The Nijmegen Health Care Computing Initiative (2005–2007)

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Verification of Medical Guidelines

Medical guidelines are systematically developed statements to assist practitioners and patient decisions about appropriate healthcare for specific clinical circumstances. Medical guidelines summarize best practices to standardize health care and to keep physicians up-to-date. It has been shown that medical errors diminish when physicians follow medical guidelines. Nevertheless, the quality of medical guidelines often varies greatly and the quality of medical guidelines can be improved upon.

Verification of medical guidelines is one of the research themes of the research done in Nijmegen that focusses on the borders between computer science and the medical domain. By translating a formal representation language for medical guidelines (e.g., Asbru) into a formal language suitable for formal verification (e.g., KIV) it has been made possible to verify properties about medical guidelines.

In particular, research in Nijmegen has focussed on the formulation of criteria of separate treatments and on the formulation of general principles of good practice medicine. Furthermore, of particular interest has been the integration of medical background knowledge into the verification process as guideline recommendations are based on the latest available medical evidence and knowledge [1,2,4,5,8].

This research has resulted in a general framework for the verification of medical guideline with respect to properties following from medical background knowledge. The framework has been applied to guidelines for the treatment of diabetes and breast cancer and has been found suitable for the verification of specified quality criteria. We were able to automate many steps of the verification process.

Besides using theorem proving we have also looked at other verification tools (e.g., model checking [6,7]) for verifying criteria. Furthermore, various tasks have been studied in which formal models of guidelines may be helpful (e.g., critiquing the treatment plan of a physician [3]).

References

[1] A. Hommersom, P. Groot, P. Lucas, M. Balser, and J. Schmitt. Verification of Medical Guidelines using Background Knowledge in Task Networks, *IEEE Transactions on Knowledge and Data Engineering*, 19(6):832–846, June 2007.

[2] A. Hommersom, P. Groot, P. Lucas, M. Balser, and J. Schmitt, Combining Task Execution and Background Knowledge for the verification of Medical Guidelines. *Knowledge-Based Systems*, 20(2):113–119, 2007.

[3] P. Groot, A. Hommersom, P. Lucas, R. Serban, A. ten Teije, and F. van Harmelen. The Role of Model Checking in Critiquing based on Clinical Guidelines. In R. Belazzi, A. Abu-Hanna, and J. Hunter (editors), *11th Conference on Artificial Intelligence in Medicine*, number 4594 in LNAI, pages 411–420, 2007.

[4] P. Groot, A. Hommersom, P. Lucas, M. Balser, and J. Schmitt. Experiences in Quality Checking Medical Guidelines using Formal Methods. *VVSS*, 164–178, 2007.

[5] A. Hommersom, P. Groot, P. Lucas, M. Balser, and J. Schmitt. Combining Task Execution and Background Knowledge for the Verification of Medical Guidelines. In M. Bramer, F. Coenen, and A. Tuson (editors), *Proceedings of AI-2006, the 26th SGAI Int. Conf. on Innovative Techniques and Applications of AI*, number XXIII in Research and Development in Intelligent Systems, pages 3–16, Springer, 2006.

[6] A. Hommersom, P. Groot, and P. Lucas. Checking Guideline Conformance of Medical Protocols using Modular Mode Checking. In the *18th Belgium-Netherlands Conference on Artificial Intelligence (BNAIC'06)*, pages 173–180, 2006.

[7] A. Hommersom, P. Groot, P. Lucas, M. Marcos, and B. Martinez-Salvador. A Constraint-based Approach to Medical Guidelines and Protocols. In *ECAI 2006 Workshop – AI Techniques in Healthcare: Evidence Based Guidelines and Protocols*, 2006.

[8] A. Hommersom, P. Groot, P. Lucas, M. Balser, and J. Schmitt. Verification of Medical Guidelines using Task Execution with Background Knowledge. In *4th Prestiguous Applications of Intelligent Systems (PAIS 2006)*, pages 835–836, 2006.

In Preparation

- Book: Computer-based Medical Guidelines and Protocols: A Primer and Current Trends.
- Overview article: Improving Medical Protocols by Formal Methods.

Background

Health care is in a phase of transition. The role of basic biological sciences in health care, for example, has increased considerably. Furthermore, there is a mounting pressure on health care organisations to improve the efficacy and cost-effectiveness, without sacrificing the quality of care. Information Technology is and will be a major factor in steering these developments.

The Nijmegen Health Care Computing Initiative is a NWO funded HEFBOOM program (2005–2007) that gave the means to recruit one postdoc for focussing on the intersection of computer science and health care. The goal was to broaden the expertise within the ICIS department of the Radboud University Nijmegen to the health care domain by setting up new research collaborations with other organizations (e.g., Radboud University Hospital, Nictiz, Philips, etc.). Some of the research topics focussed on are:

- Verification of medical guidelines.
- Classification of breastcancer from mammographic data.
- Application of scale-space smoothing techniques for preprocessing micro-array data and Bayesian networks for analysis to retreive protein interactions.
- Analysis of patient data confidentiality issues of the electronic health care record.

Publications

Breast Cancer Detection

[9] M. Samulski, N. Karssemeijer, P. Lucas, and P. Groot. Classification of mammmographic masses using Support Vector Machines and Bayesian Networks. In N. Karssemeijer and M.L. Giger (editors), *Proceedings of SPIE Medical Imaging*, SPIE Optical Society, 2007.

Bioinformatics

[10] P. Groot, C. Gilissen, and M. Egmont-Petersen. Error Probabilities for Local Extrema in Gene Expression Data, *Pattern Recognition Letters*, 2007.

[11] C. Gilissen, P. Groot, P. Lucas, J. Veltman, A. Geurts van Kessel, and M. Egmont-Petersen. Prediction of protein-to-protein interactions. In *International Conference on Advances in Microarray Technology (AMT 2006)*, 2006.

[12] C. Gilissen, P. Groot, P. Lucas, J. Veltman, A. Geurs van Kessel, and M. Egmont-Petersen. Local Extrema as a Significant Feature for Functional Interactions from Time Series Gene Expression Data (in preparation).

Knowledge Representation

[13] P. Groot, F. Bruisten, and M. Oostdijk. Patient Data Confidentiality Issues of the Dutch Electronic Health Care Record, *BNAIC*, 2007.

[14] P. Groot, A. ten Teije, and F. van Harmelen. A Quantitative Analysis of the Robustness of Knowledge-Based Systems Through Degradation Studies. In *Knowledge and Information Systems (KAIS)*, volume 7, pages 224–245, Springer-Verlag, 2005.

[15] H. Wache, P. Groot, and H. Stuckenschmidt. Scalable Instance Retrieval for the Semantic Web by Approximation. In M. Dean et al. (editors), *WISE 2005 Workshops*, volume 3807 of LNCS, pages 245–254, Springer-Verlag, 2005.

[16] P. Groot, H. Stuckenschmidt, and H. Wache. Approximating Description Logic Classification for Semantic Web Reasoning. In A. Gomez-Perez and J. Euzenat (editors), *The Semantic Web: Research and Applications: 2nd European Semantic Web Conference*, volume 3532 of LNCS, pages 318–332, Springer-Verlag, 2005.

Results

Success indicators for the Nijmegen Health Care Computing Initiative are to be measured in the collaborations set up with other research groups, the successful grant applications obtained, and number of publications.

Collaborations

The NWO HEFBOOM project has lead to a FOCUS project (B-SCREEN) together with the Radiology department of the UMC St. Radboud in which we combine Bayesian networks and expert knowledge for classifying breastcancer from mammographic image data.

Contacts

A number of contacts have been set up with various groups active in the health care domain. For example, various departments of the UMC St. Radboud such as Radiology, Human Genetics, and Obstetrics; The Netherlands Cancer Institute; The Advanced Computation Laboratory, Cancer Research UK; CBO; Nictiz.

Publications

4 journal articles, 12 conference articles, 1 edited proceeding, and 8 posters.

Awards

- Best paper award at AI-2006 (see [5]).
- AIA award for best master thesis, awarded to M. Samulski (supervised student).