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The Role of Knowledge Based Systems in Clinical Practice

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1 Introduction

This report examines the role Knowledge Based Systems (KBS) will play in health care over the next decade. In particular, it seeks to identify the key clinical areas that will require computerised decision support, and examines the way in which KBS technology may prove to be the key enabling technology.

2 The role of KBS in health care

There is a long tradition now in developing clinical support systems that focus on diagnostic assistance for clinicians. Faced with growing evidence both that diagnosis is only one of many problems in clinical medicine, as well as the manifest failure in the adoption of diagnostic systems into routine practice [2][6], we make the following general observations:

- We should refocus on the clinical user in our research. We should support their requirements rather than dictate their work practices. We can be assisted in this endeavour through techniques in user analysis and ethnography that are used by the software industry to assist with system design [2]. It must become clear for example, that designing good user interfaces is not simply a post-hoc cosmetic nicety, but that it depends critically on a deep understanding of the problem domain that must be developed *prior* to commencing system design [1][2]. The implications of user interactions cannot be conceived of independently of the overall architecture of a system.
- We should seek to support common clinical problems, which comprise the great bulk of clinical duties, rather than the more complex and rare ones which may intuitively appeal to academic interests.
- We should focus on supporting the patient management process in its entirety, rather than focusing specifically on the sub-task of diagnosis [3]. (It is important to note however, that in some domains like neurology, diagnosis is still a key task that may benefit from support).
- We should focus on supporting patient management throughout primary secondary and tertiary care institutions, not just in the traditional large hospital setting. Further, applications should be developed for a broad spectrum of clinical users from nurses and physicians, to dieticians, pharmacists, and such like.
- We should build applications today, as well as undertake research for the future. The nature of research tends to be forward looking, but at present there are significant clinical problems that can benefit from existing technology. It is incumbent upon us to demonstrate the clinical value of our technology through working applications.

3 Clinical Knowledge Based Applications

There is a clear role for computer based decision support systems in clinical care. Based upon our recommendations in the previous section, we would like to specify

application areas which we feel are appropriate for immediate implementation or further development. The list of clinical application areas includes (not prioritised):

- *Protocol design, building and maintenance tools* - clinical care is increasingly moving to protocol driven processes, and the construction and upkeep of clinical protocols will prove to be a good application for knowledge acquisition and maintenance technologies.
- *Laboratory systems* - Clinical laboratories have proven to be a good domain for the use of experts systems, both for the interpretation of measured values and automated preparation of reports, as well as in the process of guiding clinicians in the selection of appropriate tests to order.
- *Drug advisory systems* - There is clear opportunity to develop systems which assist clinicians with the prescription of medications, checking for drug-drug interactions and side-effects, as well as selecting the most cost-effective treatments.
- *Clinical Workstations* - As the amount of clinical data available on-line grows, it will become increasingly important, both to provide access to it for health care workers, as well as optimising the views of the data made available to different clinical workers. The need to manage temporal information and to manage such information over time will require intelligent temporal database technology to be incorporated into such systems.
- *Image recognition and interpretation* - Automated systems offer the opportunity to assist with mass screening programs (e.g. mammography) as well as assisting with expensive and complex investigations (e.g. MRI).
- *Signal interpretation* - The development of interpretive alarms for real time clinical signals in areas like the intensive care unit will offer some assistance with the task of clinical vigilance. Automated ECG interpretation and report systems are already a success in the clinical market place, and their improvement will continue to merit some effort.
- *Natural language / speech recognition* - The entry, and subsequent machine understanding, of freely entered clinical notes into electronic systems will be a practical issue for the next decade. The development of speech recognition systems will assist greatly in this task. Equally, there will also be value in using techniques from NLP to interpret archival printed notes and make them electronically accessibly [1].
- *Education* - The need to continually educate both patients and clinical professionals offers important opportunities for automated assistance. We should not however focus only on purpose-built tutoring systems, but recognise that education for most clinicians is an ongoing process intimately woven into clinical practice. Decision support systems should be built with this type of support in mind.
- *KBS Quality Assurance* - As many different forms of knowledge based system appear in clinical settings, there will be a need to ensure that they remain up to date, and consistent. Tools will be needed to assist with this task.

- *Multi task tools* - The construction of decision support systems may benefit from a task based approach. For example, there may be benefit in developing a generic therapy planning tool which can then be particularised to individual clinical applications [3].

4 Protocol Assisted Care

Of the applications outlined above, we believe that one of these, protocol directed care systems, deserves significant further investment. The emergence of protocol directed care in the direction and measurement of the clinical care process presents clinicians with an opportunity to formalise their knowledge of clinical practice. As such, it provides us with perhaps the first real opportunity to support mainstream clinical practice with KBS technology. Protocols are a set of procedural frameworks that describe best practice for different clinical situations, and can be used at many different levels of description, ranging from descriptions of patient care to the management of a hospital unit or a geographic region.

Protocols are currently perceived as non-prescriptive clinical guidelines, and protocol based care has become an increasingly attractive way of directing health care, benefiting clinicians as well as regulators [4][5]. The benefits associated with protocol directed care include:

- Protocols can act as clinical reminders, supporting clinicians when several actions need to be taken over an extended period of time, and enforcing adoption of minimally acceptable clinical standards.
- Where protocols are formulated by expert bodies and are disseminated widely, they can narrow the time it takes to transfer clinical knowledge from specialist bodies to practising clinicians [7].
- keeping to standard procedures allows measurements of clinical outcome to be made against different treatment regimens, facilitating the process of clinical audit and quality assurance. Protocols allow clinicians to take the discipline of clinical research and take it into clinical practice [5].
- By selecting optimal treatment strategies, and ensuring that most patients receive these treatments, payers can decrease the costs of medical care.
- Standard protocols can be used as materials for patient education.
- In some countries, it is emerging that adherence to an agreed set of protocols reduces a clinician's exposure to malpractice litigation. However, it should be emphasised that protocols are not seen as defining prescriptive standards of practice, but general guidelines, since individual patients may necessitate departure from a particular protocol.
- Protocols can also be aimed at optimising the productivity of clinical units by assisting with workflow management e.g. scheduling patients for diagnostic tests based upon a predefined sequence associated with particular conditions.
- Adherence to recognised protocols may in many countries become a prerequisite for financial reimbursement, which in of itself, will be a fundamental driving force for protocol adoption, driven both by government and private insurance payers.

4.1 Role of KBS in Protocol Directed Care

Fundamentally a clinical protocol captures some form of procedural medical knowledge, and the problems of design, acquisition and maintenance of protocols represent problems that are familiar to the KBS community, but still lie ahead of the clinical communities engaged in the task of formalising their activities. We can see several clear points in the way protocols will be used that will require some KBS technology:

- *Protocol structure and design, authoring, maintenance* - These represent the key challenges facing the clinical community as it begins the massive undertaking of agreeing upon and updating clinical protocols for a multitude of clinical procedures and treatment strategies. While this process will occur whether or not decision support systems are put in place to assist [5], it seems reasonable to assert that within a few years clinicians will be demanding assistance with the complexities of developing standard ways of describing protocols, protocol maintenance, dealing with multiple authors, and protocol validation. We would be well advised to foresee these difficulties and become involved with clinicians "at the ground floor".
- *Protocol selection* - The decision to place a patient on a particular protocol depends on making an assessment of their clinical needs. This may be straightforward, but may also be a useful application for decision support.
- *Multiple protocols, diseases, protocol departure* - While initially protocols will be designed for common conditions, and used in a straightforward manner, it may become important to support the rarer but more difficult task of handling patients who are on multiple protocols, or who because of their clinical condition, depart from standard protocols. This is not a pressing clinical problem, but may benefit from further work to clarify its importance, since in specific situations protocol recommendations may not be optimal.

4.2 Academic Research Opportunities with Protocols

While the focus of this report is on clinical practice, it is worth noting that with the introduction of computerised decision support systems designed around clinical protocols, that a number of research opportunities arise for KBS systems:

- *Temporal knowledge and planning* - protocols capture notions of sequences of clinical actions, and these sequences are often intended to represent temporal progression. The way in which such protocols are used will help focus research into temporal representation and inference on clinically useful problems. Protocols also can be thought of as plan schemas, and AI work in planning may have much to offer here, for example in the particularisation of a schema to an individual patient.
- *Task management meta-knowledge* - The overall organisation of a protocol represents a strategy to accomplish particular clinical goals, and where these can be made explicit, we have an opportunity to guide the decision support process. If we view clinical decision making as being composed of a number of generic sub-tasks [3], then protocolisation may assist in defining the knowledge necessary to switch between such tasks.

- *Task structuring for text entry / NLP* - Inferring semantics behind free entered text is an enormously difficult problem [1], and one solution is to force textual entries to follow a semantically structured method. Rather than making this enforcement a burden, if the natural flow of a protocol is used to provide the structuring, then the process may fit naturally into clinical record keeping.

4.3 Recommendations

We recognise a number of significant changes are underway in the way that clinical medicine is practised, and some of these, like the move to protocolisation of care, have potentially profound implications for developers of decision support technologies. We would like in summary, to make the following recommendations to the medical informatics research community:

- Examine the opportunities that clinical protocols offer for the design and acceptance of decision support systems.
- Examine the clinical state of the art in process of care protocols, both to understand current requirements, and to explore ways in which KBS technologies may assist in the future.
- Encourage clinicians and other health workers to continue with the process of formalising clinical practice.
- When considering clinical decision support systems, aim to assist throughout the patient management process, not just with the sub-task of diagnosis. Further, we should target a wide range of clinical users, not just physicians.
- KB research must involve itself both in clinical needs analysis, all the way through development and transfer of technology to industry. It is the isolation of the research community from its user base, as well as from industry, that has lead to many of the current difficulties which face KBS applications exposed to the realities of the clinical workplace.

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