Institution: Teesside University

Unit of Assessment: 11, Computer Science and Informatics

Title of case study: Document Engineering of Clinical Guidelines

1. Summary of the impact (indicative maximum 100 words)

The *Haute Autorité de Santé* (HAS)[1] is the French independent Health Authority, which acts as the independent healthcare regulator and quality agency. One of their roles is the production or the validation of Clinical Guidelines, through complex workflow. HAS have been using in-house, bespoke, Document Engineering tools to assist this process. We have conducted joint research with HAS since 2007 on Document Engineering techniques for clinical guidelines, which has resulted in technology transfer and the re-engineering of their internal platform. Teesside has implemented an improved version and deployed it in 2013 to replace their previous software.

2. Underpinning research (indicative maximum 500 words)

Context

Previous work at HAS has identified the role of specific linguistic expressions, known as *deontic structures*, in the structuring of clinical guidelines. Deontic expressions characterise elementary recommendations, which constitute the backbone of clinical guidelines. This has paved the way for a new approach to assist with the development of clinical guidelines using Document Engineering techniques to support document production within a human-in-the-loop approach. Shallow Natural Language Processing (NLP) techniques, focussed on the identification of deontic structures, evidence the occurrence and shape of elementary recommendations, through text marking-up and highlighting. This assists health professional in the process of authoring clinical guidelines, by providing them with objective feedback on the structure of the document they are preparing. This approach has been implemented in a proprietary software named G-DEE (for Guidelines Document Engineering Environment).

The extension of this approach is faced with a number of challenges, not least the task of deploying advanced document processing techniques in a real-world environment, with significant expectations on system performance and usability. A joint research programme was established with Teesside, who brought its own expertise in knowledge representation for task and activities, sentiment analysis, text segmentation, medical informatics, and language-independent Information Retrieval techniques.

Content of the Research

One of the first activities was dedicated to the validation of the deontic recognition techniques and the exploration of additional NLP techniques, such as the use of Rhetorical Structure Theory (RST, see [2]) to improve structuring of elementary recommendations, including their conditional part.

This activity confirmed the robustness of the original techniques for deontic recognition (multi-layered automata) and gave directions for their optimisation, to be implemented by Teesside in a new release.

The second activity extended the deontic recognition model to new document properties, including readability and hypertext structures. Deontic density was demonstrated as a reliable indicator of readability for an expert audience compared with more traditional techniques for measuring readability [1]. It was also shown to be a useful heuristic in conjunction with text segmentation when converting clinical guidelines to limited-depth hypertext format [5].

This research has been published regularly at the ACM Symposium on Document Engineering (2009, 2010, 2012, 2013), which is the specialist conference on the subject.

Findings and Contribution

Our findings can be summarised as follows: we were able to i) confirm the role of deontic expressions in structuring Clinical Guidelines, established by previous work at HAS and extend their use to new aspects, such as readability and hypertext conversion ii) suggest specific technical

[1] English home page: http://www.has-sante.fr/portail/jcms/r_1455134/fr/about-has

extensions to the existing Document Engineering environment and iii) implement a new version of the G-DEE software incorporating the new findings, whilst also improving the performance and usability of the new system (G-DEE II).

Funding
Since 2012, this research has also been supported through the FP7 project MUSE (ICT-296703, Teesside funding 446,000€), a joint project with four other institutions, including HAS.

Staff involved: Prof. Marc Cavazza, Dr Mark Truran

3. References to the research (indicative maximum of six references)

[1] Mark Truran, Gersende Georg, Marc Cavazza, Dong Zhou. Assessing the readability of clinical documents in a document engineering environment. In: Apostolos Antonacopoulos and Michael J. Gormish and Rolf Ingold (Eds). DocEng'10 – *Proceedings of the 10th ACM Symposium on Document Engineering*, September, 21-24. 2010, Manchester, United Kingdom. ACM Press, New York NY, USA. 2010, pp. 125-134.
Part of our RA2

[2] Gersende Georg, Hugo Hernault, Marc Cavazza, Helmut Prendinger, Mitsuru Ishizuka. From Rhetorical Structures to Document Structure: Shallow Pragmatic Analysis for Document Engineering. In: Uwe M. Borghoff, Boris Chidlovskii (Eds). DocEng'09 – *Proceedings of the 9th ACM Symposium on Document Engineering*, September, 15-18. 2009, Munich, Germany. ACM Press, New York NY, USA. 2009, pp.185-192.
Part of our RA2

[3] Gersende Georg, Marc Cavazza, Catherine Pelachaud. Visualizing the Importance of Medical Recommendations with Conversational Agents. In: H. Prendinger, J. Lester, and M. Ishizuka (Eds.), LNAI 5208. *Proceedings of the 8th International Conference on Intelligent Virtual Agents* (IVA 2008), September, 1-3. 2008, Tokyo, Japan. Springer Berlin Heidelberg. 2008:5208, pp. 380-393.
This work expands the use of marking-up of deontic structures to address the strength of elementary recommendations in clinical guidelines. It reports a user experiment in which importance is expressed through a virtual character reading aloud relevant text segments so as to give realistic feedback to document authors. IVA is an international conference on virtual agents with an acceptance rate on that year of 25% for full papers.

[4] Gersende Georg, Marc Cavazza. Integrating Document-based and Knowledge-based Models for Clinical Guideline Analysis. In: R. Bellazzi, A. Abu-Hanna, J. Hunter (editors). *Proceedings of 11th Conference on Artificial Intelligence in Medicine in Europe*, 7-11 July 2007; Amsterdam, The Netherlands; Lecture Notes in Artificial Intelligence 4594, Springer-Verlag Berlin Heideberg; 2007, pp. 421-430.
This paper describes an experiment in connecting advanced knowledge models for clinical activities (using task-based representations inspired from AI Planning techniques) to HAS' Document Engineering Environment. AIME is the premier venue for AI in Medicine research; acceptance rate for full papers on that year was 20%.

[5] Mark Truran, Jonathan Siddle, Gersende Georg, and Marc Cavazza. 2013. Automatic generation of limited-depth hyper-documents from clinical guidelines. In Proceedings of the 2013 ACM symposium on Document engineering (DocEng '13). ACM, New York, NY, USA, pp. 245-248.
This recent short paper illustrates an extension to Document Engineering techniques in terms of hyperdocument generation. It is based on the Reco2Clics™ (limited depth hypertext) format introduced by HAS for the online dissemination of its productions and contains early results on how the hypertext structuring process could be automated.

4. Details of the impact (indicative maximum 750 words)

HAS is the primary beneficiary of our research, through an improvement in existing processes, which are central to their activity. The production and validation of Clinical Guidelines are one of the main activities of HAS, through its "Best Practice" (SBPP) Department. The development of a single clinical guideline requires over 20 months in average and their reading groups can contain up to 15 domain experts under the guidance of a HAS project leader. To quantify the role of Document Engineering in the guidelines production workflow, it should be noted that of the 55 clinical guidelines released by HAS in the last five years (when the approach was first introduced), 25 of them required the use of G-DEE to support their preparation as well as consensus meetings, which represents 45% of all guidelines production. More recently, HAS has extended its documents provision to simplified hypertext formats, known as Reco2Clics™. These now represent up to 2,000 downloads per week by health professionals. Their production, from the text of original guidelines, also benefits from specific techniques developed as part of this research (see [5] for details).

Our framework for achieving impact in this case has been based on joint research, where we have added our own experience in automatic text analysis to the existing capability of HAS.
These activities have informed several aspects of the previous guidelines production process, based on the pre-existing workflow, throughout 2010-2012, until we implemented our findings in a new release of the Document Engineering Environment, named G-DEE II, which constitutes the end-product of this research.

A specific contribution on our side, which constitutes an essential part of achieving impact, has been our ability to undertake end-to-end software development. This made it possible to incorporate the new findings into a high quality, ready to use software deliverables, which also implemented HAS' requirements in terms of performance and usability. The software we delivered includes a range of improvements over the existing version, beyond the incorporation of joint research findings. These include: a general improvement in runtime performance due to code optimisation, which also supports new modes of interactive document analysis, including direct text input into the system; improved document importing functions (Word and PDF), improved XML exporting, optional support for Part-Of-Speech tagging, new visualisation tools for document analysis at a glance (e.g. deontic operators' density).

This impact can be best characterised as:

1) *an improvement in the clinical guidelines workflow through the incorporation of our joint research findings on the role of deontic markers in their Document Engineering platform.*
   Between 2009 and 2013, we have helped to further validate the role of deontic markers in a range of phenomena beyond overall document structure, including readability and hypertext generation. This has influenced the methodology based on the original environment.

2) *the adoption of a new, re-engineered, document engineering software (G-DEE II), developed at Teesside and incorporating the above findings.*
   An early version of G-DEE II was delivered for on-site testing in the first half of 2013. It has been fully validated, and eventually entered into service in June 2013 (confirmed by a letter of HAS' SBPP Head of Department). Further to its adoption, its first public demonstration outside HAS took place at the Guidelines International Network G-I-N 2013 conference in San Francisco[2].
   This constitutes, in our view, the most significant impact, as well as the most objective one: the delivery, and adoption by HAS for routine use, of a new Document Engineering platform replacing their in-house developments.

[2] The demonstration itself lies outside the reporting period for impact (August 2013): it is provided as additional evidence.

Overall, the *reach* of this impact is its ability to support core activities within a major European administration (in France), whose activities have a strong influence on Health policy. Its *significance* is the successful deployment of software containing advanced techniques such as content-based analysis, yet fully operational, and tailored to the needs and activities of HAS.

5. Sources to corroborate the impact (indicative maximum of 10 references)

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[3] Gersende Georg, Jonathan Siddle, Mark Truran, Marc Cavazza. Computerized Guidelines Analysis: 5-years Experience and User Feedback. G-I-N Conference 2013. San Francisco, United States. 18-21 August 2013.
Abstract/Poster presented at the Guidelines International Network (GIN) conference reporting the adoption of the new platform “G-DEE II’ re-engineered by Teesside and describing the role of document engineering tools in the workflow for Clinical Guidelines.