DebugIT

Detecting and Eliminating Bacteria Using Information Technology

Public Progress Summary
Project YEAR #2

FP7-ICT-2007-1

DebugIT
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1. Overall description of the DebugIT project

Improving the quality of healthcare and patient safety are priority health policy goals globally. Despite half a century of antibiotic use, re-emerging and new infectious diseases, partially caused by the rise of antimicrobial resistance, have become important problems. This increasing prevalence of resistance results in escalating healthcare costs, increased morbidity and mortality and the (re-) emergence of potentially untreatable conditions. The DebugIT project is developing an IT-framework to allow health care systems to better address these emergent problems and improve their management. In the context of infectious diseases, DebugIT

- detects patient safety related patterns and trends,
- acquires new knowledge through advanced data mining, and
- uses this knowledge for better decision-making on the optimal treatment for infectious diseases,
- thereby improving the quality of healthcare.

1.1 The problem: the rapid emergence of resistance among pathogens, the misuse and overuse of antibiotics

Although medical errors are currently under the spotlight, (re-)emerging infectious diseases are also becoming an important challenge. The rapid development of antimicrobial resistance, the spread of nosocomial and other infections are major concerns.

The impact of this phenomenon is most apparent in hospitals. However, community-based practice is not immune, due to the frequency and rapidity of patient transfers between the two sectors and citizen mobility. Hence, epidemics are a regular occurrence and may spread between continents. Examples of such epidemics are methicillin-resistant Staphylococcus aureus and vancomycin-resistant Enterococci or multiresistant tuberculosis. In addition, as a result of the efforts made in harmonising data on infections and antimicrobial resistance across Europe, it has become clear that a wide variability in preventive practices and outcomes across European countries exists, indicating considerable leeway for improvement.

1.2 The DebugIT response

To address the challenges of improving antibiotic therapy and reducing antimicrobial resistance, the DebugIT project will make use of data that are already routinely collected and stored in electronic Clinical Information Systems (CIS) in hospitals and primary care clinics. Today however, this occurs in widely differing systems. The DebugIT challenge is to establish the coherent and systematic exchange of a rich data set, harmonised across the DebugIT sites and their CIS systems. This data set will include information about patients and their illness situations, pathogens and drug treatments.

DebugIT is adopting a multi-stage framework of several distinct steps:

- **Collect Data**: Clinical data is aggregated from across different hospitals, countries, languages and information models, via advanced and commonly agreed data models (minimum data sets), standards and mapping algorithms, organized in a virtualized, fully integrated Clinical Data Repository (CDR)
- **Learn**: Advanced data mining techniques on multimodal, multi-source, structured and unstructured data to detect patterns, relevant for patient safety and the better treatment of infectious diseases.
- Store Knowledge: This knowledge will be stored, validated, visualized and aggregated together with pre-existing medical and biological knowledge (guidelines, regulations) in a federated knowledge repository to achieve a consolidated view on the required knowledge.
- **Apply**: Appropriate software tools will be integrated into available clinical and public health information systems. Decision support tools will apply the newly generated knowledge and help the clinician to provide improved clinical care (choice, dose and administration of antibiotics for example). The new knowledge will also be applied to the monitoring of ongoing care activities and outcomes, and may help to predict future outcomes to give additional support to treatment decision on individual patients and for populations.

DebugIT will allow healthcare providers and decision makers to take appropriate actions at various levels in the healthcare system, including policy, point-of-care, service management, and subsequently influence the future development of our health systems. Integration of DebugIT tools into existing CIS will enable the recording of activities and results and thus make sure the necessary data are generated for a next cycle of learning.

Throughout this process, DebugIT will pay strong attention to privacy concerns, taking into account the various legal and ethical frameworks that must be met across Europe. DebugIT will use a virtual repository of anonymized data without needing direct access to the original clinical data at each site.

1.3 Expected outcomes

DebugIT will contribute to achieving world-leading levels of patient safety with fewer medical errors and optimised medical interventions. The learn-predict-prevent approach embodied in the knowledge base and the decision support system of DebugIT will contribute to effective and automated risk prediction. Further expected outcomes are:

- Clinical Information Systems (CIS) of participating European hospitals, industry and their clients are updated with DebugIT knowledge
- New knowledge will be made available at a global level, preferably through a European or global Disease Control Centre/Public Authority, and/or through Open Source services
- New, advanced ICT applications and innovations will be marketed in the following domains: virtualization of Clinical Data Repository information, advanced multimodal data mining techniques on text, image and distributed storage, use of machine reasoning related to real, point of care patient data
- A distributed Medical Knowledge Repository (MKR) integrated with domain knowledge coming from external sources (guidelines and scientific evidence)
- Innovative and user friendly knowledge representation paradigms for both clinicians and IT experts

1.4 Feeding DebugIT results into applications

Real world examples of applications benefiting from DebugIT research include

- Computerised Physician Order Entry (CPOE) systems, integrated with, e.g., drug data bases and/or clinical decision support systems,
- Adverse Drug Event (ADE) reporting solutions, and hospital-wide Clinical Information Systems (CIS), Health Database Systems, or Electronic Health Record (EHR) Systems, and
- Integration of knowledge translation and decision support into hospital and GP practice systems.

Above all, the DebugIT project is a good example of how to achieve Translational and Evidence Based Medicine:

- clinical information is used to support medical research and to enhance medical knowledge,
- this new evidence is used to support clinical care.

Although the DebugIT project is focusing on infectious diseases, its translational framework will be suitable for many other clinical problems, providing a solution to increase patient safety and enhance the quality of care.

2. Progress in year two

DebugIT is in its mid-project phase. In the scheme below the overall timing and project orientation is listed:

- Year 1: investigation and requirements
- Year 2: design, prototyping, closing the loop
- Year 3: expanding scope, automatization and deploying
- Year 4: exploitation

During year two of the DebugIT project we focused on the design and first implementations of the overall system and individual components, given the requirements gathered and the investigations done during year one.

2.1 Scientific approach

The scientific approaches and choices are based on the investigations in year 1 and 2 and can be summarized as follows:

- Ontology engineering: we follow a dual approach:
  1. We build a DebugIT Core Ontology (DCO), capturing the concepts of the medical domain of infectious diseases. This ontology is based on the high level concepts of BioTop and is made in OWL-DL. The purpose of DCO is to describe the domain in a comprehensive and complete way.
  2. Besides DCO we are building a set of so called operational ontologies. These are ontologies with a domain of discourse more directed to the actual implementation and usage of the system: These ontologies formalize domains such as query building, statistics, analysis, evidence classes, reasoning, etc…. These ontologies reuse existing ontologies as much as possible and use OWL Full formalization.
- The interoperability platform heavily counts on the sparql technology. Sparql stands for “Semantic “Protocol and RDF Query Language” and means on the semantic level what sql means for querying relational databases. We argue that ultimately semantic interoperability can only be achieved by formalizing the clinical data and raising them up to the semantic layer as soon as possible. This is exactly what we do by building sparql endpoints on top of the individual clinical information sources. This also considerably facilitates aggregation of clinical data across clinical sites.
- Beyond the classical endeavor to find powerful clinical analysis and data mining algorithms we face the challenge of the consolidation of multimodal datamining (structured text, free text, images, …). Here again sparql can help us: by formalizing the results using the concepts of the used ontologies we can aggregate the different mining approaches.
- The decision support will use knowledge extracted by the clinical analysis. Different approaches are used (Bayesian belief networks, fuzzy cognitive maps, …) and part of the work is making a reasoning framework that can cope with different decision support approaches. This is done by formally describe the approach itself and use this as extra input for the reasoner. We also use (and contribute to) the open source Euler reasoning engine.
- Population monitoring is build around an “i-google”-like parametrizable dashboard, where individual visualization portlets, showing the results of sparql queries, can be dragged in, according to each users’ needs and preferences.
- Above all, in a complex project like the DebugIT project the challenge is to integrate all the different modules and technologies in a smoothly way in order to create a comprehensive framework with consistent behavior and functionalities. This is the main challenge of the WP 9 scientific co-ordination task and will be elaborated on in this deliverable. Also here we rely on sparql: many of the interactions between the different modules will be based on a request-result scenario formalized with sparql. This means that the communication between the different pieces of the total solution happens through a so called knowledge bus: formalized and ontology based communication.

2.2 Achievements

A brief overview of the scientific achievements so far (mid-project) follows below. Detailed information can be found in the individual workpackage descriptions.

- DebugIT Core Ontology and Operational Ontologies: work in progress, 800+ classes,160 properties (wp1a)
- A prototype of the interoperability platform, with already basic functionality implemented and able to federate queries and merge result sets, based on sparql (wp1b)
- Clinical Data Repositories with sparql endpoints (wp2).
- A data mining infrastructure with sophisticated post-processing capabilities (temporal and causal mapping) and already yielding some medical results (wp3)
- Image mining based on segmentation of chest x-rays
- A running knowledge repository able to store queries and accept data mining results (wp4)
- An interactive knowledge authoring tool for building queries and reviewing results (wp4)
- A decision support and monitoring service, formalizing bayesian belief network, fuzzy cognitive maps, ran by the same engine, formalization of guidelines (wp5)
- First GUI proposals and implementations for decision support prototypes and the knowledge authoring tool (wp4,wp5)

2.3 Clinical Advisory Board

We organized a first meeting on May 18th, 2009 (Helsinki). 5 External experts, 2 internal ones and 8 project representatives were present.

The key message from the Clinical Advisory Board was to consider a dashboard (for monotoring antibiotic resistance) as a first priority for DebugIT. Less important on short notice, but also needed in the futureis a system to obtain and use patient specific knowledge at the point of prescription (patient specific decision support).

Further the CAB confirmed the importance of the DebugIT project:

- infectious disease is a very important public health problem
- it generates huge costs, human and economic
- opportunity: the domain of infectious diseases is a very good domain for research
  - course usually short (2 weeks)
  - most of the time, diagnosis, pathogen and treatment are well defined
  - human and pathogens are involved. Much work can be done on pathogen (identification, clinical course, resistance patterns, etc…) without involving human data
  - outcome and impacts can be measured, such as costs

2.4 Conclusion and next steps

In year two we basically closed the full circle: so far we did the whole round trip with real (but off-line) + simulated data. Some of the connections between the individual components are still not fully automated. The challenge for year three is to integrate all components into one holistic system, deploy it and use real clinical data. In the last year of the project the system will then be deployed for clinical use.

We feel more and more comfortable with issues such as feasibility and scalability. Therefore we will start studying exploitation and increase dissemination activities.

3. Consortium

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