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SOCIAL AND ECONOMIC IMPLICATIONS OF AI: REAPPRAISING ARTIFICIAL INTELLIGENCE

BY

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ABSTRACT

This report - the ninth in a series on Artificial Intelligence (AI) - examines some remaining underlying assumptions in terms of theory and practice. It should preferably be read in the context of the series of papers produced through this project.

RÉSUMÉ

Ce rapport - le neuvième d'une série portant sur l'intelligence artificielle (IA) - examine quelques hypothèses sous-jascentes sur le plan théorique et pratique. Il est recommendé de lire le présent rapport en se référant aux précédents publiés dans la même série.

FOREWORD

This is the ninth, and penultimate, in a series of reports which examines social and economic implications of Artificial Intelligence (AI). Through this series we have been especially concerned with the potential impacts of AI, direct as well as indirect, on the Canadian Department of National Defence and the Canadian Forces.

The present paper examines some remaining underlying assumptions of AI. It looks at the most recent critical arguments which have been levelled against the theory - and implicitly applications - of this particular technology. It should be noted that arguments about theory are important, as everything else depends upon their acceptance or rejection. In one major sense, therefore, the claim is true that nothing is as practical as good theory. We have previously shown that there are several direct as well as indirect potential uses of AI for defence and military purposes, in combat as well as non-combat situations, including military education, training and exercises. Among the special uses, for example, which have been highlighted, are Expert Systems (ES) and Robotics.

For the above reasons, it would be useful and helpful to read the present paper in conjunction with the series of reports already produced under Project 96732-1: Social and Economic Impacts of Artificial Intelligence, and listed as Annex A.

A select bibliography on AI is maintained and updated throughout this series of reports, but not included in the present paper.

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INTRODUCTION

The long-term practical utility of Artificial Intelligence (AI) is indisputable. In the series of papers produced throughout Project 96732-1: Social and Economic Impacts of AI, we have examined both the general and specific impacts which can be expected from this technology.[1] We have shown some direct, practical uses which are possible and probable, [2] and also some which are already implemented or are on their way to being implemented [3].

In the case of Expert Systems (ES), for example, new developments have already taken place since this project was initiated and the present series of reports commenced. Particular military uses of AI have already been examined in some detail [4], as have industrial applications which will have indirect as well as direct socio-economic implications for defence and security [5]. We have even ventured to take a close critical look at some of the most futuristic aspects of AI, and to assess the general and specific utility and importance of Artificial Neural Network Systems (ANNS) [6].

For the sake of completeness, we shall now turn to the remaining underlying assumptions concerning AI as a technology and socio-economic 'agent for change.' We have shown that AI is a very challenging technology which will likely have quite profound and serious socio-economic impacts. Many changes are certain to follow in its footsteps, where the technology is implemented as well as where it is not. Defence, military and security implications - many of which have been discussed in some detail - could be substantial. For these reasons, and others as well, it is only to be expected that the debate

surrounding AI has been and may remain quite intense. As we have shown, at times some of the arguments which have been marshalled by proponents and (more particularily) adversaries of AI have been spurious. They should be rectified.

Time has now come to turn to the remaining, most recent, critical arguments which have been raised against AI as a technology and with respect to major socio-economic impacts. Since we have already covered the AI ground rather thoroughly we may be able in the final parts of this project to set the record straight.

RE-APPRAISING ARTIFICIAL INTELLIGENCE:

The first group of opponents to AI - and in a particular sense to its applications - have come from the "ideological" school. By this is meant that they were opposed for emotional, psychological and cultural reasons. 'Artificial Intelligence,' apart from being seen as a contradiction in terms was purely wrong, ethically and otherwise. From a scientific and technological level of analysis, we need not concern ourselves overly with this group. We should, however, observe since its source is emotive that the opposition has been strongly felt and expressed. In a sense, this group is relatively easily dealt with, as the adversary attitudes most often express themselves quite clearly. Also, as a rule there is no 'hidden agenda' in this particular case.

The second group of opponents to AI in general, and to certain aspects of this technology in particular, has come from individuals or even firms previously associated with it. This may seem somewhat contradictory, but it really is not when looked at a little more closely. Quite clearly, competition for attention - to say nothing of competition for resources - has often been at the base of opposition. One good example is to be found in the AI subfield of Artificial Neural Networks (ANNS).[7] When Dr. Francis Rosenblatt of Cornell University some 30 years ago began his critical work on simple pattern-learning networks referred to as 'Perceptrons,' criticism did not take long to arise. Some of its strongest proponents believed themselves close to actually being able to build a brain with all that this would entail. The number of persons doing 'perceptron'research reached upwards of 1000. Some very interesting ideas were developed, with quite important potential uses, for instance, in the area of data classification.

However, this tended to trouble some of the earliest AI pioneers who saw their own stature being threatened. Consequently a heated debate developed leading to interesting but clearly opposing arguments. To take a prounouced example, Marvin Minsky and Seymour Papert of MIT published Perceptrons in 1969, in which they proceeded to show by means of mathematical dissection how a 'perceptron' suffered from such profound limitations that it could not possibly work. Seen in retrospect, much of this criticism may be considered professionally biased and unfair and - even as subsequently admitted by Minsky himself - a case of 'overkill.' In retrospect, it is also clear that the initial objections to Neural Nets had been based on definitions so narrow as to rule out almost all interesting research work. As Bernard Widrow of Stanford University saw it, these critics had attempted - with considerable success - to narrow deliberately the definition of the perceptron to the point that it was of no practical use whatsoever.[9]

A main motivating factor in this group of opponents would seem to have been professional uncertainty or rivalry. In an even more basic sense, as with the third main group of AI adversaries, it may simply be competition for increasingly scarce resources. Competition in the business world is often fierce because of the high financial stakes involved. In academia or research environments competition can at times be equally fierce for the opposite reason. When stakes are low the level of pettiness often increases.

Turning from the academic or research environment to that of business, it is important to note how competition for scarce resources has been a major driving force in recent criticism to AI applications. In a critical article entitled "AI: The Technology That Wasn't," Gary R.

Martins has marshalled several arguments against the acceptance of AI as a technology, hence its utility. [10] The author is Founder and Chief Executive Officer of Intelligent Software, Inc., a software development and consulting firm located in Van Nuys, California. We have had some problems and misgivings with Martins' criticism and decided to counteract and rebut his argumentation, which we felt was typical of several major misconceptions about AI [11].

To summarize briefly, Martins' argument that AI was intended as a replacement for all other software applications and developments struck us as simply untrue. Whereas it may lead to a replacement of some other techniques, in several cases AI is an augmentation of current capabilities, rather than a replacement. We felt that this point was sufficiently important to be stressed.

With respect to Expert Systems (ES), Martins (and many with him) had chosen to concentrate criticism on particular failures. Certainly failures in this field have occurred, but some should be expected. We would argue that the technology is maturing and that, by now, the use of Expert Systems is already well entrenched in both the financial and military worlds. Not only are these uses unlikely to disappear, they will proliferate to different levels. One such example would be context-dependent help within personal computer packages. [12]

Concerning Massively Parallel Machines, Martins has argued that they would be unlikely to enjoy much commercial success. They were according to him, extremely expensive and would make software developments exceedingly complex and difficult. To put it briefly, Martins claims that they are not cost-effective and would likely remain so for the foreseeable future. However, Massively Parallel Machines

are only now being introduced, hence they were being prejudged. For example the Connection Machine may be programmed effectively in an extended version of LISP (List Processing), a useful and powerful high level language. Despite the fact that such machines only speed up certain types of problem solving (as emphasized by Martins) several aspects of AI would fall into this particular category (e.g. Image Processing).

In his recent article, Martins has singled out the Autonomous Land Vehicle (ALV) for particular criticism, even ridicule. If it travels slowly enough, i.e. less than three miles per hour, the van may sometimes be able to make it all the way around a brightly lit, carefully marked, optically smooth course without serious problems, he states. The counter-argument to this is that such technologies take time to develop. It took several years to put a man on the moon, and AI may even be tougher. In fact, the ALV project demonstrates initial feasibility.

This particular opponent of AI and some others with him have also suggested that Japan is rapidly redirecting fifth-generation computer funding away from AI and into more "productive" areas, such as advanced manufacturing technology. However, in our examination, we have found little or no evidence to this effect. In fact, the opposite applies. According to our sources as well as to on sight observers in Japan, the role of AI continues to grow, despite a temporary lull based upon short term financial considerations.[13]

Martins is also a typical representative of the particular school of thought when he argues that several companies which have invested in AI have not gained a competitive edge on those which omitted to invest. He

uses Xerox as an example of a company which has, according to him, suffered a "breathtaking" loss of market share in its primary product lines. Hence, to Martins' mind, there is no evidence that AI has improved products, markets or projects for Xerox despite 16 years of spending on this activity.[14]

Now, the direct response to the latter criticism is that Xerox has produced Smalltalk which, according to many experts is a very good and effective language for several AI and other applications. It would therefore be required, it seems, to check Martins' sources on this particular score more closely. Furthermore, if deemed necessary it would probably make more sense to argue loss of market share for other reasons.

Perhaps the most pointed part of this criticism is the claim that "Software is hard: Wall Street is easy - the guy who sells out first wins."[15] By this he probably means that whereas sales talk may be easy, development work is not necessarily so. Mr. Martins also argues that whereas some carefully hedged applications in electronic intelligence and strategic warning operations are under development, such as limited speech-recognition capabilities - these are mistakenly claimed as part of AI (our emphasis). Image Understanding technology is gradually gaining limited acceptance in certain applications, such as reconnaissance and targeting, and may therefore be able to play more significant roles for intelligence analysis as well as targeting. Also, optical (holographic) and convolutional (neural nets) adjuncts to sequential digital image processing are currently being investigated. However, Martins' final words on this sequence of, to our mind, significant events is that it is too early to evaluate the

claims being put forward for these technologies. At any rate, as he sees it, the best work in both fields have never had any connection with AI.

Now, it should be understood that it is very common in many new areas for several (rather than one or two) start-up companies to appear, similar to developments when personal micro-computers were first introduced into the market. It is normal that a 'shake-out' period occurs prior to which the leaders in a particular field establish themselves. If anything, therefore, the Wall-Street phenomenon to which references have been made, may very well be an indication that the AI business is going through its first maturing phase. Furthermore, both Natural Language Understanding (NLU) and Image Processing, contrary to what Martins and like-minded critics choose to believe are showing considerable promise and may well be 'going places.' For example, NLU is already playing an important role in embedded AI applications of office automation, whereas Image Processing has been used to reconstruct detailed terrain maps from digital satellite maps.

We have already exposed some of the underlying fallacies with individual counter-arguments to AI. [16] Having pulled these together, the time is now more or less ripe to deliver some final conclusions in this particular respect.

CONCLUSIONS

As we have already shown, the current state of affairs pertaining to AI indicates quite clearly that research has made progress, and in some areas quite spectacularly in terms of potential practical importance. However, much remains to be done.[17] This has to be expected in such a new, rapidly evolving field. It is very hard to understand why many of the critics of AI fail to accept this point.

If human-level performance seen exclusively from the present is the sole measure, then AI does not work. However, as we have argued, this is much too narrow a measurement to apply and it misses the point.[18]

A key factor when assessing the future of sophisticated and complex military computing applications, such as C^3I (Command, Control, Communications and Intelligence) or SDI (Strategic Defence Initiative) for example, is based upon the realization that there will always be a hierarchy of needs which exists. This is so because fulfilling military needs often involves different platforms, e.g. air, land, sea or undersea.[19] Therefore, the real future in computing - which includes AI as well - will depend upon how the solution to a particular hierarchial 'need' is given. We have argued, and hopefully successfully demonstrated, that since this process will involve both qualitative and quantitative aspects, which themselves are subject to change, it is fallacious and premature to sell short or write off an emerging and dynamic technology such as AI.

In addition, as we have already shown, and will elaborate upon in the final, consolidated report in this series, examples of a limited but very promising success story are already coming in.

Footnotes

1) In particular, Social and Economic Implications of AI: An Overview, Directorate of Social and Economic Analysis, ORAE, Staff Note 6/86 by Erik Solem, August 1986.

2) See in particular, Social and Economic Implications of AI: Recent Applications and New Theoretical Developments of Artificial Intelligence Tools, Directorate of Social and Economic Analysis, ORAE, Staff Note 14/86 by Erik Solem and Stan Isbrandt, December 1986. (Also issued as Directorate of Maritime Operational Research, ORAE, Staff Note 1/87).

3) See for example Social and Economic Implications of AI: Expert Systems, Directorate of Social and Economic Analysis, ORAE, Staff Note 8/86 by Erik Solem, October 1986, Social and Economic Implications of AI: Robotics, Directorate of Social and Economic Analysis, ORAE, Staff Note 13/86, December 1986, and Erik Solem, "Social and Economic Factors of Robotics Systems" in Proceedings of the DREP/RRMC Military Robotic Applications Workshop, Victoria, B.C. 11-13 August 1987, DREP Special Report 87-1 and RRMC Proceedings 87-1, Defence Research Establishment Pacific, FMO, Victoria, B.C. and Royal Roads Military College, FMO Victoria BC., 1988.

4) See, for example, Social and Economic Implications of AI: Military Applications, Directorate of Social and Economic Analysis, ORAE, Staff Note 2/87, by Erik Solem, February 1987.

5) See Social and Economic Implications of AI: Artificial Intelligence at COMPUTAS - A Case Study, Directorate of Social and Economic Analysis, ORAE, Staff Note 8/87 by Erik Solem, October 1987.

6) See Social and Economic Implications of Artificial Intelligence (AI): Artificial Neural Networks (ANNS), Directorate of Social and Economic Analysis and Directorate of Mathematics and Statistics, ORAE, Joint Staff Note 87/4 by Erik Solem and Simon Jacobs, June 1987.

7) Ibid.

8) See June Kimoshita and Nicholas G. Palevsky, "Computing With Neural Networks" in High Technology, May 1987.

9) Ibid.

10) See Gary R. Martins, "AI: The Technology That Wasn't," in the series TECHNOLOGY 2001 FORECAST, Defence Electronics, December 1986.

11) See Social and Economic Implications of AI: The "Technology Argument," Directorate of Social and Economic Analysis, ORAE, Staff Note 3/87 by Erik Solem and Stan Isbrandt, March 1987. (Also published as Directorate of Maritime Operational Research, ORAE, Staff Note 2/87).

12) See Expert Systems, op. cit, New Theoretical Developments, op. cit, and Military Applications, op. cit.

13) See for example Robotics, op. cit. and Mark Paul Turchan, A Survey of Advanced Robotics Technology in Japan, A Report to the Ministry of State for Science and Technology, May 1986 (Revised - January 1987).

14) See Martins, Op. cit.

15) Ibid.

16) See "The Technology Argument," op. cit.

17) See Recent Applications and New Theoretical Developments of Artificial Intelligence Too-Military Applications, op. cit.

18) See "The Technology Argument," op. cit.

19) Ibid, and Military Applications, op. cit. See also Steve Wallach, "The Future of Computers and Software" in Defence Electronics, December 1986.

ANNEX A

PAPERS PUBLISHED UNDER PROJECT 96732 ON SOCIAL AND ECONOMIC IMPACTS OF ARTIFICIAL INTELLIGENCE (AI), SINCE AUGUST 1986.

- Social and Economic Implications of AI: An Overview, Directorate of Social and Economic Analysis, ORAE, Staff Note 6/86 by Erik Solem, August 1986,.

- Social and Economic Implications of AI: Expert Systems, DSEA Staff Note 8/86 by Erik Solem, October 1986.

- Social and Economic Implications of AI: Robotics, DSEA Staff Note 13/86 by Erik Solem, December 1986.

- Social and Economic Implications of AI: Recent Applications and New Theoretical Developments of Artificial Intelligence Tools, DSEA Staff Note 14/86 by Erik Solem and Stan Isbrandt, December 1986. (Also issued as DMOR Staff Note 1/87).

- Social and Economic Implications of AI: Military Applications, DSEA Staff Note 2/87, by Erik Solem, February 1987.

- Social and Economic Implications of AI: The Technology Argument, DSEA Staff Note 3/87 by Erik Solem and Stan Isbrandt, March 1987.

- Social and Economic Implications of AI: Artificial Neural Networks (ANNs), Joint Staff Note 87/A by Erik Solem and Simon Jacobs, June 1987.

- Social and Economic Implications of AI: Artificial Intelligence at Computas - A Case Study, DSEA Staff Note 8/87 by Erik Solem, October 1987.

- "Social and Economic Factors of Robotics Systems" by Erik Solem in Proceedings of the DREP/RRMC Military Robotics Applications Workshop, Victoria, B.C. 11-13 August 1987, published as DREP Special Report 87-1 and RRMC Proceedings 87-1, Defence Research Establishment Pacific, FMO, Victoria B.C. and Royal Roads Military College, FMO Victoria B.C. 1988

- Social and Economic Implications of AI: Reappraising Artificial Intelligence, DSEA Staff Note 4/88 by Erik Solem, September 1988.

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