Collective Intelligence and Immersive Visualisation – New Techniques to Facilitate Collaborative Research

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Abstract

With the increased specialisation of academic research, establishing wider connections is increasingly difficult. Yet, the key importance of broad collaborations and interdisciplinary activity, including between academia and industry, is widely recognised. How this issue can be tackled is therefore of considerable importance. Two projects supported by the JISC, the Brain project (2009 to 2011), and the Inspires project (2012), have undertaken a range of work in this area. This paper outlines these activities and describes some of the key outputs produced to facilitate collaboration and collective thinking, including using innovative knowledge techniques integrated with immersive visualisation environments. The success of these techniques indicates the very substantial potential for creating new research collaborations and finding new areas for research.

Key Drivers and Requirements

Increased specialisation of academic research makes establishing wider connections and research collaborations increasingly difficult. Yet, the key importance of interdisciplinary activity is widely recognised. For example, a study carried out by the Technology Enhanced Learning Research Programme concluded that "*Interdisciplinarity is key to the successful future of TEL research*" (Conole *et al*. 2010). How this issue can be tackled is therefore of considerable importance.

A key conclusion from extensive user engagement and needs analysis was the widespread desire to build networks and communities, including interdisciplinary ones. Numerous barriers to this existed, including many organisational and cultural factors. Central to the ones which technology could help to address was the requirement reflected in the view expressed by many researchers that they wanted to make wider contacts but didn't know how to find appropriate people to discuss and potentially collaborate with.

Tools to Find Connections

Most web systems to locate experts, for instance those reviewed by Becerra-Fernandez (2006), are limited primarily to a search facility based on keywords. What is missing is the ability to find connections that users might not have thought of and therefore would not explicitly be able to search for - which would characterise many interdisciplinary connections. In response to this, a web-based tool, called ConnectApp was developed, which aimed to fulfil this requirement using information from profiles and other sources, as well as providing more conventional search facilities. The implementation of this tool is described by Hensman *et al*. (2009) and required consideration of a number of issues to allow the filtering and weighting of connections in a meaningful way, analogous to the algorithms used by search engines such as Google.

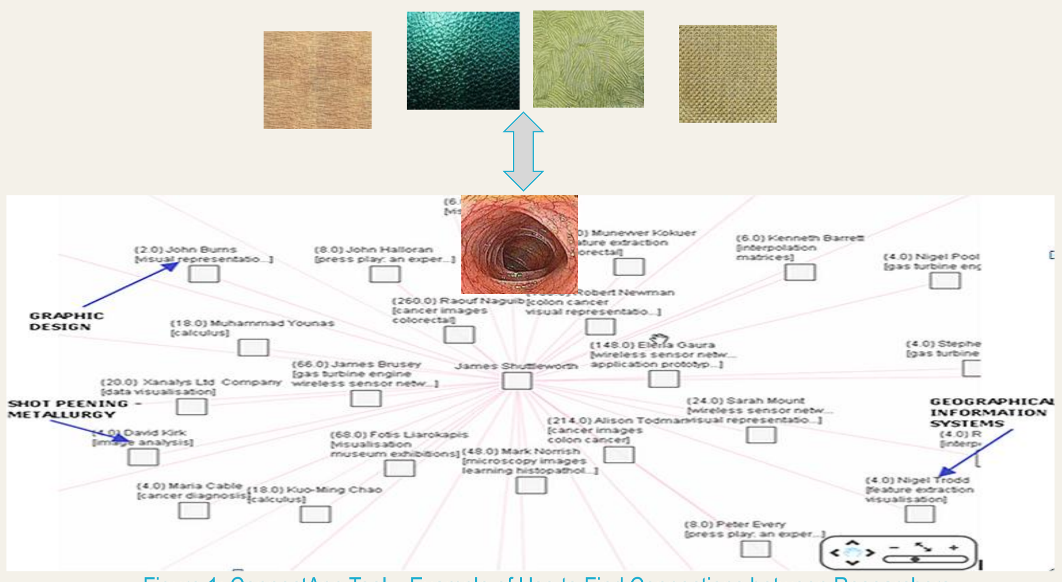

Figure 1: ConnectApp Tool – Example of Use to Find Connections between Researchers

In this example, the SPIRES network – an EPSRC network around physical, virtual and social aspects of research environments and spaces – which the Inspires project focused on, includes a researcher whose work looked at types of wallpaper and the visual analysis of their textures particularly. This connects to a group of cancer researchers at Coventry University who are using similar techniques to analyse colonoscopy images. This research in turn links to other research in areas as diverse as metallurgy, geographical information systems and graphic design, as well as to the work of a researcher at Oxford University - who is also a member of the SPIRES network - showing how extended network relationships of this kind can help find hard to discover links within specific communities.

Finding Higher Level Connections – Knowledge Structures and Ontologies

Although this system proved powerful, it was still restricted by relying on the use of common terminology to detect matches. **Can connections be found at higher conceptual levels?** Dealing with this issue requires using structured knowledge representations, such as taxonomies and ontologies, which provide ways of representing more complex connections. Creating suitable ontologies presents a number of problems. Although published representations of this kind are available for many domains, for complex multidisciplinary areas, such as those covered by many projects and research networks, they rarely exist. Furthermore, using a general ontology for a limited group of researchers, for instance pertaining to health, would lead to an unfeasibly large set of possible connections. To deal with these issues required a multifaceted approach which included the use of relevant general ontologies, but also derived specific ones based on particular communities - which in turn needed to combine using both manual and automatic techniques. Information clustering techniques can assist, and a number have been analysed and assessed (Carpineto *et al.* 2009). Tools such as Lingo3G, which can generate hierarchical clusters, as well as other tools and manual techniques have been used to help create ontologies. Previous work by a member of the Inspires project team (Ma 2011), had also developed methods for creating ontologies which included semantic distance metrics between terms and groups of terms – and these techniques were also applied.

Mapping the Knowledge of Communities

Putting these techniques together, starting from a concept map representation of relationships between topics and associated researchers, an ontological representation can be derived that represents the collective expertise of a network or community with added metrics representing the distance between chosen topics. Using different metrics for semantic distance - based on growth rates for example, allows newly emerging areas of research to be identified.

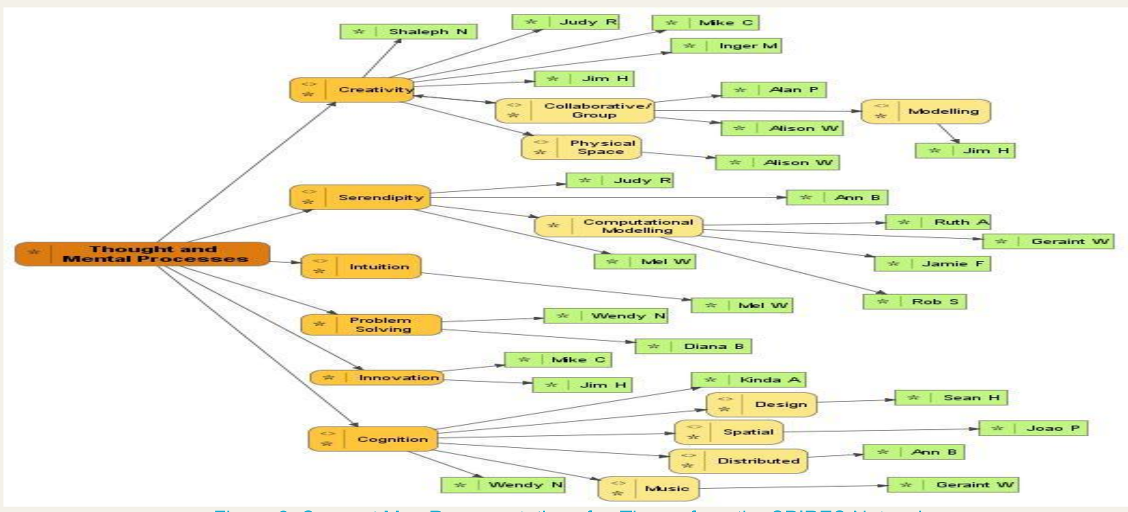

Figure 2: Concept Map Representation of a Theme from the SPIRES Network

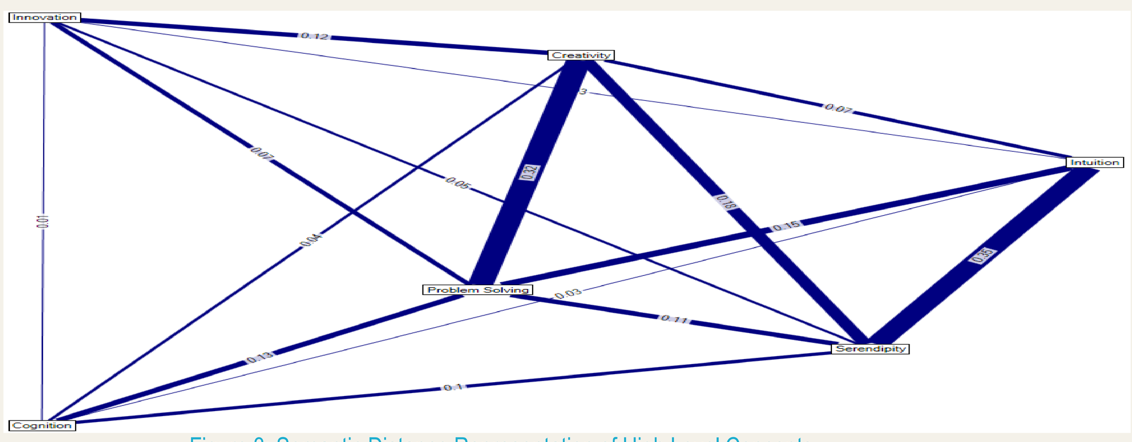

Figure 3: Semantic Distance Representation of High Level Concepts

Connecting Communities and Discovering New Areas for Research

The SPIRES community again provides an example of how this can work in practice. Finding connections to a group of petroleum engineers in the network appeared very difficult at first. However, a higher level concept into which an aspect of this fitted was earth exploration. This established a connection to a group of archaeologists within the community. Exploring further uncovered a particular example of this in the use of imaging utilising different electromagnetic wavelengths, to find potential drilling locations for one discipline and potential archaeological sites for the other. This in turn through a number of conceptual links connected to environmental research, cancer research and even spinoff research from the large hadron collider.

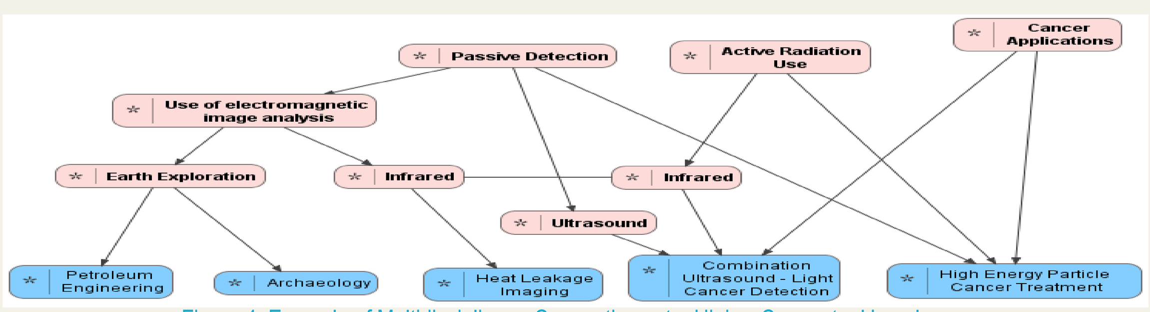

Figure 4: Example of Multidisciplinary Connections at a Higher Conceptual Level

These techniques can find connections between research which is already taking place. **Is it possible to identify completely new areas for research?** To do this the project has experimented with and implemented techniques using ontological representations interpreted as a generative framework which specifies the syntax and semantics of a "language" of research topics. Using this approach, ontologies can be used to deduce research topics that do not exist in a knowledge structure from ones that do. To use a simple example, in *Figure 2*, from the connection between the concepts of serendipity and intuition and known research in computational modelling of serendipity, we could infer computational modelling of intuition as a possible research area.

Building Networks and Communities

In building communities, organisational, social, psychological and cultural aspects have to be taken into account. Analysing some of these considerations and their implications for creating teams was one of the outputs from the work carried out (Kleanthous Loizou *et al*. 2011). Nevertheless, technology can play a key role and project outputs have been used in physical spaces and with physical meetings, as part of virtual systems - such as social networks, and through the integration of both in immersive environments. The systems developed have also been used in many contexts, from high-level institution wide strategic research initiatives and large international conferences to small research workshops.

Immersive Visualisation Environments

A particular area that the projects have worked on is the linking of the tools and techniques developed with immersive visualisation spaces to facilitate discussions and collective thinking in real time - which can also link to online participants. A typical setup uses a large screen 3-D projection facility allowing a group to interact in various ways with word clouds representing ideas they are discussing. Words displayed are drawn from what people are saying, using voice recognition in some cases, together with information from twitter streams, text messages and other social media. Some of the researcher connection finding tools described earlier and others interface to the visualisation system through web services to generate new concepts based on the expertise of the participants, visually group similar concepts together, and allow collective filtering of ideas through user interaction.

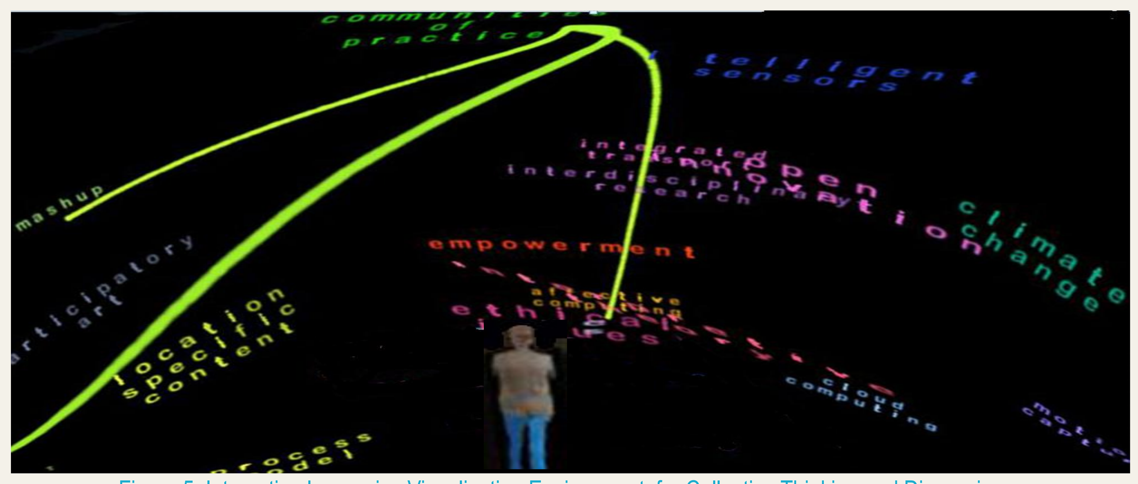

Figure 5: Interactive Immersive Visualisation Environment for Collective Thinking and Discussion

Conclusions, Future Work and Acknowledgements

The successful application of the techniques in a wide variety of situations has been demonstrated, giving an indication of the potential if they were applied more widely, particularly with immersive environments that can utilise their scope for enhancing interaction and collective thinking in real-time. Development, however, is only at an early stage and much further work is needed. The rapidly increasing availability of complex information through linked data sets and other means, and the associated developments in knowledge analysis and processing, indicate the possibilities of creating global networks that could exploit the colossal number of potential connections still unrealised, to massively advance research in every area. The current work has close links with and collaborates with a number of other projects, the EPSRC Serena project – on Serendipity and the JISC OpEx project on Open Innovation linking research and industry, for example, and we particularly invite and encourage discussions on how collaboration can be extended and the work done carried forward in the future.

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References

Becerra-Fernandez, I., 2006. Searching for experts on the Web: A review of contemporary expertise locator systems. *ACM Transactions on Internet Technology (TOIT)*, 6(4), pp.333–355.

Carpineto, C., Osiński, S., Romano, G., & Weiss, D. (2009). 'A survey of Web clustering engines'. *ACM Computing Surveys*, *41*(3), 1–38.

Conole, G., Scanlon, E., Mundin, P., Farrow, R. (2010) 'Interdisciplinary research: Findings from the Technology Enhanced Learning Research Programme'. Available from http://www.tlrp.org/docs/ TELInterdisciplinarity.pdf [26 July 2012]

Hensman, J., Despotakis, D., Brandic, A., Dimitrova, V. (2010) 'Tools to Find Connections Between Researchers – Findings from Preliminary Work with a Prototype as Part of a University Virtual Research Environment. In: Erik Duval, et al. (eds.). *Proceedings of the 2nd International Workshop on Research 2.0.* At the 5th European Conference on Technology Enhanced Learning: Sustaining TEL. Barcelona, Spain, September 28, 2010, CEUR-WS.org/Vol- 675, ISSN 1613-0073.

Kleanthous Loizou, S.; Dimitrova, V.G.; Despotakis, D.; Hensman, J.; Brandic, A., 'Team Formation for Research Innovation: The BRAIN Approach' In: Paramythis, A., et al. (editors). *Proceedings of the International Workshop on Adaptive Support for Team Collaboration 2011 (ASTC 2011)* vol. 743, pp.37-46.

Ma, X. (2011). Ontology Engineering for ICT Systems using Semantic Relationship Mining and Statistical Social Network Analysis. PhD Thesis. University of Warwick.