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The Advantage of Industrial R&D in the Training of University Students

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Abstract **-- Experience gained through industrial R&D projects supports the proposition that several benefits flow through to both students and faculty staff beyond that of simply providing associated student project titles. To be more specific, enhancing lecture material with not only specific research findings but also general experience gained from working on such projects are secondary benefits of such university-industry links. Moreover, the reputation and standing of both individual researchers and university research groups are further enhanced by such relationships. This in turn often leads to subsequent industrial R&D projects (and so the cycle continues...).**

Index Terms **— Case studies, collaborative learning, development, industry training, research.**

I. INTRODUCTION

THE independent Good Universities Guide conducts an annual ranking of universities within Australia. The University of Wollongong received the 1999-2000 award on the basis of "Outstanding Research and Development Partnerships". This award serves as external recognition of strong R&D links developed at the University over the past decade (the University of Wollongong won the award for a second time for 2000-2001, on this second occasion for "preparing graduates for the e-world").

It is the contention of the present paper that such strong R&D links are beneficial not only for the primary research activity of university faculty, but that a significant "trickle-down" effect also results for both students and staff.

II. INDUSTRIAL R&D PROJECTS

In order to illustrate the benefits of strong R&D links, we proceed to describe four representative projects:

(i) Face Recognition (SITA $850,000 1992-95),

(ii) Time Series Forecasting (Fujitsu $105,000 1994-97),

(iii) Ionogram Feature Extraction (DSTO $72,250 1995-1997),

(iv) Smart Patient ID System for GPs (IDGP $182,964 2000-2002).

A. SITA Face Recognition

During the early 1990s, the Societe Internationale de Telecommunications Aeronautique – SITA – funded a 3-year R&D project into (real-time) face recognition for airport security. The research focused around Artificial Neural Networks - ANNs. Significant research findings were forthcoming not so much with ANNs per se, but by using ANN groups, trees and group-based adaptive trees – which can better cater with topological deformations and/or translations, and more especially varying background lighting conditions [1,2]. By project end, a prototype system had been designed in readiness for field trials at a local airport.

Apart from these *direct* benefits, several secondary benefits resulted for graduate students associated with the project. The first, and most obvious, of these were two PhD topics.

Other *indirect* benefits were also forthcoming. For example, Bachelor of Computer Science undergraduates are required to undertake a final-year group software project (comprising between 4 and 6 members). This project forms the capstone of their earlier two years of study. Furthermore, the project topic tends to be driven by the research interests of the CS faculty, especially if these interests overlap with industry.

Because of the "critical mass"/track record built up in the face recognition area at the University of Wollongong, it was only natural that a subsequent final-year group software project would be undertaken in this area. Indeed, in 2000 a project was conducted into the evolution of faces using Genetic Algorithms. Initially this was targeted towards the matching of faces by witnesses within a law enforcement context, but was later switched to a medical context (e.g. plastic surgery, facial reconstruction, the aging process).

Students benefited in several ways: (i) firstly, they were able to apply their programming skills to a *real world* problem, and (ii) secondly, they became acquainted with topics to which they would not normally be exposed as undergraduates (i.e. ANNs, GAs, image processing, feature extraction, face recognition). It should be pointed out that students often perform such a good job on this final-year group software project that they are offered employment opportunities as a result.

B. Time Series Forecasting

During the mid 1990s, Fujitsu Research Laboratories, Japan approached the University of Wollongong to undertake research into time series modeling and prediction/forecasting.

Thanks are due to the industrial R&D partners who funded the projects described – namely the Societe International de Telecommunications Aeronautique, Fujitsu Research Laboratories, the Australian Defense Science & Technology Organization, and the Illawarra Division of General Practice. Funding was also forthcoming from the Institute for Mathematical & Computer Modelling at the University of Wollongong (Intelligent Systems Research Group).

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Based on our previous experience, we focused on ANNs – more specifically on higher-order ANNs and ANN groups (in order to model higher-order polynomial components of the time series in question). Significant research findings were once again forthcoming [3]. More specifically, real world financial data is typically discontinuous and non-smooth. Attempts to model such data using ANNs will be inherently inaccurate. ANN groups perform much better at this task – indeed we found their performance to be twice as good for prediction, and around four times better for simulation [4].

Direct benefits again resulted, specifically by way of graduate research topics – PhD and research Masters. *Indirect* benefits also accrued, and will be elaborated upon in Sections III and IV below.

C. *Ionogram Feature Extraction*

During the same time period, the Australian Defense Science and Technology Organization – DSTO – funded an investigation into ionogram feature extraction (ionograms are essentially radar reflections from the Earth's ionospheric layer, in the form of apparent height of reflection versus transmission frequency). Once again, ANN techniques were applied to this problem of interest (since ANNs are known to perform excellently at pattern recognition and/or classification tasks).

From a radio transmission perspective, the key features of interest of these ionogram plots are (i) nose/critical frequency, (ii) ionospheric layer height, and (iii) layer thickness. Significant research results were once again forthcoming, not only with ANNs being able to perform the necessary feature extraction per se, but also in the areas of preprocessing, ANN training, and data fusion [5,6].

Direct benefits again resulted, specifically by way of two Bachelor of Computer Science Honours project topics. Likewise, *indirect* benefits also accrued, and will be elaborated upon in Sections III and IV below.

D. *Smart Patient ID System for GPs*

A more recent (and current) R&D project involves the development of unique patient identifiers for use in a Smart-ID system for general practitioners (and not, for a change, involving ANNs!). Several different technologies are currently being evaluated for their suitability for this project, including smart cards, WAP-enabled mobile (cellular) phones and palmtop computers/personal digital assistants.

Whilst it is early days with this particular project, *direct* benefits have already manifested, namely in the form of PhD topics related to the project at hand. No doubt *indirect* benefits will also accrue during the project's lifetime, along similar lines reported for the previous three R&D projects (A – C above).

III. BENEFITS FOR STUDENTS

Direct benefits flow to students from industrially-sponsored R&D projects, in the form of thesis topics, at both the undergraduate (honours) and postgraduate level (PhD and research Masters). *Indirect* benefits also accrue, sometimes a little less tangibly, and often only becoming apparent over time. More specifically:

(i) Research findings of the kind referred to in Sections A through C have been subsequently incorporated into a graduate ANN subject taught by the author. In particular, preprocessing, feature extraction, the application of ANNs to image processing, ANN training (e.g. Rprop performing better in C than BackPropagation), and the application of ANNs to time series modeling and prediction (including the superior performance of higher-order ANN groups). Apart from this general material, there is the added benefit of incorporating case studies into the lecture material. It is anticipated that similar research results will find their way over time from the Smart_ID project of D into software engineering and distributed systems subjects (both undergraduate and postgraduate).

(ii) Apart from enhancing formal lectures, these same industrial R&D projects lead in turn to numerous student projects, at both the graduate and undergraduate level. These projects tend to be applied in nature, but nevertheless prove eminently suitable as thesis topics. Moreover, in keeping with past experience, we have found that "application-driven research has led to advances not only of an applied nature, but also to significant basic or fundamental results." [7].

IV. BENEFITS FOR FACULTY

We have observed two notable benefits for university staff, these being:

(i) Research results forthcoming from the R&D projects outlined in Sections A through C formed the basis not only of several journal articles and conference papers, but also in chapters in standard reference works [8], as well as invited papers and/or conference session chairs [7]. Both outputs further strengthen the reputation and standing of the relevant research group within the parent university.

(ii) On a pragmatic level, the development of a "critical

mass"/track record in a research field can lead over time to other industrial partners seeking out the university research group (and others) with a view to undertaking similar project work. This in fact proved to be the case with the original SITA Face Recognition project undertaken during the early 1990s. The publicity surrounding this high profile R&D project played a significant role in expressions of interest from both Fujitsu and DSTO with later ANN-based projects.

V. CONCLUSION

Industrial R&D projects undertaken at the University of Wollongong have led to primary benefits for students by way of specific project topics (both undergraduate and postgraduate). The benefits are more wide-ranging than this however. Indirect benefits also accrue for both students and faculty. In the case of the former, subject material is enhanced by specific research findings emanating from the projects, as well as providing excellent case studies for incorporation into lectures. In the latter case, benefits are forthcoming to university lecturing staff in the form of both publications directly related to the R&D projects themselves, as well as building/consolidating research strengths and reputation of both individual researcher and parent university.

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