Art-Com[1]

Web of Interrelated Knowledge Articulation and Knowledge Communication tools

Expression of Interest for an Integrated project: EOI.FP6.2002

Thematic area: 1.1.2.iv: Knowledge and interface technologies

1. Need and relevance

Knowledge articulation and communication tools are important means to support a constructive approach to learning. A range of ideas is being (and has been) developed in this respect by different research institutes in Europe. However, the goals of these research efforts often seem very unrelated, addressing topics such as ‘external representations’, ‘qualitative reasoning’, ‘collaborative learning’, ‘inspectable learner models’, ‘concept maps’, and ‘simulation-based learning’. As a result, interrelationships and important results are often difficult to assess and consequently valuable solutions may not disseminate to a larger community. There is need to bring such research efforts together under the umbrella of a set of common themes and starting points in order to collaboratively profit from the research. Such an approach will create awareness among the participants, encourage them to formulate insights in a wider context, and potentially foster a wide range of reusable and commonly accepted software products. The common theme we propose is to work on the development of a 'Web of Interrelated Knowledge Articulation and Communication tools' (ART-COM).

1.2. Common themes and starting points

Current theories on cognition and learning emphasise the idea that learning is a constructive process during which learners actively construct their knowledge. Instead of 'just receiving it' (e.g. by listening to a teacher in a classroom) they have to engage into activities that create awareness, understanding and insight. Simulation models are well suited to support such activities, because they allow learners to interact with a virtual reality that may enable constructive learning. In addition, simulations often trigger extra motivation on behalf of the learners, which adds on to the effectiveness of such interactions. However, to become a useful agent in a 'community of practice' it is important that the insights of an individual person sufficiently related to the insights of other agents in that community. To arrive at a commonly shared understanding, agents need to communicate their insights. During a process that is sometimes referred to as 'knowledge negotiation' agents interact, share knowledge, and develop (that is, actively construct) a set of beliefs that reflects the shared knowledge for that community of practice. Interactive simulations do not automatically support this knowledge negotiation process, because the interactions and learning experiences of particular learners with a simulation may be very different. It is only after agents share their insights among each other that they are forced to modify and adapt their private insights to the beliefs of a wider group and eventually the beliefs of the community. Notice that, during this process the beliefs of the community will also change, although usually at a much slower rate.

An interesting and modern research problem is to develop theory, and corresponding tools, that foster knowledge negotiation and the development of significant beliefs on behalf of the learners. A rather unstructured approach, that is often used, is to have learners chat or exchange emails while performing some learning provoking activity. Another option is to have groups write reports, discussing their discoveries. With computers we can go far beyond

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these often unstructured, and in fact rather traditional, 'text-based' approaches. The goal is to develop interactive simulations that are knowledgeable about the insights they capture and that can operate as agents in a knowledge negotiation activity. Such simulations would in fact be artificial agents in the overall community of practice, and capture a little part of the beliefs held by the community. To develop such agents we need to draw upon research on qualitative reasoning. The principles underlying qualitative reasoning research are essential to the construction of knowledgeable simulations. An important step to make in this respect is the distinction between content and indexing. The former represents the knowledge relevant to some task and/or domain, the latter represents the ontology in which that knowledge is formulated. In order to drive a knowledge negotiation an agent needs the ontology in order to talk about the content. An important research goal is therefore to explicitly represent the ontology (vocabulary) in which the contents is captured. This is an essential prerequisite. The goal is not to have one unifying-ontology, but to have as many as needed to address particular tasks and/or domains and different levels of expertise. The generality will be in how such ontologies are going to be used to drive an interaction with a learner, or among learners. Preferably, that will have a uniform character. Notice that, given the distinction 'content versus index', a number of options exist. An expert may have constructed a knowledgeable simulation, which is now interacting with a learner. Alternatively, a learner may be interacting with a simulation that has been constructed by a peer. And, maybe most interestingly, a learner may be interacting with a knowledgeable simulation that he or she is construction himself or herself (or constructing with a group of peer learners).

An important feature of knowledgeable simulation environments must be the way in which they visually present information to a learner. There will of course be a need for textual interfacing, but that may not always be the best way to convey certain types of knowledge. Often quantitative date is best understood by showing tables or line-graphs. On the other hand a notion such as causality is often easier to understand using drawings consisting of the factors and labelled arrows between them (e.g. an influence diagram). Research on external representations, visualisations and diagrammatic reasoning is therefore an important aspect of the integrated project proposed here. Again, we are not striving for a unified visual or diagrammatic language. On the contrary, the languages will most likely be domain and task specific. The research will focus on what these forms are and how they can be applied for knowledge negotiation.

2. Scale of ambition and critical mass

The use of advanced technological solutions in training and other educational settings is essential. Both for learners to profit as much as possible from the facilities offered by the new information technologies, and for preparing the next generating of the European inhabitants for living in a world empowered by digital technology. Collaborating towards, and re-use of, commonly created products will foster awareness and consensus among partners and thereby boost community wide progress. The latter is of particular importance in order to compete with the large integrated projects currently being funded in the USA on information & communication technology and education.

2.1 Expected research themes / clusters

Modelling (enabling the construction of models)

Building models (using computer software) is seen as an essential means to have learners develop insights and construct knowledge about phenomena. The process of building a model needs to be facilitated. We therefore need to understand this process in the context of different tasks, domains and users. Based on that insight, methods and tools should be developed which support the learning by building models.

Model interrelationships

Models may vary along many dimensions, such as accuracy, appropriateness, aggregation, simplification, assumptions, etc. Within a model-building environment learners may be presented with learning opportunities when trying to further develop their model along one or more of such dimensions. To provide such learning opportunities we need to identify those dimensions and use them in model building environments.

External representations and visualisation
Knowledge communication is, next to the use of text, highly facilitated by the use of drawings and diagrams. These, sometimes referred to as, external representations are often domain, task and user specific. They need to be investigated and made to use for learners to articulate their knowledge. They also are relevant for the way in which a model-building environment can make already captured knowledge insightful (for instance for a peer learner).

Collaborative learning, knowledge negotiation and knowledge sharing
The process of collaborative learning is seen as an important requirement. Different forms may exist. Typically, synchronous or a-synchronous. In the case of the former a group of learners may e.g. work on the same product but be physically in different locations. In the case of the latter, learners may work with the (partial) products already developed by peers. More forms may exist. For the project proposed here they idea of knowledgeable simulations is important. In a collaborative setting this means that the model-building environment will be able to actively support the collaboration. Game oriented settings may be a way to increase the motivation on behalf of the learners, as well as 'real-life' and 'real-time' settings.

Multiple domains, tasks and users
It is deliberately the intention to spread research across different tasks, domains and users. Among those project participants the interest and expertise focuses on tasks: prediction, diagnosis, design, and problem solving in educational settings; domains: ecology/biology, math, engineering, and science; users: high schools, university level, business-schools and industry. In addition, combinations of the previous are seen as essential, e.g. combat settings, system operations and emergency control.

Knowledge level embedding of quantitative approaches and qualitative reasoning
Complex problems often require advanced mathematical methods for solving. But solutions based on such approaches are often difficult to understand, communicate and assess. Particularly, to peers or learners with less experience or learners different domain expertise. To facilitate knowledge negotiation in this respect research is required on how those advanced mathematical approaches can be made insightful using qualitative approaches. Pure qualitative models (knowledge-models) are also considered important.

Learner assessment and student modelling
A constructive approach to learning acknowledges that they output of a learning process is often difficult to assess. Both, the approach taking by a learner and the solution can often not be classified as good or bad. Usually, they are 'better' or 'less good' then others. How to assess the quality of such learning processes will be a topic of investigating for the project.

Explanation
The notion of explanation often entails many different aspects, including many aspects relevant to knowledge negotiation and communication (and thus mentioned in this EoI). Here we want to stress the important of dialogue structures and 'story telling' in general. Often there are many things to be explained or communicated and research is required on how to sequence that bulk of information and present it to a learner in digestible portions. Particular interest is given to a 'narrative' approach in this respect.

Agent technology

Feedback and guidance may take the form of agents. This also relates to the notion of personified agents. The role and use of agent technology will be investigated.

Web-based interaction (semantic web)
To facilitate knowledge negotiation among users who (potentially) use different software packages (that is, knowledge articulation and communication tools) an effort has to be put in standardising the data exchange between such tools. This problem strongly relates to research efforts recently put together under the concept of 'semantic web'. More specifically, research is required to formulate data exchange between tools and resources using languages such as XML, RDF and possible DAML-Oil.

2.2. Participants

To be successful it is important to work with a reasonable large group of partners that have outstanding research records on the research area's relevant to the integrated project proposed here. This is the case for the partners enumerated below (in alphabetic order).

- Aristotle University of Thessaloniki, Department of Mechanical Engineering, Laboratory of Heat Transfer and Environmental Engineering, Thessaloniki, Greece (Contact: Kostas Karatzas).

- British Maritime Technology (BMT), Teddington, England UK.

- Brunel University, School of Business and Management, Uxbridge, England, UK (Contact: Tariq Khan).

- Cognitive Tools (small size research company), Leiden, The Netherlands (Contact: Anja van der Hulst).

- Environmental Software & Services GmbH, Gumpoldskirchen, Austria (Contact: Kurt Fedra).

- FirstEarth Limited (SME: on Automating Design Analysis), Aberystwyth, Wales, UK (Contact: Chris Price).

- Heriot-Watt University, Intelligent Systems Laboratory, Department of Computing & Electrical Engineering, Edinburgh, Scotland, UK (Contact: Keith Brown).

- Institut für Wissensmedien (Knowledge Media Research Center), Angewandte Kognitionswissenschaft (Applied Cognitive Science), Tübingen, Germany (Contact: Rolf Plötzner).

- LABEIN (technological research & innovation centre), Information Society Unit, Bilbao, Spain (Contact: Jose Luis Los Arcos)

- Lancaster University, Centre for Studies in Advanced Learning Technology, Lancaster, England, UK (Contact: Julie-Ann Sime).

- MARINTEK, Division of Machinery and Technical Operations, Trondheim, Norway (Contact: Tor Einar Berg).

- TECNATOM S.A., Madrid, Spain (Contact: Fernando Gonzalez).

- Technical University of Catalonia, GREC (Research Group on Knowledge Engineering) & GREC-ESADE Business School, ESADE Ramon Llull, Barcelona, Spain (Contact: Núria Agell).

- Technische Universitaet Graz, IICM Softwaretechnologie, Graz, Autria (Franz Wotawa).

- TNO Physics and Electronics Laboratory, Training & Instruction, The Hague (Contact: Hilbert Kuiper).

- Università di Udine, Dipartimento di Matematica e Informatica, Udine Italy (Contact: Elio Toppano).

- University of Amsterdam, Department of Social Science Informatics (SWI), Amsterdam, The Netherlands (Contact: Bert Bredeweg).

- Universiteit van Amsterdam, Graduate School of Teaching and Learning (Contact: Wouter van Joolingen).

- University of Duisburg, Faculty of Engineering, Institute for Computer Science / Interactive Systems, Duisburg, Germany (Contact: H. Ulrich Hoppe).

- University of Nottingham, School of Psychology, Nottingham, England, UK (Contact:: Shaaron Ainsworth).

- University of Northumbria, School of Computing and Mathematics, The Learning Technologies Research Group, Newcastle, England, UK (Contact: Paul Brna)

- University of Seville, Escuela Técnica Superior de Ingeniería Informática, Depto. Lenguajes y Sistemas Informáticos, Seville, Spain (Contact: Juan A. Ortega).

- University of Strathclyde, Department of Design, Manufacture and Engineering Management, Glasgow, Scotland, UK (Contact: Xiu-Tian Yan).

- University of Wales, Department of Computer Science, Aberystwyth, Wales, UK (Contact: Mark Ratcliffe).

- Warsash Maritime Centre, Maritime Research Centre, Southampton Institute, Southampton, England, UK (Contact: Mike Barnett)

3. Integration and expected outcome

Partners will collaborate using a cyclic approach to product development. Products will be (1) user-based design specifications, (2) implemented software tools, and (3) documents describing experimental research on evaluation, usability and impact of the tools. Overall integration will be ensured using three aspects. Firstly, the development cycle of the products will be relatively short (less then 6 months) to allow for sufficient feedback and interaction among the partners. Second, partners will collaborate in multiple research clusters, in order to actively keep in touch with results produced across clusters. Third, for the activities going on within a clusters, partners are committed to re-use results produced by other clusters. The ultimate goal is to develop a 'Web of Interrelated Knowledge Articulation and Knowledge Communication Tools' that lives on the WWW and can be used for teaching and training activities, both in individual and collaborative settings.