A Medical Informatics Perspective on Decision Support

Toward a Unified Research Paradigm Combining Biological vs. Clinical, Empirical vs. Legacy, and Structured vs. Unstructured Data

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Summary

Objectives: To summarize current excellent research in the field of decision-support systems.

Methods: We provide a synopsis of the articles selected for the IMIA Yearbook 2009, from which we attempt to derive a synthetic overview of the activity and new trends in the field.

Results: Five papers from international peer reviewed journals have been selected for the section on decision support. While the state of the research in the field of decision-support systems is illustrated by a set of fairly heterogeneous studies, it is possible to identify trends. Thus, issues related to guidelines processing implementation occupies a central role in today's field with two alternative directions: 1. broad medical applications, which attempts to assist decision-makers to process large patient sets; 2. narrow clinical applications focused on in-depth real-time signal processing for a specific population or medical specialty.

Conclusions: The best paper selection of articles on decision-supports shows examples of excellent research on methods concerning original development as well as quality assurance of reported studies. It is also observed that this year's selection point directly to more original research areas such as temporal signal processing, although more traditionally related areas, such as information retrieval and/or natural language processing, remain fairly active in the field. Altogether these papers support the idea that more elaborated computer tools, likely to combine together textual and highly structured data, including real-time data contents, are needed.

Keywords

Medical informatics, International Medical Informatics Association, yearbook, decision support

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The best paper selection of articles for the section on human factors in the IMIA Yearbook 2009 follows the tradition of previous Yearbooks in presenting excellent research on methods used to design and assess decision-support systems and resources. The five papers selected this year clearly address different aspects of human decision-support systems. Cornalba et al. [1] report on an experiment to improve risk analysis in hemodialysis. In a related and complementary vein, Razavi et al. [2] measure the *non*-compliance with guidelines in patients treated by post-mastectomy radiotherapy using a decision-tree rule generator, from which they try to derive an etiological model. The third paper, by German et al. [3], proposes an original architecture to cross-link medical knowledge repositories with clinical information systems. In a related spirit but focusing on knowledge edition Wright et al. [4] investigate how cooperative Web 2.0 environments can be used to maintain and share reference knowledge repositories. Finally, Suzuki et al. [5] attempt to use text mining methods to directly drive decision-making for Diagnosis Related Group selection.

The best paper selection for the Yearbook section 'decision support' can by no means reflect the broadness of a field that is intrinsically heterogeneous. The selected papers, however, shed light on some special aspects deserving particular attention as they concern methodological questions in the near future. Indeed, with the rapid development of electronic health records in large and medium-size healthcare institutions,

with the establishment of standards such as CEN 13606, OpenEHR, and SNOMED CT…), and with the deployment of customizable commercial solutions, the amount of clinical data available to health researchers is following an exponential growth, a trend which has been acknowledge elsewhere in sciences and in particular in life sciences with high-throughput experiments and –omics data. Like in molecular biology, the data explosion applies to both highly-structured and poorly structured data (narratives, images…) [6]. However, unlike in biology where reference knowledge sources are developed more or less in parallel with data capture processes thanks to excellent centers dedicated to annotation and biocuration, such as the Swiss-Prot Group, the situation is quite different in clinical environments. There is both an expertise and temporal gap between knowledge as stored in guidelines or text books and empirical observations as stored in hospitals and national registries data warehouses. For the first time in the history of medicine, computerized health records make possible the establishment of a closed loop between the observed medical practice and a putative evidence-based medicine. Like in molecular biology, the vision will demand to seriously invest efforts in order to exploit the hidden knowledge stored in narratives; not only in *digital* libraries such as MEDLINE, Cochrane or ClearingHouse [7] but also in clinical reports, including discharge summaries and follow-up notes [8]. Here lies the main next challenge where both bio- and medical informatics shall

meet to ultimately combine phenotypic and genotypic evidences [9], in particular at population levels.

The 2009's best paper selection on decision support is in the heart of this forthcoming revolution and the years to come will hopefully show more and more studies addressing the following challenges: 1. computer tooling to help consensus building in guidelines generation; 2. architectures to directly connect guidelines and empirical clinical data; 3. well-accepted decision-support systems focused on practical applications showing effectiveness to assess and monitor compliance with evidence-based medicine; 4. original methods to create new research model to exploit *bio/medico-un/structured* data, the BMUS paradigm.

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Appendix: Content Summaries of Selected Best Papers for the IMIA Yearbook 2008, Section Decision Support*

Cornalba C, Bellazzi RG, Bellazzi R

Building a Normative Decision Support System for Clinical and Operational Risk

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* The complete papers can be accessed in the Yearbook's full electronic version, provided that permission has been granted by the copyright holder(s)

Management in Hemodialysis

IEEE Trans Inf Technol Biomed 2008 Sep;12(5):678-86

This paper describes the implementation of a decision support system for risk management for patients treated for hemodialysis. The system capitalizes on a domain ontology to formalize a Bayesian network. Transition probabilities within the network are inferred automatically from hemodialysis data. By combining a priori knowledge and empirical available data, the system is able to estimate risk profiles for both individual patients and aggregated data to be used by departments. The tool is designed to be operationally used in practical health care environments.

German E, Leibowitz A, Shahar Y

An Architecture for Linking Medical Decision-support Applications to Clinical Databases and Its Evaluation

J Biomed Inform 2009 Apr;42(2):203-18

The paper reports on the design and evaluation of a framework, the Medical Database Adaptor (MEIDA), for linking knowledge-based medical decision-support systems (MDSSs) to multiple clinical databases. The proposed solution includes the use of software and terminological resources to map the local database (DB) schema and contents to standardized vocabu-

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2009 in the section 'Decision Support'. The articles are listed in alphabetical order of the first author's surname.

Section
Decision Support
▪ Cornalba C, Bellazzi RG, Bellazzi R. Building a normative decision support system for clinical and operational risk management in hemodialysis. IEEE Trans Inf Technol Biomed 2008 Sep;12(5):678-86.
▪ German E, Leibowitz A, Shahar Y. An architecture for linking medical decision-support applications to clinical databases and its evaluation. J Biomed Inform 2009 Apr;42(2):203-18.
▪ Razavi AR, Gill H, Ahlfeldt H, Shahsavar N. Non-compliance with a postmastectomy radiotherapy guideline: decision tree and cause analysis. BMC Med Inform Decis Mak 2008 Sep 21;8:41.
▪ Suzuki T, Yokoi H, Fujita S, Takabayashi K. Automatic DPC code selection from electronic medical records: text mining trial of discharge summary. Methods Inf Med 2008;47(6):541-8.
▪ Wright A, Bates DW, Middleton B, Hongsermeier T, Kashyap V, Thomas SM, Sittig DF. Creating and sharing clinical decision support content with Web 2.0: Issues and examples. J Biomed Inform 2009 Apr;42(2):334-46.

laries using three types of heuristics: choice of a vocabulary, choice of a key term, and choice of a measurement unit. The approach is tested with three knowledge coupling examples. Heuristics are proposed to significantly downsize the number of term-mapping candidates. Efficiency measures are provided, which suggest the operational effectiveness of the proposed approach.

Razavi AR, Gill H, Ahlfeldt H, Shahsavar N
Non-compliance with a Postmastectomy Radiotherapy Guideline: Decision Tree and Cause Analysis
BMC Med Inform Decis Mak 2008 Sep 21;8:41

The authors propose to study patterns of non-compliance with guidelines in post-mastectomy patients treated by radiotherapy. They conducted a post hoc analysis of 759 patients with malignant breast cancer to detect patterns of non-compliance with clinical guidelines using a decision-tree. Guidelines were used to separate patients into two subsets: those with recommendation to receive (RR) vs. those with recommendation not to receive (RNR) radiotherapy. The two groups of patients were analyzed separately. Generated patterns were transformed into rules to be compared with the reasons that were extracted by manual inspection of records for the non-compliant cases.

The analysis of patients in the RR set did not result in a robust decision tree. But, classification of the RNR group resulted in a denser model with nine leaves and three of them were expressing non-compliance with the guideline. A manual inspection of the automatically generated rules led to the following observations:

In the decision tree, presence of periglandular growth is the most important variable followed by number of malignantly invaded lymph nodes and level of progesterone receptors. Other features such as DNA index, age, size of the tumor and level of estrogen receptors are also selected but with more moderate contribution to the model. The most frequent pattern for non-compliance is the age parameter above the threshold. A certain level of agreement but not equivalence is found between variables acquired by manual inspection and those generated by machine learning. These results suggest that data mining can highlight non-compliance patterns useful to help authoring guidelines and to improve the quality of care in oncology.

Suzuki T, Yokoi H, Fujita S, Takabayashi K
Automatic DPC Code Selection from Electronic Medical Records: Text Mining Trial of Discharge Summary
Methods Inf Med 2008;47(6):541-8

The authors propose to design an automatic text categorization system to generate DRG codes. They use a morphological analyser and a vector-space representation to assign a set of diagnosis to discharge summaries. They work with 125 categories and the sample data are split between tuning and evaluation data. They report a precision of 56% for 14 digit DPC codes and 80% for six digit codes, suggesting that text – mining methods are suitable form automatic DRG classification.

Wright A, Bates DW, Middleton B, Hongsermeier T, Kashyap V, Thomas SM, Sittig DF
Creating and Sharing Clinical Decision Support Content with Web 2.0: Issues and Examples
J Biomed Inform 2009 Apr;42(2):334-46

Clinical decision support is a powerful tool for improving healthcare quality and patient safety. Decision support tools are powerful instruments to improve healthcare quality but they remain expensive. Web 2.0, tools, characterized by online content sharing and collaborative community models, have the potential to make DS tools more accessible and cheaper. The authors present three recent initiatives going in that direction: the Clinfowiki, a world-accessible wiki for developing decision support content;

Partners HealthCare eRooms, a set of web-based resources for developing decision support within a company ; Epic Systems Corporation's Community Library, a shared collection of decision support content for customers of a single clinical system vendor. They evaluate the potential of Web 2.0 technologies considering the following dimensions: technical, legal and organizational issues for developers, and consumers and organizers of clinical decision support content in Web 2.0. The case for Web 2.0 as a tool for collaborating on clinical decision support content appears strong, particularly for collaborative content development within an organization.