Data Driven Decision Making for Patient-Oriented Systems Using Knowledge Engineering

Nitesh Vyas, Dr. Parashu Ram Pal

Abstract— Medical data is one of the most crucial data to be processed for decision making. A slight mistake in deriving the decision from the data may cause death of the patient. Patients inside the hospitals are treated by doctors based on medical data associated with their ailment. Decisions are taken by the doctors based on the knowledge that they have for curing the patients. Level of expertise vary from one doctor to another doctor. Analysis of data and its processing with the inherent knowledge of doctor lead a decision making in which there is an involvement of human being. In this paper a model of automatic decision making based on the data and knowledge engineering has been proposed which may be helpful in development of health care service portal.

Keywords —Ontology, Knowledge Engineering, Data Driven Decision Making, Intelligent System.

1 INTRODUCTION

The essence of medical practice is decision making whether it is just symptom based decision making in which symptoms described by patients prompt doctors to take a decision and prescribe appropriate medications or report based decision making in which data inside the clinical reports prompt doctors to focus towards one decision or critical care based decision making in which patients may be struggling for their lives on bed in which fluctuating data under which they are going to be supervised prompt health professional to take quick decisions to safe patients life. In all such cases of decision making, knowledge of the health professional plays very important role. There is a wealth of data available within the healthcare systems but they lack effective analysis tools to discover hidden relationships and trends in data. Ontologies enable high scalability in searching, extracting, maintaining and generating information. Medical ontologies are developed to solve problems such as the demand for reusing and sharing patient data or the transmission of these data. [1] The emerging technologies in IT sector have opened exceptional opportunities in delivering the health care services well on time effectively. This has resulted in demand for intelligent and knowledge based systems which are enabled with advanced medical practices globally [3]. Health professionals make clinical decisions by applying healthcare knowledge that includes their experiential knowledge and explicit knowledge 'artifacts', such as clinical practice guidelines, best evidence, clinical pathways and so on [10]. Knowledge comes from experience therefore patients always prefer experienced doctors for consultation. The complete medical practice of this kind in which besides the knowledge, human cognitive ability of human being is also involved can be made automatic to develop intelligent systems of next generation by using the rule extraction and knowledge engineering techniques.

Rules are extracted from the clinical data in this way so that automatic processing can be done. KDRuleEx [4] extracts rule from the data set and put it in to decision table that has the processing capability. Automation system of this kind may help doctors, specially those who are less experienced, in curing the patients with minimum risk.

While patients are going to be cured, clinical data associated with them plays central role in decision making. This translation of decision from data is known as data driven decision making. Data-driven decision making is seen as a continuum in which data must be transformed into information and, ultimately, actionable knowledge through a set of cognitive skills and processes [12]. Data-driven decision making is a systematic process of collecting, analyzing, and synthesizing data; making a judgment about the data based on knowledge base; and then making a decision based on the knowledge derived from knowledge base in order to improve patient outcomes [16].

Decision making systems of such kind is fully automatic and take the benefit of knowledge engineering-based architectures. The accuracy of decision making depends upon the knowledge bases. Knowledge bases based data-driven decision making is action oriented and may involve making a decision for tomorrow based on today's outcomes. Action knowledge informs different types of decisions, which may include appraising goal setting, progress, or accomplishment; assessing whether individual or group needs are met; determining whether resources need to be allocated and/or reallocated; and evaluating the effectiveness of processes and practices.

1. Nitesh Vyas Ph.D. Scholar
Pacific Academy of Higher Education & Research,
Udaipur, Rajasthan, India
nitesh.v25@rediffmail.com

2.Dr. Parashu Ram Pal,Director,
Lakshmi Narain College of Technology-MCA, Bhopal, M.P., India
prpal@rediffmail.com

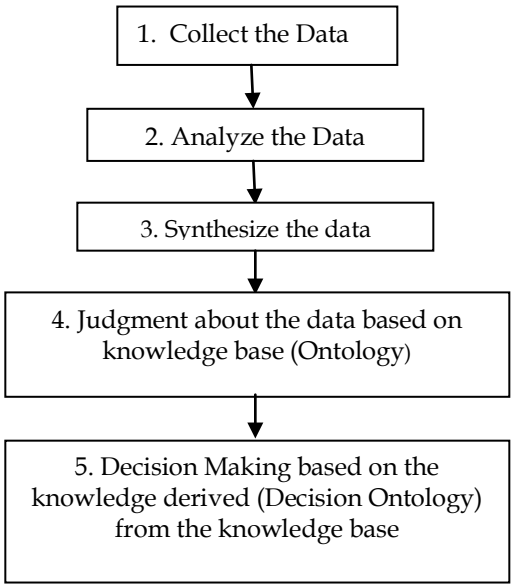


Fig 1: Model for data driven decision making

The patient ontology is used to enumerates the information that each patient requires for a decision support session. The disease ontology is used to enumerates the therapy options and expected health states for each disease. The decision support ontology stores a set of analytic methods for simulation and modeling of a disease process to determine expected outcomes across a series of health states. [20]

Data-driven decision making is seen as a continuum in which data must be transformed into information and, ultimately, actionable knowledge through a set of cognitive skills and processes [12]. This actionable knowledge base representing some kind of a domain description has the description of entities, concepts and terms designed for the specific domain. Ontology is a good way for building the domain descriptions [5]. For each medical domain one has to specify the scope of the ontology, acquire medical knowledge, select a tool and ontology language, design the ontology and present it in appropriate fashion. Connection of an ontology with a rule base as a part of decision support system is established. A long term goal is representation of this knowledge in a form that can be used by system supporting medical decision making. In medical diagnosis, a domain expert who can be asked sophisticated questions can be simulated by expert systems incorporating thoroughly developed domain ontology that formalizes expert knowledge. Healthcare decision making is an un-structured problem. Diagnoses differ from person to person. The steps of solving the diagnostic problem can be divided into the subproblems. Generally doctors break the diagnostic problem into a series of well-defined subproblems for decision making. [6]

Healthcare decision making during the diagnostic treatment cycle is a complex Activity [9]. In this paper we have proposed the model for decision making for patient oriented systems based on electronic medical data/records and knowledge repositories. For diagnosis various decision tables can be extracted from the medical datasets. Decision tables would then be capable of providing the decision rules. Set of all such kind of decision tables generate the rule base of proposed model

General patient oriented systems like CHESS [21] having no ontology has already been developed providing information services, communication services and decision support to patients and their peers in different domain.[19]

2 Ontology and Knowledge Engineering Concepts

Ontology is the term referring to the shared understanding of some domains of interest, which is often conceived as a set of classes (concepts), relations, functions, axioms and instances, providing a shared framework of common understanding of specific domains that can be communicated between people and application systems [2]. The most cited definition of ontology given by Gruber is as follows.

"An ontology is a formal explicit specification of a shared conceptualization of a domain of interest [11]" is one of the most cited definition of ontology [2].

Ontologies play an vital role in the Semantic Web as well as in Knowledge Management. The creation of ontologies require background knowledge, analysis of domain sources and obtaining consensus among the users of the ontologies. [16]

The term "ontology" in the computer and information science literature appeared for the first time in 1967, in a work on the foundations of data modeling by S. H. Mealy, in a passage where he distinguishes three distinct realms in the field of data processing, namely: (i) "the real world itself"; (ii) "ideas about it existing in the minds of men"; (iii) "symbols on paper or some other storage medium". [22]

When developing systems of artificial intelligence like expert systems, Ontologies can be used to facilitate "knowledge sharing" among agents. A broader perspective of all individual characteristics of ontology like formality, explicitness, being shared, conceptualization and domain specificity has been described below.

2.1 Formality

The formality word in definition represent that domain knowledge in an ontology is represented in such a way so that it can be processed by computer and interpreted in well defined fashion. The ontology language like OWL is used for representation of domain knowledge. OWL is capable to

define all the semantics associated with domain knowledge.

2.2 Explicitness

All the notions that exists in ontology are explicit to make the knowledge representation computational. Non explicit notions in the ontology are not machine interpretable.

2.3 Being shared

The concepts that are going to be used in domain ontology must be sharable. Shared can be understood here as there must be an agreement on a domain conceptualization among people and application systems.

2.4 Conceptuality

An ontology specifies knowledge in a conceptual way in terms of symbols that represent concepts and their relations. Conceptualization represents an intentional semantic structure that encodes implicit knowledge constraining the structure of a piece of a domain[17]. Concepts originates from human mind. Entire domain containing set of concepts are nothing but the different set of instances of abstractions. These concepts can be documented, analyzed and communicated [13]. Representation of these concepts in form of some concrete artifacts can be done by some modeling language L.

Knowledge representation is key to knowledge based intelligent systems. The process of knowledge representations can be viewed as the design and assembly of domain ontologies, the knowledge bases that instantiate those ontologies, and domain independent problem-solving methods. [14]

Every domain has certain concepts that are used to articulate abstractions of certain state of affairs. It is necessary to represent the concepts in concise, complete and in unambiguous way by using language. Figure 2 shows Ullmann's triangle [24] that represents the relationship between a language, a conceptualization and the portion of reality that this conceptualization abstracts.

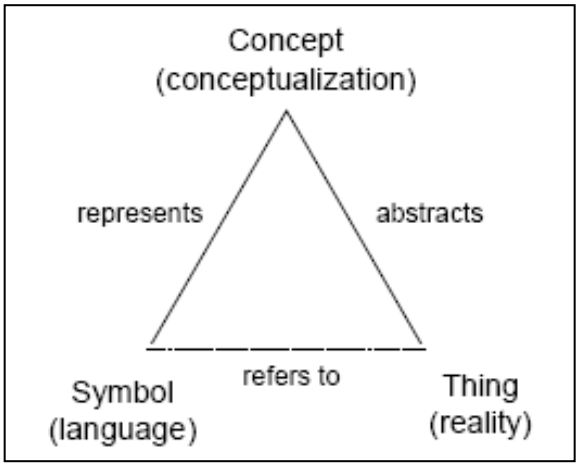
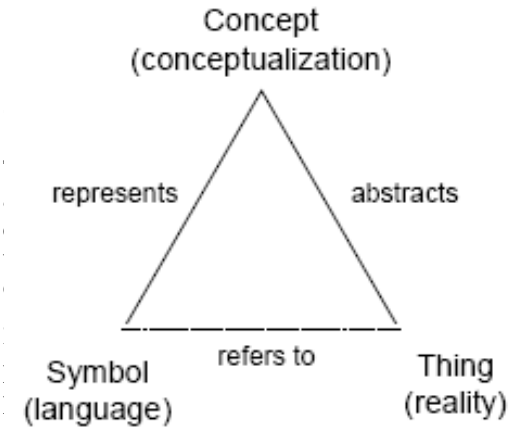


Fig 2: Ullmann's Triangle: The relationship between a thing in reality, its conceptualization and symbolic representation of this conceptualization



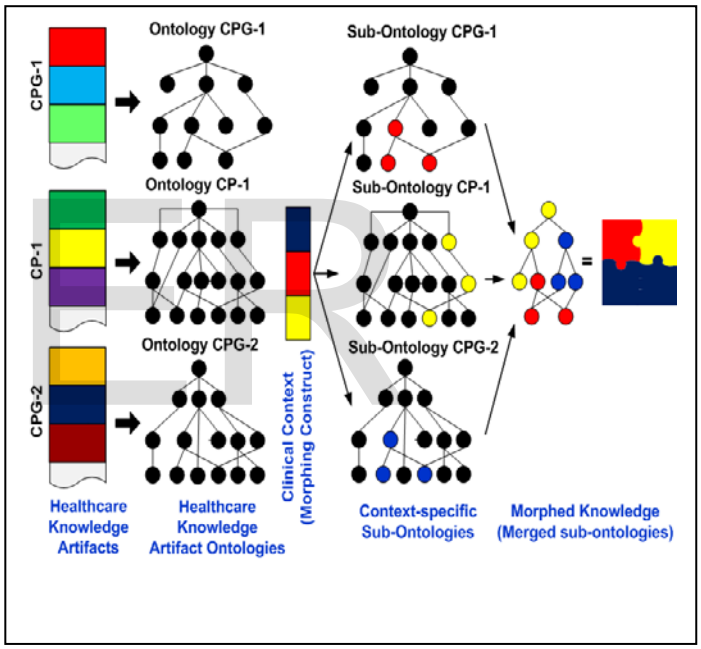


Fig 3: Healthcare Knowledge Morphing [9]

K-Morph basically follows the semantic web approach. Fundamental steps of K-MORPH are (a) Developing Knowledge Artifact ontologies to represent knowledge (b) specifying the clinical context of the knowledge morphing activity through a rich morphing construct (c) finally generating the morphed knowledge artifacts are by selecting a contextualized sub-ontologies, corresponding to the clinical context and then merging the selected contextualized sub-ontologies using reasoning algorithms applied to a set of domain specific context-specific axioms.

This is the task of ontology engineer to axiomatize the details of this domain besides covering the details of the domain. By axiomatizing the explicit specification of domain knowledge by using different ontologies can be modulerized.

Process of development of ontology require all the associated domain knowlegde concepts, relations, and instances to be constituted. In semantic network representation of ontology concepts map to generic nodes in semantic network. Concepts are represented using uniary predicates in logic, or in description logic. Concepts represent the ontological categories. All these categories are relevant to some domain of interest. Arc in semantic network represent the relationship. Binary predicates in logic and roles in description logic represent relationship. This is the relationship arc that cause connection between concepts ad instances semantically. Instances are represented by individual nodes in semantic networks or concepts in logic.

Axioms in ontology plays very important role. An ontology is represented by a set of axioms. Axioms are set of statements expressed in terms of ontological vocabulary. Ontology vocabulary contains named and identifiable concrete objects in domain of interest.

The task of conceptual modeling is quite similar to the object oriented software development or designing entity-relationship diagrams for database schemas and having the differences in the sense of purpose in which it will be used and specification of semantically rich axiomatisation of domain knowledge. Ontology captures domain knowledge in the way so that it can allow the task of reasoning. Although ontology that is going to be used in some information system is conceptual but it is also executable model of application domain. Knowledge based decision making systems can use ontology as base and knowledge representation techniques make the components of ontology machine interpretable. By reasoning about domain knowledge decisions can be taken by such system. Such systems can be helpful in health care for curing patients specially those who need complete logical reasoning [23].

3. Medical Ontologies and Proposed Model of Decision Making

Medical ontology contains all the relevant concepts related to the diagnostics, treatment, clinical procedures and patient data [15]. Ontologies are designed in such a way that allow knowledge inference and reasoning. One of the most popular example of medical ontology is GALEN. GALEN ontology is an axiomatized taxonomy [18] and has been in development since 1990. Now GALEN is used as a commercial product. The proposed model for decision oriented system for health care practice benefitting clinical/medical practice has been shown in figure 4.

The proposed model for decision oriented system for health care practice benefitting clinical/medical practice has been shown in figure 2. The ontologies which are the part of conceptual schema can be reused for the development of new ontologies [8] and can be part of it and whenever new categorical structures are possible then they must be added to it.

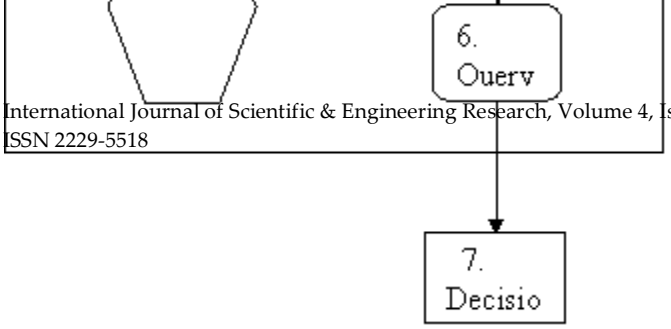


Fig 4: Proposed model for Data Driven Decision Making for Electronic Patient Record

4. Issues in Binding Formal Knowledge and Electronic Patient Records and Medical Data

Healthcare decision making demands the systematic integration of knowledge from multiple sources, such as clinical guidelines clinical pathways, knowledge of practitioners and so on. [9] In this paper we highlight following research issues that will be considered in next series of papers under research work of data driven decision making using ontology engineering techniques developing decision making system when formal knowledge, EPR's and medical data has been binded together :

- How ontologies, conceptual models and medical vocabularies will be used so that an automated procedure of diagnosing from EPRs can be established.
- How techniques for simulating computerized guidelines against the content of EPRs will be developed.
- How to evaluate the quality and safety of computerized guidelines in the light of EPRs data.
- How to Check compliance with guidelines and protocols against EPRs, including the use of quality indicators.
- How to establish interoperability of clinical guidelines for EPRs can be established.
- How to develop knowledge representation and ontologies for health-care processes.
- How to develop formalization of medical processes and knowledge-based health-care models.
- How to use of ontologies, conceptual models and medical vocabularies so that descriptive and procedural medical knowledge can be represented.
- How to combining medical guidelines with care pathways and the care delivery process.
- How to perform knowledge extraction from health-care databases and electronic patient records.
- How to perform temporal knowledge representations and exploitation.
- How to combine, personalize, and adapt knowledge for health care process.
- How to validated the knowledge. (checking compliance with guidelines and protocols against patient data, the use of quality indicators, or simulation of guideline against patient)
- How the system will learn from knowledge-based learning of health-care processes.
- How to link clinical care and clinical research.
- How to use biomedical data for medical care.

5. Tools Required

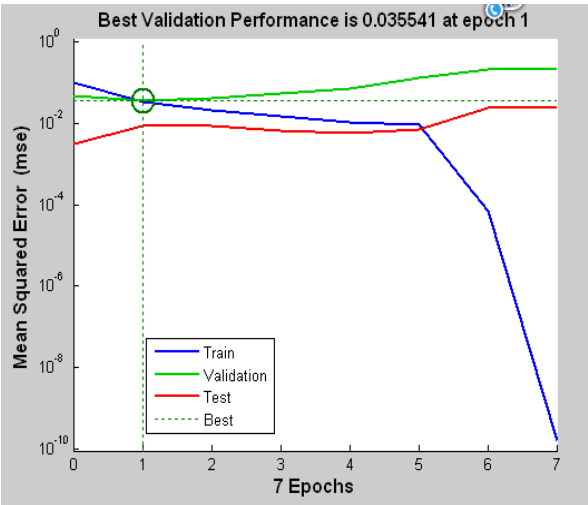
Developing of intelligent health care system as proposed in this paper would require a set of tools to achieve complete objective. Some of already developed tools can be used while for some purposes tools may be required to be developed for this purpose. Tools that 1. completely develop the ontology(Knowledge Base) as base for the information system like MATLAB, Protégé, 2. take care of version management of descriptive and procedural medical knowledge, 3. tools that will take care of acquisition, refinement and exploration of the temporal aspect of guidelines of health care, 4. tools that will support entire life cycle of guidelines of protocols and 5. tools that can model the results in the format so that description as well as automation can be done easily.

6. IMPLEMENTATION AND RESULT

The ontology system are generated for malaria and common cold identification using neural network with 11 number of features. . The feature is as follows ,

1. Fever
2. Cold stage
3. Sweating
4. Vomiting
5. Headache
6. Sneezing
7. Runny nose
8. Nuzzle congestion
9. Cough
10. Sore throat
11. Itching in eyes, nose and throat

The database of features and target diseases are used for training of neural network . The network are successfully trained and classification accuracy 97% are achieved .The trained graph is shown below:



From the graph above shows the no overtraining has been performed which is necessary for ontology system.

7. CONCLUSIONS

Ontology learning is a challenging and exciting research field at the intersection of data, text mining, natural language processing, machine learning, and knowledge representation. The present study is carried out with soft computing technique approach of analyze the issues and challenges arising in the field of medical science practices. Medical practice need sound and fair diagnosis of the problem so that the most suitable remedial action can be taken.

A constant demand for the effective, reliable and error free medical system is always in demand, thus, the study presents the system which helps to acquire and implement effective medications for the present situation. The basic advantage of the present system is systematic and efficient medical procedures by using ontology. Our proposed model for decision making can be the basis of the development of next generation e-health care systems.

7. FUTURE WORK

The present study will further proceed for its evaluation by physicians taking part in an actual network (probably in Malaria, AIDS, Asthma, diabetes): it will probably lead to other improvements of the Virtual Staff interfaces so as to enable friendly interactions between the end-user (a medical professional) and the system, by taking into account the context of this user.

REFERENCES

[1] N. Vyas, P.R. Pal, "E-Healthcare Decision Support System based on Ontology Learning: A Conceptual Model", International Journal of Computer Applications (0975 – 8887) Volume 59– No.9, December 2012.

[2] N. Vyas, P.R Pal, "Ontology Research from Generation to Using: A Survey", Proceeding of National Conference on, 2012

[3] X.Y. Djam and G.M. Wajiga, "A Novel Diagnostic Framework: The Application of Soft Computing Technology", The Pacific Journal of Science and Technology, Volume 13. Number 1. May 2012 (Spring).

[4] K.K. Sethi, D.K. Mishra, B.Mishra, "Extended Taxonomy of Rule Extraction Techniques and Assessment of KDRuleEx, International Journal of Computer Application (0975-8887), Volume 50-No.21, July 2012.

[5] A. Jović, M. Prcela, and G. Krstačić, "Medical Plans as a Middle Step in Building Heart Failure Expert System."

[6] A. S. M. Lau and S. H. M. Tse, "Development of the ontology using a problem-driven approach : in the context of traditional Chinese medicine diagnosis," vol. 1, no. 1, 2010.

[7] D. Sherrod, T. McKesson and M. Mumford, "Are you prepared for data-driven decision making?," Nursing Management, vol. 41, no. 5, pp. 51-54, 2010.

[8] C. Bousquet, P. Gasperina, and B. Trombert, "Ontological Representation of Adverse Drug Reactions Using the Fundational Model of Anatomy," pp. 507-511, 2009.

[9] S. Hussain and S. Sibte Raza Abidi, "Integrating Healthcare Knowledge Artifacts for Clinical Decision Support: Towards Semantic Web Based Healthcare Knowledge Morphing", AIME, pp. 171-175 Springer Verlag, 2009

[10] Abidi, S., Abidi, R., Hussain, S., Butler, L.: Ontology-based modeling and merging of institution-specific prostate cancer clinical pathways. In: Knowledge Management for Healthcare Processes Workshop at ECAI 2008, Patras, Greece, July 21-25 (2008)

[11] Mandinach, E. B., Honey, M., Light, D., & Brunner, C. (2008). A conceptual framework for data-driven decision making. In E. B. Mandinach & M. Honey (Eds.), Data-driven school improvement: Linking data and learning (pp. 13-31). New York, NY: Teachers College Press.

[12] L. Franco, L. Subirats, I. Molina, and E. Alba, "Early Breast Cancer Prognosis Prediction and Rule Extraction Using a New Constructive Neural Network Algorithm," pp. 1004-1011, 2007.

[13] Guizzardi, G.: On Ontology, ontologies, Conceptualizations, Modeling Languages, and (Meta)Models. In: Frontiers in Artificial Intelligence and Applications, Databases and Information Systems IV. Olegas Vasilecas, Johan Edler, Albertas Caplinskas (Editors), ISBN 978-1-58603-640-8, IOS Press, Amsterdam (2007a)

[14] Prcela, M., Gamberger, D., Bogunovic, N. (2007) Developing factual knowledge from medical data by composing ontology structures , In Proc. of 30th International Covention MIPRO 2007, part III, pp.145-150

[15] A. Jovic, M. Prcela, and D. Gamberger, "Ontologies in Medical Knowledge Representation," Proceeding of the ITI 2007, 29th International Conference on Information Technology Interfaces, pp. 535-540, Cavat, Croatia, 2007.

[16] I. C. Mcilwaine, E. Verlag, C.-hung Lee, C. Khoo, and J.-cheon Na, "Automatic Identification of Treatment Relations For Medical Ontology Learning: An Exploratory Study Automatic Identification of Treatment Relations For Medical Ontology Learning: An Exploratory Study," pp. 245-250, 2004.

[17] Runi Studer, V. Richard Benjamins, Dieter Fensel: Knowledge Engineering: Principles and Methods. Data Knowl. Eng. 25(1-2): 161-197 (1998)

[18] Gangemi, A., Pisanelli, D., Steve, D.,"Ontology Integration: Experiences with Medical Terminologies", Proceedings of Formal Ontology in Medical Systems, (FOIS), 1998

[19] George C. Scott, Leslie A. Lenert, "Extending Contemporary Decision Support System Designs to Patient Oriented Systems", AMIA, pp. 376-380, 1998

[20] G. C. Scott and L. A. Lenert, "Extending Contemporary Decision Support System Designs to Patient-Oriented Systems owledg D-Q ecisionSuppoft," pp. 376-380, 1998.

[21] DH. Gustafson, K. Bosworth, RP. Hawkins, EW Boberg, Bricker E. CHESS:

"A computer based system for providing information referrals, decision support and social support to people facing medical and other health related crisis. Proc Annu Symp Comput Appl Med Care 1992: 161-5

[22] Baldinger, K. 'Semantic Theory: Towards a Modern Semantics', Palgrave Macmillan, 1980

[23] S. Grimm, P. Hitzler and A. Abecker, "3 Knowledge Representation and Ontologies Logic, Ontologies and Semantic Web Languages".

[24] Ullmann, S. 'Semantics: An Introduction to the Science of Meaning', Basil Blackwell, Oxford, 1972