
Drug use management and IT-based medical thesauri: issues of semantics and linguistics

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Abstract

Argues that by interpreting the semantic content of different actions, it will be possible to draw boundaries between those aspects of a system that can be computerized and those that will best serve the purpose if left alone. This will dissuade systems developers from being caught in the technology trap. The argument is conducted in the context of developing IT-based medical thesauri for drug use management.

Introduction

Drug use management is an information intensive process and constitutes a number of activities which range from prescribing and dispensing of drugs to their administration and management. In addition these activities take place at different locations in a health care system with many different managerial roles and responsibilities for a variety of functions. Doctors for example, are concerned with diagnosis and drug prescription, while the main task of a pharmacist is to dispense drugs and to monitor these prescriptions. In a private health care environment, the insurance companies also play a significant role in co-ordinating and controlling the drug utilization process.

There are a large number of information technology (IT) based systems which are used to administer and manage medical drug usage. In the past few years the analysis and design of these systems has received much attention, through both documented failures and successes (Dhillon and Hackney, 1996). The Wessex Regional Authority, for example, spent £43 million on an information systems plan which was intended to link together every hospital, GP and district nurse in the authority. The project was not successful and was subsequently abandoned. The reasons generally attributed to the failure were over-complexity, imposition of a centralized structure and the resultant uncertain environment (Miles, 1993). An example of a successful project, however, can be found in the Royal Marsden Hospital information system. Here a patient administration system was developed which was restrained in scale and not too ambitious (Ker, 1994). Rather, it took a bottom-up, or user-centred approach, where all its options for interconnectability were kept open. Each application was looked at one by one and systems were designed which best served the needs of that application. Consequently the system implemented was not overtly complex, was cost-justifiable, and did not disrupt the normal processes of managerial practice.

One of the common denominators in the successful management of such systems has been the analysis of stakeholder requirements. This is an important activity since it helps the analyst to develop a consensus regarding the meaning of different activities. The relevance of doing so is further heightened when

information and communication technologies are used to transmit information over wide area networks. These networks attempt to link a wide range of stakeholders (e.g. general practitioners, hospitals, pharmacies, social services) in different organizational settings (see Dhillon and Backhouse, 1996). A particularly difficult issue is to build systems which not only allow a free flow of information but also bring about a consensus in the meanings, intentions and pertinent use of medical terminology.

At the core of medical information systems, supporting the flow of information, is the pharmacy module. Typically this module deals with prescriptions, dispensing, pharmacy reference data maintenance, ward stock records and therapeutic drug monitoring. The singular importance of this module is that it contributes directly to the overall business objectives of the hospitals. Its key function is in promoting efficiency in care delivery and effective decision support at the point of delivery. Besides, it also enables a "client-centred" approach to service quality management and "outcome management" which are activities currently associated with the business management of hospitals.

Traditionally pharmacy IT-based systems were largely independent of the patient administration systems. Over the past few years however they are increasingly being integrated into hospital-wide clinical information systems. Although this promises a wide array of benefits, in many cases the pharmacies have come under intense pressure, mainly as a result of a wider range of issues related to evaluating the quality of prescribing. This raises concerns for understanding the semantics of drug terminology. Increasingly it has become difficult to understand the meaning of medical diagnosis across various stakeholders in the hospitals and also to interpret the meaning of various terms used in drug prescription.

Medical semantics

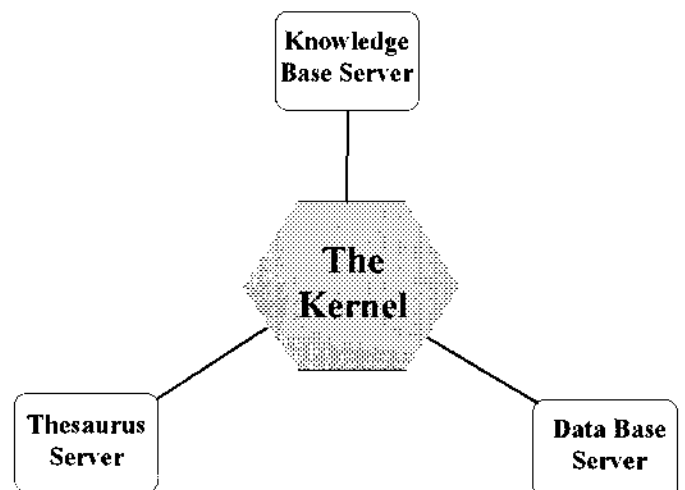
There have been numerous initiatives that have attempted to incorporate an advisory drug prescription component in computerized systems. In the earlier years these systems took the form of manual audits and some elements of computerized review of prescriptions (e.g. Helling *et al.*, 1979; Reed *et al.*, 1982). There have been three underlying

reasons for the development of computerized drug use management systems. First, to make available up-to-date knowledge on pharmaceutical products. Second, to ensure fitness of the patients by providing a knowledge base about the physio-pathological states. Third, to provide knowledge of drug prescribing practices in use in the local clinical institution.

Traditionally, the basic architecture of such drug utilization systems has been constituted of a knowledge base, database server and a thesaurus server (see Figure 1). These are in turn linked to a kernel. Typical examples of this structure can be found in OPADE and UMLS[1]. The purpose of a database server is to handle retrieval and storage of data, specifically relevant to the context of drug prescription. This data generally relates to patient information, local protocol definition, user profile and clinical site profile. The knowledge base server contains "knowledge" needed by the kernel. Such knowledge is in the form of prescribing practices, information on drugs, rules of prescribing practice, and information on the pathological states relevant to drug prescription.

In the development of drug use management systems such as OPADE and UMLS, the problems of semantics have long been recognized by many researchers (e.g. Nelson *et al.*, 1992), and there have been a number of attempts to build some kind of a thesaurus. Earlier attempts were directed at the pharmacy-based systems (e.g. Powsner, 1989; Yang, 1992). The importance of having such thesauri was highlighted in a 1988 report published by the American College of Physicians (Meyer, 1988). The report states that

Figure 1 The basic architecture of a drug use system



improvements are needed in the medical education of qualified physicians since once they graduate their knowledge of drugs does not keep up with advances in therapeutics. Clearly there are rapid changes in drug technology, diagnostic techniques and pathophysiology systems. In these circumstances even the most dedicated physicians may not be fully informed of the latest pharmaceutical developments (Fish *et al.*, 1992).

The underlying objective in building medical thesauri is to maintain a high level of quality in the drug use management process. Quality of drug utilization is defined by Fish *et al.*, (1992) along two dimensions: first, “the capacity of the physician to meet certain technical aspects of care when prescribing...”; second, by meeting a defined set of patient’s goals. Consequently, a medical thesaurus needs to include and have a consideration of a number of system attributes (Karr, 1994; Kreling and Mott, 1993). Such attributes need to provide information such that the effectiveness of drug treatment can be maximized and there are fewer chances of adverse drug reactions. This will also facilitate the choice of those medications which allow minimum therapeutic monitoring.

The focus of most research, both by academics and practitioners, has been to develop “knowledge sources” which would provide easy access to machine readable information. This information may be derived from patient records, scientific literature or factual databanks. There is, however, the classic problem of finding the relevant information for a particular question, since concepts can be expressed in different ways. The US Department of Health and Human Services’ Unified Medical Language System (UMLS), for example, tries to overcome these semantic problems by developing a UMLS “knowledge source”. The key components of the knowledge source are a Metathesaurus, a Semantic Network and an Information Sources Map. The Metathesaurus contains information on biomedical concepts, the Semantic Network has a classification of terms in the Metathesaurus and the Information Sources Map is a directory containing information about the scope, location, vocabulary, syntax and access rules of biomedical databases.

In establishing a consensus on the use of terms, UMLS uses the technique of semantic networks. The representation is based on graph theory. It is argued that the use of these

concepts in developing thesauri is problematic. The technique of semantic networks which has its roots in formalisms based upon classical logic, serves well where there is already a good deal of agreement about matters under investigation. In the field of medical diagnosis and drug prescription this cannot be assumed. Indeed, much of the work here is concerned with determining the individuality and identity of various terms, categories and sub-categories of diseases, diagnosis and relevant prescriptions. Invariably this leads to articulating and comparing different “world views” and perhaps obtaining a consensus around one in particular. Semantic networks are firmly based upon classical logic concepts and hence assume the existence of strict categorization of all meanings. These approaches raise concerns for developing a comprehensive and relevant thesaurus. It is, therefore, proposed to present an alternative conceptual viewpoint that allows us to view the problem domain as multidimensional. This will help in analysing the meanings of the terms used and also lays the foundation for developing a consensus among different stakeholders regarding various aspects of the drug use management process.

Conceptual framework

The conceptual framework proposed is based on the logic of action (Backhouse, 1991; Goossenaerts *et al.*, 1989). This is in contrast to the metaphysical assumptions of mathematical tools (e.g. semantic networks, data dictionaries), which see the world as consisting of discrete entities where knowledge corresponds to an objective and observed reality. It is regarded as important to identify responsible agents in a socially created world who are able to conform to a consensus about the meanings of their actions.

The technique based on logic of action provides us with a reliable framework for developing a thesaurus within the context of the medical domain. This basis allows us to interpret the meanings of the terms used in medical diagnosis and drug prescription. There are three fundamental questions that need to be addressed. First, how can a drug utilization system be specified with maximum formal precision such that it is compatible with the intrinsically informal manner in which drugs have traditionally been prescribed? Second, how can the analytical

problems concerned with semantics be solved such that all stakeholders interpret medical terminology in the way it was initially intended? Third, how can the methodologies for analysing and specifying drug utilization review requirements be improved prior to the software engineering task? These questions can be answered by analysing the drug utilization process at four levels, as noted in Figure 2, i.e. understanding the problem domain; identifying relationships and evaluating the meaning content; specifying key constructs; automating and developing a domain-specific electronic thesaurus.

The analysis would also involve a concurrent evaluation of the drug utilization process from two different dimensions: first, the therapeutic dimension including the interpretation of the medical diagnosis process and an understanding of disease classifications; second, the user's medical knowledge of drugs. If a thesaurus is able to establish a common meaning structure from these two dimensions then it may be assumed that the system meets the stakeholder requirements. For the purpose of this paper, it is useful to demonstrate the approach by drawing examples from the medical diagnosis process and a particular classification of illness.

The problem domain by definition is the description of a context at a higher level of abstraction. Similar approaches have been developed, based on "Structuration Theory" to interpret the links between social structure and social action within the macro level of organizational analysis (Hackney, 1996). Within this paper, however, the problem domain is the task of classifying the illnesses so that the process of drug prescription is

enriched. Therefore the ontological-epistemological approach we use is based on understanding social norms and individual behaviour at social and individual levels, related diagnosis and drug prescription processes (Stamper *et al.*, 1988). The representation of these patterns assumes reality to be the outcome of human interactions which generate shared norms and experiences in the medical field. The patterns of behaviour are, as noted, afforded by responsible agents, typically a qualified medical doctor or a pharmacist. Through the responsible agents identified, we can relate the norms, patterns of behaviour, and experiences to their referents, which are actions effected in the real world.

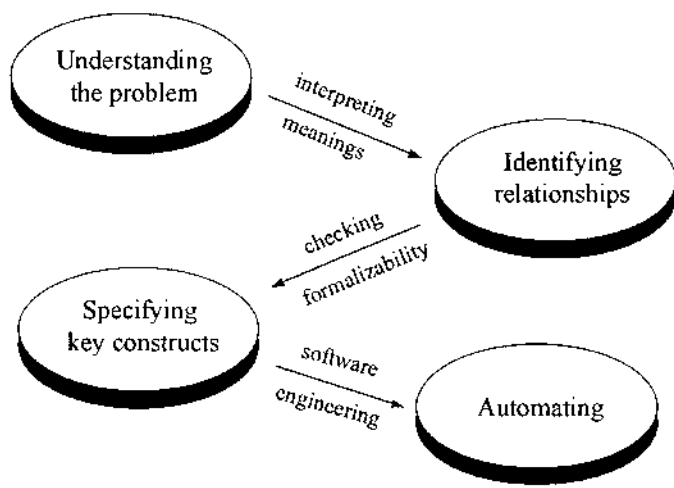
This conceptual framework assumes that the problem domain is characterized by the world of a "knowing" agent working in a complex and interactive environment. The agent in this world may be a whole jurisdiction, a team, or a person who acts in and is acted upon by this environment. In this dynamic state, agents must refer to peers, so that in performing any action the familiarity with what is biologically and socially significant to those who share that reality permits predictable and stable behaviour. A doctor operating in a hospital environment is a typical example.

The medical domain

In the context of a medical domain, it is important that those agents are identified who are capable of determining the nature of the behaviour to be realized. Such agents should also be in a position to take responsibility and their actions be associated with purposeful behaviour. An example of a purposeful behaviour is the diagnosis of a particular ailment and subsequent prescription of medication.

Agents can be recognized by their association with a communication act. Communication acts serve to change the social world (Searle, 1987). In the medical domain, authorizing a prescribed drug plan for a patient is an example of a communication act. Identification of agents and communication acts helps in identifying those parts of communication which govern the world of interrelated obligations. This presents the domain as a social and physical world affording certain mechanisms for behaviour (Gibson, 1977). The defined domain, in terms of patterns of actions, allows a semantic schema to be

Figure 2 The development of a thesaurus



prepared, by arranging them in a sequence of existence dependency.

Thesaurus elements

Following the representation of the problem domain in some graphical form such as a semantic schema, the analyst has to take decisions about selecting elements for the thesaurus. This involves the identification of words or symbols with a particular set of meanings attached to them. Any meaning structure is context-sensitive and if the words or symbols are removed from a particular social context, they may lose their relevance. Therefore careful thought needs to be given when establishing boundaries between the formal aspects of the problem domain and the informal parts. The level of quality of this stage determines the degree of success in designing a thesaurus. The process of analysing the domain allows us to interpret the meanings quite easily since they are implicit in the relationship between a sign (i.e. words, symbols) and the behaviour they afford. The informational content of a particular domain gives us the properties of the signs used.

The final step in developing a thesaurus is with respect to identifying elements that should be computerized. It may just be that some aspects of the problem domain, or even the formalized elements, would best serve the purpose if they are not automated. This again involves decisions to be taken which would demarcate the IT-based information system from the specified domain. The understanding gained by the analysis helps in taking key decisions regarding boundaries between the formal and the informal parts of the system.

“Schizophrenia” example

In order to analyse a problem domain in terms of the meaning content, an example is used from the patterns of behaviour associated with the general area of diagnosing schizophrenia (based on ICD-10, see Appendix). The representation does not refer to any specific rules or procedures employed by a medical practitioner but rather outlines the generic situations that constrain any agent in this domain. A competent practitioner will have carefully designed practices such that the patients are dealt with adequately. Others will have a less formal undertaking, where their decisions and judgements may not be purely rule-based, but where conclusions are arrived at by individuals in an informal manner.

There may be norms governing the domain which could be strong or weak. In a context where the norms are strong, the conduct of an agent will be constrained informally yet effectively. In such situations the norms may coincide with any rules that apply.

In the example chosen, the agent capable of taking responsibility is the Practitioner. This agent treats a patient through a realized set of complex assessments and diagnosis techniques. In mapping the patterns of behaviour it is possible to place the agents in an ontological “existence-dependence” manner. Such a representation of the agents symbolizes that responsible agents do not exist in some social, legal and political vacuum but are dependent on some “root agent” (patient with schizophrenia). Hence the existence of a disturbed behaviour, any illness or even the treatment of the illness would be a superfluous task with no independent existence. This demonstrates the importance of context in deriving meanings for the terms used. A similar argument can be extended to explain the process of drug prescription and monitoring drug usage.

When a practitioner assesses a person’s behaviour, he/she determines the start or finish of a behavioural condition, i.e. when did the disturbed condition begin or finish? This assessment in turn will determine the start or finish of diagnosis of an illness. The practitioner’s decision about a patient being schizophrenic is governed by a norm structure prevalent in the medical profession. The process of drug prescription is governed entirely by the norms regarding diagnosis and treatment. Thus the behaviour of agents, their roles and the associated acts help us better to understand and evaluate the environment. Furthermore, we are able to precisely identify the structures of responsibility and authority. This also implicitly creates a place for the agents, or the responsible people who decide when is a behavioural condition disturbed, which patients will be categorized as schizophrenic, when does the treatment start, and so on (the complexity of interpreting meanings can be gauged from the various elements of *schizophrenic psychoses* as presented in the Appendix).

The responsible agents are necessary elements in understanding the patterns of behaviour in a problem domain. This helps in addressing two related concerns: who decides the start of the illness and who the finish? In

most cases the responsible agents will make their decisions in line with prevailing norms, rather than arbitrarily. The greater part of the drug prescription and medical diagnosis task is to see if the system could supply appropriate diagnosis and treatment at any point in the health care delivery process. It should also be ensured that these norms reflect the practices espoused by the health service organization and in turn that its practices conform to those of various over-arching jurisdictions – statutory, professional (codes of practice) and standards, the Mental Health Act (UK), etc.

Other research areas have included, albeit partially, the importance of attempting to capture the “realities” of the operational domain. At an organizational level, for example, the relative paradigms of the actors involved will have a direct impact upon outcomes. The notion within “Structuration theory”, noted earlier, considers the so-called duality of “structure” where in any situation there will be both a formal and informal component of human action. The conceptual framework introduced in this paper recognizes the value, in developing a methodology of an IT-based thesaurus, of the need for a holistic view of the system which addresses these concerns.

Conclusion

Understanding of the meaning structures is argued to represent a central theme for the development of a thesaurus. It can lead to a deeper understanding of the problem domain by having sound semantic structures that support differing applications and interpretations of medical skills and practice. In developing an IT-based thesaurus, the benefits of having a semantic rather than a linguistic representation are evident. This is especially important for multi-lingual applications. It is also possible to show the significance of a representation which addresses the various normative elements without being dependent on any of them. Future research directions could usefully be based on using these concepts to develop medical thesauri.

Note

- 1 OPADE has been a project supported by the EEC for optimization of drug prescription through the use of advanced informatics. UMLS is a similar initiative from the US Department of Health and Human Services.

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Appendix: Schizophrenic psychoses (extracted from ICD-10 documentation)

A group of psychoses in which there is a fundamental disturbance of personality, a characteristic distortion of thinking, often a sense of being controlled by alien forces, delusions which may be bizarre, disturbed perception, abnormal affect out of keeping with the real situation, and autism. Nevertheless, clear consciousness and intellectual capacity are usually maintained. The disturbance of personality involves its most basic functions which give the normal person his feeling of individuality, uniqueness and self-direction. The most intimate thoughts, feelings and acts are often felt to be known to or shared by others and explanatory delusions may develop, to the effect that natural or supernatural forces are at work to influence the schizophrenic person's thoughts and actions in ways that are often bizarre. He may see himself as the pivot of all that happens. Hallucinations, especially of hearing, are common and may comment on the patient or address him. Perception is frequently disturbed in other ways; there may be perplexity, irrelevant features may become all-important

and, accompanied by passivity feelings, may lead the patient to believe that everyday objects and situations possess a special, usually sinister, meaning intended for him. In the characteristic schizophrenic disturbance of thinking, peripheral and irrelevant features of a total concept, which are inhibited in normal directed mental activity, are brought to the forefront and utilized in place of the elements relevant and appropriate to the situation. Thus thinking becomes vague, elliptical and obscure, and its expression in speech sometimes incomprehensible. Breaks and interpolations in the flow of consecutive thought are frequent, and the patient may be convinced that his thoughts are being withdrawn by some outside agency. Mood may be shallow, capricious or incongruous. Ambivalence and disturbance of volition may appear as inertia, negativism or stupor. Catatonia may be present. The diagnosis "schizophrenia" should not be made unless there is, or has been evident during the same illness, characteristic disturbance of thought, perception, mood, conduct, or personality – preferably in at least two of these areas. The diagnosis should not be restricted to conditions running protracted, deteriorating, or chronic course. In addition to making the diagnosis on the criteria just given, effort should be made to specify one of the following sub-divisions of schizophrenia, according to the predominant symptoms.

Schizophrenia simplex; Hebephrenia; Catatonic; Paraphrenic schizophrenia; Acute schizophrenic episode: Oneirophrenia; Latent schizophrenia; Residual schizophrenia; Schizoaffective type; Other unspecified types.