Chapter 3.10
Learning Systems Engineering

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BACKGROUND

Traditionally multi-agent learning is considered as the intersection of two subfields of artificial intelligence: multi-agent systems and machine learning. Conventional machine learning involves a single agent that is trying to maximise some utility function without any awareness of existence of other agents in the environment (Mitchell, 1997). Meanwhile, multi-agent systems consider mechanisms for the interaction of autonomous agents. Learning system is defined as a system where an agent learns to interact with other agents (e.g., Clouse, 1996; Crites & Barto, 1998; Parsons, Wooldridge & Amgoud, 2003). There are two problems that agents need to overcome in order to interact with each other to reach their individual or shared goals: since agents can be available/unavailable (i.e., they might appear and/or disappear at any time), they must be able to find each other, and they must be able to interact (Jennings, Sycara & Wooldridge, 1998).

Contemporary approaches to the modelling of learning systems in a multi-agent setting do not analyse nature of learning/cognitive tasks and quality of agents' resources that have impact on the formation of multi-agent system and its learning performance.

It is recognised that in most cognitively driven tasks, consideration of agents' resource quality and their management may provide considerable improvement of performance process. However, most existing process models and conventional resource management approaches do not consider cognitive processes and agents' resource quality (e.g., Norman et al., 2003). Instead they over-emphasise the technical components, resource existence/availability problems. For this reason, their practical utilisation is restricted to those applications where agents' resources are not a critical variable. Formal representation and incorporation of cognitive processes in modelling frameworks is seen as very challenging for systems engineering research.

Therefore, future work in engineering the learning processes in cognitive system is considered with an emphasis on cognitive processes and knowledge/skills of cognitive agents as a resource in performance processes. There are many issues that need new and further research in engineering cognitive processes in learning system. New/novel directions in the fields of systems engineering,

machine learning, knowledge engineering, and mathematical theories should be outlined to lead to the development of formal methods for the modelling and engineering of learning systems. This article describes a framework for formalisation and engineering the cognitive processes, which is based on applications of computational methods. The proposed work studies cognitive processes, and considers a cognitive system as a multi-agents system.

This project brings together work in systems engineering, knowledge engineering and machine learning for modelling cognitive systems and cognitive processes. A synthesis of formal methods and heuristic approaches to engineering tasks is used for the evaluation, comparison, analysis, evolution and improvement of cognitive processes.

In order to define learning processes, cognitive processes are engineered via a study of knowledge capabilities of cognitive systems. We are not interested in chaotic activities and interactions between cognitive agents (since cognitive tasks require self-managing activities/work), nor interested in detailed tasks descriptions, detailed steps of tasks performance and internal pathways of thoughts. Rather, we are interested in how available knowledge/skills of cognitive agents satisfy required knowledge/skills for the performance of the cognitive tasks.

The proposed research addresses the problem of cognitive system formation with respect to the given cognitive tasks and considers the cognitive agent's capabilities and compatibilities factors as critical variables, because these factors have an impact on the formation of cognitive systems, the quality of performance processes and applications of different learning methods.

It is recognised that different initial knowledge capabilities of the cognitive system define different performance and require different hybrid learning methods. This work studies how cognitive agents utilise their knowledge for learning the cognitive tasks. Learning methods lead the cognitive agent to the solution of cognitive tasks. The proposed research considers a learning method as a guide to the successful performance. That is, initial knowledge capabilities of cognitive agents are correlated with learning methods that define cognitive processes. An analysis of impact of different cognitive processes on the performance of cognitive agents is provided.

This work ensures support for a solution to resource-based problems in knowledge integra-

Figure 1. A scenario for engineering the cognitive processes
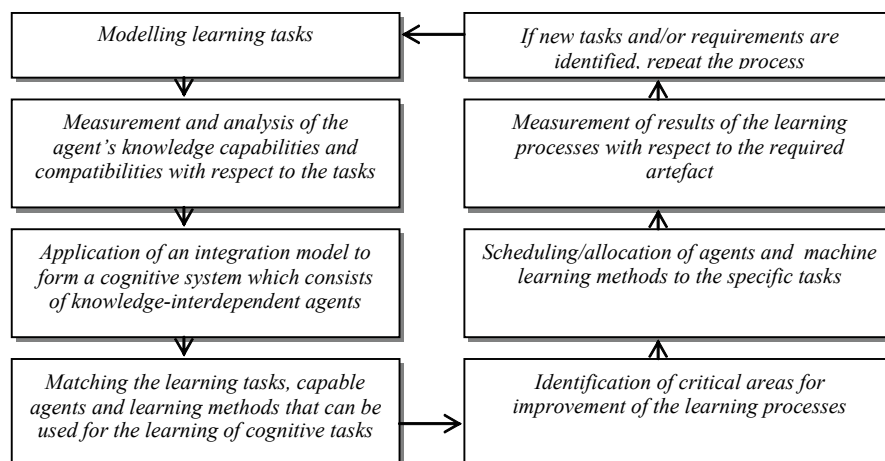
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