MEDICAL RELEVANCE IN CONTEXT TO INFORMATION SYNTHESIS

Borovicka MC[1]

Abstract

Relevance and context are two concepts which are highly valuable when trying to achieve information synthesis. This approach tries to find solutions intended to improve medical care by developing a prototype (DMIS) and applying relevance mechanisms in order to save important interaction time and allow for the integration of new or alternative sources of information. DMIS aims at been deployed within the clinical diagnosis process and is sought to have its strength in leveraging system use by acting as an assistant to facilitate information enabled decision making.

1. Introduction

Health care practise involves gathering, synthesising, and acting on information and therefore poses a great challenge to ongoing research and development for general frameworks and standards. Structured data and processable information are technically possible but still a rarity, especially when it comes to shared usage of interlinked information sources. Thinking about e.g. patient data with medications and known allergies, and drug-drug interactions, a lack of interlinking can result in insufficient data about a patient, which in turn, makes repeated data gathering necessary in the best case, or prescription of an allergic drug in the worst.

One of the commonest barriers implied is the shared vocabulary (or ontology) of terms and processes involved. Also, many hospital information systems (HIS) offer a broad spectrum of functions as to ideally cover all different departments involved in the daily process of patient care so that they become inflexible and cannot react to new beneficial needs of their users. This is also substantiated by an evaluation of the biggest regional hospital of Tyrol. Every medical user has more or less[2] the same view, regardless his personal preferences or needs, thus fragmenting information with catastrophic impact on the respective workflow. Locating the needed medical report can be similar to the situation of finding the needle in a haystack, as the presented overview conditions relevant information to be hidden within.

Generally, specialised systems that might assist in routine medical care remain scarce. Reasons range from low user acceptance [5], lack of workflow integration and inflexibility, lack in the consideration of the medical context [7] and the mapping of decision-making process to computational approaches [13], to incompatibility with legacy applications [5]. Generally speaking, most systems

[1] University of Innsbruck, Institute of Computer Science, Dept. Databases and Information Systems (DBIS)

[2] Slight difference for doctors and nurses

introduce more effort then they are worth, implying that a social perspective [10] has not been fully recognised.

Information portals might offer a solution, as they aggregate information in a user perspective manner. Although the portal concept originates from a more hedonic kind of area, its' intention and perspective can be applied to other areas as well. The DMIS project will try to approach and evaluate the concept of medical relevance and explore how information synthesis can be achieved in order to facilitate information enabled decision making.

2. Related Work

Information overload has long been a problem for users utilizing the internet for information aggregation. If useful information was found it normally was contained in many different sites. To stay informed, all these sites had to be constantly monitored. Early information portals tried to solve this problem by providing more and more information of all kinds of branches, but never succeeded in obtaining a reasonable cost-effective strategy. It was only after the 2001 dot.net crash when information portals were reborn and now pose a promising concept for information aggregation and visualisation. It could be seen [17] that information, which was stored at different sources, now was consolidated and made accessible though a single access point. Further on, sites such as netvibes[1] are now fully adjustable to the needs and perceptions of its users. As a consequence, big search portals like google[2] or yahoo[3] are now also partly configurable and a user can select from a vast abundance of services which are then bundled into his personal website, creating a *mashup* of different information of different sources.

But still, simple provision of information is not enough. Bates et al. [1] emphasise that clinicians might miss important information due to the sheer volume of information, calling for systems which can make associations between information elements. In addition, there is broad consensus that any new system must fit within the users workflow [12, 1, 5, 9, 10]. Kaplan [7] states that in order to become involved and feel as active participants, users must have the ability to modify their system. By following this principle, personalisation is seen as key to aid to the concept of workflow integration, as it provides means necessary to shape the interface along the needs.

Thus, workflow integration also requires an adaptive system which can utilise knowledge about the users' task to calculate the probability of steps following the current one. This directly correlates to Bates et al. [1] and Wetter's [18] statement about 'to anticipate needs', which adds ease-of-use and real benefit by reducing necessary interaction time [12,9]. As Perreault and Metzger [11] put it, it is necessary to enhance systems usefulness by integrating and presenting information in different ways depending on the medical context. For his routine work a clinician knows what information about a patient he needs to perform an adequate diagnosis [10]. In order to make that diagnosis, he does not need all information but rather the information for that certain situation, which appear relevant in his context.

Information retrieval considers relevance as a basic notion. When following Saracevic [15] it is understood as a relation, having a number of properties and criteria's (e.g. strength) but with many manifestations. Also Hartner [6] and Maglaughlin [8] state that it exhibits a certain duality, two braches in which it can de divided: topicality (system) or objective, meaning it can be obtained by

[1] www.netvibes.com
[2] Function provided by iGoogle, requires personal login
[3] Is invoked via MyYahoo, does not require login

experts in that discipline and situation (human) or subjective, and therefore personal, meaning it must be assed by the user himself. Harter [6] further interpreted the theory of psychological relevance presented by Sperber and Wilson [14] as an occurrence when retrieved information suggests new connections, increases or decreases the strength in a belief, thereby changing the cognitive state of the requester. Thus, it can be seen as the actual output an information system must produce in order to be beneficial.

Information needs are central to the rendering of relevance judgements, and therefore are central to the conduct of information searches [6]. Consequently, this all leads to a form of basic decision support offering easy access to general and patient-specific clinical information with adjustable and adaptive behaviour aimed at delivering the right information at the right time [12, 3] and is thereby regarded crucial for carrying out informed clinical decision making [7].

3. Analysis and Scope

In order to build a concept around medical relevance, relevance has to be brought in relation with the process of diagnosis and prerequisites have to be found:

Common ground A requirement for relevance is common ground [4], which stands for any shared concepts, vocabulary or even ontology. In the medical area, some standards have evolved, like Mesh, Snomed, LOINC, UMLS, and ICD-9. Its' benefit is the decisiveness, the definite relation and identification of clinical studies (medical reports or tests) for proper semantic identification.

Medical context Relevance is also comprised of the actual context which is defined by a combination of the environment within the clinical situation or setting (e.g. outpatient encounter in a particular medical unit like general internal medicine) and the type of disease the patient indicates, as well as the user who is interacting with the system [16]. In order to provide relevant information, the context within the user interacts with the system has to be known a priori.

Informativeness For medical documents, relevance always adds to the findings a doctor seeks. If a document does not indicate a particular disease and is perceived informative, it is still relevant, as he can exclude the diagnosis leading to this disease.

Prediction Further on, a relation between medical reports and their diagnosis has to exist, in that for any suspected diagnosis there are required tests to prove if the hypothesis is verified. This can be achieved either by incorporating knowledge into the system or deriving it from user interaction and building pathways[1] from diagnosis to studies by putting learning-algorithms in place. Either solution alone is insufficient, as rules don't allow adaptation, and without them, no new medical studies are taken into consideration, as nobody might know about them.

The importance of context becomes clearer, when e.g. considering patient characteristics from the electronical health record (EHR), some diagnoses and therefore medical studies can be already omitted (e.g. breast-cancer for men). Context is key to medical relevance and requires careful consideration. Table 1 shows factors influencing context.

It has been argued by Kaplan [7] and Peleg [10], that providing advice concerning the decision process outcome can have negative impact, as clinicians might fear dependency [5] toward the sys-

[1] Like an ant-street.

tem, or even feel that their sense of autonomy [12], [7] is omitted, rendering them useless. Of course, no system could or should real replace a clinician, but certainly it is important to respect social roles [10] and not alter their perception of being in control. As a matter of fact, to judge a person's health by examining his symptoms is probably the most important capability a doctor must develop, and by providing him with relevant information to judge upon empowers him to perform informed clinical decision making. Information synthesis therefore leaves the user to interpret the information correctly.

Table 1. Factors influencing medical context

Patient (history, constitution, allergies, medication etc)
Actual health problem
Affected body areas
Possible disease
Clinical user
Medical unit (internal, orthopaedics etc)
Environmental variables (current season, climate etc)

Combined findings from the previous chapters, literature, and interviews conducted with clinical personal rendered several factors as important, as can be seen in Table 2. This is complemented by a study on implications for visualisation of different types of hospital medical data.

Table 2. Requirements for information synthesis

Factors	Implications
Present relevant information first	Provide view for timely patient data
Provide access to all available information on request	Provide current patient overview of medical information (audio, video, text, images)
Reduce time to find information needed	Provide tabular view of measured values e.g. enzyme values from blood tests
Be adjustable and adaptive	

Compared with the nearby concept of CDSS, information synthesis would classify by Bates scale of 'degrees of computerisation' [1] as level 3 by providing relevant patient information as recommendation but without intention to influence the users' cognitive thinking process.

4. Framework and Prototype

To incorporate the key findings from the previous chapter and further develop necessary concepts for medical assistant applications, the DMIS project was launched. DMIS stands for dynamic medical information system and poses itself as a medical unit-related information portal. The primary goal of DMIS is information synthesis to provide a better cockpit for clinicians [1], offering relevant information at first sight though an adjustable and adaptive graphical user interface, thereby reducing information overload.

The intention of DMIS is to act as a composition on top of already existing HIS with EHR capabilities and is thus not meant to replace[1] them. Three different modes of display are considered: pa-

[1] For special visualisation of e.g. CTs or RTs, external programs shall be utilized

tient-at-a-glance, which has the currently available clinical studies, timely-view for selected clinical data, and a tabular view of laboratory values.

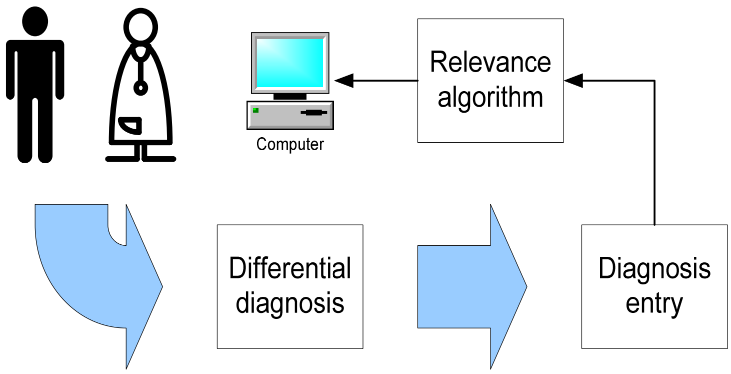

Figure 1. Framework of DMIS

The context has been set to the following: the environment considered is the outpatient setting, it is assumed that clinical data are already semantically annotated and security as an issue is recognised, however methods and techniques are not yet dealt with and proper authentication is presupposed. *Figure 1* shows how DMIS is intended to operate. It requires the clinician to make 3 to 5 suspected diagnoses and enter them in to the system. Relevance is inferred by recording user interaction and showing medical reports with a high probability of being ordered in that particular context in the past.

Studies indicated that for similar diagnoses also similar tests are ordered, which leads to a converging number of possible tests, even if more differential diagnoses are entered. From these possible diagnoses entered, DMIS starts to show clinical studies already available in the EHR or suggests ordering them, as relevance not only requires display of what is available, but also what is necessary.

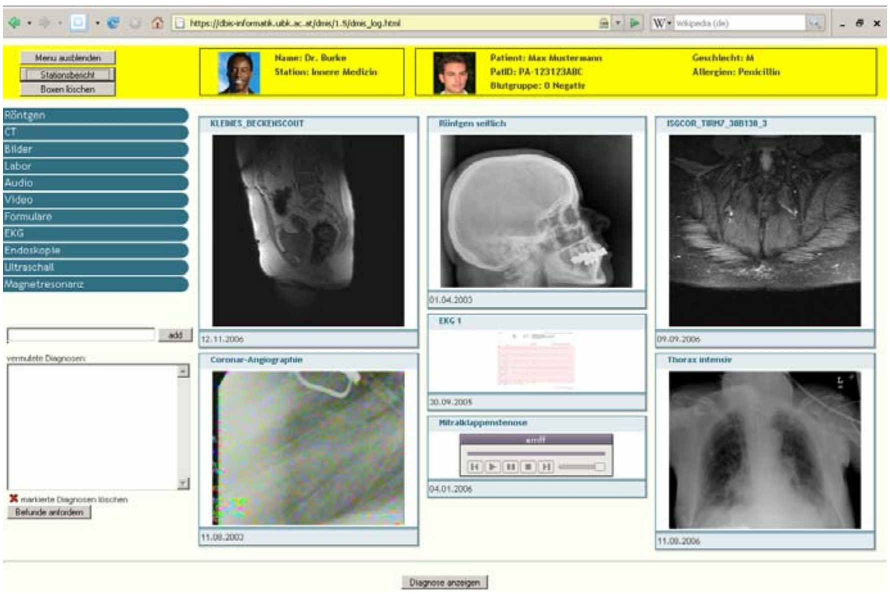

Figure 2. Screenshot of the DMIS prototype

In order to realise the proposed framework, a prototype was build to incorporate those ideas. *Figure 2* shows the user interface implemented so far. A web-based front-end was chosen which utilizes Web 2.0 technologies (AJAX) to provide both flexibility, extensibility, and facilitate ease-of-use.

To encompass visualisation, access to information in required. Depending on the underlying infrastructure, i.e. EHR client used, different ways of storage and therefore access are implied. To bypass this problem, a standard representation of patient data will be used. Here, the HL7[1] clinical document architecture (CDA) was chosen, as it represents a widely referred standard, to serve as an intermediary between DMIS and the underlying data source. In particular, projects like EGADSS [2] or health@net[2] already took advantage of the CDA.

Currently the prototype is able to visualise various clinical data (audio, video, images, text) and provides an easy-to-use interface with drag-and-drop functionality. Each examination process produces medical data combined with semantic medical information, e.g. a CT image of the patients head. Such an item is hereby referred as a clinical element. Clinical elements are grouped into classes, each class having its own methods and properties. Every displayed element therefore belongs to exactly one class.

An instance as a representation of such a class is realised through widgets. They act as sort of mini-applications providing basic functionality like e.g. printing, but can encompass also more high-level functions like navigation if needed. To provide also access to not only the EHR but to external sources, RSS-Feeds, Web-Services, and other XML-based services are also possible classes for clinical elements.

5. Limitations and Outlook

DMIS at this stage is merely a first step, and many are intended to follow. The limitation to the internal unit has been done to ease development at the beginning, but poses no problem for ongoing development, as unit types are taken into the concept of context. Further development of the clinical element classes and evaluations on how the relevance algorithm is best equipped with have to be conducted. More certainty has to be reached to narrow down the concept of relevance according to the respective users and their requirements, e.g. different units requiring different items. A learning algorithm to extract most wanted items from a field study is proposed to be added to the relevance algorithm. Further, the navigation within DMIS to select additional medical studies has not been tangled yet and needs intensive studies on what proves to be most beneficial. Also, elements to definitely exclude from reasoning therefore reducing output possibilities could improve filtering. Last, security issues will have to be integrated and therefore pose a subject of further study.

6. References

[1] D.W. BATES, et al., "Ten Commandments for Effective Clinical Decision Support: Making the Practice of Evidence-based Medicine a Reality," J Am Med Inform Assoc, vol. 10, no. 6, 2003, pp. 523-530; DOI 10.1197/jamia.M1370.

[2] I. BILYKH, et al., "Using the Clinical Document Architecture as Open Data Exchange Format for Interfacing EMRs with Clinical Decision Support System," 19th IEEE Symposium on Computer-Based Medical Systems, 2006.

[1] www.hl7.org

[2] www.healthatnet.at

[3] C.A. BROVERMAN, "Standards for Clinical Decision Support Systems," The Journal of the Healthcare Information and Management Systems Society, vol. 13, no. 2, 1999.

[4] E. COIERA, Guide to Heath Informatics., Hodder Arnold, 2003.

[5] A.X. GARG, ET AL., "Effects of Computerized Clinical Decision Support Systems on Practitioner Performance and Patient Outcomes: A Systematic Review," JAMA, vol. 293, no. 10, 2005, pp. 1223-1238; DOI 10.1001/jama.293.10.1223.

[6] S.P. HARTER, "Psychological relevance and information science," Journal of the American Society for Information Science, vol. 43, no. 9, 1992, pp. 602-615.

[7] B. KAPLAN, "Evaluating informatics applications--some alternative approaches: theory, social interactionism, and call for methodological pluralism," International Journal of Medical Informatics, vol. 64, no. 1, 2001, pp. 39-56.

[8] K.L. MAGLAUGHLIN AND D.H. SONNENWALD, "User Perspectives on Relevance Criteria: A Comparison among Relevant, Partially Relevant, and Not-Relevant Judgments," Journal of the American Society for Information Science and Technology, vol. 53(5), 2002, pp. 327-342.

[9] T.H. PAYNE, "Computer Decision Support Systems," Chest, vol. 118, no. 90020, 2000, pp. 47S-52; DOI 10.1378/chest.118.2_suppl.47S.

[10] M. PELEG, et al., "Decision Support, Knowledge Representation and Management in Medicine," IMIA Yearbook of Medical Informatics, Stuttgart, Germany. Schattauer, 2006

[11] L. PERREAULT AND J. METZGER, "A pragmatic framework for understanding clinical decision support," Journal of Healthcare Information Management, vol. 13(2), 1999, pp. 5-21.

[12] M.M. SHABOT, "Ten commandments for implementing clinical information systems," Proc (Bayl Univ Med Cent), vol. 17, no. 3, 2004, pp. 265–269.

[13] I. SIM, et al., "Clinical Decision Support Systems for the Practice of Evidence-based Medicine," J Am Med Inform Assoc, vol. 8, no. 6, 2001, pp. 527-534.

[14] D. SPERBER AND D. WILSON, "Relevance: Communication and cognition," Cambridge, MA: Harvard University Press, 1986.

[15] S. TEFKO, "Relevance: A review of the literature and a framework for thinking on the notion in information science. Part II: nature and manifestations of relevance," J. Am. Soc. Inf. Sci. Technol., vol. 58, no. 13, 2007, pp. 1915-1933; DOI http://dx.doi.org/10.1002/asi.v58:13.

[16] S. TU, et al., "The SAGE Guideline Model: Achievements and Overview," J Am Med Inform Assoc, vol. September-October;14(5), 2007 pp. 589-598.

[17] G. VOSSEN AND S. HAGEMANN, "From Version 1.0 to Version 2.0: A Brief History Of the Web," In: Working Papers, European Research Center for Information Systems No. 4. Eds.: Becker, J. et al. Münster, 2007.

[18] T. WETTER, "Lessons learnt from bringing knowledgebased decision support into routine use," Artif Intell Med; 24(3), 2002, pp. 195-203.