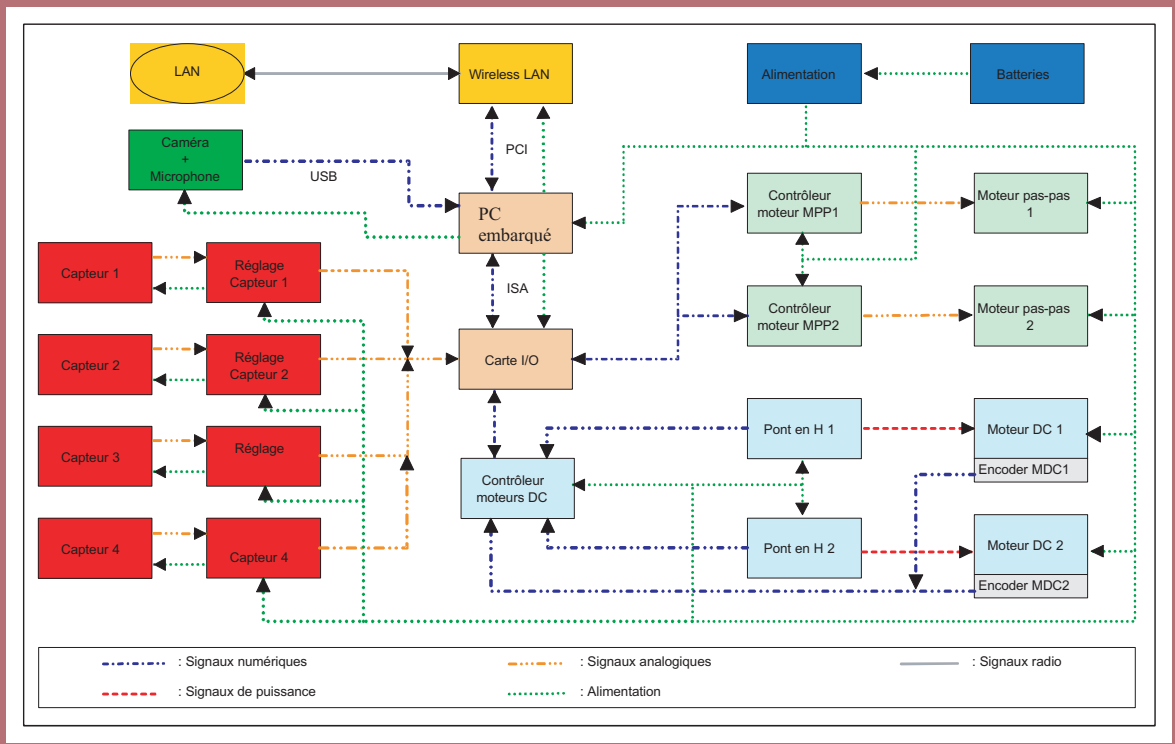

Figure 2: Structure globale du système électrique et électronique.

Tableau 1: Composantes de l'OE et Interfaces

Composants	Description
Processeur	AMD 1300 MHz
Disque rigide HD	Modèle standard de 1.2 GB
Mémoire Vive	SDRAM de 64 MB
Carte I/O	CIO-DAS08 avec connexion sur bus ISA, 8 A/D de 12 bits, 3 Timers de 16 bits, 24 E/S digitales 5V TTL, librairie pour différents langages de programmation.
Caméra avec Microphone intégré avec liaison USB	QuickCam de Logitech Capture vidéo 640x480 pixels Débit d'images jusqu'à 30 images/sec Format de l'image en mode RGB 24 bits ou YUV 12 bits
Détecteurs optiques d'obstacles	À infrarouge (AIRRS) avec sortie analogique, Détection: 0.1 à 0.8 m

Tableau 2: Paramètres du Robot nécessaires

Paramètres	Symbole	Valeur
Masse du robot	M_R	15 Kg
Rayon des roues motrices	R_A	0.06 m
Coefficient d'adhésion entre roues et sol	μ_0	0.05
Bras de levier de la résistance au roulement	f_{ROUL}	0.10 mm
Vitesse de pointe minimale du robot	$v_{R,P,MIN}$	2 m/s
Accélération de pointe (positive) minimale du robot	$\alpha_{R,P}$	3 m/s^2
Nombre de moteurs	N_M	2
Angle d'inclinaison du plan	α	0^o

Comme on peut le remarquer, la carte intègre la majorité de composants de base d'un *OB* intégrés. Ce qui permet de la rendre encore plus proche d'un vrai *OE*.

Les autres composantes qui forment le robot selon les besoins immédiats de l'actuelle réalisation, sont montrées au tableau 1.

4.2 La caméra

Afin de mieux explorer l'environnement dans lequel *Nessie* est placé et, de conséquence pour permettre un meilleur contrôle du robot, la caméra doit être mobile. Comme le montre la figure 3, on a donné à la caméra un mouvement à deux degrés de liberté. Deux moteurs pas à pas sont donc utilisés pour assurer cette fonction.

4.3 LAN Sans fil

Afin de garantir une liberté de déplacement, une liaison sans fil entre le robot et le point d'accès au réseau est nécessaire. Pour réaliser cette liaison on a utilisé deux produits de l'entreprise *D*-Link: le *DWL-520* et le *DWL-900AP*. Ces deux produits réalisent une transmission transparente point à point entre le point d'accès au réseau (par le *DWL-900AP*) et le robot (par le *DWL-520*). La configuration est visible sur la figure 4.

4.4 Les moteurs à courant continue

Le tableau 2 donne les paramètres du robot nécessaires au choix des moteurs à courant continue (CC).

Il est important de signaler que certaines hypothèses ont été considérées pour établir les valeurs du tableau 2:

- La masse du robot est surdimensionnée pour tenir compte d'une surcharge possible,
- Les valeurs du coefficient de frottement entre les roues et le sol sont relatives aux roues (caoutchouc) roulant sur l'asphalte,
- Ces valeurs ne correspondent pas aux valeurs réelles des roues vu que leur matériel de composition est inconnu,
- Le robot doit respecter les valeurs de vitesse et d'accélération minimales de pointe seulement lorsque le plan du mouvement est horizontal.

Grâce à ces paramètres, nous calculons deux caractéristiques fondamentales des moteurs, la vitesse de rotation maximale des roues et le couple maximal absolu nécessaire. Ces nouveaux paramètres nous permettent donc de choisir les moteurs à utiliser pour la propulsion et par conséquent déduire les caractéristiques des hacheurs à quatre quadrants (4Q). Après calcul, un moteur du type GM9236S015 de la compagnie Pittman a été choisi.

4.5 L'alimentation et les batteries

La tension d'alimentation des moteurs CC est de 24 V alors que celle de la carte mère par l'intermédiaire d'une alimentation ATX devrait être comprise entre 18 et 32 V. La solution la plus simple est donc d'utiliser deux batteries de 12 V en série vu sa disponibilité sur le marché. En plus on a choisi de faire deux alimentations séparées: une pour les moteurs *CC* et une pour le bloc *ATX*. Cette décision a été prise pour éviter les interférences et les bruits lors de l'utilisation des moteurs (surtout au démarrage quand il y a une requête de courant important et lors de la commutation des convertisseurs statiques). Avec la charge totale en Ampère-heures (Ah) des batteries, et en considérant la consommation globale du robot, l'autonomie en énergie assurée dépasse facilement une heure.

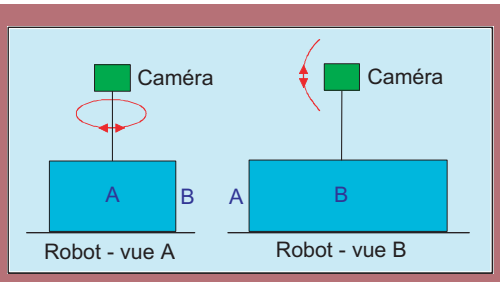

Figure 3: Mouvement de la caméra

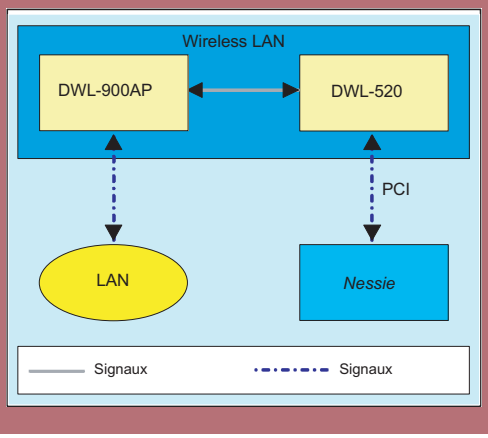

Figure 4: Système LAN sans fil

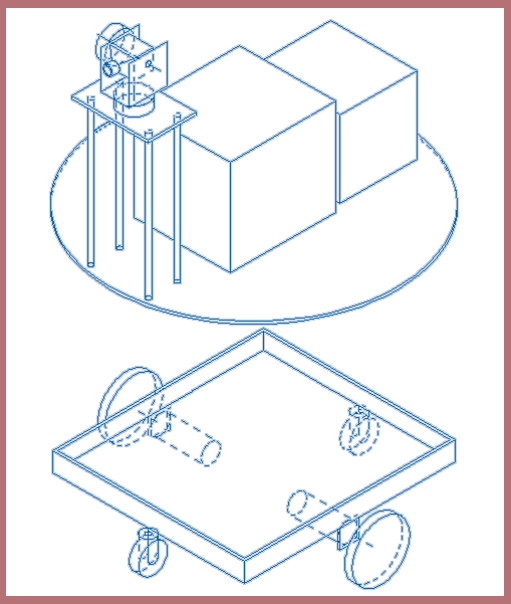

Figure 5: Vue des structures du robot

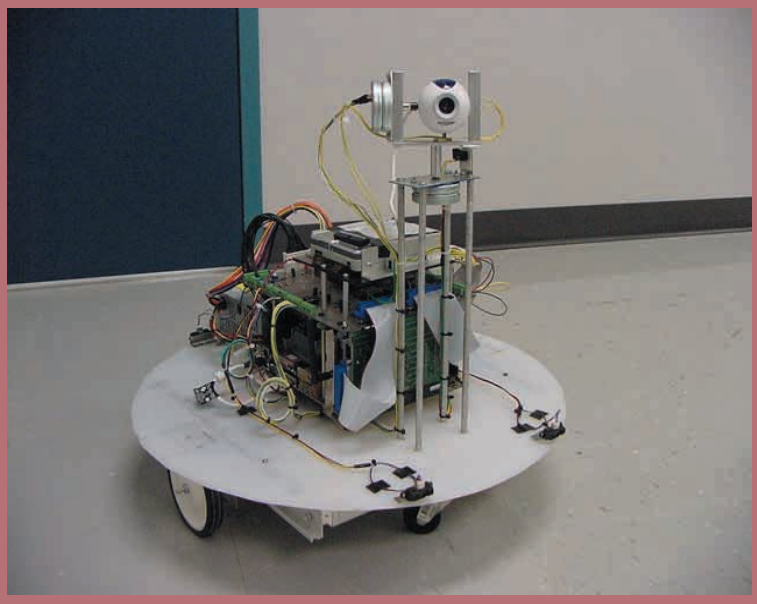

Figure 6: Nessie, vue d'ensemble

4.6 Stratégie de locomotion et Structure mécanique

Il y a plusieurs configurations possibles pour un robot mobile muni de roues. La stratégie choisie est dite *à vitesse différentielle symétriques* qui propose de placer deux moteurs de propulsion et de direction couplés à deux roues motrices. Les roues motrices sont disposées au centre du robot et deux roues libres sont disposées à l'avant et à l'arrière pour assurer la stabilité. Cette configuration permet au robot une très grande versatilité de mouvement.

4.7 Disposition des éléments

Le robot est structuré en deux parties. La première représente le support (de forme carrée et de 40 cm de côté) qui est la structure de base du robot assurant une bonne solidité et un faible poids. Pour ces raisons on a choisi l'aluminium comme matériel de fabrication. Tous les éléments du robot de poids important sont fixés directement sur ce support afin d'augmenter la stabilité. De conséquence les moteurs, ainsi que les roues libres, sont fixés à la partie inférieure du support, alors que les batteries sont fixées sur sa partie supérieure. La deuxième structure est une plaque ronde (en plexiglas et de 30 cm de rayon) sur laquelle sont fixés les autres éléments (carte de commande, le PC embarqué, l'alimentation ATX, les capteurs…). La caméra est fixée directement sur un support placé sur des tiges d'une longueur de 30 cm. Les figures 5 et 6 illustrent le schéma d'assemblage ainsi qu'une photo réelle du robot.

5.0 Entraînement des moteurs

Afin d'assurer une bonne couverture visuelle, la caméra doit pouvoir bouger selon deux axes. L'utilisation de deux moteurs pas à pas est donc indispensable. La propulsion du robot est assurée par deux moteurs CC commandé en vitesse. Le tableau suivant résume les circuits associés pour entraîner les moteurs utilisés. Une carte de commande a été donc développée pour inclure les diverses fonctions de ces entraînements électroniques.

Tableau 3: Entraînement des moteur

Moteur	Driver	Commande	Alimentation
Pas à pas	UCN5804	Mode unipolaire	UCN5804
Courant continu	IRF2110A	MLI et mesure de la vitesse/direction sur CPLD	Pont en H à Mosfets muni de capteur de courant à effet Hall et une protection en courant

6.0 Développement de la partie informatique

Le développement de la partie informatique se compose de deux programmes (*Robot_Client* et *Robot_Server) qui sont* des applications *win32* écrites en langage *C*.

6.1 Robot_Client

Ce programme permet à l'utilisateur de se connecter à distance au robot et le commander via une interface graphique.

6.2 Interface avec l'utilisateur (GUI)

L'utilisateur peut commander le robot avec les touches du clavier pour faire bouger le robot et la camera. Pour commander le robot, les mouvements possibles sont:

- ▲ : Marche avant,
- ▼ : Marche arrière,
- ◀ : Tourne à gauche (sur place),
- ▶ : Tourne à droite (sur place),
- ▲ & ◀ : Virage à gauche,
- ▲ & ▶ : Virage à droite.

La caméra peut à son tour, bouger sur l'axe horizontal et vertical. Les touches qu'il faut utiliser sont les suivantes:

- F: Tourne à droite,
- S: Tourne à gauche,
- E: En haut,
- D: En bas.

En outre, l'utilisateur peut définir la puissance des moteurs, F1 sert à augmenter la puissance et F2 à la diminuer.

Pour permettre à l'utilisateur de commander le robot il faut aussi lui fournir des informations sur l'environnement et les variables dynamiques du robot. Les informations disponibles sont:

- La vitesse du déplacement,
- La distance mesurée par les capteurs de proximité,
- La position de la camera, et

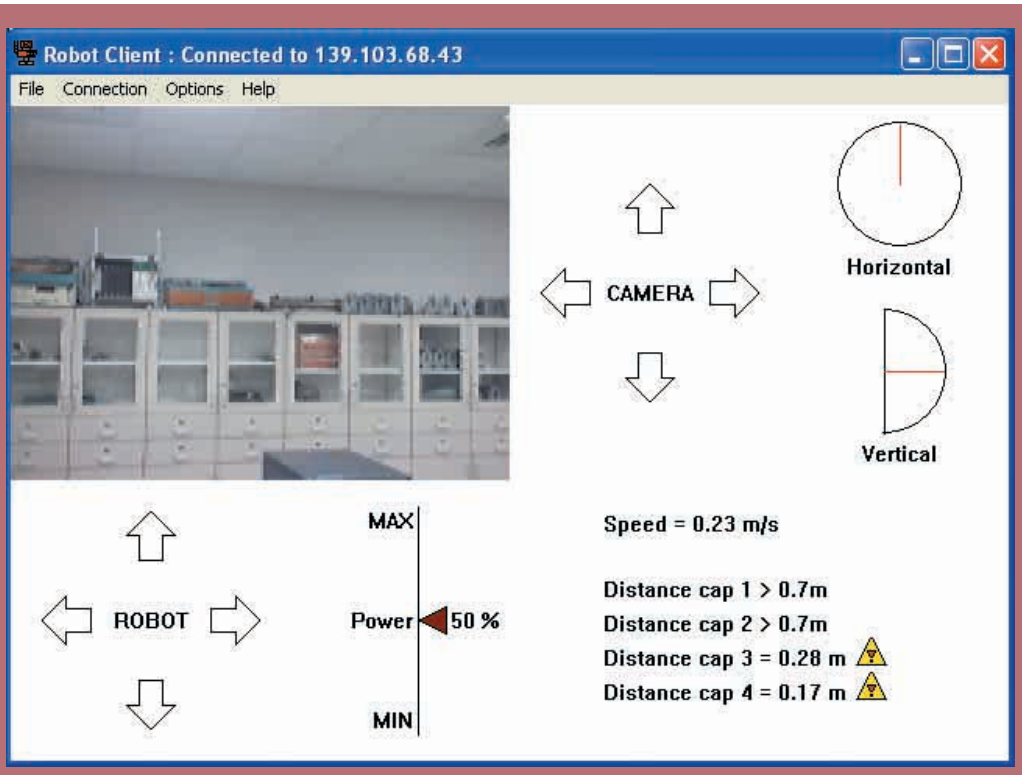

Figure 7: Interface graphique de l'utilisateur (GUI)

- L'information audio-vidéo capturée par la camera.

L'image vidéo a une résolution de 160x120 pixels avec 10 frames/sec. L'affichage est fait sur un rectangle de 320x240 pixels (zoom x2). L'information audio est de format wave pcm avec 8 bits/sample et 11.5 k/sec. La fenêtre vue par l'utilisateur est montrée à la figure 7.

6.3 Robot_Server

Cette application accomplie les tâches suivantes:

- Recevoir les commandes envoyées par le programme *Robot_Client* et les interpréter pour que le robot puisse exécuter les opérations désirées par l'utilisateur (mouvement du robot et de la caméra),
- Recevoir les informations sur l'environnement du robot, les interpréter et les envoyer au programme *Robot_Client* (donc à l'utilisateur). Pour la vidéo, la compression d'images est utilisée,
- Détecter les obstacles.

7.0 Résultats

Les résultats obtenus répondent à nos attentes et au cahier des charges. Voici les points fondamentaux:

- *Nessie* est contrôlable par Internet ou par réseau local. Il est capable de se déplacer en avant ou en arrière, de tourner sur lui-même dans les deux directions et d'exécuter des virages et de suivre les commandes de l'utilisateur,
- Il détecte les obstacles et il cherche à éviter toute collision possible,
- Le son et la vidéo sont transmis entièrement à distance.

La vitesse maximale du robot répond aux perspectives et elle est de l'ordre de 5 m/s.

En ce qui concerne l'accélération nous n'arrivons pas aux valeurs théoriques désirées à cause d'une grande adhérence des roues motrices. L'utilisation d'un autre type de roues avec une meilleure adhérence devrait résoudre le problème.

Lors des essais effectués, la transmission de l'image vidéo fonctionne suffisamment bien pour permettre à l'utilisateur de conduire le robot sans difficultés majeures. Le seul inconvénient rencontré est un retard d'environ une seconde et demi pour des transmissions à longue distance. Ce retard à été rencontré précisément pendant les tests réalisés entre Moncton (au Canada) et Fribourg (en Suisse).

Pour l'audio, les résultats ne sont pas optimaux. Pour des faibles distances la communication fonctionne avec une qualité suffisante. Pour des longues distances, par contre, le flux des paquets n'est pas constant et donc la fonctionnalité audio n'est pas utilisable. De plus, l'utilisation d'un microphone de meilleure qualité améliorera la qualité du son capté.

Quant à la plage de détection des obstacles, celle-ci est limitée à 80 cm pour les capteurs optiques utilisés. Le choix de ce type de capteurs a été motivé principalement par le coût faible. L'intégration de capteurs ultrasoniques s'impose donc comme une autre alternative afin d'élargir cette plage de détection sur plusieurs mètres.

8.0 Conclusion

Le but de ce projet était la conception et la réalisation d'un robot mobile commandé à distance à travers le réseau Internet ou un réseau local. Les contraintes principales étaient le retard de transmission et la bande passante disponible. Avec notre robot, nous avons pu montrer qu'au niveau technologique actuel un système de ce genre est réalisable avec des bons résultats. Certaines améliorations et extensions des fonctions du robot conçu sont maintenant envisagées pour augmenter l'autonomie, assurer un fonctionnement fiable et intelligent et améliorer et enrichir l'interface graphique de l'utilisateur.

Les applications de ce type de robot peuvent inclure la surveillance à distance ou l'inspection dans des environnements accessibles difficilement alors que la structure mécanique peut prendre diverses formes pour une meilleure adaptation aux besoins spécifiques de l'utilisateur.

9.0 Remerciements

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Davide Zanetti a obtenu le diplôme d'ingénieur HES en électronique de l'École d'ingénieurs et d'architectes de Fribourg, Suisse, en 2002. Son projet de diplôme, présenté dans cet article, a été réalisé sous forme de stage à la faculté d'ingénierie de l'Université de Moncton, Canada. Depuis le mois de septembre 2003, il est étudiant en maîtrise à l'institut ALaRI de l'Université de Lugano, Suisse. Actuellement, il travaille sur sa thèse de maîtrise; un projet concernant l'optimisation en terme de consommation d'énergie de l'utilisation d'un module Bluetooth.

Ramon Zambelli a reçu son diplôme d'ingénieur HES à l'école des ingénieurs de Fribourg en 2001. Il a réalisé son projet de diplôme à l'université de Moncton pour la réalisation du projet décrit dans cet article. Il s'intéresse à l'électronique, au développement des applications en temps réel et à l'automatisation. Il travaille présentement pour l'entreprise SICPA de Lausanne à titre d'ingénieur de développement et intégration.

Mohsen Ghribi a obtenu un baccalauréat en génie électrique, une maîtrise en électronique industrielle de l'université du Québec à Trois-rivières et un doctorat en génie électrique de l'université Laval, respectivement en 1987,1989 et 1994. Il a enseigné à L'école de technologie supérieure (Montréal), l'école polytechnique de Masuku (Gabon) et depuis 1997, il a joint l'université de Moncton. Dans ses activités, il s'intéresse à l'entraînement électronique des machines électriques, l'électronique et la commande par processeur de signal (DSP).

Ottar Johnsen a reçu son diplôme d'ingénieur électricien et le titre de Dr ès Sciences techniques de l'EPFL en 1974 et 1979. De 1979 à 1983 il a été Member of Technical Staff, Bell Laboratories, Holmdel, USA, et en 1983-1984: ingénieur système, à Tricom, Berne. Depuis 1984 il est professeur de traitement du signal et de télécommunications à l'Ecole d'ingénieurs et d'architectes de Fribourg en Suisse. Il a été chercheur invité à University of California, Santa Barbara et professeur invité à l'Ecole d'ingénieurs de Bergen, Norvège.

Azeddine Kaddouri a obtenu un doctorat en génie électrique de l'université Laval, Québec, Canada, en 2000. Entre 1993 et 1999, il a occupé un poste d'assistant de recherche au sein du groupe de recherche (GREPCI) de l'École de technologie supérieure, Montréal, Canada. En 1999 il a joint la faculté d'ingénierie de l'Université of Moncton, Nouveau-Brunswick, Canada, où il occupe un poste de professeur adjoint. Actuellement, il est le coordonnateur du groupe de recherche (GRET) à l'Université of Moncton. Il s'intéresse à la commande non-linéaire ainsi que le développement de logiciels spécialisés en génie électrique.

Expo-Sciences ~ Bell ~ Science Fair, Québec

Ville de Québec, 24 avril 2004

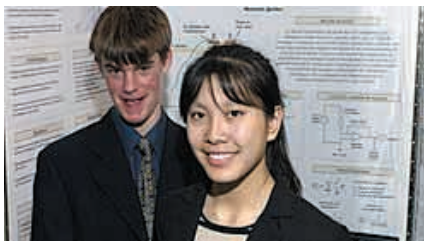
Lors de l'Expo-sciences Bell tenue à Québec récemment, **IEEE Montréal Conférences inc.** a présenté des prix de $500 à deux équipes.

At the recent Bell Science Fair held in Quebec City, **IEEE Montreal Conferences Inc**. awarded two teams with bursaries of $500 each.

L'article sur Mme Yue Guo et M. Gervais

Mme Si Yue Guo et M. Raphaël Gervais, respectivement du Collège Regina Assumpta et de l'École secondaire Pierre-Laporte à Montréal, ont remporté le prix Génie électrique pour leur projet "La conductance quantique". Ils ont par la suite remporté le grand prix canadien toutes catégories et de nombreux prix internationaux; voir http://www.ysf.ca/.

Résumé: De nos jours, l'importance croissante des microprocesseurs et la taille décroissante des transistors nécessitent une compréhension du comportement de la matière à une échelle atomique, notamment de ses propriétés électriques. Afin de simuler la diminution de diamètre des transistors, nous avons mesuré la conductance des substances conductrices (or, argent, cuivre, etc.) à l'échelle atomique, en utilisant un système que nous avons conçu et construit. Il consiste en un procédé simple, rapide et peu coûteux, qui inclut une jonction de coupure mécanique et un système automatisé. À partir des données de conductance recueillies, l'analyse nous permet de comprendre les propriétés de ces substances qui se manifestent à cette échelle et, par conséquent, des phénomènes tels la miniaturisation des transistors.



Article from Mr. Kirstman

Mr. Ilya Kirtsman from Herzliah Snowdon, Montreal Regional Science & Technology Fair, was presented the Computer Engineering award by Mr. Eric Holdrinet (left in photo), president of the IEEE Eastern Canada Council, for his project on "The Mozart Effect". He also won the Canada-wide senior prize for best psychology project.

Abstract: In 1993, American researchers discovered the so-called Mozart Effect: long-term periodicity found in certain Mozart Sonatas has positive effects on several cognitive abilities, including a brief enhancement of spatial-temporal reasoning. Subsequent studies tried to assess whether listening to Mozart had any other psychological effects. For my experiment, I conducted a psychological test over the internet with the help of a Flash website. The website, programmed in ActionScript, tested the effect of a certain Mozart Sonata on participants' arithmetic pattern-recognition skills. The results, after thorough statistical analysis, showed that listening in the Mozart condition did not affect either the speed or accuracy as compared with the controls.

Powering the Future with Photovoltaics

1.0 Introduction

Photovoltaic cells perform an impressive feat: they transform radiant energy from the most abundant, least expensive and widely available source - the sun - into one of the most versatile energy forms known - electricity. The cells accomplish this without moving parts or chemical reactions; their operation causes no noise or environmental pollution. With such attributes, could they be the solution to the world's energy problems? Despite impressions given by the global petroleum trade and continental electrical grid operators, many energy needs can in fact be met using alternate technologies such as photovoltaics. What's more, the alternate technologies can be better overall solutions.

In the 50 years since researchers at the Bell Labs in New Jersey created the first practical cells, photovoltaic (PV) systems have become the technology of choice for an increasing range of applications - from outer space to pocket calculators, to weekend cottages. Technological advances, declining system costs and rising prices for conventional energy make PV systems ever more viable as a solution to an ever wider range of energy needs.

PV systems are also being used successfully as distributed electrical generation sources feeding into the electrical grid (as opposed to constituting an alternative, such as grid-independent power). Such grid-connected systems can be integrated into building designs to provide secondary benefits such as shading and can also offset other building material costs (Figure 1). Specialized products are already on the market to facilitate integration of PV into various types of roofs, such as shingles or tiles, feasible on a mass-market scale.

Identifying appropriate applications for PV systems is both a business opportunity and engineering challenge, as it requires an understanding of a variety of topics. The challenge is well worth accepting, since a successful PV installation is a win-win-win for suppliers, consumers and our natural environment alike.

Figure 1: A 20 kW grid-connected, building-integrated PV system at Queen's University provides summer shading and year-round electricity. (Photo: Anton Driesse)

by *Anton Driesse*
Queens University, Kingston, ON

Abstract

Photovoltaic cells convert energy from sunlight directly into electricity without moving parts or chemical reactions. The technology of photovoltaic cells and of the components that make up photovoltaic systems continues to evolve and mature, but it is already the technology of choice to provide electricity in many situations. This article provides an introduction to photovoltaics and an overview of the different system components and configurations with reference to applications in which they are used. The article also describes recent developments from the research side, and identifies some starting points for further reading on this subject.

Sommaire

Les cellules photovoltaïques transforment l'énergie solaire en électricité sans moyens mécaniques ou processus chimiques. Cette technologie évolue sans cesse, tout comme celles des autres composantes qui constituent les systèmes photovoltaïques, mais elle est déjà une option privilégiée pour assurer l'approvisionnement en électricité dans de nombreuses situations. Cet article se veut une introduction aux systèmes photovoltaïques : il a pour but d'expliquer leur fonctionnement et de donner un aperçu de leurs différentes composantes, configurations et applications. Des développements récents dans ce domaine de recherche sont également présentés, ainsi que quelques références pour approfondir le sujet.

2.0 The Solar Resource

Although sunshine is widely perceived to be variable and difficult to predict, the sun in fact provides the earth with a nearly constant influx of energy. In specific locations this influx is modulated by atmospheric or climatic conditions and of course, the rotation of the earth. At first this variability appears to make the sun a very unreliable source of energy, but is this really so?

The motion of the earth around the sun is very predictable. Sunrise and sunset times can be calculated with high precision and the exact path of the sun in the sky as seen from any position on earth can be determined for any relevant future date. Both daily and seasonal variations are well understood and reliable.

Atmospheric conditions are more difficult to predict, but in this case the accuracy of the predictions depends on how far into the future they are made, and what period of time the prediction represents. For example, it may be possible to achieve a very high accuracy for predictions that are merely one hour in the future; or for predictions several years into the future that represent monthly averages. In fact, long-term monitoring has shown that such averages show only small variation from year to year and can therefore be quite reliably predicted.

The key to using the sun's energy is to understand its variability, and to understand how this variability relates to the energy needs of the application. These may correlate positively, such as in the case of a pump to provide drinking water; or negatively, such as in the case of street lights. When the correlation is less than perfect a PV system requires either a supplementary source of generation (making it a hybrid system) or some form of energy storage. A mechanical tracking system can also be used to keep solar cells facing the sun throughout the day and year, thereby modifying the energy supply profile as well as increasing the capacity factor (Figure 2).

Figure 2: A mechanical tracking system keeps solar cells facing the sun, thereby capturing more of the available solar energy. (Photo: National Center for Appropriate Technology)

Despite this complexity a simplified understanding of the solar resource can be adequate for smaller designs. The available solar energy is therefore often described as an average number of hours of bright sunshine per day in a particular location. This also corresponds to the way sunshine was historically measured and much data is available in this form.

3.0 Photovoltaic Cells

3.1 Fundamentals

By far the most common types of PV cells in use today are made of silicon. Each cell is a large, flat diode with a thin, negatively doped layer facing the sun. Solar radiation striking the cell transfers energy to electrons in the valence band of the molecules. If the energy of a photon exceeds the band-gap energy of the silicon, it will push an electron up into the conduction band where it becomes mobile. The electric field that exists across the diode's P-N junction then causes the mobile electron to migrate to the edge of the diode and travel through an external circuit where it releases its energy.

The band-gap energy of silicon is such that a large fraction of the solar radiation can produce this photovoltaic effect. Energy from photons with insufficient energy (light of longer wavelengths) is converted to heat, as is excess energy from photons that exceed the band gap level (shorter wavelengths). Thus it is impossible for a silicon cell to convert all the available energy to electricity.

Since individual silicon cells produce a relative low voltage, typically 0.5 V under load, a dozen or more are wired in series and then packaged in modules of various design. The module makes a rugged and convenient unit that both protects the cells and facilitates installation.

Commercial silicon cells or modules are commonly available in three basic types: mono-crystalline, polycrystalline, and amorphous (or thin-film). Mono-crystalline cells lead in terms of performance with typical module efficiency of 12-15%, which means that with a nominal radiation intensity of 1000 W/m^2, a module of 1 m^2 would produce 120 to 150 W. Polycrystalline cells are somewhat less expensive to produce and slightly lower performers, typically 11-14%. Specialty low volume, high cost cells have efficiencies of 20 - 26%.

Amorphous silicon cells are not produced as individual cells, but as modules. They consist of a very thin layer of semiconductor material deposited on a substrate such as metal or glass. The reduced material requirements and the simpler manufacturing process lead to cost reductions, but unfortunately module efficiencies are also much lower, typically only 5-7%.

While prices are set per module, the focus of the designer is usually on the price per rated watt of power output, which is relatively uniform for each technology. The module power rating is determined under standard test conditions and is used as the basis for this unit price. In actual installations the modules rarely operate at standard conditions, but the rating does provide a basis for comparison.

High module efficiency would seem to be an important criterion, but it is usually less important than the price per watt since the primary source of energy is free. However in situations where only a limited space is available, or where there are important costs associated with space such as for a complex support structure, higher efficiency modules may be the better choice.

For many researchers higher photovoltaic cell efficiency represents the ultimate challenge, and much work has gone into identifying the limiting factors, both theoretical and practical, and approaching, circumventing, or removing those limitations. For premium applications such as outer space higher efficiencies are particularly valuable, and eventually such advances also find their way into terrestrial products. The following sections provide an overview of some more advanced technologies that promise either higher efficiency, lower cost or other competitive advantage.

3.2 Advances in Cell Technologies

Given their long history it may seem surprising that so few variations of (or alternatives to) the original silicon PV cell are readily available. This lack of variety belies the fact that there is a broad range of new technologies on the horizon. Some are little more than proof of concept but others are in fact already in production; and most of these new designs are significantly different from their precursors.

Both mono-crystalline and poly-crystalline cells are made from thin wafers of silicon, and essentially the only difference between them is the quality of the raw material. The quantity and quality of silicon used to make wafer-based solar cells today constitute one of the big barriers to further cost reduction. Amorphous silicon cells certainly require less material, but at a significant performance penalty. Newer thin-film technologies therefore attempt to capture the best of both worlds. For example, techniques have recently been developed to grow a very thin layer of crystalline silicon on an inexpensive substrate, raising the prospect of achieving the same performance as wafer-based cells with a fraction of the material. Spheral solar cells (a Canadian product) are just becoming available now, and although they are not in the category of thin-films, they also provide better performance using both a lower quantity and a lower quality of silicon raw material.

Flexible PV cells and modules (as opposed to rigid ones) are a category of particular interest since they can be more readily adapted for mobile applications and mounted on curved or irregular surfaces. This is another advantage of the spheral and thin-film technologies.

3.2.1 Alternatives to Silicon

Silicon is not the only semiconductor material, of course. The much lower band gap energy of germanium would result in very low efficiencies, but several compound semiconductor materials have characteristics that make them very attractive for building PV cells. Such materials can be formed of group III and V elements such as gallium arsenide (GaAs), group II and VI elements such as cadmium telluride (CdTe), or even trio of group I, III and VI elements such as copper-indium-diselenide (CuInSe2 or CIS). These compounds typically have band gap energies different from that of silicon, and therefore their theoretical maximum efficiency in converting sunlight to electricity is also different. GaAs cells in particular have shown efficiencies in excess of 25%.

The fact remains, however, that there is no single band gap energy that would permit a PV cell to capture all the available solar energy because this energy is spread over a range of frequencies. For this reason there are designs for multi-junction cells where the materials used to make each junction have different band gap energies, and are thus sensitive to different parts of the solar spectrum. With multiple junctions of compound semiconductors there is an explosion of possible combinations of materials, and thus prospects for new products. Designs exist for as many as 5 layered junctions, and triple-junction cells are already on the market today.

3.2.2 Concentration for Efficiency

While a fundamental limit such as the one imposed by the band-gap energy is hard to break, there exist more than one work-around. Besides the multi-junction approach, greater theoretical as well as practical efficiencies can be achieved by concentrating sunlight before capturing it.

The optical components must track the position of the sun in order to keep it focused on the cells and make this apparatus more bulky and complex than a simple cell, but the economics show some interesting advantages. First, the cost of cells for a given output is reduced by the concentration factor, and then further reduced by the gain in efficiency. Second, potential cell enhancements that would not be cost-effective under direct sunlight also see their payback multiplied. This is why the more expensive but top performing GaAs cells are seen in concentrator systems. Naturally the concentrator components around the cell also have a cost, but particularly in larger systems this cost remains well below the cost of PV cells they displace.

3.2.3 Novel Approaches

What is perhaps most fascinating about recent developments in photovoltaics is that different mechanisms are being discovered to convert sunlight to electricity. Among them are the dye sensitized/activated solar cells, the organic/polymer solar cells, and the photo-electrochemical cells. The time-to-market is still very uncertain for all of these of course, but nevertheless in a press release earlier this year, Siemens AG announced that its researchers had achieved efficiencies of 5% for their experimental organic cells, and they expect to be able to increase this to 7% - which would be comparable to the amorphous silicon cells of today.

3.3 Advances in Module Technologies

While developments in cell technologies are pushing the limits of scientific understanding, the evolution of PV modules is taking place primarily in the realm of product development and is driven by the evolving market. The basic rectangular module is still the mainstay of the industry, but it is now also possible to obtain modules that integrate mechanically, electrically and aesthetically with asphalt shingle (Figure 3), tile, or standing seam metal roofs. There are also triangular modules to more closely fit the shape of a sloping roof; frameless modules to create a nearly continuous surface; semi-transparent modules to double as windows; and custom solution can be assembled as well.

3.4 Environmental Concerns

The potential for lower cost per watt is the major driving force behind innovations in cell technology. Reductions in material requirements also have tangible environmental benefits such as reducing the amount of energy it takes to make the cells, also referred to as embodied energy. Estimates indicate that modules on the market today take about 2-4 years to generate the amount of electricity that went into their production, and are expected to last 30 years or more - which seems exceptional for any product manufactured today.

Another area of concern is that some of the newer compound semiconductor cells contain toxic substances. Although these do not enter into contact with the environment during the lifetime of the product, they must be carefully managed during production and recaptured after decommissioning.

4.0 Photovoltaic Systems and Components

PV modules are the heart of PV systems, but there are several other key components. Exactly which of these components are required depends on the configuration of the system, which in turn depends on the application's requirements. The fundamental options to be considered are: energy storage, additional energy sources, and a grid interface.

4.1 Direct-Powered Loads

The simplest system consists of one or more PV modules connected directly to a load. This is appropriate for applications such as pumping water because the water can be stored in a reservoir and used later; or ventilation fans and other cooling applications because they are most needed when the sun is shining.

The challenge with this configuration is matching the load to the PV modules so that the system will stop and start automatically and run reliably over a range of operating conditions. The fact is that the current-voltage characteristics of PV cells are a very poor match for motor and resistive loads, and the PV component is usually oversized to make this work. Other options are to add a small storage battery to provide extra starting current and voltage regulation, or to add a DC/DC converter to improve the match.

4.2 Autonomous Systems with Storage

Most applications require some energy at times when sunlight is not available. This energy may be supplied by another source, such as a wind turbine, a diesel generator, or the electrical grid, for example, or it may be collected in advance and stored until needed. Applications for systems with storage abound where grid power is not available, unreliable, or too expensive to install, or where the need is relatively small, temporary, or mobile (Figure 4).

Storing electrical energy in significant quantities is notoriously difficult, and methods rely on some form of reversible conversion of energy into another form. And although every method entails energy losses and other drawbacks, storage systems are successfully integrated into many PV systems and enable them to meet a much broader range of needs. Two types of storage are of particular interest: batteries and fuel cells.

Rechargeable electrochemical cells are well known and have myriad applications outside of PV systems. Both lead-acid and nickel-cad-

Figure 3: Photovoltaic modules in the form of shingles for roof integration. (Photo: Warren Gretz)

Figure 4: Small autonomous systems such as traffic signs (shown here), lights, telephones and parking meters are effective in both rural and urban areas. (Photo: Dan Ton)

mium types are common, and the proliferation of portable electronics has led to the development of other types that can store more energy per unit of mass. For most stationary PV applications, however, a bank of lead-acid batteries that is optimized for daily cycling and occasional deep discharge constitutes an adequate storage solution.

The main drawback of all batteries is that the storage capacity is fixed. If this poses a problem, a system comprising an electrolyser, hydrogen storage and fuel cell can be considered instead (see IEEE Canadian Review, No. 44). With expandable hydrogen storage and greatly improved fuel cell efficiencies it should be possible in the future to consider seasonal storage in stand-alone applications using this method.

In addition to the PV modules and a storage system, autonomous systems are usually also equipped with a charge controller to ensure that the storage is not charged or discharged excessively. Furthermore, to permit the use of conventional loads and equipment, an inverter converts the direct current into 120 or 240 V ac. Recent advances in power electronics combined with increased demand and production have resulted in a greater selection of products and lower prices in this category. Nevertheless inverters remain a major cost component and longevity is a concern.

Charge controllers and inverters (for grid connection) may be equipped with a maximum power point tracking function as well. This permits the unit to adjust the electric load that it imposes on the PV modules in order to extract maximum power under continuously varying sunlight and temperature conditions. In all these components high efficiencies are key to minimizing the number of solar panels needed in the system, and thus, minimizing system cost.

4.3 Hybrid Systems

If an application requires more energy than could reasonably be supplied by a stand-alone PV system, one or more other forms of electricity generation such as wind turbines or gas/diesel gensets can be integrated. Each of these has different strengths and limitations, and together they can constitute a reliable and versatile electricity supply system.

Once a genset is involved it may be tempting to eliminate the other generating sources for the sake of simplicity. But genset operating costs are either high or very high, and being sized for peak loads their efficiency at average or small loads is always poor. In a hybrid design the PV modules and storage can be sized to provide the base load, and the genset can provide peak loads and occasionally top up the storage if needed. Particularly in remote locations, where the cost of transporting fuel for the gensets may exceed the cost of running them, this can be a very attractive solution.

4.4 Grid-Connected Systems

Although vast areas of Canada are not supplied by the electricity grid, most populated areas are. When a PV system is connected to the grid it can be simplified a lot: storage is no longer necessary, hybrid solutions do not need to be considered, and control strategies can be simplified since the grid can supply shortages or absorb excesses. It also operates more efficiently on average, since it can always deliver its maximum output.

But if grid electricity is available, why bother? What is the advantage? Certainly from the limited viewpoint of today's electricity prices and today's PV system costs in Canada, there does not appear to be any advantage for the individual. But today's fossil fuel based electricity generation causes significant environmental pollution and is in limited supply, so if electricity from PV systems reduces fossil fuel use it certainly does provide important benefits to society . The fact that there are grid-tied systems in Canada today is evidence that individuals, companies and governments are looking forward and are willing to invest in the future.

At the same time, there are factors that can make a significant positive difference in the economics of grid-tied PV. For example, maximum PV electricity generation usually coincides with summer peak loads, i.e. at times when the market price of electricity also peaks. As a form of distributed generation, grid-connected PV systems are near to their loads, and therefore avoid significant transmission and distribution losses. And finally, when integrated physically and functionally into buildings, PV systems can provide additional benefits by influencing solar heat gain and daylight penetration, while at the same time displacing cost of other building materials (Figure 5).

Figure 5: Grid-connected systems such as these solar roofs in the Netherlands are the way of the future. (Photo: Alfred Brunger)

Industry standards for grid-connection have been developed already, and are embodied in inverter products on the market in a wide range of power ratings - from hundreds of watts to tens of thousands. Besides transferring the maximum available solar energy to the grid, these inverters continuously monitor the voltage and frequency on the grid, and shut down automatically within fractions of a second if any of these measurements indicate an anomaly.

5.0 Global Context and Future Trends

Globally the PV industry is experiencing strong, sustained growth, as illustrated in Figure 6. The grid-connected distributed market segment has grown the fastest in recent years, due in large part to incentive programs in Germany and Japan. Yet the cumulative installed capacity is still only a drop in the barrel compared to total fossil fuel based generating capacity, which means there is ample opportunity for this growth to continue and even accelerate.

Canada's relatively low energy prices have not helped encourage investment in renewable energy technologies, and installations in Canada have been primarily of autonomous PV systems as opposed to grid-connected ones, as is clearly seen in Figure 7. The most common application areas are for telecommunications and monitoring equipment in remote locations, and off-grid homes. It seems inevitable that all energy prices will go up, however, and looking into the future may be as easy as looking at what is happening in Europe or Japan today, where energy prices are already much higher.

The first and obvious effect of higher energy prices is that the economics of all PV systems improve, and more applications will be labelled as cost-effective. The second effect is that higher volumes lead to lower PV system production costs, and further improvements in the econom-

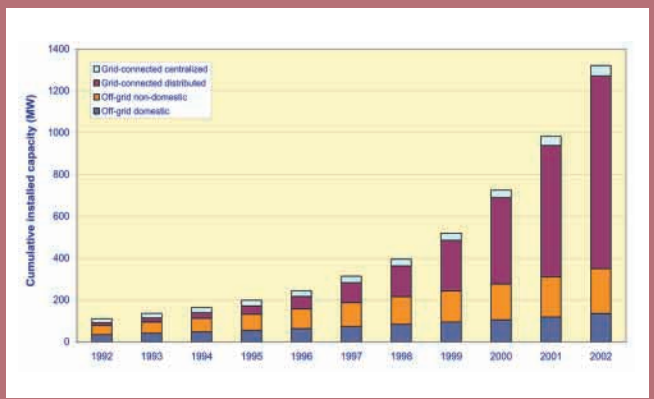


Figure 6: Cumulative global installed PV power by submarket. (Source: IEA Photovoltaics Power Systems Programme)

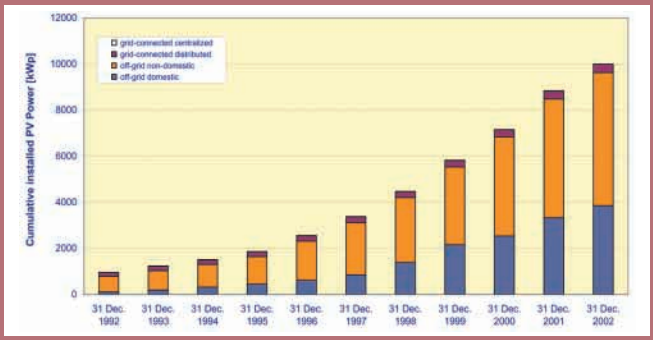


Figure 7: Cumulative installed PV power in Canada by submarket. (Source: IEA Photovoltaics Power Systems Programme)

ics. Since this is a global industry, Canada is already benefiting from lower costs thanks to high sales volumes in other countries. The third effect is a greater general awareness of the true cost of energy, the true value of conservation, and a greater appreciation for the inherent advantage of a renewable resource such as PV. This in turn drives political agendas and policies, research funding and implementation subsidies - and further growth.

The potential for growth is particularly high in the grid-connected market segment, and it is there that Japan and many European countries show by far the greatest growth. Grid-connected systems have an inherent advantage because of their simplicity and the fact that they can deliver the maximum available energy all the time. And while their presence may encourage awareness of energy use, they do not inhibit or restrict energy users in the same way autonomous systems might, and public acceptance is good.

Regardless of whether Canada follows these trends or charts its own course over the coming years, more PV systems will be installed because more and more people are becoming aware of the possibilities and benefits. As engineers, we should be leading this evolution.

6.0 Suggested Reading

Books

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[2]. Wenham, S.R., Green, M.A., and Watt, M.E., "Applied Photovoltaics", Centre for Applied Photovoltaics, Australia, 1994.

[3]. Ross, M., and Royer, J. (editors) "Photovoltaics in Cold Climates" James & James, London, 1999.

[4]. "Photovoltaic Systems Design Manual" CANMET, Ottawa, 1991.

Web Resources

[5]. Solar Energy Society of Canada (www.solarenergysociety.ca)

[6]. Canadian Solar Industries Association (www.cansia.ca)

[7]. NRCan Renewable Energy Decision Support Centre (www.retscreen.net)

[8]. US National Center for Photovoltaics (www.nrel.gov/ncpv)

[9]. IEA Photovoltaic Power Systems Program (www.oja-services.nl/iea-pvps)

About the author

Anton Driesse completed his B.Sc. degree in Electrical Engineering at Queen's University at Kingston in 1988, and subsequently obtained a M.Sc. in Computer Science from the same institution. He was active in the Information Technology sector in Kingston and Montreal for 7 years before turning his attention to Renewable Energy. While he maintains his primary focus on Photovoltaics, his interests encompass the full range of solar technologies, particularly as they complement each other in buildings. He is currently active as a consultant and as an associate researcher at the Queen's University Solar Calorimetry Laboratory. He is also a director of the Solar Energy Society of Canada.

IEEE William E. Newell Power Electronics Award

The William E. Newell Power Electronics Award is presented annually by the Power Electronics Society for outstanding achievement in power electronics. It is dedicated to the memory of Dr. William E. Newell of the Westinghouse Research and Development Center in Pittsburgh, Pennsylvania. Awarded annually since 1977, this award has come to represent recognition by one's peers as an outstanding contributor to the field of power electronics.

M. Azizur Rahman (F'88) of Memorial University has been awarded the IEEE William E. Newell Power Electronics Award for outstanding achievement in Aachen, Germany on June 24, 2004 at the occassion of the Power Electronics Specialists Conference.

The recipient receives a plaque and cash prize of US $5000. Dr. Rahman is the second Canadian recipient of Newell award; the first Canadian winner was Shashi B. Dewan from University of Toronto in 1979.

Azizur received his B.Sc.Eng, M.A.Sc and PhD degrees from the Bangladesh University of Engineering and Technology (BUET), Dhaka, University of Toronto and Carleton University in 1962, 1965 and 1968 respectively. In addition to his teaching for 42 years, Dr. Rahman has over 10 years of concurrent industrial experiences. He is a professional engineer in Newfoundland and Ontario.

In 1993, Dr. Rahman was the first Canadian to receive the **IEEE Power Engineering Society's Cyril Veinott Electromechanical Conversion Award**. He also received the IEEE Industry Applications Society Outstanding Achievement award in 1992 and is one of the few Canadian scholars to have received the highest achievement awards from three IEEE Societies.

RedR - Registered Engineers for Disaster Relief

Established in London in 1979, RedR is now an international organization working to save lives and reduce suffering around the world from offices in the U.K., Australia, New Zealand, Canada and India. Members provide engineering expertise and technical, logistical and management support to front-line humanitarian relief agencies like the Red Cross, CARE, Oxfam and Save the Children.

Every year, millions of people at home and around the world suffer the devastating impact of natural and man-made disasters. Humanitarian agencies and governments respond with financial aid, and shipments of food, clothing and medical supplies.

At RedR, members complement the front-line relief groups by providing technical assistance vital to restoring the everyday lives of the affected communities by:

- Rebuilding roads and bridges,
- Re-establishing fresh water supplies,
- Managing waste,
- Restoring communications,
- Protecting the environment, and
- Managing financial, material and human resources

by Kirk Thompson
Executive Director of RedR Canada, Ottawa, ON

1.0 RedR Canada

In January 2001, the Association of Consulting Engineers of Canada (ACEC) signed a memorandum of understanding with RedR International, paving the way to the establishment of a RedR office in Canada. RedR Canada was incorporated as a federal charitable society in August 2001 when three other leading engineering organizations joined the ACEC as Founding Partners:

1. The Canadian Council of Professional Engineers (CCPE), representing the 160,000 professional engineers licensed to practice engineering in Canada;
2. The Engineering Institute of Canada (EIC), representing the engineering technical societies;
3. The Canadian Academy of Engineering (CAE), which honours individuals who have had eminent careers in engineering.

2.0 Update on Activities

RedR Canada has completed its first year of operations with very encouraging results. The Board of Directors finalised and adopted a governance model along professional lines, a start-up strategy was elaborated, membership recruiting and accreditation processes were set-up, 36 members were successfully registered, a member training plan was developed and initiated, and field placements were orchestrated.

On September 1, 2003, a grand ceremony was organised in Ottawa in honour of the humanitarian work performed by Her Royal Highness the Princess Royal (Princess Anne). Firstly, Princess Anne addressed the second annual general meeting of RedR Canada held at the Fairmont Château Laurier hotel noting that she agreed to come to the RedR annual meeting because she believes the organization has an enormous potential to make a difference. And she urged different aid delivery groups to work together to find ways of delivering assistance efficiently. Having money is not enough, she said; there must be coordination, understanding and efficient use of the expertise available. The party then travelled to Rideau Falls Park, where HRH laid a wreath of flowers on the monument to honour Canadian humanitarian aid workers following prayers led by representatives from seven of Ottawa's religious faiths. A group of about 150 was in attendance, including families of aid workers who lost their lives in the performance of their duties.

Later that night, at the Chateau Laurier, Princess Anne received the first RedR Canada Award for Meritorious Service in Humanitarian Aid, which was presented by the then Minister for International Cooperation, the Honourable Susan Whelan.

3.0 Membership

RedR Canada now has 36 members on the 2000 strong global Register and has created a new class of membership, reflecting the requirements of many of its clients: the Member-in-Training. Like the successful Engineer-in-Training program of the provincial engineering governing bodies, RedR's MIT program brings in younger and less experienced engineers to acquire experience, whereby they can become full members. With regards to membership, the goal is to recruit at least 14 more members by the end of the year.

4.0 Placements

Of the Canadian membership, four of them are presently on assignment overseas as a result of their own efforts. RedR Canada was instrumental in placing a New Zealand engineer with an American non-government organization (NGO) operating in Iraq. All Canadian members are well-qualified and the aim is to place as many of them as possible with RedR clients - the NGOs who operate on the front lines of disaster relief. But the office lacks the resources at present to do this in any meaningful way and we therefore hope to engage the efforts of volunteers to seek out placement opportunities.

5.0 Training

RedR's Canadian Training Program was initiated with a 2-week training program in Kingston that certified 8 Canadians as RedR Trainers and 21 Canadian participants which took an Essentials of Humanitarian Practice course. The idea of this first training period was to develop a pool of Canadian trainers able to present training packages in Canada and the rest of N. America as demands require, and to present the first RedR Canada training course. The course was led by a UK training team and produced a very successful event. All participants expressed that the course had been very good and all had fully participated.

In the near future, RedR Canada plans to establish and improve the training skills and confidence of the new trainers with several 2-day "So You Want To Be an Aid Worker" courses in the Ottawa, Kingston, Toronto and London (Canada) areas. Efforts are also under way for 3 day Conflict Resolution and Media relations skills course.

6.0 The Future

At its most recent general assembly in Auckland, NZ, RedR International decided to start addressing needs in disaster preparedness, in addition to its traditional markets in disaster relief, and to pursue partnerships in the commercial sector. This new development was supported by the Canada office and should be of considerable interest to engineering consulting firms with staff working on overseas development projects. RedR Canada will take a proactive position with regard to assisting disaster preparedness and is prepared to promote engineering services in this regard.

But to achieve this new objective, RedR Canada must first focus on two key goals - firstly, to spread awareness about RedR Canada, particularly within Canada's engineering community, and secondly, to create a stable financial basis from which to operate. RedR Canada is the only Canadian charitable organization that focuses on providing engineering expertise to disaster relief and preparedness operations, and every Canadian engineer should rightly be proud of the role that this organization is playing to help alleviate worldwide suffering. It is hoped that RedR Canada will become one of the charities of choice for the engineering community and that all engineers will consider making a modest contribution to support its activities.

To find out more about Red, visit our web sites: www.redr.ca and www.redr.org

IEEE Canadian Foundation

Dear Canadian IEEE members, please consider making a ***tax-deductible donation*** to help support the education of our next generation. The IEEE Canadian Foundation, a registered Canadian charitable foundation:

- Annually awards ten scholarships to exceptional Canadian IEEE student members in electrical, electronics, and computer engineering or technology programmes, for their final year of undergraduate studies;
- Awards a variety of one-time special grants to promote the theory and practice of electrical and electronics engineering in Canada;
- Provides financial assistance to establish and maintain over 25 ***McNaughton Learning Centres*** in Canadian universities and colleges, for study and collaborative projects.

You can easily make a one-time tax-deductible donation - simply enter the amount of your gift on the IEEE Canadian Foundation line at the bottom of your membership renewal form. If you renew online at **http://www.ieee.org/renewal,** please enter the amount on the IEEE Funds page. Receipts for Canadian tax purposes will be issued by March 31 of the following year. Donations may also be made at any time during the year by contacting:

IEEE Canadian Foundation Treasurer,
456 Roger St.,
Peterborough, Ontario, K9H 1W9.
Phone: (705) 743-7712,
email: Donations@ieeecanadianfoundation.org

For more Information, visit:
http://www.ieeecanadianfoundation.org/

Fondation canadienne de l'IEEE

Chers membres canadiens de l'IEEE, veuillez envisager la possibilité de faire un don ***déductible d'impôts*** pour aider à ***supporter l'éducation de notre prochaine génération.***. La Fondation canadienne de l'IEEE, une fondation charitable canadienne enregistrée:

- Décerne annuellement ***dix bourses d'études*** à d'exceptionnels membres étudiants canadiens de l'IEEE enrôlés en génie électrique, électronique et informatique ou dans des programmes techniques, pour leur dernière année d'étude au premier cycle universitaire;
- Décerne plusieurs ***bourses spéciales ponctuelles*** dans le but de promouvoir la théorie et la pratique du génie électrique et électronique au Canada.
- Fournit de l'aide financière pour ***établir et maintenir plus de 25 Centres d'apprentissage McNaughton*** dans des universités et collèges canadiens pour des projets d'étude et de collaboration.

Vous pouvez aisément faire un don déductible d'impôts – simplement en saisissant le montant de votre don à la ligne « IEEE Canadian Foundation » au pied de votre formulaire de renouvellement de membre IEEE. Si vous renouvelez en ligne à **http://www.ieee.org/renewal**, veuillez saisir le montant sur la page « IEEE Funds ». Les reçus d'impôt canadien seront émis d'ici le 31 mars de l'année subséquente. Les dons peuvent aussi être faits en tout temps durant l'année en contactant le trésorier de la Fondation canadienne de l'IEEE;

Le trésorier de la Fondation canadienne de l'IEEE,
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IEEE Canada

2004 IEEE Region 7 (IEEE Canada) Student Branch Web Site Contest

The winners of the 2004 IEEE Region 7 (IEEE Canada) Student Branch Web Site Contest are:

First place:
Algonquin College IEEE Student Branch
IEEE Student Branch web site: http://ewh.ieee.org/sb/ottawa/algonquin/
Alternatively, re-directs: http://algonquin.ieee.ca
http://www.ieee.org/algonquin

Second place:
Red River College IEEE Student Branch
IEEE Student Branch web site: http://ieee.rrc.tyr.ca

Third place:
University of British Columbia IEEE Student Branch
IEEE Student Branch web site: http://www.ece.ubc.ca/~ieee

The first place web site was entered into the international competition. It may receive a cash prize of $1,000, $750, $500 or $250, depending of the ranking obtained at the international competition, and the amounts are in US dollars! You can find more details on this contest at:

http://www.ieee.org/portal/index.jsp?pageID=corp_level1&path=membership/students/programs&file=websitecontest.xml&xsl=generic.x

The winners of the Region 7 Student Branch Web Site Contest will receive a letter of congratulations and a certificate from IEEE Canada.

Congratulations to all the volunteers who took part in the judging process, as well as the participating Student Branches who made a wonderful job of promoting their activities and the IEEE.

Maike Luiken Miller
IEEE Region 7 Chair of the Student Activities Committee
email: Maike.Miller@ieee.org

CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS
CONSEIL CANADIEN DES INGÉNIEURS

Sweeping recommendations aim to help International Engineering Graduates

A seminar on "Working in Canada", a database of recognized engineering degrees and a comprehensive, single source website are just three of 17 recommendations announced in May by the Canadian Council of Professional Engineers (CCPE) and its members. The recommendations are part of a collaborative effort to help international engineering graduates (IEGs) integrate into the Canadian engineering profession and workforce.

The recommendations are the result of a three-phase initiative entitled From Consideration to Integration (FC2I) that has been tackling a range of difficulties in licensing and employing IEGs. The recommendations address the issues without compromising public safety or lowering professional standards. FC2I is fully funded by Human Resources and Skills Development Canada.

"All Canadians benefit when new Canadians can gain employment in their profession," says Human Resources and Skills Development Canada Minister Joe Volpe. "This initiative supports the Government of Canada's approach to innovation and learning that addresses the national challenge of ensuring Canadians possess the skills and knowledge to fully participate in the knowledge-based economy."

The Canadian Council of Professional Engineers leads the FC2I Steering Committee which has representatives from federal and provincial governments, the engineering regulatory bodies, employers, immigrant-serving organizations, educators, engineers and IEGs themselves. This diversity of representation, the level of consultation and the holistic approach with which the engineers tackled the project, set it apart from other similar initiatives.

"We know that many immigrants with a background in engineering want to work in the profession once they are here," says Darrel J. Danyluk, P.Eng., Chair of the FC2I Steering Committee, "but we also know they face language and cultural barriers, employment difficulties and challenges in accessing clear information; we looked at each of these areas, in addition to the licensing process itself."

Other recommendations include:

- Providing IEGs with a provisional licence once they have met all requirements for licensure except the one year of Canadian experience. In this way, employers can have full confidence in the IEG's technical and communications abilities,
- Developing a mentoring program,
- Determining which elements of the engineering licensing process can be done overseas, to speed the process after they arrive in Canada.

"Canada has a reputation for engineering excellence," says Saeed Ziaee, P.Eng., founder and product development manager of Intelligent Engineering Solutions Inc., a research and development firm in Toronto with a specialty in medical devices, and an IEG from Iran. "As immigrants with an engineering background, we want to help maintain that excellence and to contribute to the Canadian economy; these recommendations will help us do that faster and with fewer complications.

"We're very pleased that our unique approach to this issue - extensive consultations and a widely representative Steering Committee - has resulted in such a substantive set of recommendations," says Marie Lemay, Chief Executive Officer of CCPE. "We look forward to implementing these with our partners so we can make a positive difference for IEGs."

An implementation plan is currently in development. As part of that plan, FC2I organizers are organizing a series of roundtable meetings with settlement groups, the engineering and technical community, and with the provincial and territorial licensing bodies. The goal is to determine what role these stakeholders may see for themselves in implementing the recommendations. An implementation plan should be in place by late fall, 2004.

Launched in January 2003, FC2I is a three-phase project. In Phase I, work focused on understanding the IEG experience, examining provincial and territorial engineering licensing procedures, and learning from those who work with and employ IEGs. In Phase II, the Steering Committee analyzed the information, determined where the process of integration needs improvement and began to build consensus among stakeholders on possible solutions.

In Phase III, the Steering Committee will work with key stakeholders to implement the recommendations and to develop supporting information materials.

The Canadian Council of Professional Engineers is the national organization of the 12 provincial and territorial associations/ordre that regulate the practice of engineering in Canada and license the country's more than 160,000 professional engineers.

For more information, contact:

Deborah Wolfe, P.Eng.
Director, Education, Outreach and Research, CCPE
(613) 232-2474, Ext. 235
deborah.wolfe@ccpe.ca

You can also visit the CCPE website at: **http://www.ccpe.ca**

IEEE Senior Member Upgrades

The following members were upgraded to Senior Member status at the June 2004 Admission and Advancement Panel meetings:

Name	Section
Shahram Shirani	Hamilton
Anthony M. Ponsford	Kitchener-Waterloo
Vincent Hayward	Montreal
Marc Lacroix	Montreal
William K. Marshall	New Brunswick
Carlisle M. Adams	Ottawa
Xiaoyi Bao	Ottawa
Alan B. Blatchford	Southern Alberta
Dragan V. Brankovich	Southern Alberta
Wai Tung Ng	Toronto
Shawn S. Otal	Toronto
Krzysztof Iniewski	Vancouver
Vincent G. Rowe	Vancouver

For more information on the Nominate a Senior Member Initiative (NSI) Program, please visit:

http://www.ieee.org/ra/md/smprogram.html

IEEE Canada Student Paper Competition Awards

IEEE Canada is pleased to announce the winners of the 2003 IEEE Canada Student Paper Competition. For each Council in Canada (Western, Central and Eastern), there are three awards. The first one is the **IEEE Life Member Award** that is granted to the best overall paper, which consists of a prize of $500 per team. When this award is granted, the two other awards are granted amongst the remaining papers, with the **Hackbusch Award** going to the best paper by University student(s) and the **Palin Award** to the best paper by College student(s). These two awards consist of a $250 prize per team.

In addition to the cash prizes, the winners receive a congratulatory letter and a certificate. The title of the winning papers as well as the name of their authors is published on the IEEE Student Paper Contest Hall of Fame web site (on the IEEE Student Concourse web site). I thank all volunteers who took part in the judging process. I thank also all the participants and their student branch counselors for their interest in this competition.

Maike Luiken Miller

Region 7 (IEEE Canada) Regional Student Activities Coordinator

E-Mail: maike.miller@ieee.org

Student Paper Competition Awards

Council	Type	Project	Authors	University/College
Western	Life Member Award	UV Monitor Design	Ryan M. Tourigny, Michael A. Jaspar, John M. Anderson	University of Saskatchewan, Saskatoon, SK
	Hackbusch Award	The lighting DataLogger for Developing Nations	Eric T. Hennessey	Simon Fraser University, Burnaby, BC
	Palin Award	Head Tracking Mouse	Julie Remillard	Red River College, Winnipeg, MB
Central	Life Member Award	A Swarm of Collaborative Autonomous Robots	James Gaston	Ryerson University, Toronto, ON
	Hackbusch Award	3D User Interface for a File Management System	David Carter	University of Western Ontario, London, ON
Eastern	Life Member Award	Face Detection Using Skin Colour	Bhavin J. Shastri	McGill University, Montreal, QC
	Hackbusch Award	Networking Video on Palm Pilot Devices	Adam Gobi	Dalhousie University, Halifax, NS

3rd International Conference for Upcoming Engineers (ICUE 2004)

ICUE is a platform where students and faculty members work together in organizing the conference, and a forum to exchange ideas amongst undergraduates, graduate students and faculty researchers.

The ICUE 2004 was advertised in the IEEE Canadian Review that reaches about 16,000 subscribers (thanks to Dr. Vijay Sood) in Canada and the APEO Newsletter that reaches many more. Thanks to the students who created the professional web page at http://www.icue.ca and widely mailed the Call For Papers. ICUE web page was linked to the IEEE Toronto Section web page which is visited by an even larger audience. These efforts brought 85 technical paper submissions (32 international) and 29 design project submissions to ICUE 2004.

ICUE 2004 was held on May 13-14. It was a festival of students; we had 45 technical papers scheduled to present with participants coming from universities such as Toronto, Western Ontario, Carleton, Ottawa, Waterloo and Regina. There were five technical sessions:

- Shannon (Computers, Networks and Information Theory),
- Fourier (Signal Processing and Multimedia),
- Marconi (Wired, Wireless and Optical Communications),
- Edison (Power, Machines and Controls),
- Newton (Cross disciplinary and Emerging Areas).

There were five state-of-the-art tutorials delivered by experts such as Alberto Leon Garcia (U of Toronto), Muhammad Khalid (U of Windsor) and Xiang-Gen Xia (U of Delaware), Bin Wu and Peter Hiscocks (Ryerson).

In ICUE 2004, for the first time we had an integrated design demo with 10 student design projects from the University of Toronto, 10 projects from Ryerson and some from outside. Please visit the ICUE web site (http://www.icue.ca/icue2004album) to see the photographs and details. IEEE Canadian Review will cover the award winners and publish a follow-up on ICUE 2004 soon.

Funding for the ICUE was received from sources such as IEEE Canadian Foundation, IEEE Toronto Section, and RyeSAC. The IEEE student members paid $20 only if they were attending the banquet (non-members $30). This way, we made sure all other benefits were available to the students free of charge.

The ICUE committee appreciates the donation of four text books from **J.Wiley and Sons** as awards for the winning participants.

The ICUE 2003 award winner James Gaston won the first prize in the IEEE Canada Central Region Engineering Paper Competition. This year, "The Dr. Robert T.H. Alden IEEE Canadian Foundation Scholarship" which is co-sponsored by the IEEE Toronto Section was awarded to Litifa Noor who was also the Organizing Chair of ICUE'04. Likewise students benefited tremendously from ICUE.

ICUE 2004 Award Winners:

Best Undergraduate Technical Paper (see also article in this issue of the IEEE Canadian Review):

- "Source and Channel Coding Techniques for Faithful Transmission of Digital Mammograms" by Danoush Hosseinzadeh and April Khademi (Ryerson University)

Best Graduate Technical Paper:

- "Design and Development of a Liquid Level Transducer Using Sonar" by M. Mehrandezh, and V. Soman' (University of Regina)

Best Design Projects:

- "Self-Navigating Robot with Stereo Video Recognition" by Jonathan Waisman, Ekaterina Laskin, Valeri Kirischian and Colin Lee (University of Toronto)
- "A High Fidelity Audio Amplifier" by Gary Ali (Ryerson University)

We take this moment to thank all those helped and participated in this tech festival.

Xavier Fernando and Alagan Anpalagan

Co-Chairs, ICUE 2004

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IEEE Canada

CCGEI 2005

"Eclairons nôtre future"

18e Conférence Canadienne de génie électrique et informatique

1 – 4 mai, 2005, Saskatoon Inn

Saskatoon, Saskatchewan, Canada

APPEL AUX COMMUNICATIONS

La conférence canadienne de génie électrique et informatique 2005 de l'IEEE offre un forum pour la présentation de travaux de recherche et de développement dans les domaines du génie électrique et du génie informatique provenant du Canada et du monde. Des communications en français ou en anglais sont sollicitées sur des sujets qui incluent, mais ne sont pas limités à :

- Systèmes à base d'agents et sur Internet
- Communications et systèmes sans fil
- Traitement de signal et conception de filtres
- Électromagnétisme, optique et photonique
- Contrôle de procédé/Automation industrielle
- Robotique et mécatronique
- Réseaux et systèmes informatiques
- Réseaux neuronaux et logique floue
- Bases et exploration de données
- Électronique et systèmes de puissance
- Machines électriques et entraînements
- Circuits, Systèmes et ITGE
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- Systèmes en temps réel et embarqués
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- Production de l'énergie et énergies renouvelables
- Informatique nomade
- Calcul haute performance
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- Calcul évolutionniste
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- Simulation et visualisation
- Interaction personne-machine
- Nanotechnologie et nanorobotique
- Antennes et EMC/EMI
- Micro-ondes et RF
- Bioinformatique
- Télédétection et applications
- Théorie du Contrôle et applications
- Ingénierie biomédicale
- Instrumentation et mesure
- Aérospatiale et Avionique

1.0 Soumission de communications régulières:

Veuillez soumettre par courrier électronique un résumé de 300 mots de votre communication au comité technique par la procédure décrite sur notre site http://ieee.ca/ccece05 avant le 10 decembre 2004. Choisissez le lien "Français" et suivez les instructions données sous "Appel de communications".

2.0 Proposition de tutoriaux, d'ateliers et de sessions sur invitation:

La proposition de sessions invitées, ateliers pré- et post-conférence et tutoriaux sera acceptée jusqu'au 17 décembre, 2004. Veuillez contacter le responsable des ateliers à l'adresse mentionnée ci-haut.

3.0 Compétition de soumission par étudiants

Veuillez soumettre votre article en suivant la procédure décrite ci-haut. S'il vous plaît, lisez les informations trouvées sur la page "Français", sous "Appel de communications" et "Fonds pour étudiants".

4.0 Dates Importantes:

Date limite pour la soumission des résumés d'articles:	**Vendredi, 10 décembre, 2004**
Date limite pour la soumission de sessions spéciales:	**Vendredi, 17 décembre, 2004**
Avis d'acceptation:	**Vendredi, 14 janvier, 2005**
Date limite pour l'inscription:	**Vendredi, 28 février, 2005**
Date limite pour la soumission finale des articles:	**Vendredi, 28 février, 2005**

5.0 Expositions industrielles:

Veuillez contacter le responsable des liaisons industrielles et des expositions afin d'obtenir des informations au sujet des présentations industrielles durant la conférence.

Si vous êtes intéressés par CCGEI 2004 et voudriez être ajouté à notre liste de distribution, veuillez contacter le secrétariat de la conférence à l'adresse inscrite à gauche. Notre site Internet sera mis à jour régulièrement.

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IEEE Canada

CCECE 2005

"Shining Light on Our Future"

18th Annual Canadian Conference on Electrical and Computer Engineering

May 1 - 4, 2005, Saskatoon Inn

Saskatoon, Saskatchewan, Canada

CALL FOR PAPERS

The 2004 IEEE Canadian Conference on Electrical and Computer Engineering provides a forum for the presentation of electrical and computer engineering research and development from Canada and around the world. Papers are invited, in French or English, including but not limited to the following topics:

- Advanced Computer Architecture
- Agent-Based & Internet-Based Systems
- Bioinformatics
- Circuits, Systems & VLSI
- Computer Networks & System
- Database & Data Mining
- Electromagnetics, Optics & Photonics
- High-Performance Computing
- Instrumentation & Measurement
- Microelectronics & Optoelectronics
- Nanotechnology & Nanorobotics
- Power Electronics & Systems
- Process Control/Industrial Automation
- RF & Microwaves
- Signal Processing & Filter Design
- Visualization & Simulation
- Teledetection Remote Sensing & Applications
- Aerospace & Avionics
- Antenna & EMC/EMI
- Biomedical Engineering
- Communications & Wireless Systems
- Control Theory & Applications
- Electrical Machines & Drives
- Evolutionary Computation
- Human-Machine Interactions
- Intelligent Systems
- Mobile & Pervasive Computing
- Neural Networks & Fuzzy Logic
- Power Systems & Renewable Energy
- Real-Time Embedded Systems
- Robotics & Mechatronics
- Software Engineering
- Virtual Reality & Artificial Life

1.0 Regular Paper Submission:

Please submit a 300-word abstract of your paper to the Technical Program Committee using the on-line submission process on our web site at http://ieee.ca/ccece04 before December 10, 2004. Click on "Call For Papers" and follow the instructions provided.

2.0 Workshop, Tutorial, and Invited Session Proposal Submission:

Proposals for invited sessions, pre- and post conference workshops and tutorials will be accepted before December 17, 2004. Please contact the Workshops Chair using the same web page as noted above in 1.0.

3.0 Student Paper Competition:

Please submit your paper using the on-line submission process using the same web page as noted above in 1.0. Please read the information provided in the "Call For Papers" and "Student Funding" pages of our web site.

4.0 Important Dates:

Paper abstracts must be received by:	**Friday, December 10, 2004**
Special Session proposals must be received by:	**Friday, December 17, 2004**
Notification of acceptance will be sent out by:	**Friday, January 14, 2005**
Registration must be received by:	**Friday, February 28, 2005**
Final papers must be received by:	**Friday, February 28, 2005**

5.0 Industrial Exhibits:

Please contact the Exhibits Chair at the Conference Secretariat for information about industrial exhibits at the conference.

If you are interested in CCECE 2004 and would like to be added to our contact list, please contact the Conference Secretariat at the address on the left. Check our Web site regularly for news and updates.

Sponsors: IEEE Canada and the Saskatchewan Sections