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# An intelligent decision support system for manufacturing technology investments

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## Abstract

Making strategic decision on new manufacturing technology investments is difficult. New technologies are usually costly, affected by numerous factors, and the potential benefits are often hard to justify prior to implementation. Traditionally, decisions are made based upon intuition and past experience, sometimes with the support of multicriteria decision support tools. However, these approaches do not retain and reuse knowledge, thus managers are not able to make effective use of their knowledge and experience of previously completed projects to help with the prioritisation of future projects.

In this paper, a hybrid intelligent system integrating case-based reasoning (CBR) and the fuzzy ARTMAP (FAM) neural network model is proposed to support managers in making timely and optimal manufacturing technology investment decisions. The system comprises a case library that holds the details of past technology investment projects. Each project proposal is characterised by a set of features determined by human experts. The FAM network is then employed to match the features of a new proposal with those from historical cases. Similar cases are retrieved and adapted, and information on these cases can be utilised as an input to prioritisation of new projects. A case study is conducted to illustrate the applicability and effectiveness of the approach, with the results presented and analysed. Implications of the proposed approach are discussed, and suggestions for further work are outlined.


*Keywords:* Case-based reasoning; Neural networks; Fuzzy ARTMAP; Decision support; Investment and financial planning in production; Manufacturing strategy

## 1. Introduction

Manufacturing companies are constantly striving to improve their competitive capability, and to lower production costs by investing in new or

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proven manufacturing technologies. In general, a typical manufacturing technology (MT) delivery process can be seen as a three-stage process, namely: MT Concept Identification; Proof of Concept; and MT Roll-Out (see Fig. 1). How can managers decide whether to invest in a new MT project when benefits are hard to justify prior to its initial proof of concept stage, and when financial consideration still plays a dominant role?

There are many evaluation approaches available for MT investment. Most of them assess an MT project based on its alignment to the identified corporate objectives, and fulfilment of a set of investment assessment criteria. In general, the evaluation of the criteria is a very subjective and unstructured process. It relies heavily on managers' experience, knowledge, as well as intuition. However, managers can hardly consider all the relevant criteria due to bounded rationality and a limited capacity for information processing (Deng, 1994). Thus, the evaluation approach is often not effectively carried out, as managers do not make effective use of their knowledge and experience of previously delivered technologies and projects as an input to the prioritisation of future projects. The impact of this is that managers are not confident that resources are being optimised and applied to a mixed portfolio of projects to maximise benefits. Thus, how could managers retain and reuse their knowledge of previously (successful and unsuccessful) delivered technologies and projects to support the future decision making in MT investments?

Knowledge-based intelligent systems, including case-based reasoning (CBR), have played an increasingly important role in today's industrial applications (Lee et al., 2004; Mezgar et al., 2000; Yen et al., 1995). The reasons for this growth are manifold: intelligent systems based on the artificial intelligence (AI) methodology are becoming increasingly popular and mature in solving real-life problems; knowledge-based systems have favourable characteristics compared to conventional approaches or pure, symbolic AI systems; and the tools for developing AI systems are becoming easier to use nowadays (Mezgar et al., 2000). A review of literature shows that intelligent systems such as CBR and neural networks could give many benefits to domain users, such as providing consistency in decision making, improving learning capability, supporting knowledge reuse and retention, and yielding instantaneous decision support.

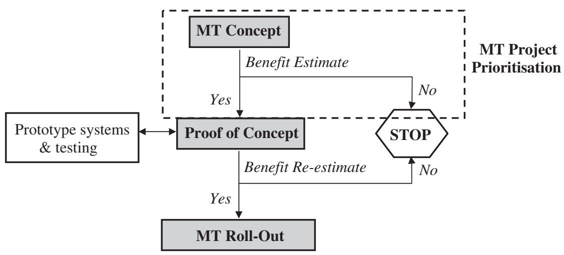


Fig. 1. Manufacturing technology delivery process.

Two main objectives are focused in this research. First, an intelligent system based on a hybrid CBR and fuzzy ARTMAP (FAM) (Carpenter et al., 1992)—a supervised adaptive resonance theory (ART) (Carpenter and Grossberg, 1987) neural network model—is proposed for undertaking the incremental learning problem in CBR. Second, the proposed intelligent system is applied to decision support in MT project evaluations—a complex decision-making task in business investment which is often affected by changing environments. A case study in the pharmaceutical industry, where injection of new technologies into manufacturing processes is frequent, and critical to success, is conducted to demonstrate the effectiveness of the proposed intelligent system in supporting the MT project evaluation process.

The idea of combining CBR and neural networks is not new. From the literature review on similar work with this research, i.e., integration of CBR and clustering-based and/or prototype-based neural network models (Malek and Amy, 1997; Reategui et al., 1997; Gutpa and Montazemi, 1997; Kim et al., 2002; Park et al., 2004; Yang et al., 2004), one can see that the main objective of this line of research is to instil a more efficient learning procedure into CBR. Malek and Amy (1997) proposed an integration of CBR and a prototype-based neural network to make the indexing system, hence the retrieval process, of CBR more efficient and, at the same time, to maintain a continuous learning process. Good