AI and Ed: a Happy Open Marriage

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Abstract. We claim that this marriage has never been closed and exclusive. It started because both AI and Education share the goal of understanding the human process of knowing, and getting to know, i.e. learning. The difference is how the two areas exploit the understanding they aim to develop. AI is more focused on making machines that know and learn like people or better than them. AIED is more interested in supporting people to learn better.

Keywords: AI in Education, AIED, AI

1 Introduction

AI originated from the curiosity of understanding how the human mind works and creating models of reasoning and machines that mimic and improve on human reasoning (using the capacities of computers). The early research in AI started with theoretical studies in reasoning and knowledge representation, metacognition, and learning of a single human (single agent). This research, married the area of Cognitive Psychology and lead to the creation of the area of Cognitive Modeling. The need for practical applications drove the formation of many "children" areas of applied AI: Expert Systems, Probabilistic Reasoning, User Modeling, Ontologies (and more recently, Semantic Web and Linked Data), and Advanced Learning Algorithms (which branched more recently into Data Mining, Data Analytics, Data-warehousing etc.).

Around the mid 1990ies, the theoretical interest shifted towards situated action and social reasoning, and multi-agent architectures, leading to the creation of the area of Multi-Agent Systems. Theoretical studies in Argumentation and Negotiation followed with the creation of their own research areas. The area of Interactive Virtual Agents (IVA) emerged around the end of the 1990ies. Another "child" area of applied AI is Recommender Systems (RecSys), which deploys user modeling and advanced learning algorithms to emerging CS application areas, such as e-commerce. Around the same time, some AI researchers turned their sight to modeling other human psychological phenomena such as emotion and affect, which lead to the establishment of the Affective Computing area.

2 AI and CogPsy Meet Education

AI in Education has been "married" to all of these children of AI. Early ITS work in the 1980s and early 1990ies on pedagogical planning, domain knowledge modeling,

student modeling and ITS shells applied techniques from the areas of planning expert systems, and knowledge representation. The second half of the 1990s saw attention shift to agent-based tutoring systems, tutorial dialogues, animated characters, and the first works on modeling learner affect and adapting the interaction with the tutor. In the beginning of the new century the application of ontologies and semantic web technologies for learning material annotation and concept maps for domain knowledge representation took a center stage and the first applications of recommender systems for learning materials considering both content based and social recommendations, and visualizations appeared to explain both the recommendations and the student model (social navigation, open learner modeling). We have seen many research topics in AIED evolve into its own children areas, such as CSCL (a child of AIED, the Learning Sciences and CSCW) and EDM (a child of Data Mining and AIED).

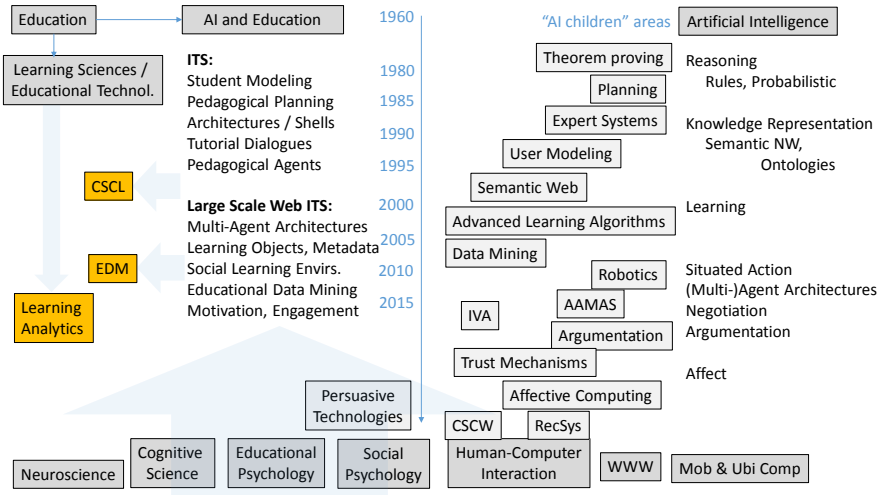

Figure: Approximate evolution of AIED research topics along with AI research topics and the emerging applied AI - children areas, and the influences of other areas of CS and other disciplines AI research topics and

Motivation is an important factor in learning, and the first attempts to model computationally motivational pedagogical strategies started around 1995. The OCC model of emotions triggered interest in incorporating affective factors in HCI around 2000, and it was very soon followed by work in the AIED area, on modeling affect in learning scenarios.

The realization that students engage in off-task behaviours or "game the system" around 2005 lead to increased interest in learner motivation and engagement, as well as educational games (and gamification) which started 10 years earlier. Yet the inspiration for this work is found often in other disciplines (Social Psychology, Persuasive Technology, Behaviour change and even Neuroscience), rather than in Affective Computing.

3. Exploration vs Rigour

The influence of the above AI-children areas, broader computer science areas and other disciplines has been not just in the choice of research topics of AIED researchers, but also in the methods used to carry out, design and evaluate the research. In the early years the focus was on constructing working ITS and a typical research paper included a detailed design justification, description and perhaps a couple of screen-shots as "proof of existence", with not much evaluation. Later on it became necessary to present evaluation data – even if it consisted only of the number of students who liked the system. With the increasing influence of Educational Psychology, evaluation methods from the behavioural sciences were introduced in the area. This coincided with the rapid development of web technologies and tools that allowed an easy design of systems and easier experimentation with more subjects as the ITS prototypes were now accessible on the web. The CMU cognitive tutors were successfully applied with thousands of children in the US, and they started producing a lot of data allowing to evaluate the learning effects on a large scale and for long term use. After 2005, statistical methods for evaluation became a standard, and a typical research paper in the area became much more like a psychology paper or a natural science paper than an engineering paper. The main point became studying the phenomenon of a human interacting with an "experimental tool" designed based on a particular theoretical foundation, and in a way, a significant part of the research in AIED became a branch of applied Cognitive Science. Researchers who were more interested in building systems than in studying human cognition wandered off to other areas that focused more on the technologies, for example ICALT, EC-Tel, Web-Based Learning.

Yet, there are still researchers interested in developing further the "tools", not only from the point of view of the underlying cognitive theories, but also, from the available new technologies developed in the meantime by the Mobile & Ubiquitous Computing community, new data-mining techniques that can allow to automatically learn and improve pedagogical decisions (not necessarily based on theory). The AIED community needs the researchers interested in technology so that the field doesn't become stagnant, overly constrained by methodology, making miniscule improvements based on the same mature AI technologies. So the marriage between AIED and the younger AI children (such as Recommender Systems, or Affective Computing, and even "embryo" areas such as Mechanism Design, Trust, and Negotiation in AAMAS) is important.

When we look at the complex map of how the research topics and children areas emerged, we can notice that in several areas the connection is bi-directional. For example, the area of User Modeling and Personalization, which emerged as a child of AI, has been strongly influenced by AIED. Similarly, IVA, and Affective Computing, have moved ahead to a large extent due to insights and case studies in the context of educational applications. Newly emerged areas, such as Persuasive Technologies also have a lot to learn from the area of AIED, and AIED has a lot to learn from them.

3 Conclusion

So, in conclusion, the marriage between AI and Education and AI is in name only, as much as the name AI describes the inspiration of understanding how the human mind works and creating models (with practical use) of human mind. In fact it has been more of an "open marriage" with quite a few partners – the children areas of applied AI and some other areas and disciplines (as shown in The Figure). Yet, AI is a good family to be in – a large and productive family of smart people. In many ways, it is a perfect marriage.