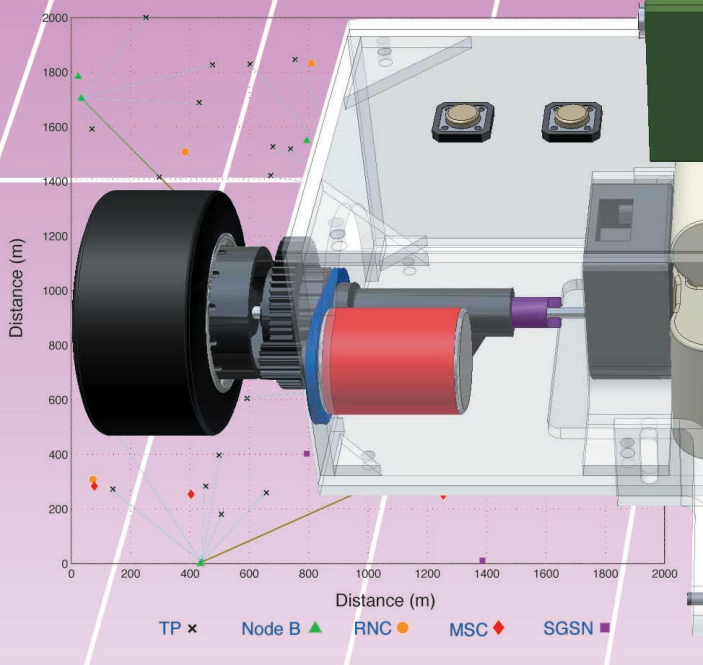
Fall / Automne 2006, No. 53

IEEE Canadian Review

La revue canadienne de l'IEEE

- Application of International Software Engineering Standards in Very Small Enterprises
- A New Approach to Planning 3G Cellular Networks
- Stabilization of an Inverted Pendulum on a Mobile Robot
- Autonomous Flight: State-of-the-art Estimation & Guidance Systems

Planning & Control



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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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Editorial / *Éditorial*

Eric Holdrinet SMIEEE, Rédacteur en chef / Managing Editor, Consul et délégué commercial, Consulat général du Canada à Los Angeles

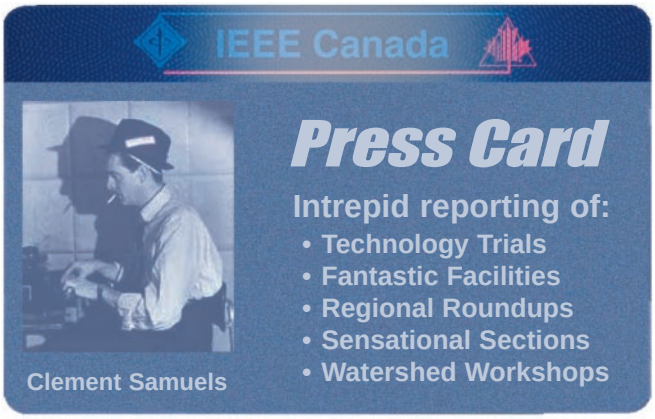
Vous avez peut-être remarqué que la revue que vous tenez en main est le numéro d'Automne de la Revue canadienne de l'IEEE. Qu'est-il arrivé au numéro d'été? En fait, il n'est pas arrivé. Il n'y avait pas assez de matériel de qualité dans le pipeline pour imprimer un numéro de taille respectable.

Nous sommes en train de remédier à cette situation, tout d'abord en se recentrant sur la mission de la Revue qui est de « Donner un aperçu des professions du génie électrique, électronique, des communications et informatique au Canada, ainsi que des milieux d'affaires et académiques leur étant associés. » Ceci sera obtenu par des articles tels ceux imprimés dans *Spectrum* et *The Institute* que dans *IEEE Transactions on Power Electronics*.

Les résultats d'un sondage effectué au printemps dernier ont été clairs: nos lecteurs consultent d'autre sources que notre Revue pour des articles scientifiques dans leurs domaines de prédilection. De notre part ils réclament toujours des articles techniques (nous sommes l'IEEE après tout), mais des papiers qui présentent des nouvelles, des opinions, et l'avancement au Canada des technologies d'intérêt à l'IEEE.

Pour cela il nous faut obtenir des nouvelles sur ce qui se passe dans vos communautés, centres de recherche, compagnies; nous avons besoin de Reporters IEEE volontaires à peu près partout au Canada. Cela veut dire aussi que nous accueillons de la part des chercheurs des articles qui ne seraient pas facile à publier dans les revues scientifiques: des articles qui présentent des opinions. Par exemple : « L'État de l'art sur la génération photoélectrique au Canada », des tutoriaux comme « La meilleure façon de concevoir un schéma unifilaire … »

Appelez-nous pour savoir comment devenir un Reporter IEEE. Soumettez des articles et des nouvelles, soumettez souvent, soyez publiés, soyez reconnus, devenez célèbre!



Ça pourrait être vous!

Si vous n'avez pas pu être reporter étoile de votre journal étudiant, voici l'occasion de laisser votre marque. Dénichez les scoops, envoyez vos articles à e.holdrinet@ieee.org

Could this be you?

If you couldn't be lead reporter for your high school newspaper, here's your chance to leave your mark. Beat Clement to the scoop; keyboard your story ideas to e.holdrinet@ieee.org

Cover picture / *Photo de couverture*

Shown front and centre is a cut-away illustration of the motor and gearing components of the inverted pendulum robot project that took first place in the IEEE Canada Telus Innovation Award, September 2005, and won the IEEE Canada Life Member Award in December 2005; see "control" story on page 8. To the left and down is a solution to updating 3G Cellular networks; see "planning" story on page 18. Flying discreetly at top right is an autonomous aircraft, as feature in story on page 22.

You may have noticed that the magazine you have in hand is the Fall issue of the IEEE Canadian Review. What happened with the Summer issue? Well, simply put, it didn't happen. There was not enough quality material in the pipeline to print a sizeable issue.

Well, we are in the process of remedying the situation, first by focusing on the Review's Mission, which is to "To project an image of the Canadian electrical, electronics, communications and computer engineering professions and their associated academic and business communities." This will best be done with articles of the type found in *Spectrum* and *The Institute* rather than in *IEEE Transactions on Power Electronics*.

Results from a survey we conducted last Spring were clear: Our readers are looking at other sources than the Review for scientific articles in their areas of predilection. From us they still want technology-based articles (we are IEEE after all), but pieces that report on news, opinions, and the advancement of IEEE-related technology in Canada.

What this calls for is news articles about what is happening in your communities, research centres, companies; we need volunteer IEEE Reporters pretty much everywhere in Canada. It also means that we will welcome articles that researchers could not easily get published in learned journals: articles that present opinions. For example: "The State of the Art on Solar Power Generation Technology in Canada"; Tutorials: " On How Best to Make a One-Line Diagram…", etc.

Call us on how to become an IEEE Reporter. Submit articles and news, submit often, get published, get recognized, get famous!

Contents / *Table des matières*

Bob Hanna, FIEEE, FEIC, FIEE, President of IEEE Canada: 2006-2007 / Président de l'IEEE Canada: 2006-2007

I am pleased to report that our 19th annual IEEE Canadian Conference on Electrical and Computer Engineering (CCECE 06) which took place from May 07-10, 2006 in Ottawa was a great success, judging by the impressive technical program and number of attendees. One of the key highlights was our traditional Monday banquet, where IEEE Canada presented awards to distinguished members for their technical achievements and extraordinary services. We appreciate the tireless work contributed by our conference organizers, plenary session speakers and the authors. See http://ieee.ca/ccece06.

On May 9-12, 2006 the Engineering Institute of Canada held its first conference on Climate Change Technology: Engineering Challenges and Solutions in the 21st Century, http://www.ccc2006.ca/. IEEE Canada was a key participant in this conference and we are grateful to the many of our volunteers who have contributed tremendously to its success.

I have previously stated that it was becoming extremely challenging for Region 7 to produce a balanced budget for 2006 and beyond without incurring considerable cut backs in our services and support to volunteers. Although our members have benefited from a strong Canadian Dollar in Region 7, our rebate from IEEE has been negatively impacted. In June 2006 I made a presentation to the IEEE Board of Directors requesting a modest adjustment to our membership assessment fee in order to partially offset the loss in revenues as well as the cost of inflation. Our membership assessment has remained unchanged at $15 US since 1993. Approval was obtained to increase the membership assessment fee to $19 US, effective January 01, 2007. It is worth noting that our overall membership fee in Canadian currency will be less in 2007 than in 2006 because our currency has to date increased by 10% in 2006.

On August 18, 2006 I attended the 50th anniversary celebration of the Victoria Section and made a presentation recognizing the section achievements. The section established a scholarship to be named "IEEE Pacific Rim Vijay Bhargava Scholarship" in recognition for Prof. Vijay Bhargava's excellent services to the Victoria Section, IEEE Canada and IEEE. The Southern Alberta Section celebrated its 50th anniversary on September 27, 2006 and the South Saskatchewan Section also on October 27, 2006. Our hearty congratulations to these sections on their achievements.

We have been working very closely with the IEEE Job Site to encourage the job advertising of Canadian companies on our website. We have made good progress and encourage you to visit our website at http://careers.ieee.org.

IEEE has recently embarked on several initiatives to improve services to our members and the public. These include IEEE.tv which is an internet broadcasting network that produces and delivers special-interest programming about technology and engineering. It also launched "TryEngineering" which is intended for pre-university students, parents, teachers, school counselors, and the general public. The program web site http://TryEngineering.org lets visitors explore how to prepare for an engineering career, ask experts engineering-related questions, and play interactive games.

IEEE Canada held its Fall meeting on September 15-17, 2006 in Toronto. During this event, a student training workshop, GOLD meeting and IEEE Canada TELUS Innovation competition also took place. This year, students from 10 Universities have submitted projects to compete for the prize of $10,000. A panel of six judges, which consists of two from Telus, two from the industry and two from IEEE Canada, has been formed to carry out the evaluation. We are very grateful to Telus for funding this project and providing a forum to our students in advancing their technical innovation. As an indication of the calibre of the work that our young engineers are doing, you can read the article on page 8 of this issue, which features solving the complicated control problem of an inverted pendulum mounted on an autonomous robot. The authors of this piece are last year's winners of the Telus Award as well as the IEEE Canada Life Member Award.

Je suis heureux d'annoncer que notre 19e Conférence annuelle canadienne en génie électrique et informatique (CCGEI 06) qui s'est tenue du 7 au 10 mai 2006 à Ottawa a été un grand succès, à en juger par le programme technique impressionnant et le nombre de participants. Un des moments forts a été notre traditionnel banque du lundi, où le IEEE Canada présente ses prix aux membres qui se sont distingués pour leurs réalisations techniques et services rendus. Nous apprécions le labeur persistant fourni par les organisateurs de la conférence, les auteurs et présentateurs de sessions. Voir http://ieee.ca/ccece06.

L'Institut canadien des ingénieurs du Canada a tenu du 9 au 12 mai 2006 sa première conférence sur la Technologie et changements climatiques: Défis et solutions en matière d'ingénierie au 21ème siècle, http://www.ccc2006.ca/ . Le IEEE Canada a été un participant clé à cette conférence et nous somme reconnaissants envers nos nombreux volontaires qui ont contribué énormément à son succès.

J'ai indiqué précédemment qu'il devenait extrêmement difficile pour la Région 7 de produire un budget équilibré pour 2006 et ensuite sans recourir à des réductions considérables dans nos services et le support aux volontaires. Quoique nos membres aient bénéficié d'un dollar canadien fort, la ristourne du IEEE en a été impactée négativement. En juin 2006 j'ai présenté ceci au Conseil d'administration du IEEE en requérant un modeste ajustement à notre cotisation régionale de membre pour contrebalancer partiellement la perte de revenus ainsi que l'inflation. Cette cotisation est restée inchangée à 15 $US depuis 1993. Approbation a été obtenue pour l'accroître à 19 $US, effectif le 1er janvier 2007. Il faut noter que l'accroissement total de cette cotisation en dollars canadiens sera moindre en 2007 qu'en 2006 car notre monnaie s'est appréciée de 10% jusqu'à présent en 2006.

Le 18 août 2006 j'ai assisté aux célébrations du 50e anniversaire de la Section de Victoria, et ai livré une présentation pour souligner ses accomplissements. La Section a établi une bourse d'étude qui sera intitulée "IEEE Pacific Rim Vijay Bhargava Scholarship" en reconnaissance des excellents services fournis par Prof. Vijay Bhargava à cette Section, IEEE Canada et le IEEE. La Section d'Alberta du sud a célébré son 50e anniversaire le 27 septembre 2006, et celle de Saskatchewan du sud le 27 octobre. Nous sincères félicitations.

Nous avons travaillé de près avec le Site d'emploi du IEEE pour encourager la promotion des compagnies canadiennes sur notre site internet. Nous avons fait bon progrès et vous encourageons à visiter notre site http://careers.ieee.org.

Le IEEE s'est récemment engagé dans plusieurs initiatives pour améliorer les service à nos membres et au public. Ceci inclut IEEE.tv, un réseau de diffusion internet qui produit et livre de la programmation spécialisée sur la technologie et le génie. Nous avons aussi lancé « TryEngineering » qui est destiné aux étudiants préuniversitaires, parents, enseignants, conseillers scolaires, et le grand public. « TryEngineering.org » permet aux visiteurs d'explorer comment se préparer à une carrière en génie, poser des questions sur le génie à des experts, et jouer à des jeux interactifs.

Le IEEE Canada a tenu sa réunion d'automne du 15 au 17 septembre 2006 à Toronto. Durant cet événement un atelier de formation étudiante, une réunion DDD et la Compétition Telus se sont tenus. Cette année des étudiants de 10 universités ont soumis des projets en compétition pour 10 000$ de prix. Un panel de six juges : deux de Telus, deux de l'industrie et deux du IEEE Canada, a été formé pour cet événement. Nous sommes reconnaissants envers Telus de financer ce projet et fournir un forum à nos étudiants pour faire progresser leur innovation technique. Comme témoignage du calibre du travail effectué par nos jeunes ingénieurs, lisez l'article en page 8 qui présente une solution à un problème de contrôle de pendule inversé monté sur un robot autonome. Les auteurs de cet article ont gagné le Prix d'Innovation Telus l'an dernier ainsi que le Prix des membres à vie de l'IEEE Canada. Avec de tels talents parmi la prochaine généra-

With such talent within the ranks of Canada's next generation of technology leaders, our country's position in the economy of the future looks positive indeed. For results of such competitions and all the most up-to-date news and announcements, please visit our website at www.ieee.ca.

I had the opportunity to witness the talent of yet another, much younger group of students at the Ottawa Section-organized Fourth Annual Ottawa Robotics Competition, held in conjunction with CCECE '06. Sponsored by the Faculty of Engineering at the University of Ottawa, the competition drew 18 teams from across the city with 103 elementary school students participating. Congratulations to Ottawa Section for this highly successful outreach project, which is featured on page 26.

By now you will have received the 2006 IEEE annual election ballot material. We have excellent candidates running for offices. I appeal to all members to exercise their duty and vote for the candidates of their choice and participate in advancing the goals of IEEE. I also encourage our members to attend our section events, seminars and special meetings as well as considering becoming a volunteer.

Congratulations to the Newfoundland & Labrador section for hosting an event on September 24, 2006, that recognizes as an IEEE Engineering Milestone the site of the 1st Transatlantic Telephone Cable (TAT-1) between Clarenville, Newfoundland and Oban, Scotland. A summary of the day's events is presented on pages 16 and 17. To date, IEEE has recognized 60 Milestones worldwide, three of which are located in Newfoundland. This is indeed a prestigious honour for Newfoundland and we hope that other regions within Canada will follow suit.

As I mentioned in my last column, I am very grateful to all our volunteers in IEEE Canada, who work hard to serve our 15000 members across this beautiful country.

tion de leaders technologiques, la position du Canada dans l'économie du futur se présente bien. Pour les résultats de ces compétitions, les annonces et nouvelles les plus récentes, veuillez consulter notre site web à www.ieee.ca.

J'ai eu l'opportunité de constater le talent d'un groupe d'étudients beaucoup plus jeune lors de la 4e Compétition annuelle de robotique d'Ottawa, organisée par la Section d'Ottawa et tenue conjointement avec le CCGEI'06. Commandité par la Faculté de génie à l'Université d'Ottawa, la compétition a attiré 18 équipes comprenant 103 étudiants du niveau élémentaire. Félicitations à la Section d'Ottawa pour le très grand succès de ce projet, illustré en page 26.

Vous devriez avoir reçu vote bulletin de vote pour les élections annuelles IEEE 2006. D'excellents candidats se présentent. J'en appelle à tous les membres de faire leur devoir et exercer leur vote pour les candidats de leur choix, et participer à faire progresser les buts de l'IEEE. J'encourage aussi nos membres à participer aux événements, séminaire et réunions spéciales de sections ainsi qu'à considérer devenir volontaires.

Félicitations aussi à la Section de Terre-Neuve et Labrador pour avoir tenu événement le 24 septembre 2006 célébrant par une Borne de génie IEEE le site du premier câble téléphonique transatlantique (TAT-1) entre Clarenville, Terre-Neuve et Oban, Écosse. Un résumé de cette journée est présenté en pages 16 et 17. Jusqu'à présent le IEEE a inauguré 60 bornes à travers le monde, dont trois à Terre-Neuve. Il s'agit d'une reconnaissance prestigieuse pour Terre-Neuve et nous espérons que les autres régions du Canada s'en inspireront.

Je suis reconnaissant envers tous les volontaires du IEEE Canada, qui travaillent fort pour servir nos 15 000 membres à travers ce beau pays.

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Canadian Newslog / Coupures de presse canadienne

Newslog Editor

Rédacteur des Coupures de presse

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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

MONTREAL, QC. Sept. 8, 2006. Miranda Technology has announced the launch of a product which combines multi-room, multi-image display plus routing in a single chassis. Each chassis can display 96 multi-format video inputs any number of times, in any size, across eight displays of any resolution and orientation. As a router, it offers switching of 96 inputs to 48 HD/SD outputs for feeding quality monitors, test equipments and master control of production.

GAITHERSBURG, MD. Aug. 8, 2006. Simutronics has announced today its first licensee for its new HeroEngine, a complete integrated platform for development of massively multiplayer online (MMO) role-playing games (RPG). BioWare Austin will use HeroEngine for development of its new MMO project. MMO games are the faster growing segment of the video games market with two billion dollars in global revenues.

TORONTO, ON. Jun. 12, 2006. Comnetix, a leading provider of biometric and identification solution has announced today that it has received a formal "intent to Award" notification from the Kern County Sheriff's Department in California for its county wide fingerprint live scan system. The system is expected to consist of several components of the company's intelligence suite of software solutions.

TORONTO, ON. Jul. 17, 2006. Route1, a market leader in providing secure, identity-managed remote computing solution has announced that the Route1 MobiKey embraces the new federal requirements for laptop encryption and two-factor authentication mandated for civilian agencies. The Route-1 MobiKey is an ultra-portable computing solution embedded on a cryptographically-enabled USB token device that stores a user's identity in order to ensure secure access to desktop and network resources from any Internet-enabled, Windows-based PC. The MobiKey is a virus, malware and attack resistant solution.

TORONTO, ON. Jun. 6, 2006. Comverse and Rogers wireless have announced the launch of instant messaging (IM) on Rogers wireless network based on Comverse Mobile IM solution. The Comverse Mobile IM solution brings instant messaging to the mobile environment, providing a desktop-like IM experience that is designed to encourage immediate service adoption and usage. The service will enable Rogers subscribers to initiate and engage in discussions through Yahoo messenger and MSN messenger anywhere anytime from the convenience of their mobile phone.

BEIJING, Apr. 25, 2006. Avaya has announced that Zongshen, a leading player in China's motorcycle industry has implemented an Avaya IP telephony solution to build a communication system that connects its headquarters to 49 branches across the country. Employees in all of Zongshen's offices can now enjoy rich and secure IP telephonic functionalities. For instance, with the fax over IP technology of the platform, internal daily working reports can be exchanged via fax rapidly.

MISSISSAUGA, ON. Aug. 31, 2006. Eruces, a provider of data encryption software is licensing Certicom's security modules to add Suite B algorithms to its products. Under the agreement, Eruces has licensed Certicom's security builder GSE which includes AES for encryption and elliptic curve cryptography implementations for digital signatures and key management as well as security builder SSL which includes a standards-based Transport Layer Security protocol module for implementing a secure tunnel between a server and client device.

MONTREAL, QC. Jun. 8, 2006. Nstein Techologies is pleased to announce that its chairman and chief executive officer, Mario Girard has been named Quebec's Personality of the Year in Information Technology for 2005. This honor was awarded by the Federation de l'Informatique du Québec during its annual OCTAS Gala which was held recently.

OTTAWA, ON. May 18, 2006. March Networks, a leading provider of Internet protocol-based digital video surveillance solutions, has announced that a US-based department store has selected March Network Platform as its enterprise-wide digital video solution. The retailer, with approximately 600 stores and outlets, has started deployment of the March Networks solution that will be used to improve store security, reduce loss and enhance operational efficiency.

QUEBEC CITY, QC. Aug. 22, 2006. Medical Intelligence Technologies has announced that its French subsidiary has signed an agreement with financial institution Locam for the factoring of a substantial portion of its subscription revenues from its Columba phone bracelet tele-security services. The agreement provides for Locam to advance Medical Mobile a significant portion of the subscription revenues for agreements signed by the company with institutions that purchased the bracelet. Locam will also be responsible for billing and collecting monthly subscription fees from institutional customers. The Columba form bracelet is used to prevent disappearance among of Alzheimer's patients.

TORONTO, ON. Aug. 1, 2006. Tri-vision International has announced today that it has licensed its V-chip technology under US Patent No5,828,402 to Syntax-Brillian Corporation and Taiwan Kolin Company. The license covers all digital receivers products produced for sale in the United States. The license is valid through the expiration of the Patent in 2016.

TORONTO, ON. Jul. 17, 2006. Mass Engineered Design and Jerry Moscovitch have filed a patent infringement lawsuit on July 7, 2006 against Dell, CDW, Tech Data Corp, and Ergotron. The lawsuit alleges that certain of the defendants' multi-display units infringe Moscovitch's US Patent. Moscovitch is the founder of Mass Engineered Design, a Canada-based firm producing fully integrated multi-screen display solutions.

BEIJING. Jun. 7, 2006. The Ministry of Railways in China is announcing an enhancement of the customer service for millions of rail passenger by boosting the performance and capacity of its computerized ticketing and reservation system using a Nortel Solution. The Nortel solution will enabled the issue of two hundred thousand tickets each day during peek travel time. The Nortel solution which enable application optimization delivery and availability though the use of sophisticated application and device while balancing; intelligent traffic management, application redirection, application layer security, security acceleration and bandwidth management.

A View from the West

By Terrance Malkinson
University of Calgary Senate Member

- The Alberta Energy and Utilities Board (EUB) predicts continued massive growth in the oilsands sector, where more than $100B worth of projects is scheduled for construction in the next decade. Oilsands production is expected to triple in the next 10 years to three million barrels a day. Concerns however have been expressed on the need to improve the infrastructure necessary to support the development, improve transportation to the area, and ecological issues associated with oilsands development.

- More than 500 people met in Edmonton (Alberta) in July at the 16th annual summit of the Pacific NorthWest Economic Region to examine energy workforce issues. http://pnwer.org/meetings/Summer2006/06%20Summit.htm. At least $US 100B in energy projects are projected over the next ten years to meet the unprecedented growth in the regions energy sector to accommodate rises in power demand. The projects will require a huge workforce. Indeed a looming labour shortfall in many business sectors is of concern to industry leaders.

- Enmax Energy Corporation and its partners have been chosen by BC Hydro to develop four "green" energy generation projects that will come on-steam over the next three years. Two of the projects are run-of-river hydro plants of 10 megawatts each and the remaining two projects will generate clean electricity using waste heat recovered from gas compressor stations.

- WestLink Innovation Network Ltd (http://www.westlink.ca/) is a university-based network for coordinating activities, bundling technologies and sharing information between its members. One of the strategies offered by WestLink is its technology commercialization internship program (TCIP) that specializes in developing Canada's future technology commercialization leaders. They help develop people who know technology but who also know management and have entrepreneurial skills.

- Industry Canada's office of consumer affairs in Ottawa recently released a 90-page guide which offers step-by-step information on how to adopt Corporate Social Responsibility (CSR). "Corporate Social Responsibility: An Implementation Guide for Canadian Business"(http://strategis.ic.gc.ca/epic/internet/incsr-rse.nsf/en/Home). CSR is generally understood to be the way an organization achieves a balance or integration of economic, environmental, and social imperatives while addressing shareholder and stakeholder expectations. Corporate social responsibility is a concept that is increasingly being incorporated into good business practice within Canada and globally.

- The Natural Sciences and Engineering Research Council of Canada (www.nserc.gc.ca) recently announced 475 new grants worth $56.7M and 922 scholarships worth $15.9M in the prairie provinces. NSERC supports over 22,000 university students and postdoctoral fellows in their studies. NSERC awards are building a world-class research environment throughout Canada creating the skilled workforce needed to sustain economic growth and job creation.

- It is hoped that the softwood lumber deal between Canada and the US will help revitalize the forestry industry which for 20 years has struggled through closures, downsizing, globalization, and many other pressures. Softwood lumber is one of Canada's largest exports to the United States, with 21.5 billion board feet of lumber shipped in 2005 alone. Those exports were worth $8.5B. This trade matters to both Canadians and Americans. Canada's forestry sector employs approximately 280,000 Canadians, and roughly 300 communities are dependent upon the forestry sector. US lumber producers cannot meet domestic demand for softwood lumber. Canada now supplies over a third of the United States' consumption of this product.

- Alberta-based SemBioSys Genetics Inc. (www.sembiosys.com) a biotechnology company focused on the development, commercialization, and production of biopharmaceuticals and non-pharmaceutical products based on its proprietary technologies recently received is 20th US patent. SemBioSys' management and scientific team members are active contributors to the plant-made pharmaceutical scientific community and have been at the forefront of developing regulations for the production of pharmaceutical producing plants, working with the USDA, the FDA and the Canadian Food Inspection Agency (CFIA).

About the Author

Terrance Malkinson is a proposal manager/documentation specialist, an elected Senator of the University of Calgary, a Governor of the Engineering Management Society, international correspondent for IEEE-USA Today's Engineer Online, editor-in-chief of IEEE-USA Today's Engineer Digest, and editor of IEEE Engineering Management. The author is grateful to the Haskayne School of Business Library at the University of Calgary. He can be reached at malkinst@telus.net .

Stabilization of an Inverted Pendulum on a Mobile Robot

By Andrew Roberts[1], Marc Kennedy[2], Alex Nequest[3]

[1] Lakehead University, Thunder Bay, ON

[2] Research In Motion, Waterloo, ON

[3] Laipac Technologies, Richmond Hill, ON

Abstract

The inverted pendulum stabilization problem is commonly studied in control theory since it clearly demonstrates how a nonlinear system can be locally stabilized while visually observing the performance. Implementation of previous inverted pendulum experiments required large power supplies and a geared track. The system sensors and motors were previously hard-wired to a nearby PC which performed the necessary calculations. The objective of this project is to implement an embedded control system on a mobile robot, with all sensors, actuators, and other required components to be contained in a small, lightweight package, without compromising the power required to stabilize the pendulum. The implementation of such a system demonstrates the ability to create other fully autonomous robotic systems which use a comprehensive embedded control system, while having powerful and lightweight physical characteristics. Although there are no direct applications for the inverted pendulum, this project is a demonstration of how autonomous robotic applications can be implemented in various fields, for example lightweight autonomous aircraft.

Sommaire

Le problème de stabilisation d'un pendule inversé est couramment étudié en théorie du contrôle car il démontre clairement comment un système non-linéaire peut être stabilisé localement tout en observant visuellement son comportement. Les implantations précédentes de pendules inversés exigeaient de gros blocs d'alimentation et une piste dentée. Les senseurs et moteurs étaient branchés à un micro-ordinateur qui exécutait les calculs nécessaires. L'objectif de ce projet était d'implanter un système embarqué de contrôle sur un robot mobile avec tous les senseurs, actuateurs, et autres composantes requises contenues dans un ensemble léger, sans compromettre le courant nécessaire pour stabiliser le pendule. L'implantation d'un tel système démontre la possibilité de créer d'autres systèmes robotisés entièrement autonomes qui utilisent un système de contrôle embarqué complet, tout en étant puissants et légers. Quoiqu'il n'existe aucune application immédiate pour un pendule inversé, ce projet démontre comment des applications robotiques autonomes peuvent être implantées dans plusieurs domaines, par exemple les aéronefs autonomes légers.

1.0 Introduction

The problem of stabilizing an inverted pendulum is very challenging and requires a system which can react quickly and predictably. In the past, systems of this type have been mounted on geared tracks, giving perfect traction while also being controlled and powered by third party machines such as computers and power supplies [C]. This makes for a system that is predictable and effective, yet limited in its range of motion by physical connections.

The objective of this project was to design and implement a mobile platform, free of physical constraints imposed by third party devices, on which all control, motive force, and power could be enclosed in one unit. Not only was our mobile platform to maintain the vertical position of the pendulum, but to also maintain a wirelessly inputted, user defined cart position.

In order to implement a stand-alone inverted pendulum system, or any robotic platform, significant consideration must be given to the physical construction of the system. For this system, powerful actuators or motors were required to achieve the desired acceleration of the platform in order to stabilize the pendulum. This requirement places a large demand on the battery or power source which is often the heaviest component in a robotic system.

The proposed control system for this experiment is model-based, which requires a dynamic model for the physical system. A control law was formulated using the linear quadratic regulator (LQR) method. In order to develop the controller, a linear approximation to the nonlinear system model must be made.

2. Physical System

The components housed inside the enclosure include 2 drive-train assemblies, 2 motors, 2 batteries, 2 optical encoders, and 2 electronic speed controls. Every moving part has a ball bearing in order to reduce friction as much as possible to ensure reliability and consistency.

Two independent drive trains were implemented for future development of the system to allow for the cart to move in two dimensions, rather than a straight line. Future work could also involve remove the 'training wheels', thus creating a double inverted pendulum system.

To gain as much traction as possible, every consideration was taken to maintain a low center of gravity and a large contact patch with the ground. To maintain a low center of gravity, the largest masses (motors and batteries) were mounted as low in the cart as possible and centered. This low center of gravity allows the car to change direction quickly while minimizing the tendency for the momentum to lift the wheels off the ground. To gain as much grip as possible, the softest rubber tires available were chosen.

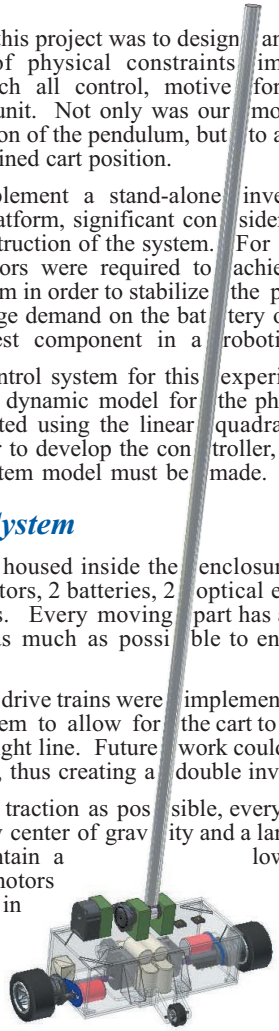

Fig. 1: Mobile Robot Chassis with Pendulum

2.1 Power Train Electronics

The power train components of the vehicle consist of 2 motors, 2 electronic speed controllers, and two 5-cell battery packs. All of the parts were designed for specific use in 1/18th scale model cars, and thus, are small, efficient, and reliable. Selecting quality parts ensures that predictable operation remains uniform over the course of the experiment.

DC Motor

The permanent magnet DC motor selected for use in this experiment is the Team Orion Big Block shown in Figure 2. The Big Block design makes it ideal for use in this experiment due to its high torque abilities, high rpm, and compact form factor. Although this particular motor is widely used in the 1/18th scale model car scene, the manufacturer Team Orion has not performed physical tests yielding technical data such as torque constants and armature resistance values. Therefore, necessary experiments were performed to determine the motor physical characteristics.

Fig. 2 - Team Orion Big Block Motor

N.Ed. The article presented here stems from a project that won the first IEEE Canada Telus Innovation Award in September 2005, and the IEEE Canada Life Member Award in December 2005. We are grateful to TELUS for sponsoring this very popular activity.

N.Ed. Cet article est issu d'un projet qui a remporté le premier Prix d'Innovation Telus de l'IEEE Canada en septembre 2005, et un Prix des Membres à vie IEEE Canada en décembre 2005. Nous sommes reconnaissants envers TELUS pour sa commandite de cette activité très populaire.

Electronic Speed Controls (ESC)

Purchasing an electronic speed control offers several advantages over designing a motor controller. Firstly, the ESC is housed in a small form factor case that easily integrates into our chassis. The case measuring (28.4mm x 24.1mm x 12.1mm) is lightweight and specially suited to the Team Orion Big Block motor. Second, the device is capable of handling a peak current of 25A while maintaining a high level of efficiency and linearity. These features along with precision quality provide a high level of reliability and accuracy.

The ESC chosen for the system is the Team Novak Micro Spy ESC. This powerful ESC is capable of operating between 4.8V to 8.4V. The design for the inverted pendulum utilizes 5 cells or 6.0V in operation. Pictured below in Figure 3, the ESC is ready built with all the appropriate connections and required no modifications to be fitted to the design.

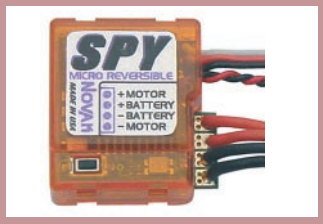

Fig. 3: Novak Spy ESC

Fig. 4: Team Losi 5-Cell Battery Pack

The ESC controls the speed and direction of the motor using a pulse-width modulated (PWM) input signal operating at a fixed frequency of 51Hz. Depending on the duty cycle of the PWM signal, the ESC will modify the direction and speed of the motor. The corresponding output signal of the ESC is also a PWM signal with a frequency of 1 kHz, duty cycle varied between 0% - 100% and a switching polarity corresponding to the desired direction. The neutral position or off position is located at 7.5% duty cycle. Since this range of operation is small, the system microcontroller must have the ability to vary the duty cycle accurately. When selecting a microcontroller for the system one must consider the minimum obtainable PWM frequency which is dependant on the crystal frequency in addition to the available pre-scale (or frequency divide) registers on the device.

Batteries

Since the vehicle is completely standalone, powerful batteries are required to supply the necessary current to the motors. Experimentation with a wide variety of batteries led to the conclusion that specially designed battery packs were required. High capacity NiMH AA batteries grouped together in parallel were initially used since they are small and lightweight. However, upon experimenting, they did not provide the high current demanded by the motors. This failure led to the use of specially designed packs for use in 1/18th scale model cars. Team Losi 5-cell sport packs (Figure 4) proved to be the best source for power. Their NiMH composition and small form factor fit perfectly into the vehicle and are easy to remove and recharge.

2.2 Digital Control Electronics

Accompanying the digital signal controller on the circuit board are a host of other purpose designed ICs. These include two 24-bit quadrature counters, remote control decoder, wireless RF receiver, 555 timer (used for filtering), and a low dropout voltage regulator. Connected to the pendulum (through gears) and each wheel are optical encoders shown below.

Fig. 5: HEDS-5500 Optical Encoder
(printed with permission of Avago Technologies)

Avago Technologies HEDS-5500-A06 Optical Encoder

The HEDS-5500-A06 is a high performance metal code-wheel incremental optical encoder. Using an infra-red LED light source and matching detector IC, the HEDS-5500 provides 500 increments per revolution. The encoder provides an accurate account of the shafts position via 2-phase differentiated square wave signals. These phase differentiated channels are transmitted to the quadrature encoder counter to increment or decrement the counter values based on the direction of shaft rotation.

US Digital LS7266 Dual-Axis Quadrature Encoder Counter

The quadrature encoder counter (QEC) is used to record the number of pulses received from the optical encoders. The quadrature encoders communicate to the counters using two phase differentiated square waves. By using the two square waves it is possible to determine the direction of rotation on the encoder. The counters convert the pulses into a quantitative value that can be retrieved by the systems processor for use in calculating the linear and angular positions. The control design for the inverted pendulum makes use of 2 dual-axis QEC ICs to accommodate for the systems 3 optical encoders.

Resolution is an important concern when dealing with precision measurements. Like many QEC ICs, the LS7266 makes use of resolution multipliers. This user selectable mode allows for x1, x2, and x4 mode of operation, where x4 mode represents an effective increase of 4 times the normal operating resolution of the optical encoder by making use of all edge transitions of the square waves. This increase in digital resolution coupled with the 1:5.3 gear ratio of the pendulum gives us an effective 10615 increments per revolution and an accuracy of .03 degrees. The resolution multiplier of the linear measurement is set to x2 mode giving 1000 increments per revolution of the wheels, which translates to an accuracy of 0.17mm.

Microchip dsPIC 30F4011 Digital Signal Controller

The dsPIC30F4011 digital signal controller (DSC) is a single chip that seamlessly integrates the control attributes of an advanced microcontroller (MCU) with the computational abilities and robustness of a digital signal processor (DSP). The 30F4011 was chosen as the primary controller for several reasons. Integrated PWM control, optimization for C code, flexible re-programmability, and DSP abilities are all features that a designer might consider when developing an embedded controller.

One purpose of the DSC is to translate the data obtained from the quadrature encoder counters (QEC) into tangible values of linear and angular positions of the wheels and pendulum, respectively. Having obtained the instantaneous pendulum angle and wheel positions, the pendulum angular velocity and each wheel linear velocity must be calculated. Since the pendulum angle and wheel position are obtained using discrete devices, filtered derivatives are used to calculate system velocities. Once these values (or system states) are obtained, the corresponding state space feedback gains are applied. The DSC is also required to control the cart position through the use of integral control. The control system integration as well as the filtered derivatives are evaluated using numerical methods by the DSC.

In order for accurate control of the speed, the output of the DSC must meet the requirements of the ESC. The 30F4011 has a 3 channel PWM module, each with independent duty cycle registers.

Since the DSC communicates with a host of other ICs on the controller board, a number of inputs and outputs (I/O) were required. Port-B on the 30F4011 is a dedicated 8bit data bus interfacing the LS7266 Quadrature Encoder Counters to the DSC. In addition to the 8bit bi-directional bus, 5 control lines are used for full communication and control of the LS7266.

The programming environment supplied with the 30F4011 is Microchips MPLAB Integrated Development Environment (IDE). MPLAB (IDE) is a free, integrated toolset for the development of embedded applications using the dsPIC and other families of microcontrollers. Since many of the system control algorithms would be tedious to program in assembler, the use of a C-code compiler was used. The Hi-Tech C-compiler is designed to work with the MPLAB environment allowing the programmer to use both C and assembly languages. Programming of the 30F4011 DSC was completed onboard the vehicle via the Microchip ICD2™ through an RJ-45 modular adaptor. The ICD2 is a combination of an In-Circuit-Programmer and an In-Circuit-Debugger. Utilizing the ICD2 had many advantages including quick and easy debugging and eliminated the need to remove the 30F4011 IC. The 30F4011 can also be programmed via a separate universal adaptor.

2.3 Wireless Transmitter and Receiver

Controlling the linear position of the cart via a fixed physical connection was not an option since it would require cables to be dragging along with the cart during operation. This setback would prove to be a nuisance and would take away from the vehicles "cable-free" design. Thus, wireless functionality was added.

ABACOM AM-RT5-433 Transmitter & Holtek HT12-E Remote Encoder

A wireless link was required to start and stop the system, as well as increment or decrement the desired cart position. In order to accomplish this, a handheld transmitter and encoder were needed. The choice was made to use a Tx/Rx combination commonly used widely in robotics and remote control applications. The devices chosen for use in the remote control were the ABACOM AM-RT5-433 RF transmitter and the Holtek HT12-E remote encoder.

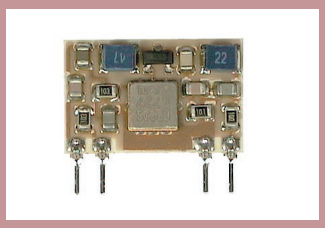

Fig. 6: AM-RT5-433 RF Transmitter

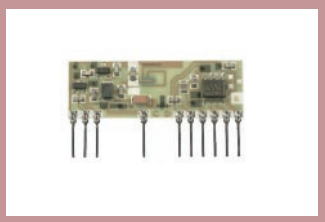

Fig. 7: AM-HRR3-433 RF Receiver

The AM-RT5-433 is an amplitude modulated 433MHz complete transmitter module. As seen in Figure 6, the RT5 is very small and has no adjustable components. A simple whip antenna measuring 16cm simplified the design by removing the need to integrate a helical or loop antenna.

Given that the transmitter will be performing multiple functions, an encoder was needed to convert the multiple push buttons into a single data stream that the RT5 could transmit. This was achieved using a parallel to serial data encoder. The HT12-E encoder is a 12bit (8bit address, 4bit data) wide encoder used for remote control applications. Its minimal external components and low standby current make it ideal for use in portable applications.

ABACOM AM-HRR3-433 Receiver & Holtek HT12-D Remote Decoder

Incorporated into the controller board are an RF receiver and a remote control decoder. The decoder transmits data to the DSC which then actuates the corresponding pins. The devices chosen to perform these operations are the sister components of the transmitter and encoder ICs which are the AM-HRR3-433 RF Receiver and the Holtek HT12-D Remote decoder.

The AM-HRR3-433 is an AM demodulating compact hybrid RF receiver used to acquire the signal sent by the RT5 transmitter. The HRR3 operates on a single supply of 5V and requires no adjustments or tuning which often isn't the case for stable regenerative receivers.

Only 4 connections are required on the HRR3 which are VCC, GND, ANT, and DATAout. Similar to the RT5, the HRR3 receiver utilizes a 16cm whip antenna as its means of receiving the signal.

Decoding of the signal is performed by the HT12-D decoder. The HT12-D is the complement of the HT12-E used in the handheld transmitter. Its address/data structure is identical to the HT12-E which translates to a received 4bit wide data bus. An important feature of the HT12-D is its built-in error checking. This error checking is performed for verifying the received words 3 times over ensuring that the intended signal is the one received. Once the data is verified, the 3 corresponding bits are then transmitted to the DSC so the corresponding operation may be carried out.

3. Dynamic Model

A nonlinear dynamic model of the system was formulated using the Newton-Euler method[1], and is given by equations (1) and (2). The model includes the dynamics of the motor and uses the motor voltage as the input to the system.

$$\ddot{\theta} = \left(\frac{mg\ell\sin\theta}{I+m\ell^2}\right) + \left(\frac{-m\ell\cos\theta}{I+m\ell^2}\right)\ddot{x} \qquad (1)$$

$$\ddot{x} = \left(\frac{-m\ell\cos\theta}{m+M}\right)\ddot{\theta} + \left(\frac{-k_G k_T)^2}{(m+M)r^2 R_a}\right)\dot{x} + \left(\frac{m\ell\sin\theta}{m+M}\right)\dot{\theta}^2 + \left(\frac{k_G k_T}{(m+M)rR_a}\right)V \qquad (2)$$

where,

θ = Pendulum angle
ℓ = Pendulum length
I = Pendulum moment of inertia
m = Pendulum mass
x = Cart position
M = Cart mass
k_T = Motor torque constant
k_G = Motor gear ratio

3.1 MATLAB® Non-Linear System Block

The dynamic model given by non-linear equations (1) and (2) are used to create a model file in MATLAB®. The non-linear system block is also used to specify initial conditions for x, θ, and their derivatives.

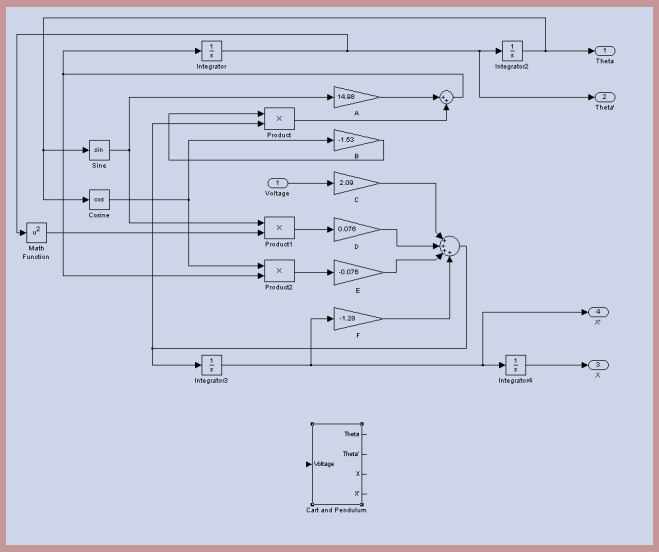

Fig. 8: Non-Linear System Model

3.2 Dynamic Model Linearization

A linear approximation to the non-linear system equations is obtained using the small angle formula. This leads to linear expressions (3) and (4) relating the linear acceleration and pendulum angular acceleration, respectively.

$$\ddot{x} = \left(\frac{-(m\ell)^2 g}{(m+M)I+mM\ell^2}\right)\theta + \left(\frac{-(k_G k_T)^2(I+m\ell)^2}{((m+M)I+mM\ell^2)r^2 R_a}\right)\dot{x} + \left(\frac{k_G k_T(I+m\ell^2)}{((m+M)I+mM\ell^2)rR_a}\right)V \qquad (3)$$

$$\ddot{\theta} = \left(\frac{mg\ell\left((m+M)I + mM\ell^2\right) + (m\ell)^3 g}{(I+m\ell^2)((m+M)I + mM\ell^2)} \right)\theta + \left(\frac{m\ell(k_G k_T)^2}{((m+M)I + mM\ell^2)r^2 R_a} \right)\dot{x} + \left(\frac{-m\ell k_G k_T}{((m+M)I + mM\ell^2)rR_a} \right)V \quad (4)$$

4. Control Design

In order to stabilize the pendulum at its unstable equilibrium point and the cart at an adjustable linear set-point, a closed loop state feedback control was implemented. To calculate the corresponding controller gains, the Linear Quadratic Regulator (LQR) method was used [2].

In order to ensure a zero steady-state error for the linear set-point, a tracking controller was added. This tracking controller integrates the difference between the cart's position and the desired set-point over time and slowly develops an error signal which corrects any deviation.

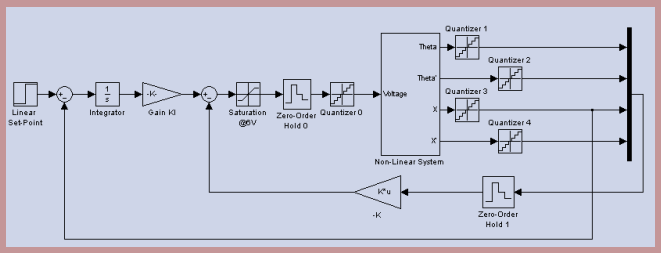

Fig. 9: MATLAB System Block Diagram

Non-Linear System Stabilization Simulations

Having obtained a control law from the LQR method based on the known system physical parameters, simulations were performed to determine the controller performance. Since the controller is based on a linearization of the system around its equilibrium point, or when the pendulum is vertical, the simulations help reveal the range of the initial pendulum angle which the controller is able to stabilize. For the given simulation, the ability of the control to respond to a pendulum angle of 10 degrees is tested while the linear position of the cart is changed to 1m.

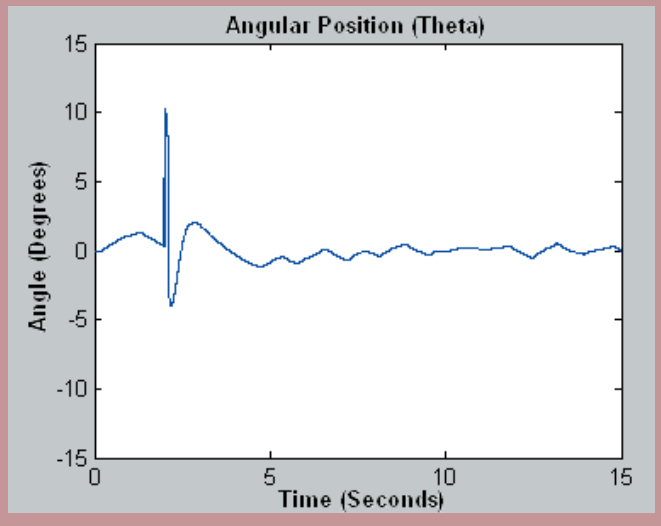

Fig 10: Angular Position with Disturbance

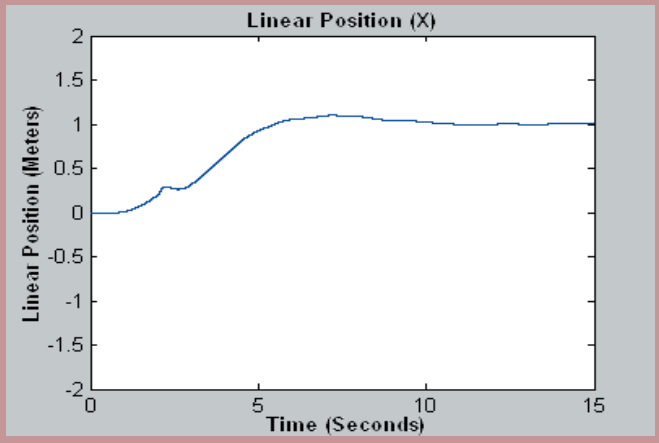

Fig. 11: Linear Position with Disturbance

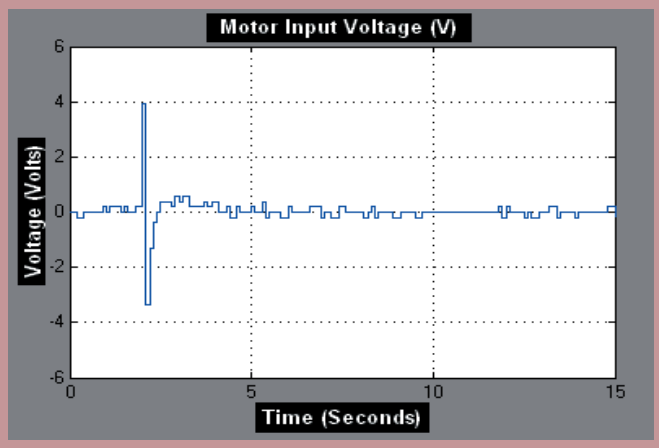

Fig. 12: Voltage Applied to Motor for Disturbance

5. Software Design

In addition to the communication with all system peripherals, the microcontroller was required to perform a number of calculations pertinent to the control system implementation. Programming these floating-point algorithms using fixed-point assembly architecture would prove to be very difficult. This was avoided through the use of the Hi-Tech C compiler which allowed for these algorithms to be programmed in C while allowing for the communication of the other electronics using assembly language.

5.1 Numerical Algorithms

Since the control design required the calculation of system velocities and the integration of an error signal, numerical representations of continuous time algorithms were obtained to be programmed in the DSC using C.

Filtered Derivatives

The equation for a filtered derivative in continuous time is given in (5), followed by an equivalent discrete-time version given by (6). These filtered derivatives are used to calculate the pendulum angular velocity and each wheel linear velocity in discrete time.

$$\dot{X} = \frac{s}{\tau s + 1} X \quad (5) \qquad \dot{X}_f^{(1)} = \frac{\tau \dot{X}_f^{(0)} + X^{(1)} - X^{(0)}}{\tau + T_S} \quad (6)$$

$\dot{X}_f^{(1)}$ = Current value for filtered derivative
$\dot{X}_f^{(0)}$ = Previous value for filtered derivative
$X^{(1)}$ = Current value of state variable
$X^{(0)}$ = Previous value of state variable
τ = Filter time constant (reciprocal of filter cut-off frequency)
T_S = Loop sampling time.

Set Point Integrator

The set point integrator is used to develop an error signal based on the integral of the difference between the desired set point and the actual linear position of the cart. The trapezoid method is used to calculate this integral. Similar to the filtered derivative, the trapezoid method uses previous and current values for the state variables, as well as a previous value for the integral. The expression used to approximate value of the integral is given by equation 7.

$$\int_0^{(k+1)T} (x_d - x)dt = \int_0^{kT} (x_d - x)dt + T_S\left(x_d - \frac{x^{(1)} + x^{(0)}}{2}\right) \quad (7)$$

5.2 Applying Control

Once all state variables have been calculated, the controller uses the gains to determine the required motor voltage. The required voltage is given by equation 8.

$$V_{motor} = -k_1\theta - k_2\dot{\theta} - k_3 x - k_4\dot{x} + k_I\int(x_d - x)dt \quad (8)$$

The program calculates the required motor voltage but then must convert it into a value corresponding to the correct duty-cycle. Any dead-zone associated with the ESC must also be accounted for. The program calculates the change in the duty cycle register value required to obtain the motor voltage and places it in the corresponding duty-cycle register.

5.3 Direction Control

Initially, the same signal was applied to each speed controller. Due to differences in the electronic speed controllers, motors, and/or mechanical differences, the trajectory of the robot did not follow a straight line. This problem was corrected without remodeling the system; however, it would be ideal to derive a model in 3 dimensions to account for the direction of the cart. To account for this problem the difference in position between the two wheels is calculated during every loop. When the difference in position exceeds 1cm a small effort is applied to the lagging wheel by adding or subtracting 2 increments from the corresponding duty-cycle register. Choosing which wheel is boosted depends on the direction of the cart. As shown in Figure 13 if the cart is moving in the upwards direction, the left wheel is boosted by 2 increments. If the cart is moving in the downward direction, the right wheel is boosted.

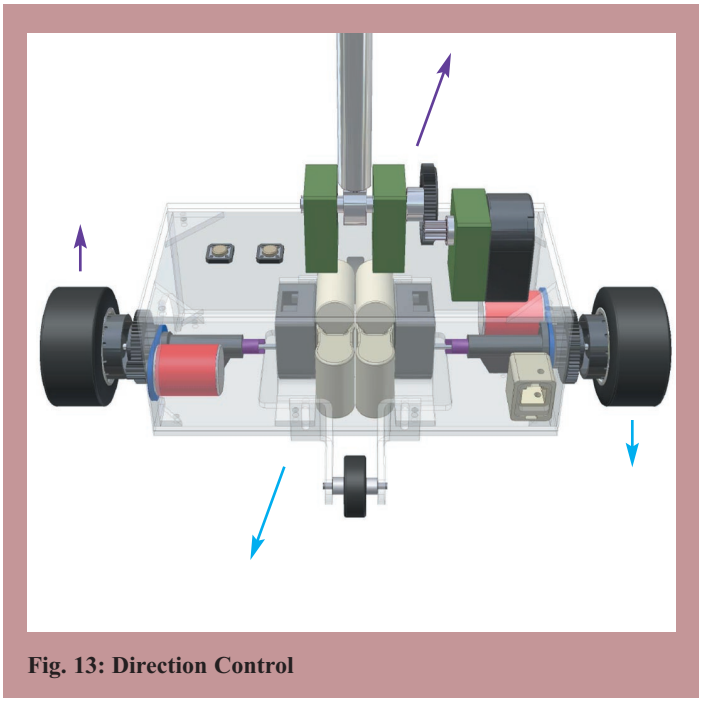

Fig. 13: Direction Control

Since the boost is not accounted for in the control system, it is important that its effect be as small as possible to avoid disturbing the desired control signal which could result in system failure.

6. Experimental Results

Although quantitative data was not available, the experimental results were observed to be similar to the simulations. The maximum capture range for the robot was observed to be approximately ±10°. For any greater disturbance, the cart can not change direction quickly enough to re-stabilize. This is due mainly, once again, to the lack of static friction required to overcome the momentum of the cart.

In practice the linear position of the cart tends to oscillate more so than in the simulations. We can see from the simulations that the linear position varies only slightly from the set-point. In practice, however, we notice that the cart will tend to oscillate about ±0.1m while stabilizing the pendulum about ±1°. When moving to a new set-point, we noticed that in practice it takes considerably longer for the cart to reach the new location, and with more oscillation. This oscillation was most likely caused by the backlash on the gears connected to the pendulum encoder. Inaccuracies in physical parameters of the dynamic model, for example changes in battery voltage, are also likely explanations for differences in simulations and experimental results.

The results obtained from the robot vary significantly depending on the value given for the time constant of the digital filters used in the filtered derivatives. A low value for the time constants would cause the robot to react faster to disturbances. This could intensify the problems with traction. If larger values were entered for the digital filters, the robot would react slower and more sluggish. This could lead to prolonged oscillation of the pendulum.

7. Conclusion

The goal of this project was to create a completely stand-alone, remote controlled, inverted pendulum balancing robot. State-space representation with a linear quadratic regulator control algorithm was used to determine the controller gains. The control system was implemented using a digital signal controller. To measure the linear positions and pendulum angle, three optical encoders with 2 dual quadrature counters were used. The drive-train utilized two programmable electronic speed controllers that powered two independent permanent magnet DC motors.

The physical model of the inverted pendulum on a cart was modeled in 2 dimensions using the Newton-Euler method. The non-linear model was used to develop a linear controller based on the linear approximated system equations. The linear control of the non-linear system was subsequently modeled and simulated using MATLAB.

The obtained model did not account for friction or non-linear performance of the electronic devices. The model only considered two dimensions which neglected turning of the robot. This could result in differences between the simulated and observed results. Due to the stand-alone nature of the robot it is difficult to send quantitative data to a computer to provide a comparison of actual and simulated results. Despite this problem, the observed system performance agreed qualitatively with the simulations. The robot is able to balance the pendulum and converge to a desired set point. The simulations also show the angle of the pendulum tends to oscillate indefinitely about its unstable equilibrium point, which is also observed in practice. The robot is able to correct for disturbances applied to the pendulum, and correct its orientation to a desired trajectory. A remote control was added to start and stop the robot, as well as increment and decrement its desired set-point.

The inverted pendulum stabilization problem has been extensively studied in control theory. As discussed, it clearly demonstrates the application of model based control on a nonlinear system, and allows the user or spectator to visualize the concept of a locally stable system, which is not always possible. Although there are no direct applications for the inverted pendulum, the motivation of this experiment was to implement a fully autonomous system that was small and lightweight. With technological improvements in batteries, motors, and embedded devices, autonomous robotics will also likely become smaller, lighter, while becoming increasingly robust and more sophisticated in its capabilities.

Acknowledgements

On behalf of all group members, we would like to extend this sincere thank you to the following people for all of their support and encouragement throughout the course of this project. Without their help this project would not have been possible.

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- Yvon Leblanc - Mechanical drawing and Autodesk Inventor support
- Manfred Klein - Component supply and equipment support
- Bruce Misner - Component supply and equipment support

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About the Authors

Andrew Roberts, **Marc Kennedy**, and **Alex Nequest** completed the stand-alone inverted pendulum project while undergraduate students in electrical engineering at Lakehead University, located in Thunder Bay, Ontario. After completion of their degrees, the groups degree project was entered into the IEEE/Telus Innovation competition and were subsequently awarded 1st place and $10,000 CAD for their design. The group was also awarded the IEEE Life Member Award for the best student paper in Western Canada for a paper based on the project.

Currently, Alex Nequest is employed with Laipac Technologies in Richmond Hill, Ontario. Marc Kennedy is employed with Research In Motion in Waterloo, Ontario. Andrew Roberts is continuing at Lakehead University in the Master of Science in Control Engineering program, under the supervision of Dr. A. Tayebi. His current research and thesis focus are the stabilization and control of vertical take-off/landing unmanned airborne vehicles.

2005 IEEE Canada TELUS Innovation Award recipients, L-R: Andrew Roberts, Alex Nequest & Marc Kennedy, Lakehead U.; presented by Bill Kennedy, IEEE Canada Past-President & Ibrahim Gedeon, Chief Technology Officer, TELUS.

Tesla honoured with Niagara Falls monument

NIAGARA FALLS - When Nikola Tesla was a young boy in Serbia, he envisioned drawing power from Niagara Falls. Now, the inventor of alternating current has a permanent tribute overlooking the Horseshoe Falls: a monument unveiled September 3, 2006.

Members of St. George's Serbian Orthodox church have donated a bronze statue of Tesla, who has national hero status in his homeland1. They wanted to create a lasting tribute on the 150th anniversary of Tesla's July 10 birth. "He's someone the Serbian community feels has been, if not neglected, certainly overlooked throughout history," said Dushan Kolundzic, the president of St. George's church.

As a boy, Tesla saw a picture of the Horseshoe Falls in a travel book and told his uncle he wanted to put a wheel under the falls to harness the power of the moving water. The new statue stands at the same point where that photograph was taken. "Having him here at the Falls is extremely important, because it captures the complete circle," Kolundzic said.

The 2,000-pound statue shows Tesla in a long overcoat, carrying a top hat in his left hand. In his right hand, he's carrying a cane, depicting the moment he conceived of alternating current by drawing diagrams on the ground. He's standing atop an AC motor, one of the 700 inventions he patented. The motor is similar to the "Teslatron" statue in the Fallsview Casino's entrance, which also pays homage to the inventor.

The Tesla monument’s total price tag could be $220,000 by the time the bills for a concrete foundation and landscaping come in, Kolundzic said. An international design competition led to more than 20 submissions; the judging committee liked one that came from Hamilton artist Les Drysdale. "The honour of being chosen to alter the landscape of the Niagara Parks is incredible. Who gets to do that?" said Drysdale.

Drysdale wore a T-shirt with Tesla's picture as "the man who powered the world," as he supervised the placement of the statue. The Niagara Parks Commission doesn't have many statues in Queen Victoria Park, but Tesla is a fitting addition, said Debbie Whitehouse, the executive director of parks. "The history of Niagara Parks and hydro-electricity are entwined together. You see that everywhere you go in the Niagara Parks."

Artist Les Drysdale, of Hamilton, created this monument to Nikola Tesla. It is in place at Queen Victoria Park. Photo courtesy of the Niagara Falls Review.

N.Ed. Material for this article and photo of Nikola Tesla’s statue were provided graciously by the Niagara Falls Review. Our thanks to Gord Howard, NFR’s Night Editor, and to Ron Potts, Life Members Chair, IEEE Canada.

N.Ed. Le texte source pour cet article et la photo de la statue de Nikola Tesla ont été gracieusement fournis par le Niagara Falls Review. Merci à Gord Howard, “Night Editor” au NFR, et à Ron Potts, Président du comité des Membres à vie, IEEE Canada.

Drysdale's statue captures Tesla's spirit, said Bill Auchterlonie, who led the church's statue committee. The inventor often appeared in photographs looking "serious, as if he was day-dreaming, look in his eye," Auchterlonie said. "He's got Tesla. You feel like your looking at Tesla. ... He may be standing on this generator. His mind is a million miles away."

Celebrating Tesla's accomplishment is a big deal not just for Serbian-Canadians, but back in his native land as well. A news crew from Serbia's national broadcaster was in Niagara Falls filming the statue's installation and its unveiling. Belgrade's airport is being renamed in Tesla's honour and the statue that finished second place in St. George's competition is being erected at the airport.

The IEEE hands out annually the IEEE Nikola Tesla Award to an individual or a team that have made outstanding contributions to the generation and utilization of electric power. Search for “Tesla” at http://www.ieee.org/ . Submission deadline is January 31st.

There have been four Tesla Awards given to Canadians in recent years: Gordon R. Slemon (U.Toronto, 1990), Thomas H. Barton (U.Calgary, 1992), Prabhashankar Kundur (Powertech Labs, Surrey, BC, 1997), Paul Dandeno (U.Toronto, 1998). The 2006 IEEE Tesla Award went to Konrad Reichert (ETH Zentrum, Zuerich, Switzerland).

To note: Nikola Tesla was awarded the IEEE Edison Medal (the AIEE Edison Medal at the time) in 1917. His acceptance of the award was surprising in view of the deep animosity between the two pioneers. The medal went missing after Tesla’s death in 1943.

1 N.Ed. Nikola Tesla is claimed as a hero both by Croatia and Serbia; he was born in a minority ethnic serb village in Croatia. He is quoted has having claimed to be "equally proud of my Serb origin and my Croatian homeland". Both communities are, in return, equally proud of him.

The application of International Software Engineering Standards in Very Small Enterprises

By Claude Y. Laporte[1], Alain April[1] and Alain Renault[2]
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Abstract

At a time when software quality is increasingly becoming a subject of concern, and process approaches are maturing and gaining acceptance in companies, the use of ISO systems and software engineering standards remains limited to a few of the most popular ones. However, these standards were not written for enterprises with fewer than 25 employees in mind. As they are difficult to apply in such settings, a new international standardization project has been mandated to address some of those difficulties by developing profiles and by providing guidance for compliance with ISO software engineering standards in very small enterprises. A survey was conducted to ask very small enterprises about their utilization of ISO/IEC JTC 1/SC7 IT standards and to collect data to identify problems and potential solutions to help them apply standards.

Sommaire

Alors que l'intérêt pour la qualité du logiciel augmente et que les approches de processus gagnent en maturité et en adoption par les entreprises, l'utilisation des standards ISO engénie systèm et génie logiciel reste limitée à quelques uns des plus populaires. Cependant, ces standards n'ont pas été écrits en considérant les entreprises de moins de 25 employés. Comme il est difficile de les appliquer dans un tel contexte, un nouveau projet international de standardisation a été mandaté pour s'attaquer à certaines de ces difficultés en développant des profils et en fournissant une orientation pour la conformité avec les standards de génie logiciel ISO dans les très petites entreprises. Un sondage a été tenu auprès des très petites entreprises à propos de leur utilisation des standards TI ISO/EIC JTC 1/SC7 dans le but de colliger des données pour identifier les problèmes et solutions potentielles et les aider à appliquer les standards.

1.0 Introduction

In Europe, 85% of IT sector companies have between 1 and 10 employees [1]. A survey of the Montréal area in Canada has revealed that close to 80% of companies that develop software have fewer than 25 employees, as illustrated in Table 1 [2]. Over 50% have fewer than 10 employees. There is a need to help these organizations, which are defined as very small enterprises (VSEs), to understand and use the concepts, processes and practices proposed by the ISO's international software engineering standards.

Size (employees)	Software Companies		Jobs	
	Number	%	Number	%
1 to 25	540	78%	5,105	29%
26 to 100	127	18%	6,221	36%
over 100	26	4%	6,056	35%
TOTAL	**693**	**100%**	**17,382**	**100%**

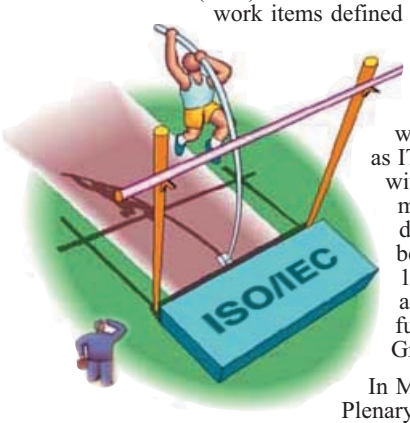
Table 1: Size of software development companies in the Montréal area [2]

2. Historical Perspectives

At the Brisbane meeting of ISO/IEC JTC 1/SC71 in 2004, Canada raised the issue of small enterprises requiring standards adapted to their size and maturity level. A meeting of interested parties was held with delegates from five national bodies, at which a consensus was reached on the general objectives:

- Make the current software engineering standards more accessible to Very Small Enterprises
- Provide documentation requiring minimal tailoring and adaptation effort;
- Provide harmonized documentation integrating available standards;
- Align profiles with the notions of maturity levels presented in ISO/IEC 15504.

It was also decided that a Special Interest Group be created to validate these objectives, as well as to assign priorities and develop a project plan.



In March 2005, the Thailand Industrial Standards Institute (TISI) invited a number of software experts to advance the work items defined at the Brisbane meeting. A key topic of discussion was to clearly define the size of VSE that would be targeted by a future ISO/IEC JTC 1/SC7 working group. A consensus was reached to define our target VSE as IT services, organizations and projects with between 1 and 25 employees. The major output of this meeting was a draft of a New Work Item that would be discussed at the next ISO/IEC JTC 1/SC7 Plenary meeting. A list of actions that could be undertaken by a future ISO/IEC JTC 1/SC7 Working Group was also developed.

In May 2005, at the ISO/IEC JTC 1/SC7 Plenary meeting in Finland, a resolution was approved to ballot a proposal for the development of software life cycle profiles and guidelines for use in very small enterprises.

The text below describes the mandate [4]:

- Provide VSEs with a way to be recognized as producing quality software systems, which would lessen the effort required to implement and maintain the entire suite of ISO systems and software engineering standards.
- Produce guides which will be easy to understand, short, simple and readily usable by VSEs.
- Produce a set of profiles and provide guidance to VSEs in establishing selected processes.
- Address the market needs of VSEs by allowing for domain-specific profiles and levels.
- Provide examples of use.
- Provide a baseline for how multiple VSEs can work together or be assessed as a project team on projects that may be more complex than can be performed by any one VSE.
- Develop scalable profiles and guides so that compliance with ISO/IEC 12207 and/or ISO 9001:2000 and ISO/IEC 15504 process assessment becomes possible with a minimum impact on VSE processes.

[1]ISO/IEC JTC 1/SC7 stands for the International Organization for Standardization/ International Electrotechnical Commission Joint Technical Committee 1/Sub Committee 7. For more information about the international standardization in information technology, refer to [3].

The proposal was accepted, and twelve countries committed to participating in the new working group: Belgium, Canada, the Czech Republic, Ireland, Italy, Japan, Korea, Luxemburg, South Africa, Thailand, the United Kingdom and the United States. We recall that participation in ISO/IEC JTC 1/SC7 working groups mostly occurs through national bodies or professional organizations, and no companies are represented.

3. VSE Survey and Profile Development Proposed

A new working group, WG 24, was established, made up of the following members, in addition to individuals sent by their national bodies:

- Mr. Tanin Uthayanaka (Thailand), who was appointed Convener.
- Mr. Claude Y. Laporte (IEEE Computer Society), who was appointed Project Editor.
- Mr. Jean Bérubé (Canada), who was appointed Secretary.

The Thailand Industrial Standards Institute invited a Special Working Group, in September 2005, to prepare material to facilitate the start-up of the new working group. The main outputs of the meeting were:

- Proposed requirements for International Standard Profiles (ISPs) based on technical report ISO/IEC TR10000-1 [5].
- A proposed survey on VSE exposure and their need for software development life cycles
- Proposed approaches to profile development
- Proposed business models
- Proposed agenda for the first WG24 meeting
- Proposed draft strategic plan for WG24

In October 2005, WG24 held its first working sessions in Italy to:

- Present the project to the official members of WG24;
- Finalize project requirements to constitute the project baseline;
- Gain consensus among WG members and obtain their commitment regarding the project;
- Process the comments received during the balloting of the New Work Item (NWI);
- Define the profile creation strategy;
- Identify lists of situational factors and business models;
- Build survey material to validate project requirements and to collect missing information from VSEs.

After the meeting, the survey questionnaire was translated into 9 languages. In addition, a Web site, hosted by the ÉTS, was developed to maximize the number of responses, which were collected between February 20 and May 12.

In May 2006, WG24 members met at the ISO/IEC JTC 1/SC7 Plenary meeting in Thailand. Two new countries, India and Mexico, sent delegates to WG24. The main outputs of the meeting were analysis of the survey responses and evaluation of documents tabled by national delegations; the Mexican Standard [6] was selected as an input document for the development of profiles and guides. Based on the survey analysis, WG24 decided to focus first on enterprises with fewer than 10 employees.

Survey Analysis

*345 responses collected from 26 countries

- 219 responses were received from enterprises with 25 employees or less;
- More than 67% indicated it was important to be either recognized or certified (e.g. ISO, market)

Decision by **WG24 to prioritize the development of profiles and guides for organizations with 25 employees or less (total staff). These profiles and guides should also be usable for projects and departments of less than 25 employees.

Separate profiles proposed for:

- Enterprises with fewer than 10 employees,
- Enterprises with 10 to 25 employees.

WG24 decided to focus first on enterprises with fewer than 10 employees.

*Since the original study, additional data have been received for a current total of 432 responses from 30 countries

**Working Group 24, which had its first meeting in Italy in Oct. 2005

The next WG24 meetings will be held in Luxemburg in October 2006 and St. Petersburg in May 2007.

4. Additional Information

To complete the survey:
http://iso-iec-sc7wg24.gelog.etsmtl.ca/Webpage/iso-iec-sc7wg24_english.html

Username: isosurvey
Password: vse

Public site of WG24:
http://profs.logti.etsmtl.ca/claporte/English/VSE/index.html

5. References

[1] http://www.esi.es/en/main/iitmark.html

[2] Gauthier, R., Portrait et vision de l'industrie des technologies de l'information et des communications (TIC) au Québec, presented at Conférence la Boule de Cristal CRIM, Montréal, 2004.

[3] Coallier, F., International Standardization in Software and Systems Engineering, Crosstalk, February 2003.

[4] New Work Item Proposal - Software Life Cycles for Very Small Enterprises, ISO/IEC JTC 1/SC7 N3288, May 2005. http://www.jtc1-sc7.org/.

[5] ISO/IEC TR 10000-1, Information technology - Framework and taxonomy of International Standardized Profiles - Part 1: General principles and documentation framework, Fourth Edition, 1998.

[6] NMX-059-NYCE-2005, Information Technology-Software-Models of Processes and Assessment for Software Development and Maintenance. Part 01: Definition of Concepts and Products; Part 02: Process Requirements (MoProSoft); Part 03: Guidelines for Process Implementation; Part 04: Guidelines for Process Assessment (EvalProSoft). Ministry of Economy, Mexico, 2005.

About the Authors

Claude Y Laporte is a software engineering professor at the École de technologie supérieure and the editor of ISO/IEC JTC 1/SC7 Working Group 24, tasked with developing software life cycle profiles and guidelines for use in very small enterprises. He can be reached by e-mail at: Claude.Y.Laporte@etsmtl.ca

Alain April is also a software engineering professor at the École de technologie supérieure and has contributed to ISO 9126 (Part 3). He is the associate editor of the SWEBOK (Software Engineering Body of Knowledge) software maintenance and quality chapters that have recently been published as an ISO/IEC Technical Report 19759. Alain.April@etsmtl.ca

Alain Renault is project leader at the Public Research Center Henri Tudor in Luxembourg (www.tudor.lu). He is also a member of ISO/IEC JTC 1/SC7 Working Group 24.

IEEE Milestone: 40th Anniversary of TAT-1

First transatlantic telephone cable system

On Sunday, September 24 an IEEE Milestone commemorating the first transatlantic cable was dedicated at the site of a former cable station of the system in Clarenville, Newfoundland. There are approximately 60 of these milestone sites in the world honouring significant achievements in the history of electrical and computer engineering, of Six Milestones are in Canada. In recognition of its pivotal role in the development of worldwide communications, half of the Canadian sites are in Newfoundland. The first successful transatlantic telegraph cable, in 1866, is commemorated by a Milestone at Heart's Content. There is a Milestone at Signal Hill in St. John's honouring the reception of the first wireless signal across the Atlantic by Marconi in 1901. The latest Milestone recognises Clarenville as the eastern terminal of the first transatlantic telephone cable, TAT-1 which entered service on September 26, 1956.

The TAT-1 inaugurated the modern era of global communications. Before TAT-1, voice was carried on unreliable radio channels and text messaging was carried on submarine telegraph cables (the technology of the previous 90 years), which was reliable, but slow and expensive. TAT-1 operated with exemplary reliability until 1978, when advances in technology made it obsolete. An article giving details of TAT-1, as well a history of submarine telegraph and telephone cable can be found in the spring 2006 edition of the IEEE Canadian Review.

by Jeremiah F. Hayes
Concordia University

The dedication ceremony, blessed with fine weather, drew about 100 spectators. The roster of speakers began with greetings and best wishes for the political leaders of the community: Mayor Fred Best of Clarenville, Ross Wiseman, MHA, Trinity North and Bill Matthews, MP, Random-Burin-St.George. Dr. Camilla O'Shea from the Clarenville Heritage Society eloquently explained the role of Clarenville in the transatlantic project. The Heritage Society and the town of Clarenville were instrumental in establishing the Milestone. The role of the people of Newfoundland in telecommunications was celebrated by Dr. Wallace Read, a resident of Cornerbrook and the former president of the IEEE. Dr Ferial El-Hawary, President Elect of Region 7 conveyed the best wishes of IEEE Canada. Dr. Jerry Hayes, a former worker on TAT-1, called for a moment of silence remembering the men and women who worked for global telecommunications. The plaque was unveiled by Lloyd Currie and Kathleen Chafe. Ms. Chafe, Chair of the Newfoundland-Labrador Section, did wonderful work as chair of the committee that arranged the ceremony. Gerard Dunphy, IEEE Canada External Relations Groups Chair and a past Chair of the Newfoundland-Labrador Section, was the Master of ceremonies.

A proud and happy moment at the dedication of the TAT-1 IEEE Milestone plaque, September 24, 2006

From left to right: Gerard Dunphy, IEEE Canada External Relations Groups Chair; Dr. Wally Read, IEEE Canada Past President; Kathleen Chafe, Chair of Newfoundland-Labrador Section, IEEE Canada; Dr. Camilla O'Shea, Clarenville Heritage Society; Ferial El-Hawary, President-Elect of IEEE Canada; Ross Wiseman, MHA - Trinity North; Bill Mathews, MP - Random-Burin-St. George; Dr. Jerry Hayes, IEEE Life Fellow, author/historian; His Worship Fred Best, Mayor of Clarenville. *Photo courtesy of Kirk Squires.*

One of two displays flanking the monument, this artwork gives visitors to the site an excellent overview of the need for TAT-1, the technical challenges in designing the system, and the story of its installation. At bottom left of the board the routing of incoming calls is described. After reaching Clarenville, calls were trenched across the Isthmus to Terrenceville, Fortune Bay, then connected into a submarine cable to Sydney Mines, Nova Scotia. From Sydney Mines, the calls were routed by micowave radio facilities to the United States and Canada. Our thanks to Clarenville Heritage Society for permission to reproduce this display. *Artwork by Brad Reid.*

CLARENVILLE REMEMBERS FIRST TRANSATLANTIC TELEPHONE CABLE

WIRELESS TELEPHONE service between North America and Europe began in 1927 but it was costly and unreliable because of atmospheric disturbances affecting the signals. Although transatlantic telegraph cables had been in service since the mid 1860s, the design of a transatlantic telephone cable had been an engineering challenge for many years. It was not until after World War Two that improvements in insulation, vacuum tube reliability and coaxial cable technology were at the stage where a transatlantic telephone cable could be considered.

In the early 1950s, a consortium of the UK General Post office, AT&T and Canadian Overseas Telecommunication Corporation, decided the technology had advanced to a point where a transatlantic telephone cable was viable. They decided Oban, Scotland and Clarenville, Newfoundland would be the eastern and western terminals. Clarenville was chosen to avoid congestion with the transatlantic telegraph cables landed in Trinity Bay. Two cables were planned, one for each direction of transmission.

AT&T designed the transatlantic cable, incorporating "flexible" repeaters in its design, meaning the repeaters were wound with the cable into the cable ship's holds. These repeaters amplified the telephone signals every 37 miles, requiring 51 repeaters in each cable. The first telephone link, named TAT-1, provided 36 transatlantic circuits.

The Monarch was the largest cable ship afloat, approximately 480 feet long, displacing 8962 tons. Its four cable tanks could hold 1500 nautical miles of deep-sea coaxial cable. The Monarch left Clarenville on July 22 1955, under Captain J. P. F. Betson, and headed toward Scotland. In a public ceremony, a bottle of water from Heart's Content harbour (the site of the first successful transatlantic telegraph cable) was ceremoniously broken on the new cable.

The cable was laid in three sections: the first 200 miles east of Clarenville in shallow water, using a heavy underwater cable to minimize the risk of damage from icebergs and fishing gear. The next 1250 miles was across the Atlantic cable arrived at Port Lathaich, south of Oban on 26 September, 1956, only a few days after riding out the remnants of Hurricane Ione. The following summer, on 14 August, 1956, the Monarch installed the east to west transmission cable at Clarenville.

The Clarenville cable extended underwater up Northwest Arm to a point near Adeytown and trenched across the isthmus to Terrenceville, Fortune Bay, where it connected into a submarine cable to Sydney Mines, Nova Scotia. The Cabot Strait section consisted of a single cable using fourteen two-way "rigid" repeaters. Sixty two-way circuits were available on this system: 36 for transatlantic telephone traffic and 24 for circuits between Newfoundland and the rest of Canada.

At Sydney Mines, the telephone lines were routed by microwave radio facilities to the United States and Canada.

The transatlantic cable cost approximately 120 million pounds. Twenty-nine circuits were used for telephone traffic between London and New York, six between London and Montreal and one was shared between the United States and Canada to provide 28 telegraph circuits.

The inaugural telephone call took place on September 25, 1956 between the British Postmaster General, the chairman of AT&T and the Canadian Minister of Transport. In the first day of public service, there were 588 calls from London to the United States and 119 to Canada. During its first year, the telephone cable carried twice the calls made by radiotelephone.

Clarenville was also the site of the second transatlantic telephone cable in 1959. This cable was owned by AT&T, the French Ministry of Posts, Telegraphs and Telephones, and the German Federal Ministry of Posts and Telecommunications. This link was named TAT-2 and gave North America a direct telephone cable to the European continent at Penmarch, France.

A direct telephone connection to North America had already been established, with seven of TAT-1's circuits assigned to European cities.

TAT-2 was longer than TAT-1 and required 57 repeaters. The cables entered Smith Sound and came ashore just north of Snook's Harbour, on Random Island, where they were trenched overland, north of Elliott's Cove and extended by submarine cable to Clarenville. TAT-2 used this route rather than TAT-1's Northwest Arm route to minimize the risk of grappling the wrong cable during maintenance.

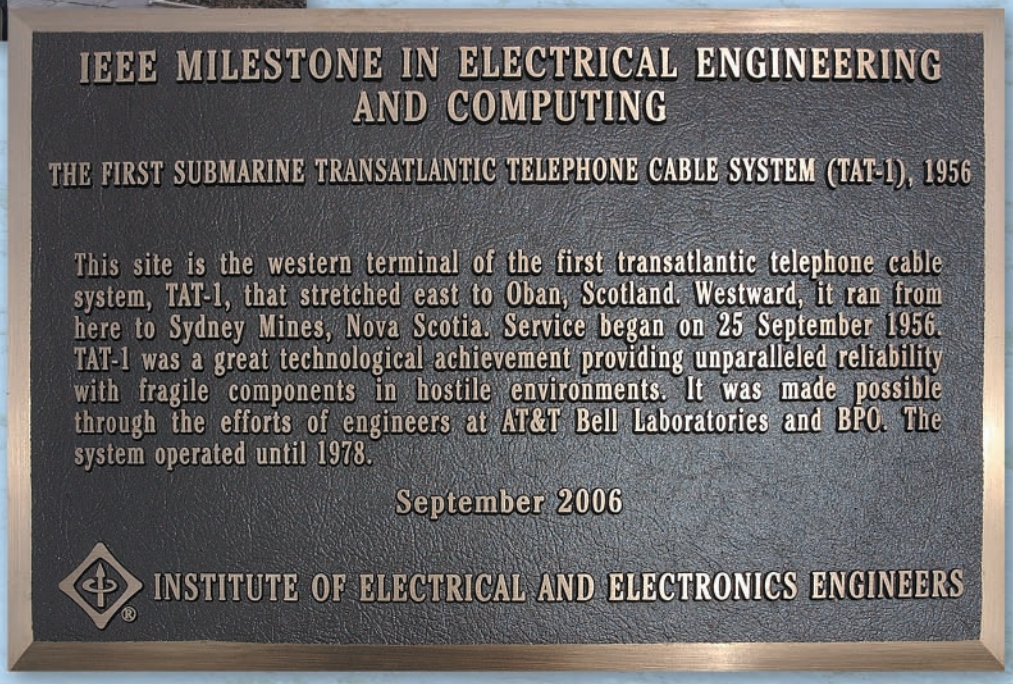
On June 14, 1959, while the vessel Ocean Layer was placing the TAT-2 cable from France, it caught fire and became a total loss. The cable was cut almost 950 miles from shore and the Ocean Layer was towed away for scrap. The Monarch completed laying the cable, assisted by the Ampere on the French end and the John W. Mackay on the North American side. A second Terrenceville to Sydney Mines cable was also installed as part of this system.

The Clarenville station was managed by Eastern Telegraph and Telephone, a subsidiary of AT&T. The station was originally powered by four diesel generators, which were used for back-up when commercial power from the Lockston power station became available in 1957. The large array of batteries was housed in the basement and the communications equipment was located on the first floor. Although all telephone conversations between North America and Europe passed through the building, the design of the transatlantic system required long distance calls between Clarenville and Europe to be routed via Montreal.

A new transatlantic telephone cable came ashore at Hampden, White Bay in 1961. The cable called CANTAT-1 was operated by the COTC. In 1974, CANTAT-2 was installed between Widemouth England and Beaver Harbour, Nova Scotia. This co-axial facility carried 1840 voice circuits and made the earlier cables obsolete. As a result TAT-1 was retired in 1978, followed by TAT-2 in 1982, resulting in the permanent closure of the Clarenville station.

Clarenville Heritage Society

Kathleen Chafe, Chair of Newfoundland-Labrador Section, addresses the gathering. To the right of Kathleen is the Clarenville Cable Station (also depicted in artwork above). Built during the Cold War as part of the TAT system, it was considered a military target because it linked North America with Europe. The station had walls two feet thick to withstand enemy bombs. Ironically, it was new advancements in communications technology made during World War II that made the dream of a transatlantic telephone cable achievable. *Photo courtesy of Kirk Squires.*



Of the approximately 60 IEEE Milestone Sites worldwide, six are in Canada. In addition to TAT-1, they honour Hydro Québec's 735 kV Transmission System; Manitoba Hydro's Nelson River HVDC transmission system; DeCew Falls Hydro Electric Plant in St. Catherines, ON; Transatlantic Telegraph Cable of 1866, NA terminus at Heart's Content, NFLD; and, First Transatlantic Radio Signals, 1901, Signal Hill, Nfld.

A New Approach to Plan 3G Cellular Networks

By Marc St-Hilaire[1], Steven Chamberland[2] & Samuel Pierre[2]

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[2]Department of Computer Engineering, école Polytechnique de Montréal

Abstract

In this paper, we describe a new approach to plan third generation (3G) cellular networks. Instead of partitioning the problem into three subproblems, we use a global approach in which all the subproblems (cell, access and core networks planning subproblems) are considered simultaneously. Since a global model is NP-hard, we concentrate our effort on the development of approximate solution algorithms (heuristics). The proposed approach can be used to plan a new network and to update an existing infrastructure. Two examples are presented in order to illustrate these concepts.

Sommaire

Dans cet article, nous décrivons une nouvelle approche pour planifier les réseaux mobiles de troisième génération. Au lieu de partitionner le problème en trois sous-problèmes, nous utilisons une approche globale dans laquelle les sous-problèmes (planification des cellules, du réseau d'accès et du réseau dorsal) sont considérés simultanément. Comme le modèle global est NP-difficile, nous considérons des méthodes de résolution approximatives (heuristiques). L'approche proposée peut être utilisée pour planifier un nouveau réseau et pour mettre à jour une infrastructure existante. Deux exemples sont présentés pour d'illustrer ces concepts.

1.0 Introduction

Over recent years, the third generation (3G) mobile networks, based on the universal mobile telecommunications system (UMTS) standard, are used by an increasing number of subscribers. As a result, these network operators must invest a large portion of their budget within their network infrastructure. A typical UMTS architecture is illustrated in Figure 1. As we can see, the area of coverage is divided into cells. Each cell contains a base station, called node B, which provides radio interfaces to mobile users (MUs). The wideband code-division multiple access (WCDMA) scheme is typically used in those networks. With this scheme, the capacity of each cell is based on the interference levels (for more information, see Amaldi et al. [2]). A radio network controller (RNC) connects one or more node Bs and deals with resource and mobility management. All these elements are part of the UMTS terrestrial radio access network (UTRAN). Each RNC is then linked to the core network. The latter is divided into two different parts: the circuit switched and the packet switched core network. The former is composed of mobile switching centers (MSCs) which take care of telephone call setup and routing as well as providing access to the public switched telephone network (PSTN). On the hand, the packet switched core network is composed of serving GPRS (General Packet Radio Service) support nodes (SGSN) that provide connectivity to the packet data network (PDN) and the Internet. For more details concerning UMTS networks, see Yacoub [12].

The UMTS network planning problem has been widely studied in the literature. Due to its complexity, it has been divided into three NP-hard subproblems: the cell, the access network and the core network planning subproblems:

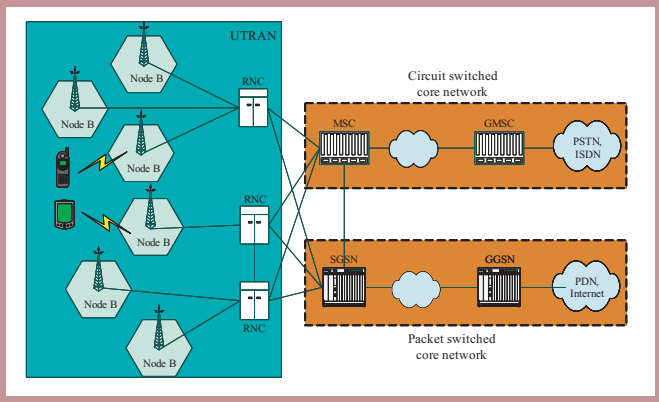

Figure 1: Typical UMTS architecture

- The cell planning subproblem consists in finding the number, the location and the type of node Bs subject to signal quality and coverage constraints. The objective is to minimize the cost of the node Bs (including the installation cost). Many different authors including Amaldi et al. [1, 2], and Thiel et al. [10] worked on this subproblem.
- The access network planning subproblem consists in determining the number, the location and the type of RNCs, the assignment of node Bs to RNC as well as the number, the location and the type of links to be used. Several authors tackled this subproblem. Here are the most interesting works: Harmatos et al. [5], Lauther et al. [8], and Wu and Pierre [11].
- The core network planning subproblem consists in determining the number, the location and the type of MSCs and SGSNs to install, the assignment of the RNCs to the MSC/SGSN and finally the number, the location and the type of links to connect the RNC to the MSC/SGSN (see Harmatos [4]).

For more details on each subproblem and for an extensive literature review, see [9].

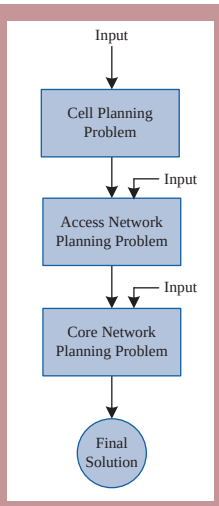

Figure 2: Sequential Planning

In order to plan a UMTS network, a sequential approach is generally used. This means that each subproblem is solved successively. As a result, we first solve the cell planning problem. Then, given the optimal number and location of the base stations, we then find the optimal number (and location) of RNCs. Finally, given all this information, we try to find the optimal solution for the core network (see Figure 2).

This methodology has the advantage of dividing the complexity of the planning problem into three different subproblems. However, the final solution obtained is usually not optimal since:

- once a decision has been made in a subproblem, it cannot be changed thereafter;
- the interactions between subproblems are not taken into consideration;
- the optimal solutions to each subproblem do not provide, in general, an optimal solution to the global problem.

Recently, St-Hilaire, Chamberland and Pierre [9] proposed an innovative global approach for planning UMTS networks. This approach considers

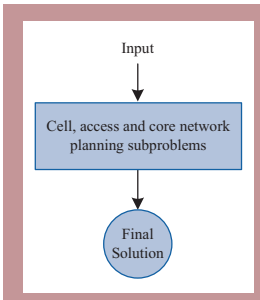

Figure 3: Global Planning

the three subproblems simultaneously (see Figure 3) and therefore, optimal solutions are always obtained. However, since this approach is NP-hard, we concentrate our efforts on the development of approximate algorithms (heuristics).

In the following section, we will provide illustrative examples of the proposed global approach. The proposed heuristic is based on the tabu search (TS) principle. The basic principle of the tabu search is to define a set of possible solutions, and starting from the current solution, to find a better one in its neighborhood. A neighborhood is a set of solutions that are found by applying an appropriate transformation of the current solution. In order for the algorithm to move away from a local minimum, the search allows moves resulting in a degradation of the objective function value, thus avoiding the trap of local optimality. To prevent the search from cycling, solutions obtained recently and moves that reverse the effect of recent moves are considered tabu. For more details about TS, see [7].

2. Illustrative Examples

In this paper, only the uplink direction (i.e., from the mobile users (MUs) to node Bs) is considered. The uplink traffic is very important when the amount of data exchanged is balanced between the uplink and the downlink directions. To simulate the traffic, we introduce the notion of test points (TPs). Each TP can be viewed as a centroid where a given amount of traffic is requested. Therefore, one TP can represent several MUs in a given area. When planning the uplink direction, the restrictions are the MU transmit power and the interference [6].

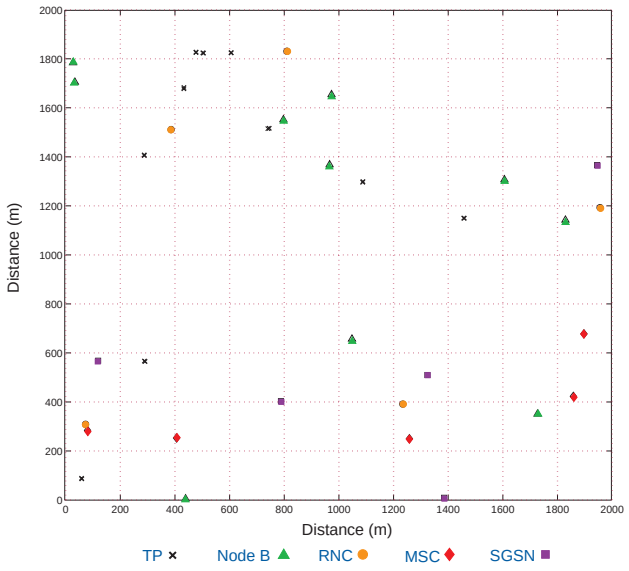

Figure 4: Region to be planned

The area to be planned is presented in Figure 4 where the geographical location of TPs and potential sites are depicted.

In order to simulate the behavior of the signal propagation, we used the extension of the Hata model proposed in [3].

To design the network, three Node B types, two RNC types, two MSC types and two SGSN types are available. Their features are respectively presented in Tables 1 to 4. Moreover, OC-3 and OC-12 links can be used to connect the node Bs to the RNCs, DS-3 links are used to connect the RNCs to the MSCs and gigabit ethernet (GE) links are used to connect the RNCs to the SGSNs (see Table 5). The costs of the interface (port) types are presented in Table 6.

Two different examples will be presented. The first one will be a planning example followed by an update example.

	Type A	Type B	Type C
Capacity (circuits)	100	200	400
Capacity (Mbps)	120	240	480
Number of interfaces	1	2	2
Sensitivity (dBm)	-90	-100	-110
Cost ($)	20,000	30,000	50,000

Table 1: Features of the node B types

	Type A	Type B
Switch fabric capacity (Mbps)	2,000	5,000
Number of nodeB interfaces	10	20
Number of MSC/SGSN interfaces	15	30
Cost ($)	50,000	90,000

Table 2: Features of the RNC types

	Type A	Type B
Switch fabric capacity (circuits)	100,000	200,000
Number of interfaces	50	100
Cost ($)	200,000	350,000

Table 3: Features of the MSC types

	Type A	Type B
Switch fabric capacity (M bps)	20,000	40,000
Number of interfaces	16	32
Cost ($)	40,000	60,000

Table 4: Features of the SGSN types

Link type	Capacity	Cost ($/km)
DS-3	2688 circuits	2,500
OC-3	155 Mbps	1,500
OC-12	622 Mbps	4,000
GE	1 Gbps	4,000

Table 5: Cost of the links

Interface type	Cost ($)
DS-3	1,500
OC-3	2,000
OC-12	4,500
GE	2,000

Table 6: Cost of the interface types

2.1 Planning Example

Starting from a green field (i.e., there is no existing infrastructure), we want to find the minimum cost network in order to cover the ten TPs as illustrated in Figure 4.

The solution obtained with the TS heuristic is presented in Figure 5. The cost of this network is $408,797. As we can see, the solution is composed of two node Bs of type C, one RNC of type A, one MSC of type A and one SGSN of type A. Note that with the sequential approach, the cost found is $422,508. This is a difference of 3.35%. Considering that the cost of UMTS network equipments is still very high, 3.35% is not negligible.

2.2 Update Example

Let's say that a network operator currently has a network infrastructure as the one presented in Figure 5. Due to its attractive plan, 35 new TPs want to subscribe to this provider. At the same time, five TPs are not satisfied and want to leave for a competitor. As a result, the operator needs to update its infrastructure at the lowest possible cost.

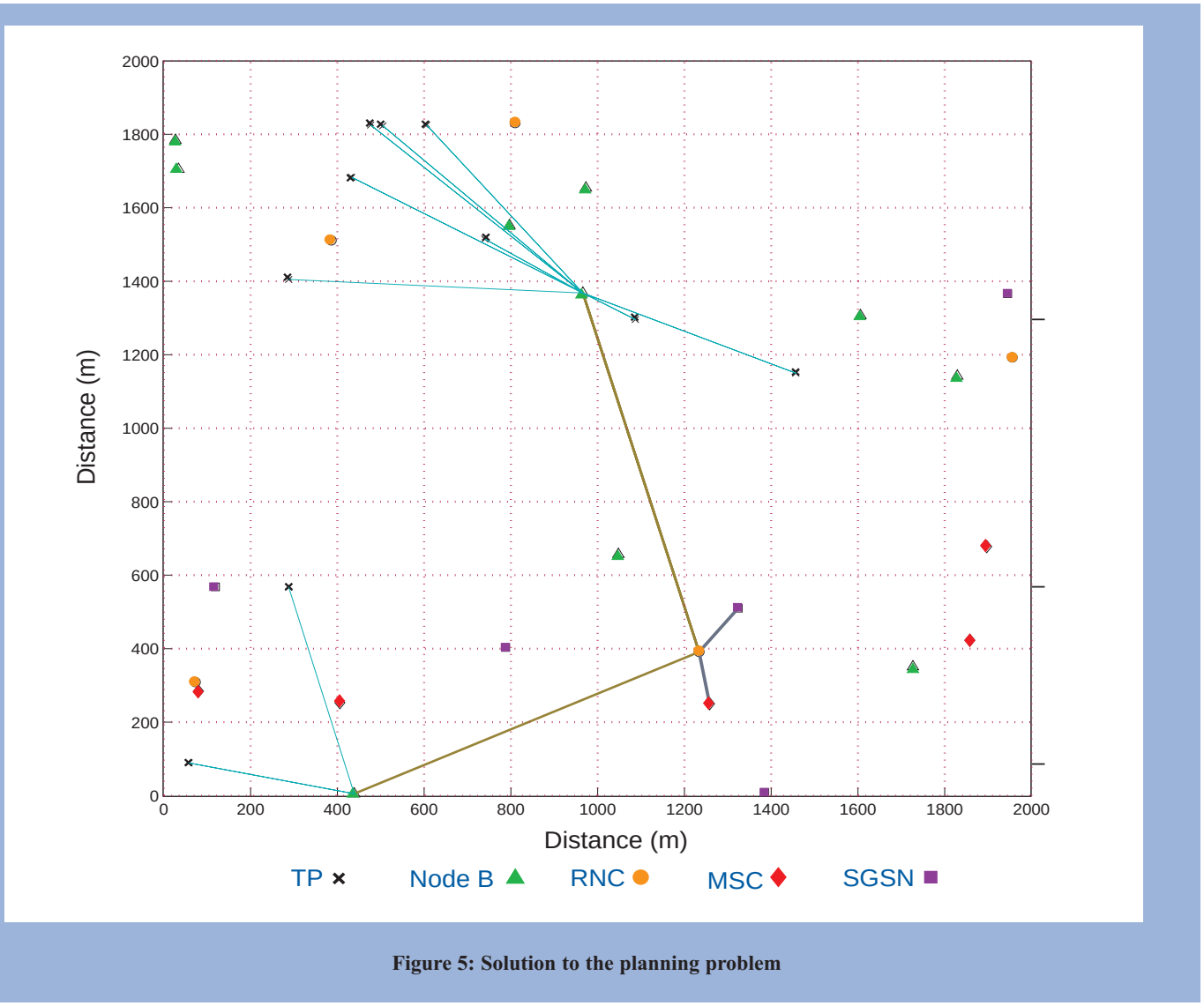

Figure 5: Solution to the planning problem

Besides the costs presented previously, additional costs are involved in an update scenario. There is a cost involved when removing (or moving) an equipment (see Table 7). There is also a cost of $100/km to remove a link between two equipments.

The solution obtained with the TS heuristic for the update problem is presented in Figure 6. The cost of this expansion amounts to $151,378. As we can see, four node Bs have been added in order to satisfy the new (and remaining) clients. The number of RNC, MSC and SGSN has not changed since they still have enough capacity to support this upgrade.

3. Conclusions

In this paper, we presented (with the help of examples) a new way to plan UMTS networks. The proposed approach can be used to plan a new network or to update an existing one. This can be very useful for service providers since the number of subscribers is continuously growing and they need tools to up-date their network in a cost effective manner.

We are currently building graphic interfaces in order to develop a software that could be used by network operators. The goal of this tool is to hide the complexity of the model and to provide an easy access to the users.

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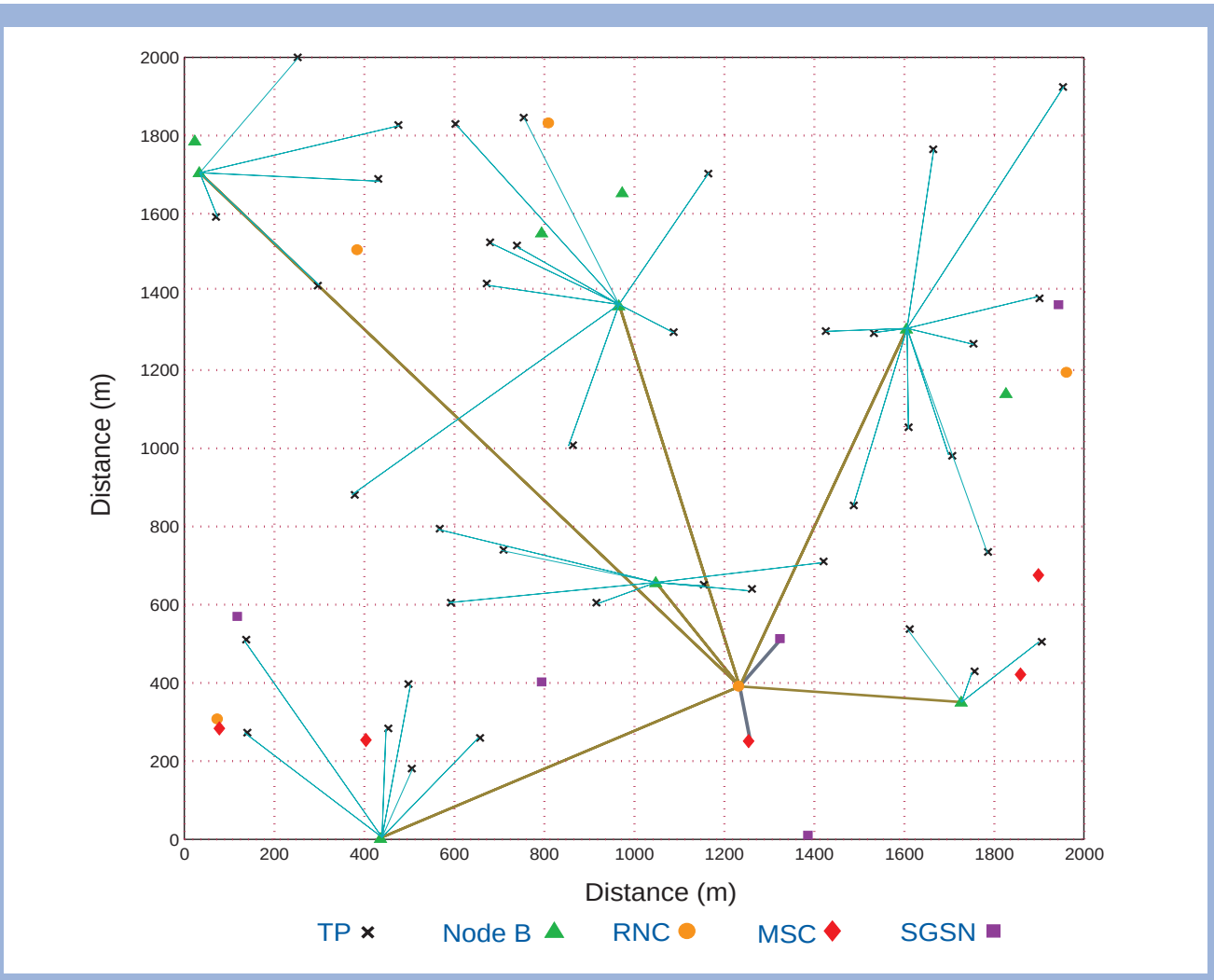

Figure 6: Solution to the update problem

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Autonomous Flight: State-of-the-art Estimation and Guidance Systems

1.0 Introduction

Unmanned aerial vehicles (UAVs) are encountered in an increasing number of civilian and military applications like: surveillance, communication relay, target designation, and payload delivery [1]. Such applications require the UAVs to be equipped with a guidance system. What is most often termed as "guidance" is the combination of a noise filter/estimator with a guidance policy or guidance law [2]. The objective of this guidance system is to deliver a control command that will steer the UAV toward a desired state (or location) that can vary in time. This guidance command is calculated online from a feedback signal involving the current state of the UAV and the desired state. Whenever the full feedback signal is available to measurements, the guidance law is in the form of an output feedback controller; there is no estimation system required (although one could still be beneficial to filter the noises). Otherwise, the feedback signal is only partially subject to measurements and the full feedback signal must be reconstructed by introducing an estimation system prior to the guidance law, see Fig.1.

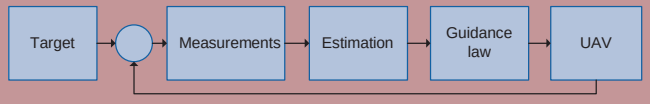

Figure 1: A control loop example

The estimation system has for objective to reconstruct online a full feedback signal based on: (i) partial measurements, (ii) some assumptions about the dynamics, and (iii) some assumptions about the measurement and dynamical uncertainties.

The dynamical uncertainty is the difference between the true dynamics and that of the dynamical model assumed by the estimation and guidance system. Examples of uncertainties are the noise in the instruments and the unmodeled phenomena like unknown aerodynamic coefficients or unknown inputs (e.g., a gust of wind that displaces the UAV or a bias in an actuator). The assumptions (ii)-(iii) about the uncertainties may be time-varying.

This article discusses some of the interactions between the estimation systems and the guidance law, and presents possible state-of-the-art solutions currently investigated. An effective selection of estimation and guidance systems should provide close-to optimal closed-loop flight performance, while allowing for a real-time implementation on-board a UAV. The selection of a Kalman filter in the estimation system is specifically discussed with respect to other most advanced estimators. Finally, the article illustrates some of the effects encountered in the control loop when employing advanced estimators.

2. The Control Loop

Fig. 1 shows a typical feedback control system enabling a UAV to reach a target. In this example, an estimation system reconstructs the feedback signal from the measurements. Whenever the uncertainties are represented using a stochastic description (like a Gaussian uncertainty), the estimation system involves a sequence of two components illustrated in Fig. 2. The first component is an estimator whose output is a probability density function (p.d.f.), this p.d.f. associates a domain of candidate feedback signals to the probability of being the exact signal (i.e., the signal if there was no uncertainties). An example p.d.f. is shown in Fig. 3 in which two neighborhoods of most probable candidate signals are indicated by the peaks. A physical interpretation of such p.d.f. is that due to noises and other uncertainties, the exact location of a target is never exactly known. Thus, engineers and scientists have to find ways to best use this uncertain information on the target state, such as its location, and that involves stochastic considerations.

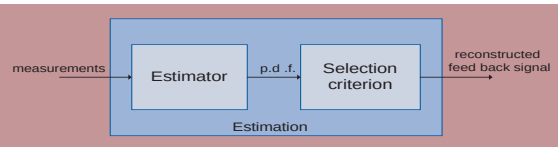

Figure 2: Estimation system with stochastic uncertainties

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Abstract

Unmanned aerial vehicles (UAVs) are rapidly becoming a strategic asset of today's military forces and an enabler of transformation for the civilian airspace community.

In autonomous flight, accuracy from the guidance system is necessary for performance and safety reasons. Increased accuracy can be achieved by improving the information processing and by accounting for the uncertainties. With the ever increasing on-board computational capabilities, a growing number of sophisticated estimation and guidance algorithms are becoming feasible. However, along with the new possibilities offered by these algorithms, new challenges are also encountered. This article describes some of these possibilities and challenges and presents some of the investigated solutions to optimize their application. Of particular interest is the selection of the estimation algorithm with respect to the uncertainties and the dynamics, and the coupling between the estimation and guidance systems.

Sommaire

Les drones, ou avions sans pilote, sont maintenant devenus des atouts stratégiques des forces militaires et sont en voie de transformer l'espace aérien civil. En vol autonome, un guidage de précision est nécessaire pour des raisons de performance et de sécurité. Un guidage de précision accrue peut être obtenu en améliorant le traitement de l'information et en tenant compte des incertitudes. Avec les capacités de calcul embarquées sans cesse croissantes, un nombre accru d'algorithmes d'estimation et de guidage sophistiqués deviennent accessibles. Toutefois, de nouveaux défis accompagnent les nouvelles possibilités offertes par ces algorithmes. Cet article décrit certaines de ces possibilités et des défis associés et présentes certaines des solutions étudiées pour optimiser leur application. La sélection de l'algorithme d'estimation par rapport aux incertitudes et à la dynamique est ici d'un intérêt particulier, de même que les interactions entre les systèmes d'estimation et de guidage.

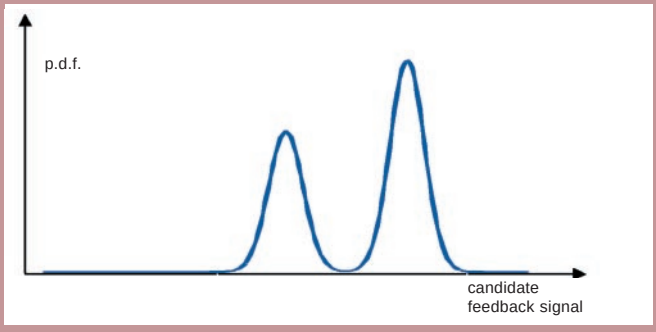

Figure 3: An example P.D.F. Each point of the x-axis is a candidate feedback signal

The second component of the estimation system is a selection criterion to choose a specific candidate feedback signal from the domain of admissible candidate feedback signals. The chosen signal becomes the reconstructed feedback signal. The selection process is conditioned by the p.d.f. Two common selection criteria are: (i) the adoption of the point

at the mean of the p.d.f., the so-called minimum mean square estimate (MMSE), and (ii) selecting the point at the maximum of the p.d.f., the so-called maximum a posteriori probability (MAP) estimate [3].

After reconstruction of the feedback signal, the guidance system issues a control command. This control command is implemented by the UAV through an autopilot. The choice of the estimation system with respect to the guidance system is discussed in the following sections.

3. The Kalman Filter

The Kalman filter (KF) is a commonly encountered estimator that describes the dynamics and the measurements by a linear model, while the measurements and the dynamical uncertainties are represented by Gaussian distributions. The output of the KF is always a Gaussian p.d.f. This KF can be calculated in recursive form (see Fig. 4) allowing for real-time implementation.

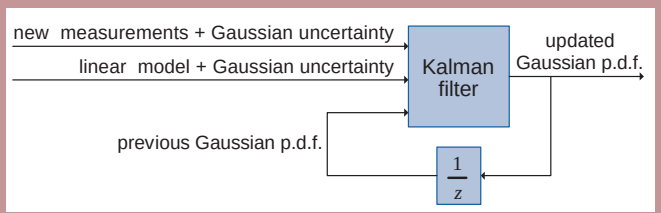

Figure 4: Recursive Kalman filter

In nonlinear systems, the Kalman filter can be applied by linearization of the nonlinear equations to which a sufficient Gaussian uncertainty is added to represent the linearization error. Whenever the linearization is state-dependent, the estimator is called an extended Kalman filter (EKF). Historically, the KF and the EKF are distinguished as many of the KF related proofs do not carry over to state-dependent linearizations. However, recent advances have now proven the convergence of the EKF [4].

A significant shortcoming of the KF is the necessity of describing the uncertainties by Gaussian distributions. In au tonomous flight applications, important uncertainties are not accurately represented by Gaussian distributions, like those that are correlated in time (e.g., flight maneuvers). In the next section, more advanced estimators applicable to broader classes of uncertainties are discussed.

4. More Advanced Estimators

Several recursive estimators with manageable computational requirements have the ability to calculate non-Gaussian p.d.f., such as the p.d.f. illustrated in Fig. 3. One class of such estimators delivers a non-Gaussian p.d.f. by running a bank of KF in parallel, each KF assumes a different model for the system. The p.d.f. is obtained as a weighted sum of Gaussian p.d.f.; each Gaussian p.d.f. being calculated by its own KF, see Fig. 5.

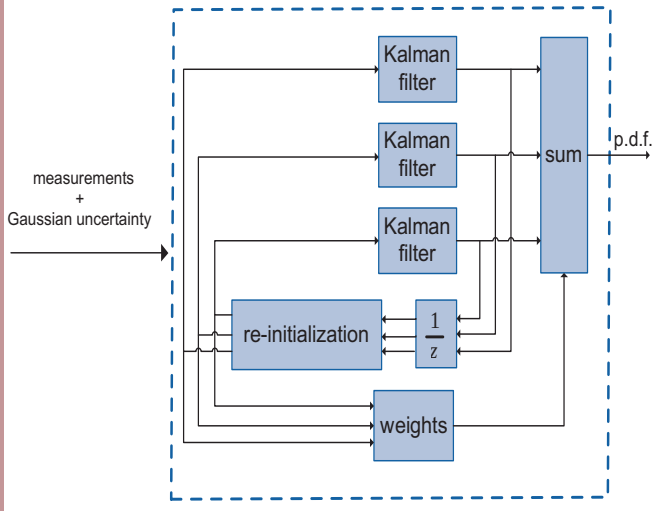

Figure 5: Example of a multiple model estimator with three models

From this approach, several different algorithms can be derived depending on which procedures are selected to calculate the weights and to re-initialize the bank of KF. A common algorithm in this class is the so-called interacting multiple model (IMM) estimator; the last is known to deliver an advantageous ratio computation/performance [3]. The IMM estimator applies to hybrid systems and it assumes that: (i) there are several behavioral modes for the system, and (ii) the system transitions between these modes according to a Markov chain. The assumption (i) is accounted for by the bank of KF: the model adopted by each KF is one of the admissible behavioral modes. The assumption (ii) is accounted for by the selected re-initialization procedure. In autonomous flight applications, each behavioral mode can represent a different flight regime. The IMM is found more suitable than the KF for tracking of uncooperative targets whose flight regime are uncertain [5].

Another class of estimators called particle filters (PF) applies to general nonlinear systems with non-Gaussian uncertainties. The PF is based on the fact that a p.d.f. can be expressed as the solution of an integral equation [6]. In few systems, this integral can be solved analytically. Such is the case when the system is linear with Gaussian uncertainties; the analytical solution is then the KF. In the case of the PF, an approximate numerical solution of the integral equation is sought instead of an exact analytical solution. In essence, the PF employs the exact model but approximates the calculation of the p.d.f.; the KF approximates the model and calculates an exact p.d.f. with respect to the approximated model.

The PF obtains the numerical solution by recursive Monte Carlo integration involving a set of so-called particles. At each iteration, the particles are evolved using the nonlinear model with non-Gaussian uncertainties. Each particle is assigned a weight based on the received measurements. From these weights, a p.d.f. is calculated and the set of particles is decimated and re-sampled. Different techniques can be employed for the decimation and re-sampling of particles, and for the calculation of the weights. The PF algorithm is depicted in Fig. 6. The algorithm is recursive and requires a large number of particles to deliver an accurate solution; the latter may involve large computational requirements.

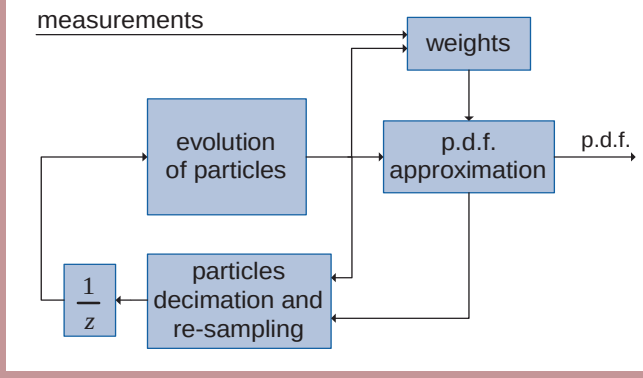

Figure 6: An example PF algorithm

The PF is of interest in autonomous flight applications in situations where the nonlinear dynamics is poorly approximated by linearization, or when significant uncertainties are poorly represented by Gaussian approximations.

5. Selection Criterion and Guidance Law

The guidance law requires a feedback signal to be reconstructed from the measurements. By employing an estimator to process the measurements, the reconstructed feedback signal is delivered by applying a selection criterion to the calculated p.d.f. When the estimation system employs the KF to calculate the p.d.f., the selection criteria MMSE and MAP deliver the same reconstructed feedback signal; that is, the average point of the p.d.f. coincides with the unique maximum of the p.d.f. Essentially, the tuning of the estimation and guidance system is limited to the optimization of the KF and of the guidance law. By comparison, when the estimation system employs a more advanced estimator like the IMM or the PF, the reconstructed feedback signals varies with the selection criterion; this provides an additional level for optimization.

The most common approach for optimization of the estimation system and guidance law in the control loop is to optimize them independently

and to employ the MMSE criterion to reconstruct the feedback signal from the p.d.f. Although the couplings are then neglected, such an approach is optimal in linear quadratic Gaussian systems by virtue of the separation principle [7]. In broader classes of nonlinear systems with non-Gaussian uncertainties, the separate optimization of the estimator was shown to be still optimal, but it was also demonstrated that the optimization of the selection criterion and of the guidance system should then be coupled with the employed estimator [8]. The latter argument means that a modification to the estimator may call for modifications in the selection criterion and in the guidance law.

Several state-of-the-art optimizations in the control loop accounts for the coupling between the estimation system and the guidance law. One simple approach is to optimize the guidance law by assuming that the estimation system introduces a delay (or a lag) in the feedback signal. In autonomous flight applications, the approximation by a delay of the closed-loop dynamics introduced by the estimator was reported successful [9]. A second class of state-of-the-art approaches attempts to optimize the guidance law in such a way as to steer the UAV on a trajectory that will increase the information contained in the measurements, while preserving the satisfaction of the guidance objective [10]. Unfortunately, both requirements can be contradictory in autonomous flight applications and a trade-off may be necessary.

Another class of state-of-the-art approaches attempts to op timize the selection criterion and the guidance law with respect to both the p.d.f. and the control effort capabilities [11], [12]. For example, an alternative adaptive selection criterion (called HPI) is presented in [11] where it is shown to deliver better performance than the MMSE and MAP criteria with a non-Gaussian p.d.f. Simulation results illustrating this phenomenon are displayed in Fig. 7.

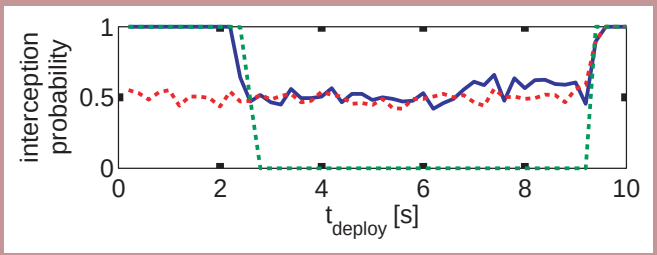

Figure 7: Example of closed-loop performance when modifying the selection criterion. The scenario is that of a moving target to be intercepted. To evade, the target deploys a decoy. The x-axis is the deployment time instant of the decoy. The whole engagement last 10 [s]. The estimator and guidance systems are the same in all the curves; the estimator delivers a non-Gaussian p.d.f. Three selection criteria are considered: MMSE (green line), MAP (red line), and HPI (blue line).

In the figure, the same estimator (with non-Gaussian p.d.f.) and guidance law are common to all the curves, only the selection criterion for the reconstructed feedback signal changes from one curve to another.

6. Concluding Remarks

The paper described some of the issues and challenges involved in the selection of the estimation system and guidance law in autonomous flight applications. The coupling of the estimation system with the guidance law was of particular interest. For instance, it was pointed out that advanced estimators capable of delivering non-Gaussian p.d.f. provide for new freedom and new challenges in optimizing the closed-loop system. With the ever increasing on-board computational capabilities, it is believed that many of these advanced estimators and control techniques will be feasible in a growing number of applications.

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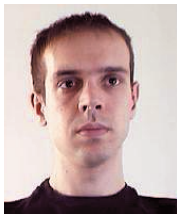
About the Authors

Dr. Dany Dionne is a postdoctoral fellow at the Dept. of Mechanical Engineering, Concordia University. He has earn his Ph.D. degree in electrical engineering from McGill University, Montreal, in 2005. He has worked on multi-UAVs task allocation, predictive control, estimation and guidance in autonomous flight, and on the robust control of an experimental car suspension. In 2005, Dr. Dionne was a recipient of a Japan Society for the Promotion of Sciences fellowship and acted as an invited researcher in Dept. of Computer Sciences, Kyushu Institute of Technology, Japan.

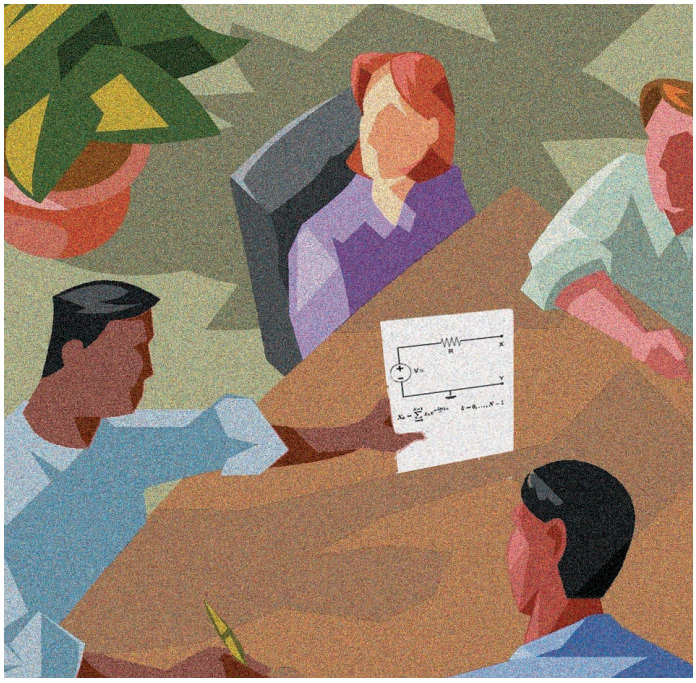


Dr. Camille A. Rabbath is a Defence Scientist at DRDC Valcartier and Adjunct Professor at McGill University. He has worked for three years in industry in the areas of control systems design and distributed simulations of aerospace and robotic systems. During that period, he has implemented real-time gas-turbine engine control systems, he has developed and implemented an environment for the real-time distributed simulations of combustion engine control and has lead a research project for the Canadian Space Agency that resulted in the development of an efficient algorithm for the automatic parallelization, scheduling and load balancing of electromechanical systems. His current research interests include realtime cooperative control algorithms for teams of multiple UAVs, and robust multi-rate digital guidance and control of aerial systems.

Engineering Management: What's New in the Literature?

by Terrance Malkinson
- IEEE Engineering Management Society Governor

◆ Asking the right questions of yourself and a potential employer can help to ensure that you end up in the right job. In: "Finding the Right Job Fit" (HR Magazine, 51(3), pp. 63-67, 2006, http://www.shrm.org/hrmagazine), Lisa Daniel and Carolyn Brandon discuss the importance of avoiding becoming a "casualty of the bad-fit syndrome"— you thought you had landed the perfect job for you only to find out a few months later that this was not the case. Today, a good fit is often considered to be more important than compensation, benefits, or other incentives. Knowing yourself is the first step. The authors provide many useful employment interview tips that will help you in your assessment. An inset consisting of a list of twenty-five suggested questions to ask during a job interview is included.



◆ We each have nuggets of wisdom or "secrets" that we believe have contributed to our success. In: "My Golden Rule" (Business2.0; 6(11): 108-130, 2005; www.business2.com), the editors report on their interviews with 30 business visionaries. These accomplished people include individuals such as Warren Buffett, Steve Ballmer, and George Steinbrenner. They reveal the single philosophy that each believes to be the "secret of their success." These men and women have all achieved considerable personal and life success. Their nuggets of wisdom might be important to you.

◆ Innovation is critical to corporate (and personal) success. In: "The 12 Different Ways for Companies to Innovate" (MIT Sloan Management Review, 47(3), pp. 75-85, 2006, http://sloanreview.mit.edu/smr/), Mohanbir Sawhney, Robert Wolcott, and Inigo Arroniz discuss a new framework for innovation called "innovation radar" that helps you to avoid a restricted view of innovation in which you might miss opportunities. As a result of their research they have developed twelve dimensions of business innovation. These were developed through interviews with managers across a range of industries, and through a comprehensive examination of the academic literature on innovation. The validity of the process and results obtained was tested in industry.

◆ Off-site meetings are often used by organizational leaders to plan for the future. In "Off-Sites that Work" (Harvard Business Review; 84(6), pp.117-126, 2006, www.hbr.com), Bob Frisch and Logan Chandler use their twenty years of experience to provide a set of best practices for organizations so that they can make the most of their off-site meetings. Of the many tips and strategies discussed most important is having a pre-planned and rigorously structured meeting that will facilitate candid discussion. The authors believe that a well-designed off-site meeting might be a genuine turning point and contributor for business success.

◆ Krysten Crawford and Matthew Maier provide a year-in-review of the "bold moves, big bets and brilliant innovations" of 2005 in "The Smart List" (Business 2.0, 7(1), 89-94, 2006, http://money.cnn.com/magazines/business2). The year's big winners and the decisions that were critical to success are discussed. In a following article in the same issue (pp. 98-110) Adam Horowitz et. al. provide the "101 Dumbest Moments in Business" in 2005.

◆ Many employees donate a portion of their time to assist charitable organizations. In "Intra-organizational Volunteerism: Good Soldiers, Good Deeds, and Good Politics" (Journal of Business Ethics, 64(4), pp. 357-379, 2006, http://www.springerlink.com), John Peloza and Derek Hassay discuss their research into the motives for this pro-social behavior. Results provide insight of value to employees and managers important to corporate social responsibility. An extensive list of references provides links to further sources of information on business and employee philanthropy.

◆ In all organizations, people are the most valuable asset. In "Producing Sustainable Competitive Advantage through the Effective Management of People" (Academy of Management Executive, 19(4), pp. 95-105, 2005), Jeffrey Pfeffer envisions the workforce as being a source of strategic advantage, not just as a cost to be minimized or avoided. Achieving success through people means in many cases altering how we think about the workforce and the employment relationship. The author provides thirteen policies and practices for managing people. Pfeffer concludes that organizations that respect and work with their people are often able to outmaneuver and outperform their competitors.

◆ In today's complex business environment Codes of Conduct are increasingly regarded as a necessity for all organizations. Employees are often required to read and sign their compliance with codes of conduct as a condition of employment. In some jurisdictions it is a legal necessity. In "Up to Code: Does Your Company's Conduct Meet World Class Standards?" (Harvard Business Review; 83(12): 122-133, 2005; www.hbr.com), Lynn Paine et. al. discuss their research on basic standards of corporate behavior. A Global Business Standards Codex that consists of a set of principles and conduct standards for implementing the principles into practice is provided. This Codex is meant to be used as a benchmark to be used by those who wish to create their own customized code of conduct.

About the Author

Terrance Malkinson is a Governor of the Engineering Management Society, international correspondent for IEEE-USA Today's Engineer Online, editor-in-chief of IEEE-USA Today's Engineer Digest, and editor of IEEE Engineering Management. The author is grateful to the Haskayne School of Business Library at the University of Calgary. He can be reached at malkinst@telus.net .

IEEE Fourth Annual Ottawa Robotics Competition: A Success Story of Local Involvement

By Rami Abielmona, University of Ottawa

The 2006 Institute of Electrical and Electronics Engineers (IEEE) 4th Annual Ottawa Robotics Competition has grown and strengthened, from a mere five schools in 2003 to this year with no less than 11 schools and 18 teams competing in two challenges – for a total of 103 Ottawa area elementary school students.

Schools participate in competitions like this because "It's important to expose students to the wider community, and gives them a chance to make friends with their peers form other schools," asserts Dr Aisha Sherazi, Principal of the Abraar School in Ottawa's west end. "It also helps them learn about other things, that are not necessarily part of the curriculum."

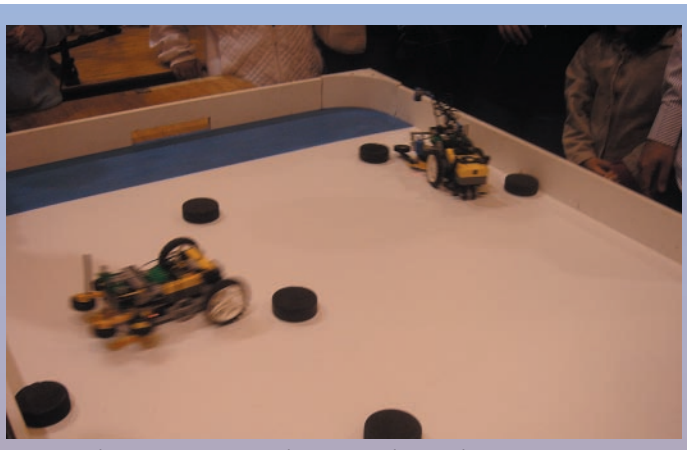
On Sunday May 7, 2006, the IEEE Ottawa Section ran the two challenges at the Ottawa Congress Centre in conjunction with the IEEE's annual Canadian Conference on Electrical and Computer Engineering (CCECE). For the Junior Challenge, Abraar School's *Robo-Tech* won the overall challenge, with Henry Munro Middle School's *Munrobots* getting an award for Team Spirit, and Goulbourn Middle School's *Linebot 3* winning an award for Technical Innovation. For the Senior Challenge, Katimavik Elementary School's *Error 404* won the overall challenge, with Katimavik Elementary School's *Error 404* and *Firewalls* sharing the Team Spirit award, and Roberta Bondar School's *Bondar Bots* winning the Technical Innovation award.

The competition, sponsored by the Faculty of Engineering at the University of Ottawa, was a huge success. As the IEEE Canada President, Dr. Robert Hanna, said in the closing moments, "As far as I am concerned, everyone is a winner!" See the competition's web site at http://www.ottawaroboticscompetition.org for more information.

About the Author

Rami Abielmona (S'00-M'02) is a Ph.D. candidate with the School of Information Technology and Engineering at the University of Ottawa, where he received his B.A.Sc. and M.A.Sc. degrees in computer engineering. He received the "Best Student Poster Award" at the Knowledge Network Conference in 2002, and the "Student Research Excellence Scholarship" by CITO in 2003. He is currently the Chair of the local IEEE Robotics Competition Committee.

The Goulbourn Middle School's *Linebot3* team calibrates their light sensor in preparation of their timed run through the junior challenge. The junio teams found out that the shadow under the bridge needed to be accounted for, as it differed from the values they obtained with their own school mockups.



Two senior challenge entries battle it out in the hockey arena. Points were awarded for performance in the arena, robot design, project report and project poster. A difficult aspect of this challenge was the puck-seeking, since the pucks are randomly placed and the robots only have two light sensors to work with, along with their two touch sensors to recover from collisions.

Some advice from teacher Andrew Hicks for a member of the Roberta Bondar senior challenge team. The team ended up garnering the Technical Innovation award for their novel use of an over-the-top light sensor to pre-detect pucks within the arena.

The *Bondar Bots* team gathers around their design table to make some last-minute adjustments in preparation of their quarterfinal matchup against Katimavik Public School's *Error404*s, the eventual overall winners of the senior challenge.

The Katimavik Elementary School team's spirit almost reaches the ceiling as they pose (very briefly) with their trophy as senior challenge overall winners. They dubbed their entry "*Error 404*", a name only this generation of aspiring engineers could select.

Roberta Bondar School came first in the Technical Innovation category of the senior challenge for their entry *Bondar Bots*, seen orbiting just to Bob Hanna's right. Don't be surprised if the next photo from this group comes from the international space station.

Goulbourn Middle School's junior level team, a bit tired after an exciting but long day, took home the Technical Innovation award for their entry *Linebot 3*. Watch out for them next year!

Awards Presentation - 8 May 2006
Ottawa Congress Centre

Canada Council Awards

J.J. Archambault Eastern Canada Council Merit Award "For Investigation and Submission of the IEEE Milestone for Hydro-Quebec 735 kV Transmission Line."	 **Gilles Baril**	**Prix du mérite J.J. Archambault est du Canada** "Examen et soumission du prix IEEE Milestone pour la technologie de transport d'électricité à 735 kV d'Hydro-Québec."
M.B. Broughton Central Canada Council Merit Award "For outstanding contribution and expanding volunteer work in the activities of IEEE Central Canada Council and the IEEE Hamilton Section."	**Scott Lowell** 	**Prix du mérite M.B. Broughton centre du Canada** "Pour sa contribution remarquable ainsi que pour le développement du travail bénévole pour les activités du Conseil du Centre du Canada de l'IEEE et de la Section IEEE de Hamilton."
Ted Glass Western Canada Council Merit Award "For outstanding contributions to IEEE Canada's financial management and membership development."	 **Hilmi Turanli**	**Prix du merite Ted Glass- ouest du Canada** "Pour ses contributions remarquables à la gestion financière de l'IEEE Canada et au développement de l'effectif."

Service Awards

Wallace S. Read Service Award "In recognition of service to the profession and to the society."	 **Adam Skorek**	**Prix du service Wallace S. Read** "En reconnaissance de services rendus à la profession et à la société."
Outstanding Engineering Educator Award "For decades of dedication and outstanding contributions to engineering education and profession."	**Paresh Sen** 	**Prix d'exellence en enseignement du génie** "Pour des décennies de dévouement et pour ses contributions remarquables à la profession et à la formation en génie."
Outstanding Engineer Award "For excellence in the electrical engineering profession in both academia and industry."	 **Charles Despins**	**Prix d'exellence en ingénierie** "Pour l'excellence dans la profession d'ingénieur électrique en milieux universitaire et industriel."

Medals

Fessenden Medal "For sustained leadership in the formation and execution of University based National and Provincial research programs."	**David Plant** 	Médaille Fessenden "Pour son leadership soutenu dans la création et l'exécution de programmes de recherche universitaire nationaux et provinciaux."
McNaughton Medal "For contributions to Canadian and International computer networks research and, in particular, optical networking, photonic switching and wireless communication networks." *The A.G.L. McNaughton Medal is IEEE Canada's highest honour, and it recognizes outstanding contributions made to the engineering profession in Canada.*	 **Hussein Mouftah**	Médaille McNaughton "Pour ses contributions à la recherche sur les réseaux informatiques canadiens et internationaux, en particulier les réseaux optiques, les commutateurs photoniques et les réseaux de communication sans fil." *La plus haut distinction de l'IEEE Canada, la medaille A.G.L. McNaughton, reconnais des contributions remarquable à la pratique de l'ingénierie au Canada.*

President Bob Hanna of IEEE Canada presents Banners to three Canadian Sections celebrating 50 years of Service

David Gregson & Susan Perkins receive the Victoria banner

Mehran Mehrandezh, South Saskatchewan secretary, takes delivery of their banner

Lawrence Whitby accepts banner on behalf of Southern Alberta section

IEEE Canadian Foundation Scholarships

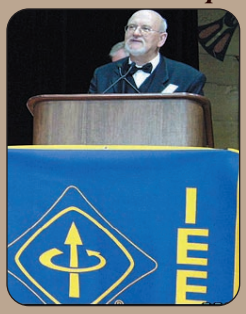
Up to 10 Scholarships are awarded annually to student leaders in student branches with IEEE McNaughton Learning Resource Centres. Certificates are handed to the respective Section Representatives, who then arrange suitable presentations to the winning students. The scholarships (currently $3500 at universities or $1750 at colleges) are credited to recipients' accounts for partial payment of final year undergraduate fees.

In section order as per photo to the left, scholarship recipients are: Nina Selak, UBC; Jordan Choi, University of Calgary; Nuzhat S Rehman, Carleton University; Louis Girard, Université de Sherbrooke; Stephen Woodrow, University of Manitoba; Robert Coish, Memorial University of Newfoundland; Ramnesh Bansal, Ryerson University.

Standing (L-R): Foundation President Bob Alden, Rasvan Mihai (Vancouver), Lawrence Whitby (Southern Alberta), Branislav Djokic (Ottawa), Amir Aghdam (Montreal). **Seated** (L-R): Dawn Nedohin-Macek (Winnipeg), Kathleen Chafe (Newfoundland & Labrador), Bob Hanna, IEEE Canada President (Toronto).

EIC Fellowship

Witold Kinsner shares his thoughts upon receipt of the Fellowship of the Engineering Institute of Canada



RAB Leadership

Eric Holdrinet receives the IEEE Regional Activities Board (RAB) Leadership Award for "leadership, a global vision, and sustained contributions and support for the growth of IEEE in Canada, especially in Eastern Canada and Montreal."

- 20th Annual -

Canadian Conference on Electrical and Computer Engineering

Our Common Future

Vancouver, BC, Canada

Sheraton Wall Centre Hotel

22-26 April 2007

IEEE Canada

http://ieee.ca/ccece07/

CCECE 2007

Call for Papers

Papers are invited, in French or English, including but not limited to the following topics:

- Advanced Computer Architecture
- Agent-Based & Internet-Based Systems
- Analog & Digital Electronics
- Antennas & EMC/EMI
- Artificial Intelligence
- Biomedical Engineering & Bioinformatics
- Communications & Wireless Systems
- Computer Networks and Systems
- Control Theory & Applications
- Database & Data Mining
- Digital Signal Processing
- E-Learning, E-commerce, E-business
- Electrical Machines and Drives
- Electromagnetics and HV Engineering
- Electronic Circuits and VLSI
- High-Performance Computing
- Human-Machine Interactions
- Image & speech Processing
- Instrumentation and Measurement
- Intelligent Systems
- MEMS & Nanotechnology
- Microelectronics & Optoelectronics
- Mobile & Pervasive Computing
- Neural Networks & Fuzzy Logic
- Optical Systems & Photonics
- Pattern Recognition
- Power Electronics
- Power systems & Renewable Energy
- Power Systems Reliability
- Real-Time Embedded Systems
- Robotics & Mechatronics
- RF & Microwaves
- Remote Sensing, Sensors and Devices
- Security, Privacy and Trust
- Software Engineering
- Virtual Reality and New Media

The Conference

The 2007 IEEE Canadian Conference on Electrical and Computer Engineering provides a forum for university, industrial and government delegates from Canada and around the world to exchange their ideas on research and disseminate their results and experiences in the field of Electrical and Computer Engineering.

Held annually since 1988, CCECE is the major IEEE event and flagship conference in Region 7 (Canada). Since then the conference has been held in Vancouver, Montreal, Ottawa, Quebec City, Toronto, Halifax, Calgary, St. John's, Waterloo, Edmonton, Winnipeg, Niagara Falls, and Saskatoon. As the 2007 conference will be the twentieth, several special events are planned.

Who attends?

Based on the statistics of the conference in the recent years, we are expecting an attendance of about 500 delegates, consisting mostly of researchers from universities, industry and government. At the previous recent conferences, about 10% of the delegates were from outside Canada. We expect and encourage the following groups of individuals to attend CCECE'07:

- Researchers, educators and students in the field of electrical and computer engineering
- Representatives of governmental organizations, business and trade associations concerned with the field
- Executives, R&D staffs, entrepreneurs, consultants and advisors of high-tech companies
- All those with an interest in electrical and computer engineering

Conference organization

The conference will include:

- Plenary sessions with keynote addresses by leading academics, executives and government representatives
- Parallel sessions and workshops
- Poster presentations
- Student paper competition

Submission Guidelines and Important Dates

Submit a 300-word abstract as a PDF Document and send it to ccece2007@ece.ubc.ca on or before November 30, 2006. The following important dates are to be noted:

Abstract Submission: 30 Nov. '06

Acceptance/Rejection: 08 Dec. '06

Full Paper Submission: 08 Jan. '07

Papers accepted will be published in the Conference proceedings and will be available worldwide through IEEE Xplore.

Further Information:

Vijay Bhargava
General Chair, CCECE2007
Department of Electrical and Computer Engineering
The University of British Columbia
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Vancouver BC Canada V6T 1Z4

E-mail: ccece2007-info@ece.ubc.ca

web site: http://ieee.ca/ccece07/

- 20e Annuelle -

Conférence canadienne de génie électrique et informatique

Notre avenir commun

Vancouver, BC, Canada

Hôtel Sheraton Wall Centre

22-26 avril 2007

CCGEI 2007

http://ieee.ca/ccece07/

IEEE Canada

La conférence

La Conférence IEEE canadienne de génie électrique et informatique 2007 procure un forum aux délégués universitaires, industriels et gouvernmentaux du Canada et du monde pour discuter de leurs idées de recherche et présenter leurs résultats et expériences dans les domaines du génie électrique et informatique.

Tenue annuellement depuis 1988, CCGEI est la conférence emblématique du IEEE en Région 7 (Canada). Elle s'est tenue à Vancouver, Montréal, Ottawa, Québec, Toronto, Halifax, Calgary, St. John's, Waterloo, Edmonton, Winnipeg, Niagara Falls, et Saskatoon. Comme la conférence 2007 sera la vingtième, plusieurs événements spéciaux sont prévus.

Qui sont les participants?

Selon les données statistiques des dernières années, nous prévoyons que la CCGEI 2007 accueillera environ 500 délégués composés majoritairement de chercheurs des universités, de l'industrie et du gouvernement. Lors des récents congrès, environ 10% des délégués provenaient de l'étranger. Nous attendons et encourageons la participation des groupes suivants :

- chercheurs, enseignants et étudiants dans les domaines du génie électrique et du génie informatique;
- représentants des organismes gouvernementaux et associations d'affaires et de commerce intéressés par ce domaine;
- dirigeants, personnel en R&D, entrepreneurs, consultants et conseillers auprès des compagnies en haute-technologie;
- tous ceux et celles qui ont un intérêt pour le génie électrique et le génie informatique.

Aperçu de la conférence

La conférence se composera de :

- sessions plénières avec discours d'ouverture par des conférenciers de renom du milieu académique, de l'industrie et du gouvernement;
- sessions parallèles et ateliers;
- présentation d'affiches thématiques techniques;
- compétition d'articles d'étudiants.

Guide de soumission et dates importantes

Vous devez soumettre un résumé de 300 mots de votre article en format PDF. La soumission doit être faite par courriel à l'adresse ccece2007@ece.ubc.ca au plus tard le 30 novembre 2006. Veuillez prendre note des dates suivantes :

Soumission du résumé:
- **30 novembre 2006**

Annonce des résultats:
- **08 décembre 2006**

Soumission de l'article complet:
- **08 janvier 2007**

Les articles acceptés seront publiés dans les actes de la conférence et disponibles en ligne sur IEEE Xplore.

Informations additionelles:

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2332 Main Mall, Kaiser 5500
Vancouver BC Canada V6T 1Z4

Courriel: ccece2007-info@ece.ubc.ca

web site: http://ieee.ca/ccece07/

Appel aux Communications

Des communications en français ou en anglais sont sollicitées sur des sujets qui incluent, mais ne sont pas restreints à:

- Architecture avancée des ordinateurs
- Systèmes à base d'agents et sur Internet
- Électronique analogique et numérique
- Antennes et EMC/EMI
- Intelligence artificielle
- Génie biomédical et bioinformatique
- Communications et systèmes sans fil
- Réseaux et systèmes informatiques
- Théorie du contrôle et applications
- Forage et bases de données
- Traitement numérique des signaux
- Apprentissage en ligne et commerce électronique
- Machines et entraînements électriques
- Électromagnetique et ingénierie de la haute tension
- Circuits électroniques et ITGE (VLSI)
- Calcul haute performance
- Interaction homme-machine
- Traitement de l'image et de la parole
- Instrumentation et mesure
- Systèmes intelligents
- Systèmes microélectromécaniques et nanotechnologie
- Microeléctronique et optoélectronique
- Informatique diffuse
- Réseaux de neurones et logique floue
- Systèmes optiques et photoniques
- Reconnaissance de formes
- Électronique de puissance
- Systèmes d'énergie et énergies renouvelables
- Fiabilité des systèmes d'énergie
- Systèmes en temps réel et embarqués
- Robotique et mécatronique
- RF et micro-ondes
- Télédétection, capteurs et dispositifs
- Sécurité, confidentialité et confiance
- Génie logiciel
- Réalité virtuelle et nouveaux médias

EAST ...

LEOS Annual Meeting 2006
2006-10-29...11-02, Montreal, QC
http://www.ieee.org/organizations/society/leos/LEOSCONF/LEOS2006

IEEE Int'l Workshop on Haptic Audio Visual Environments and their Applications (HAVE)
2006-11-04...05, Ottawa, ON
http://www.discover.uottawa.ca/have2006/

16th Annual Newfoundland Electrical and Computer Engineering Conference
2006-11-09, St John's, NL
http://necec.engr.mun.ca/

Electrical Power Symposium 2006
2006-11-09...10, Ottawa, ON
http://www.ewh.ieee.org/soc/pes/ottawa/EPS2006/

Communication Networks and Services Research Conference (CNSR)
2007-05-14...17, Fredericton, NB
http://www.cnsr.info/cnsr2007/

10th Int'l Conference on Information Fusion (FUSION)
2007-07-09...12, Québec, QC
http://www.fusion2007.org

27th IEEE Int'l Conference on Distributed Computing Systems (ICDCS)
2007-06-25...29, Toronto, ON
Ihttp://www.eecg.utoronto.ca/icdcs07/

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WEST ...

2007 IEEE Electrical Safety, Technical and Mega Projects Workshop
2007-02-26...27, Calgary, AB
http://www.ieee.org/megaprojects

IEEE/IAS PCIC Electrical Safety Workshop 2007
2007-02-27...03-02, Calgary, AB
http://www.ewh.ieee.org/cmte/ias-esw

Int'l Conference on COTS-Based Software Systems (ICCBSS)
2007-02-26...03-02, Banff, AB
http://www.iccbss.org/2007/

20th Canadian Conference on Electrical and Computer Engineering
***20e Conférence canadienne en génie électrique et informatique* (CCECE/*CCGEI*)**
2007-04-22...26, Vancouver, BC
http://www.ewh.ieee.org/reg/7/ccece07/

IEEE/IAS Industrial & Commercial Power Systems Technical Conference (I&CPS)
2007-05-06...09, Edmonton, AB
http://northerncanada.ieee.ca/ias-pes/ICPS2007.html

10th Canadian Workshop on Information Theory (CWIT)
2007-06-06...08, Edmonton, AB
http://www.ece.ualberta.ca/~cwit2007

4th IEEE Int'l Workshop on Visualizing Software for Understanding and Analysis (VISSOFT)
2007-06-24...25, Banff, AB
http://www.program-comprehension.org/vissoft07/

IEEE Petroleum and Chemical Industry Technical Conference (PCIC)
2007-09-17...19, Calgary, AB
http://www.ieee-pcic.org

MTS/IEEE OCEANS 2007 : "On the Edge of Tomorrow"
2007-09-29...10-04, Vancouver, BC
http://www.oceans07mtsieeevancouver.org/

Int'l Topical Meeting on Microwave Photonics (MWP)
2007-10-02...05, Vancouver, BC

IEEE Avionics, Fiber- Optics and Photonics Technology Conference (AVFOP)
2007-10-02...05, Victoria, BC