Ontological Development of a Medical Decision-Making System (MDMS)

Vaios Papaioannou[0000-0003-2654-6733] and George-Peter Economou[0000-0001-7200-5036]

Department of Computer Engineering & Informatics, University of Patras, 26504, Greece
{vaios, econom}@upatras.gr

Abstract. This paper introduces the main viewpoints of a novel approach concerning ontological aspects of Medical Decision-Making Systems (MDMS) development. A Feed Forward Artificial Neural Networks (fANNs) based MDMS on has been extensively tested using real world patients' clinical data in the field of Pulmonary Diseases (PDs) and has been developed as an application for Android Devices. One of the main goals of our approach is to integrate the diverse knowledge that is accumulated throughout the development lifecycle of a medical computer system but also extend it to its whole lifetime. We advocate that semantically rich information can alleviate the problems of systems analysis and failure and offer compliance to critical implementation issues in a health care sensitive domain.

Keywords: Ontologies, Neural Networks, Medical Decision-Making Systems, Software Engineering.

1 Introduction

Since the early days of large information systems development, it became very clear that its success or failure was largely dependent on the analysis and requirements engineering phases rather its implementation [5][2][10]. Nowadays, computational systems play a critical role in many aspects of our life. Medical Decision-Making Systems (MDMS) are very crucial in supporting medical experts such as Doctors of Medicine (MDs) or trainees in their diagnoses [8]. Moreover, when doctors or paramedics are faced with unfamiliar symptoms, they can utilize MDMSs to optimize their judgement results or cater for their patients during transportation to medical centers, respectively.

Thus, it is apparent that failures in medical information systems could have an enormous impact on the care of patients. Therefore, systems such as expert diagnosis systems should follow consistent development approaches to meet the domain requirements and operation procedure guidelines. In this approach, we propose that such development process should commit to an ontological framework in order to achieve overall integrity against a complex, safety critical problem domain. Future extensions should also be encoded to the common ontology.

2 The MDMS Problem Domain

Medical and software experts developed a Pulmonary Diseases (PDs) MDMS [4], tested in a University Hospital Clinic to patients with great accuracy [6]. The overall MDMS structure, comprises of different feed forward Artificial Neural Networks (fANNs) layers. Additionally, it can be configured to other medical interests [1].

Our research has shown that fANNs is the optimum architecture for the proposed MDMS. There is a basic structure of three layers that track the temporal propagation sequence of MD's (Fig. 1). For training the fANN, we forwarded back propagation equations and Kalman filtering of back propagation learning algorithms [9]. The Kalman filtering of back propagation learning algorithms [9] since they required less initialization steps demonstrated better performance.

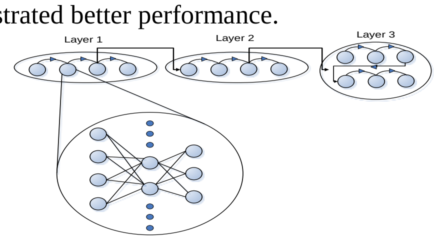

Fig. 1. Layers: Composition of ANNs'.

Working clinical data were used to train the MDMS. During the initial and advanced experiments, it was very efficient to symptoms classification and PDs (83% in potential non-learnt PD clinical cases out of a thousand in total). It showed efficiency up to 98% in wide-range testing out of a combination of one hundred non-learnt PD cases [3], indicating that the ratio will ultimately augment.

The MDMS application designed for the Android OS where the MD can select the data sets of the symptom for loading in order to perform instant diagnosis [6].

3 The ontological approach

The aim of the project is to efficiently manage, preserve and reuse the knowledge that is accumulated throughout a computer system development and use it as a solid basis for all current and future extensions. This knowledge is essentially encapsulated within the Software Engineering deliverables, but it must also include other aspects of the whole development. More specifically, based on the description of the problem domain above, we can identify knowledge elements such as:

- Information about the Pulmonary Diseases, such as categories of PD, symptoms of PD, diagnosis, possible integration with treatment plans for PD which is closely connected to information about PD patients, etc.
- Information about the MDMS solution as a computer system which include neural network concepts, fANN architectures as described above, software engineering deliverables such as requirement documents, systems analysis

conceptual models, systems design models, programming code, user interface design, android design models, hardware specifications, etc.

Therefore, we adopted principles found in HERE approach [5] in order to organize the output and feedback originating from the SE activities into a concrete manageable set of specifications with the ability to analyze, manage, and communicate these specifications and knowledge to all stakeholders in order to achieve their objectives.

At the conceptual level, we aim at the integration and coupling of the disparate information elements which are produced during the SE processes into an explicit, unified, clarified, and defragmented representation [5].

Ontology plays a crucial role into integrating the problem domain knowledge so that any future changes or enhancements should explicitly commit to the existing ontology.

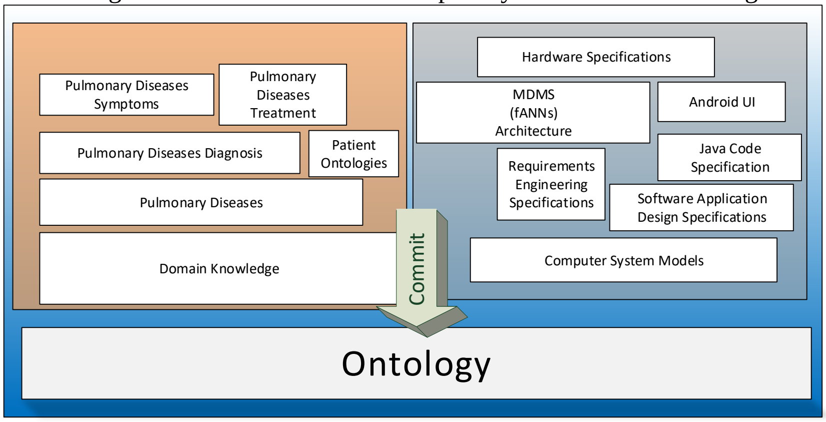

Fig. 2. Integrating the problem domain knowledge**.**

4 Ontological Application Development

Based on the approach described above an ontological OWL specification evolved describing aspects of the problem domain. It also included the MDMS application software, its specifications and system design along with problem descriptions and user requirements under the precondition that these ontological models will be globally agreed by all stakeholders and explicitly specified. Therefore, no element was excluded from the overall ontology and all development from that point onwards will be fully aligned with these ontological specifications.

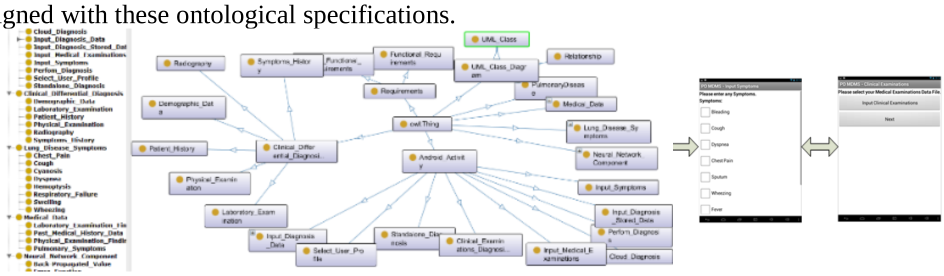

Fig. 3. Ontology and application development

The outcome of the project includes not only the MDMS itself but also an ontology that integrates all required knowledge for MDMS development. Future implementations will reuse this knowledge to help software processes and avoid implementation inconsistencies [5][10]. Finally, all ontological conceptualizations can be reasoned allowing for traceability and diverse views of the recorded knowledge.

5 Conclusions

Medical problem domains and their respective computational systems are highly critical for their application on real world patients. Thus, the domain and development knowledge acquired towards the evolution of such systems is highly valuable and should be maintained as the base of all current operations and future extensions. Our approach proposes the global, explicit and commonly agreed ontological specification of this knowledge in parallel to the systems developed. Consequently, there can be no inconsistencies and most importantly all systems development will be fully aligned to problem domain descriptions. Future integrations such as treatment plans and patient profiles [7] and other diseases can also commit to this common ontology. All specifications are globally agreed upon and future specifications will also be included within the ontology. Forthcoming work will refine ontological specifications and their role towards a semantically rich medical applications development.

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