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U.S. CANADA BILATERAL COOPERATION OPPORTUNITIES IN DEFENCE ROBOTICS

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U.S.-Canada Bilateral Cooperation Opportunities in Defence Robotics

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Abstract

Robotics is a key emerging technology where successsful implementation depends on the user's ability to effect advantageous solutions at the lowest possible development cost. This implies the need to the use the best and most suitable technologies, irrespective if their origin is national or foreign, thereby calling for effective cooperative international efforts. Robotics is a multidisciplinary domain with numerous subspecialties. This complicated nature of the technology affects the knowledge transfer and makes it much more difficult to find quid pro quo "nuggets," particularly in jurisdictions of other countries. Mechanisms facilitating identification of those special technologies must be improved. Various options available to address this problem on the U.S.-Canada bilateral level are presented. Similarly, possibilities for cooperative research and development in robotics-related areas are addressed.

Introduction

Background

In many countries today, robotics is seen as a key emerging technology with application in both the military and civilian environment. There are benefits, however, to leveraging sources for that technology outside national boundaries. The benefits of leveraging foreign technology include

- it is in keeping with today's increasing environment of multinational military ventures;
- it allows you to capitalize on the advanced technology developed by allies;
- it can make programs more affordable by spreading costs among a number of partners; and
- it avoids duplicative research and development (R&D) expenditures.

New economical realities are also resulting in some new constraints and some new opportunities in cooperative developments. The quid pro quo stand is necessary to effect exchange of technology and to prevent its unidirectional flow. Concurrently, fewer available resources call for the most cost-effective and pragmatic approach to development. This implies the need to use the best and most suitable technologies, regardless if their origin is national or foreign, thereby calling for effective cooperative international efforts.

Currently, no formal bilateral arrangements exist between Canada and the United States specifically in the robotics area. However, the 30-year-old Defence Development Sharing Agreement (DDSA) between the U.S. and Canada is very broad and could therefore facilitate a type of cooperation about specific topics in robotics R&D. Additionally, a multinational information exchange about operator-robot interaction (ORI) has been in place for the last 4 years through the NATO, AC/243 Defence Research Group, Panel 8/Research Study Group (RSG-18). Its membership included Canadian and the U.S. representatives, along with a number of European countries, and it enhanced familiarization with robotics in the member countries. Similarly, the Technical Cooperation Program (TTCP) is a multinational activity involving Australia, Canada, United Kingdom, and the U.S. Some information exchange took place also under this program through the activities of the Subgroup W, Technical Panel WTP-6.

Objectives

This paper focuses on bilateral cooperation opportunities in defence robotics. Various applications of robotics in support of defence requirements in each country may be identified and pursued. The unmanned ground vehicle (UGV) theme may serve as an example for land operations requirements. The report describes a process for identifying foreign technology opportunities and discusses various facilitating mechanisms available on the U.S.-Canada bilateral level. Specific ongoing programs and possibilities for collaborative research and development in UGV-related areas are briefly outlined.

The Quest for Technology "Nuggets"

Obstacles

The search for technology nuggets (i.e., foreign technology concepts/components/methodologies that could potentially enhance a nation's robotics program) is impacted by several factors:

- The first question to be resolved by each nation is to determine where to start. Many countries have a robotics program in progress, but which ones have something to offer that the others do not? Limitations of resources demand that this question be answered in some other way than by visiting each country. Then again, robotics activity may be spread within a country, that is, among the universities, Government laboratories, and various commercial ventures.
- Experience has taught us that technology nuggets exist at the subsystem/component level. For example, many countries have UGV programs, but these may differ in their technical approach. One country may have a UGV obstacle-detection and-avoidance package that, at a quick glance, appears to have the same performance characteristics as those in most other UGV programs. However, this particular obstacle-detection and-avoidance package may have a particular unique design approach that would classify it as a nugget.
- Robotic solutions are used in a very broad spectrum of applications ranging from manufacturing in highly structured environments to hazardous material handling, underwater operations, space activities, or UGV operations involving what is commonly called "unstructured" environments. Robotic solutions are also used in a broad range of other applications that are not explicitly identified as a part of the robotics domain (for example, simulation technology). Consequently, some robotic technological nuggets may be difficult to locate and identify because of their "remoteness." Nevertheless, they may be most suitable and most desirable for "transplanting" to applications in other than the original environment or application. Therefore, a broad access to the full spectrum of applications is most desirable.
- Robotics is a multidisciplinary domain with numerous technical subspecialties. The complicated nature of robotics affects knowledge transfer and makes it much more difficult to find technology nuggets. It is impossible to take a full battery of experts to another country or even to an in-country conventior to cover all topics of interest (e.g., the compute scientist to cover control architecture, the senso specialist to obstacle/target detection technology, o the mechanical engineer who specializes ir manipulator design).
- How do you validate a technology? Anothe: country can claim to have a UGV with a road-following system that allows travel down a paved roac at speeds exceeding 60 mph. Is this claim valid? Are there certain conditions which seriously impact it. performance? For instance, the same UGV may be able to travel at 60 mph down a paved road but in rain might be stopped altogether by rain puddle reflections that cause image-processing confusion. These questions underline the need for dynamic equipment demonstrations, standard performance metrics, access to valid performance data, and candid discussion with the researchers of origin by experts in the topic.

Facilitating Mechanisms

Conferences

At both the national and international level, robotics-oriented conferences exist that can facilitate the nugget search process. Examples include the International Robotics and Vision Conference next scheduled for 1995 in Detroit, Michigan, the 24th International Symposium on Industrial Robots held in Tokyo, Japan, October 1993, the 20th Annual Technical Symposium and Exhibition sponsored by the Association for Unmanned Vehicles Systems (AUVS) that occurred June 1993 in Washington, DC, IEEE, The International Society for Optical Engineering (SPIE), and a number of other bodies sponsor regularly a number of excellent technical conferences of importance to the robotics field. NATO-sponsored conferences such as the DRG Seminar on Robotics in the Battlefield, held in Paris in 1992, provide an overview of the international defence robotics scene. The workshops about military robotic applications held biannually in Canada facilitate an overview of the Canadian advances in the field.

Reports/Magazines/Periodicals

Published conference proceedings can sometimes substitute for actual attendance. Such publications can also fill information gaps that were missed, even if the conference was attended. For example, the 20th Annual AUVS Technical Symposium and Exhibition (mentioned before) published a 1148-page proceedings manual and a full list of attendees, with addresses and telephone numbers, that would be very useful in follow-up actions.

Other examples of reports/magazines/periodicals are *Robot Times, Industrial Robot International Quarterly, Journal of Robotic Systems, Military Robotics, AMSE Journal of Dynamic System Measurement and Control, IEEE Transactions on Robotics and Automation, International Journal of Robotics Research, and Robotics World.* Many times, however, relevant articles exist in publications that are not directly related to robotics, making the literature search process very difficult. These more esoteric sources could have a military orientation, such as *National Defense*, the journal of the American Defense Preparedness Association, or a peripheral technology orientation, such as the *Proceedings: Image Understanding Workshop* sponsored by the Advanced Research Projects Agency.

University Research Centers

Universities are typically working on the cutting edge of technology, but the research they conduct is normally basic in scope and not ready for integration into functional prototypes for some time. Reports about university results are generally easy to access (i.e., not restricted as proprietary data); however, many academic institutions in both the U.S. and Canada are involved in robotics research, and it is difficult to keep track of all their activities.

Personnel Exchange Programs/Visits

The exchange of scientists and engineers is possible through some of the international agreements/forums described below. Such exchange programs help foster collaboration and, more important, are one of the best ways to identify specific quid pro quod opportunities.

Trade Shows/Demonstrations

Trade shows offer the opportunity of conducting quick, usually static, surface-level searches for technology nuggets. Examples include the 20th - Annual AUVS Technical Symposium and Exhibition mentioned before.

Demonstrations are preferred to trade shows because demonstrations typically offer dynamic performance data in a quasi-realistic operational environment. Demonstrations are key to addressing the technology validation obstacle discussed before. A joint U.S./Canadian demonstration of countermine-robotics is being considered by both nations. Such a demonstration tends to supplement each other's program with the knowledge and capabilities of the other country and promotes concerted action to identify and close important gaps in the collective technology base.

International Agreements/Forums

The most active U.S./Canada agreement in use by military robotics interests is the Defence Development Sharing Agreement (DDSA). DDSA working groups are responsible for nominating candidate R&D projects to be considered for joint U.S.-Canadian funding. Currently, discussions are progressing that have a working objective of developing a joint U.S.-Canadian engineering development program about a tactical unmanned ground vehicle.

Another possible avenue for collaborative activities is the Technical Cooperation Program (TTCP). TTCP affects the interchange of information, personnel, and material for the participating countries (i.e., Australia, Canada, United Kingdom, and U.S.) with each other's defence technology programs in

- Basic research
- Exploratory development
- Advanced technology demonstrations

A proposed project is currently being staffed through TTCP Working Technical Panel-6 entitled "Operational Assessment of Battlefield Robotics." The objective of that project is to identify, evaluate, and recommend methodology that will be used to define, with confidence, the utility of robotics on the battlefield. The U.S. and United Kingdom have agreed to conduct the operational assessment in that project, with Canada and Australia providing technical input and review.

A robotics-oriented Information Exchange Annex between the U.S. and Canada is currently in staffing. This Annex will provide for the exchange of data about research and development program descriptions and experience in the field of robotics for the planning, design, and operation of robotics systems for military forces. DEA coverage includes teleoperated and autonomous robotic vehicle platforms and manipulators, for both weapons system and materials handling applications, as well as the component technologies of robotic systems such as high payload-to-weight ratio manipulators, artificial intelligence aspects of robotic systems, and simulation techniques used to assess the military effectiveness of robotic systems and component technologies.

A Proposed Process

The obstacles to the search for foreign technology nuggets and existing mechanisms for producing international cooperative opportunities suggest the following five-step process.

Phase 1 (initial search)

The initial (macro) search process aims at narrowing down the robotics technology nugget search process down to specific countries and perhaps specific general subject areas (e.g., manipulators, navigation, autonomous driving). Mechanisms that best support this objective are

- Review of reports, magazines, and periodicals
- Attending conferences, symposia, and so forth
- Attending trade shows

Phase 2 (focused search)

The focused (micro) search process centers on further narrowing the search to a particular activity of interest within a specific country. At this point, the problems associated with the multidisciplinary nature of robotics typically begin to surface. If the target nugget is technically diverse, then it may be necessary to try to bring enough technical detail back for further analysis by subject experts. Mechanisms that best support the focused search phase are

- Personnel exchange programs or visits
- Attending trade shows and demonstrations

Sponsorship of an international agreement or forum may be important at this phase, particularly if there is a requirement to bring back technical detail for further analysis by subject experts.

Phase 3 (classification)

Having located a potential technology nugget, it becomes necessary to validate its worth to one's robotics program before considering acquisition possibilities. As suggested before, this might require convening a panel of experts who would cover the complete range of technical facets of the nugget in question. At this time, preliminary discussions of quid pro quo would also be appropriate.

Phase 4 (acquisition)

Having decided in the previous phase that the nugget is worth pursuing, the issue then becomes how to acquire it. It may be as simple as outright purchase, or especially if advanced technology is involved, a quid pro quo would be appropriate. Again, sponsorship through an international agreement or forum may be important in this phase.

Phase 5 (evaluation and integration)

Following acquisition, the last logical phase would be hands-on evaluation of the nugget and subsequent integration into a national robotics program.

Conclusions

This paper looks at the quest for foreign technology nuggets in robotics, discusses the obstacles, facilitating mechanisms, and a suggested process. This is not to say, however, that all has been resolved. On the contrary, the nuggets continue to elude the search process; there are so many countries, industries, and universities throughout the world doing work in robotics that it is difficult to accomplish any sort of comprehensive search without using significant resources. The problem is compounded by the fact that nuggets often occur on the periphery, that is, exist in another technology area but could be of significant benefit to a robotics system. The whole process might be simplified if something like the Paris Air Show existed for robotics, but there is nothing comparable. Perhaps as robotics matures and applications abound, increased interest will bring with it the resources that will make the quest easier.

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