

DebugIT for patient safety – the fight against emergent microbial diseases using multimedia data mining of heterogeneous clinical data

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Summary

The debugIT project is a large-scale integrating project funded as part of the 7th EU Framework Programme (FP7). The main objectives of the project are to build IT tools designed to have significant impacts on the monitoring and control of infectious diseases and antimicrobial resistances in Europe; this will be done by building a technical and semantic infrastructure able to a) share heterogeneous clinical data sets from different hospitals in different countries, with different languages and legislations; b) analyse large amounts of this clinical data with advanced multimedia data mining; c) apply the knowledge obtained for clinical decisions and outcome monitoring. The concepts and architecture underlying this project are discussed.

Introduction

Building a safer and more efficient care system has become the most shared goal of all actors involved in healthcare. From the historical perspective there has been, in the last 25 years, an impressive shift towards awareness of the impact of errors in medicine. In the early nineties research papers and reports were published on patient safety, incident reporting and initial order-entry systems, chiefly originating from academic settings. At approximately the same time the first reports of the US Institute of Medicine (IOM) on computerised patient record systems stressed the potential of ICT-based solutions in improving the quality of care [1]. Ten years later, by the end of the nineties, a famous report of the IOM called attention to the wide prevalence of errors in healthcare [2]. While medical errors are under the spotlight, (re-)emerging infectious diseases are becoming major challenges. Most important among are them the rapid development of antimicrobial resistances [3], the spread of nosocomial and other infections [4], inadequate care and lack of appropriate tools to guide the care system faced with these new emergent problems [5]. The issues surrounding infectious diseases are closely interrelated and have immediate and important

effects on safety, quality of care and efficiency. In half a century of antibiotic use, new challenges have emerged: rapid emergence of resistances among pathogens, and misuse and overuse of antibiotics. Antimicrobial resistance means escalating healthcare costs, increased morbidity and mortality and the (re-)emergence of potentially untreatable pathogens.

The project

Dedicated to infectious diseases, the DebugIT (Detecting and Eliminating Bacteria Using Information Technology) project aims to 1) detect patient safety-related patterns and trends, 2) acquire new knowledge and 3) use this for better quality healthcare. A consortium of eleven partners has been built to gather scientific competencies in all the domains involved, as well as to ensure access to specific information from more than 2 million clinical records.

Table 1. Consortium

Belgium	Agfa HealthCare
Bulgaria	GAMA/SOFIA Ltd.
Czech Republic	IZIP – Internetový Přístup Ke Zdravotním Informacím Pacienta
France	Institut National de la Santé et de la Recherche Médicale (with European Hospital Georges Pompidou)
Germany	empirica GmbH
Germany	University Medical Center Freiburg
Greece	Technological Educational Institute of Lamia
Sweden	Linköping University
Switzerland	University Hospital Geneva
Switzerland	University of Geneva, Computer Science Department
United Kingdom	University College London

The project has strong clinical leadership provided by a Clinical Advisory Board and a Scientific Advisory Board involving European

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and American experts from the infectiology and scientific domains.

Outcomes and benefits will be measured in clinical and socioeconomic terms. Results will be integrated into clinical information systems (CIS) of participating European hospitals, industry and their clients, and become available globally through a European or global disease control centre/public authority, also as an open source solution. Advanced ICT applications and innovations concern the virtualisation of the clinical data repository through ontology and terminology binding and mediation, advanced data mining techniques, the use of machine reasoning related to real, point-of-care patient data, as well as consolidation of all these techniques in a comprehensive but open framework. Output will be applicable to other clinical fields.

The concept developed as the foundation for the DebugIT project addresses all of these issues in an operational manner with the ultimate goal of developing a new, highly advanced and preeminent tool aimed at producing a new and efficient weapon for the war against infectious pathogens across all health system actors and levels.

The overall project outcome will not only be a theoretical work and proof of concept, but also a practical implementation of a highly improved and advanced computerised system in the field of infectious disease treatment and antibiotics usage. This application, which – due to its generic conceptual base – should be easily expandable and adaptable to other similar medical application fields, will initially be evaluated by the participating project partners, but should be made publicly available to other healthcare organisations soon after.

The conceptual framework

The conceptual framework of this project is an ever-continuing iterative cycle, implementing the principle of translational medicine and true evidence-based medicine (EBM). Translational medicine links medical research and clinical care by providing research with clinical data and the results of the research – the medical knowledge – as input for clinical care. While medical research often focuses on prospective and tightly controlled studies, retrospective studies with access to huge amounts of data, merely waiting to be analysed, are a welcome addition to clinical research.

The framework can be broken down into several distinct steps:

Collect data: Clinical data will be collected and aggregated across different hospitals, countries,

languages, information models and legislations, via advanced and commonly agreed data models (minimal data sets), standards and mapping algorithms.

Learn: Advanced data mining techniques on multimodal, multisource, structured and unstructured data will detect patterns relevant for patient safety and the treatment of infectious diseases, such as resistance of bacteria, adverse events and operational practices. This will result in new knowledge and new evidence for existing knowledge.

Store knowledge: This knowledge will be stored, visualised, validated and aggregated together with preexisting medical and biological knowledge (guidelines, regulations) to achieve a consolidated view on the knowledge needed, to be applied in the next step.

Apply: Software tools will be integrated into the available clinical and public health information systems. *Decision support* tools will apply the knowledge generated and help the clinician to provide clinical care (choice, dose and administration of antibiotics, for example). The knowledge will also be used to *monitor* ongoing care activities and even *predict* future outcome, to provide additional feedback both on the individual patient and at cohort level. This will allow healthcare providers and decision makers to take appropriate action at various level of the healthcare system, including point-of-care, management or policy, and subsequently influence the future development of our health systems. By integration into existing CIS it will be possible to record activities and results and thus ensure that the necessary data are generated for a subsequent cycle.

Technology and architecture

To achieve its goals the DebugIT project will make extensive use of clinical and operational information originating from running clinical information systems (CIS) across the EU, building a virtualised, fully integrated clinical data repository (CDR).

The CDR will feature transparent access to the original CIS and provide data aggregations in local stores. The CDR is specifically tailored for knowledge discovery, featuring ethically sound, transparent access to data at or from the original CIS and/or collection and aggregation of data in a local data store.

Multimodal data mining (MDM) will have a strong focus on new fields of research doing mining on distributed storage, using highly

advanced new text, image and structured data mining on individual patients as well as on populations.

New knowledge will be fed into a medical knowledge repository (MKR) and mixed with domain knowledge derived from external sources (guidelines and scientific evidence). Innovative and user-friendly knowledge representation paradigms will be developed to enable not only

knowledge engineers but also clinicians to use the repository. After validation this knowledge will be used by a decision support module (DSM) and monitoring tool in the clinical environment to present and report on patient safety issues, both at population and patient level for direct care. Coordination and steering of both the analysis and the care process will be done by a high-performance and versatile reasoning engine.

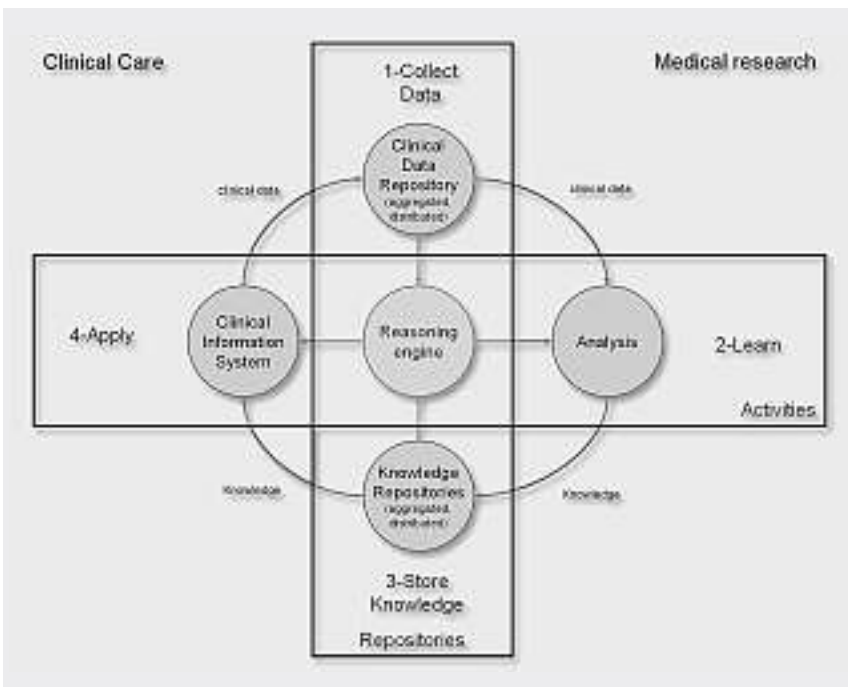


Figure 1. The conceptual framework.

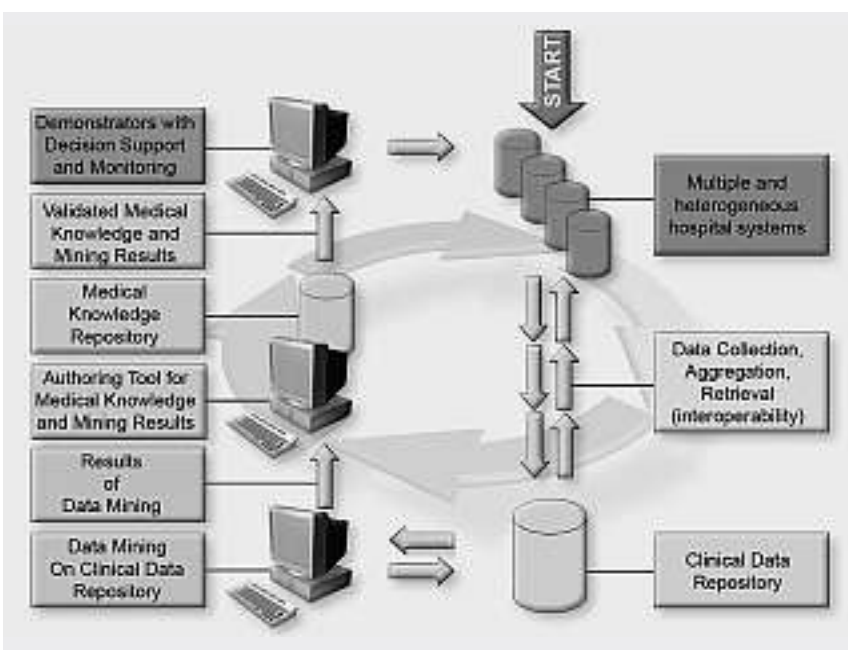


Figure 2. Overview of the project.

Privacy

Close attention is paid to privacy concerns, taking into account the various legal and ethical requirements to be met. Privacy is thus made a central part of the project *by design*, using a virtualised data repository without dealing directly with the original data. Identification elements provided by the clinical data repositories can be carried all along the process, blindly, to allow the original clinical information system to feed back decision support without the need for patient identification.

Conclusion

The DebugIT project is focused on using large existing and heterogeneous clinical datasets covering hundreds of thousands of patients from several clinical information systems in different European countries. DebugIt proposes to build an interoperability platform to populate a relevant dataset on the infectious domain, to achieve a very large shared virtualised clinical repository allowing knowledge-driven data mining. This “semantic mining” will be based on innovative methodologies to deal with the characteristics of real-world clinical data. A knowledge repository will drive the data mining and serve as a storehouse for the results. Finally, a decision support engine will exploit the aggregated knowledge to loop back to the real world.

To achieve this system, several aspects will need to reach the frontiers of current state-of-the-art and beyond. Two strategies can be chosen for this. The first is to invent something radically new. The second involves using all existing knowledge and methods, putting them together and trying to build on this base. For most of its research, the second strategy is the one chosen in this project because operational results for clinical information systems must be available and sustain the DebugIT outcomes after the end of the project.



To meet these requirements, the project has been organized according to architectural component-based considerations:

- Interoperability platform (IOP);
- Clinical data repository (CDR);
- Multimodal data mining (MDM);
- Medical knowledge repository and associated knowledge authoring tool (MDR)
- Decision support and monitoring engine (DSM);
- Clinical applications.

This scientific and technical framework, associated with access to large amounts of clinical databases and led by experts in the medical field, will represent a serious advance in building a large IT infrastructure aimed at creating new knowledge in the field of monitoring, surveillance and efficient measures to fight infectious diseases.

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