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An Intelligent Learning Environment for Traditional Chinese Medicine Practitioners and Students

Jia L[1], Stranieri A[1], Shen J[2]

[1]Health Informatics Laboratory, Centre for Informatics and Applied Optimisation, University of Ballarat, Australia
[2]College of Science, Harbin Engineering University, China

Abstract

Objectives:

This study aims to support the training of Traditional Chinese Medicine practitioners by embedding an expert diagnostic model for arthritis into an Intelligent Interactive Learning Environment (IILE).

Background:

The increasing prevalence of Traditional Chinese Medicine (TCM) outside China is characterised by the emergence of university level practitioner training and stringent regulatory requirements. TCM differential diagnosis is a difficult task that was traditionally taught by exposure to large numbers of patients in a master-apprentice context. In university degree programs, students and novice diagnosticians cannot have the exposure to cases possible in the traditional context. An online system that engages students in the interactive construction of a virtual case and provides immediate feedback on the appropriateness of student actions and the accuracy of diagnostic conclusions can enhance student learning. The system, an Intelligent Interactive Learning Environment (IILE) is based on an approach that has been shown to improve learning outcomes in intensive care nurse training.

Methods:

An expert model of diagnostic reasoning elicited from TCM expert practitioners lies at the core of the IILE. The knowledge acquisition is performed using an argumentation tree representation that has been shown to be effective in structuring complex knowledge and facilitating engineer – expert interactions. Problems associated with keeping knowledge bases up to date are mitigated with the use of a knowledge model known as ripple down rules permits dynamic updating of knowledge so that knowledge bases evolve over time. A simple narrative model builds up the virtual case study as user interaction proceeds.

Results and discussion:

This article reports preliminary results in the study that includes an overview of TCM differential diagnosis, the argument tree, the ripple down rule representation and the narrative based IILE. Segments of the knowledge model based solely on TCM literature are illustrated.

Objectives:

This study aims to support the training of practitioners by embedding an expert diagnostic and treatment model into an Intelligent Interactive Learning Environment (IILE). These systems are computer programs that engage students in the interactive construction of online, simulated case studies and provide immediate feedback on the appropriateness of actions and diagnostic conclusions reached. The IILE will enable students of Traditional Chinese Medicine (TCM) to practice their diagnostic skills on virtual patients with arthritis like symptoms and is expected to play a role in elevating the quality of TCM based diagnosis in Australia

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and internationally to global best practice standards. In addition, exposure to many patients so central to traditional TCM pedagogy can be, to some extent, maintained.

Background:

Traditional Chinese Medicine (TCM) represents a complementary alternative model of patient centred health care that is rapidly growing in prevalence worldwide. The trend driven by Chinese government impetus and a growing public interest in complimentary and alternative medicines involves the emergence of university level practitioner training and new levels of accreditation in many jurisdictions. In Australia, TCM is taught by several tertiary institutions and over 1900 practitioners in Australia are accredited by the Australian Acupuncture and Chinese Medicine Association. Many of these are also licensed general practitioners.

Just as in Western medicine, case studies offer the trainee practitioners insight into the application of background knowledge for diagnosing and treating patients. Under the traditional master-apprentice system, the trainee was exposed to many thousands of cases first hand. This is not practical in university based training hence the need for an intelligent interactive learning environment. Further, studies surveyed by .(Lukmana et al 2007) identified wide variation in diagnosis when the same patients are presented to numerous TCM practitioners for diagnosis. The opportunity for practitioners to hone their diagnostic reasoning skills by interactive exposure to virtual cases where the differential diagnosis is performed by an embedded expert model promises to address the issue of varying diagnoses to some extent.

This study focuses on arthritis to limit the scope toward a condition that is a significant health concern in Australia. In TCM, "Bi-syndrome" is congruent with arthritis and manifests as pain, soreness, or numbness of muscles, tendons and joints. The four main patterns of Bi syndrome are the wind, cold, damp and heat patterns. Although there are over 18 Bi-syndromes, (Zhang et al 2005) ten as most prevalent for the differential diagnosis of arthritis like conditions including: I, wind-cold, damp-cold, wind-damp-cold; II wind-heat, damp-heat, wind-damp-heat ; III phlegm and blood stagnation; IV deficiency (Liver, Kidney, Qi, Blood) and other combinations.

This study aims to develop a model of diagnostic reasoning that expert TCM practitioners deploy in the differential diagnosis of Bi-syndromes. Conventional expert system have been developed to model TCM reasoning in other areas including treatment of mothers after birth by (Shi et al 2005) and the diagnoses of chronic hepatitis by (Zhao et al 1994).

Methods:

This project aims to embed a ripple down rule knowledge representation model into an interactive learning environment so that TCM students and novice practitioners can practice their diagnostic skills. Ripple down rules (Compton and Jansen 1990)(Compton et al 2006) is a representation of knowledge whereby rules can readily be added without invalidating existing rules. (Compton et al 2006) describes how a ripple down rule system installed in the pathology laboratory of a Sydney hospital initially has grown, over the years without extensive use of a knowledge engineer. Experienced pathologists add rules whenever the system was considered to have erred so that the knowledge base now rarely misclassifies a case.

Study Design, data sources and interventions:

This study initially involves the transformation of an IILE for critical care nursing developed by (Yearwood and Stranieri 2006). In that approach a simple narrative model follows a set, infer, narrate cycle. In the set phase, the user, a trainee intensive care unit nurse selects an action such as increasing the oxygen level, or preparing for catheter insertion. The system infers whether the action selected is the most appropriate for the patient at that time using the diagnostic model. The diagnostic model also infers the consequences if the action is inappropriate. The consequences derive from two sources; the impact of the action performed inappropriately and the consequences of the omission of the correct action. For example, the incorrect action of increasing

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the oxygen does not led to harm but the omission of the correct action, failing to check the pleth wave results in a potentially misleading presumption that the oxygen level reading is accurate.

The knowledge is elicited as a structure known as an argument tree initially from literature and refined in consultation with experts. An argument tree is a hierarchy of relevant factors that underpins a model of reasoning advanced by (Yearwood and Stranieri 2006a). Figure 1 illustrates a partial argument tree for the diagnosis of a bi-syndrome.

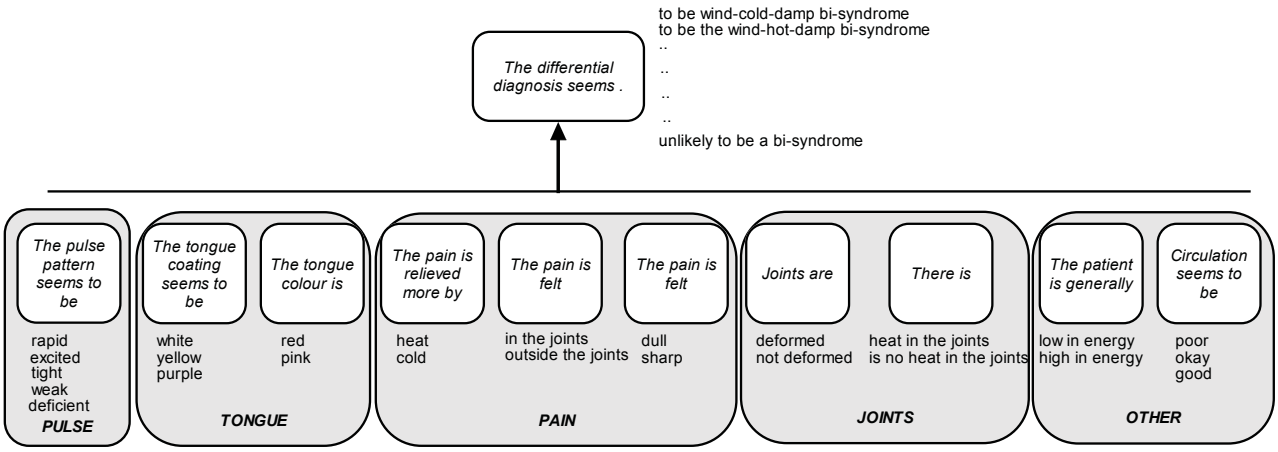

Figure 1. *Argument tree for differential diagnosis of Bi-syndrome*

The argument tree root node represents the ultimate Bi-syndrome diagnosis. The factors immediately relevant for a Bi-syndrome inference are listed as children nodes. A root node value is inferred from child node values with the invocation of an inference procedure which is a mapping of child values to a parent value. In the generic actual argument model of (Yearwood and Stranieri 2006a) the inference procedure may be implemented as a set of rules, logic clauses, neural networks or any other algorithm for performing the mapping. In the intensive care IILE by (Yearwood and Stranieri 2006), the inference is performed with the use of a conventional set of rules. In the current approach, the inference will be performed with ripple down rules so that the knowledge base of appropriate inferences can evolve more readily. Figure 2 illustrates part of the ripple down rule tree.

A ripple down rule tree is a directed graph where a node represents a rule and there are optionally, two arcs from each node; an if-true arc and an if-false arc. If-true arcs represent the context where the rule antecedent is true. To perform an inference, the rule in the tree's root node is evaluated. If the rule antecedent (if part of the rule) is true then the if-true arc is traversed to the next node. If an if-true arc does not exist, the rule's consequent (then part) supplies the inference. If the rule antecedent is not true, then the if-false arc is traversed. Ripple down rules provides an approach that enables new rules to be easily added without invalidating previous rules on a case by case basis. For instance, we can imagine the diagnosis of a patient with pain in the joints that is somewhat relieved by heat, a white tongue covering, tight pulse and the patient presents low in energy. Following the ripple down rules down the tree for all symptoms except the experience of low energy, results in a diagnosis of the wind-cold-damp.

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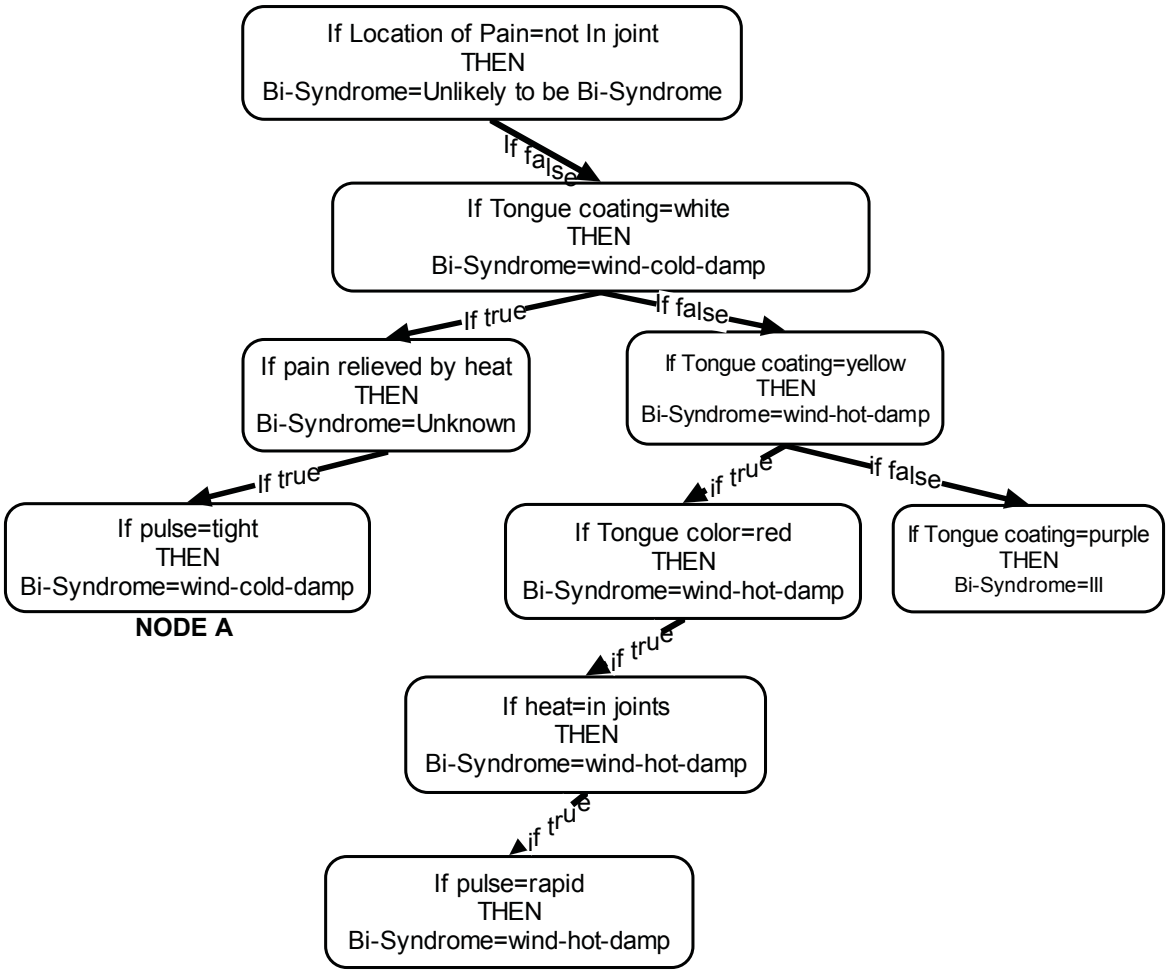

Figure 2. *Partial Ripple Down Rule tree*

However, an expert diagnostician aware that the addition of the low energy symptom will transform the diagnosis to a Bi_syndrome of type IV adds a rule on the if-true arc of the node labelled Node A in Figure 2. This is illustrated in Figure 3.

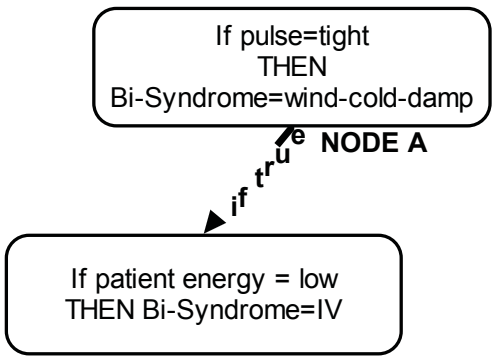

Figure 3. *Addition of a new rule*

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Results and discussion:

The initial knowledge acquisition based solely on literature is currently progress. The model will be enhanced with TCM experts at a specialist TCM university in China and further validated with panels of TCM experts and students in Australia and China. According to (Beilby 2005), decision support systems have not been as prevalent in health as expected despite some government initiatives that have encouraged their use. Those authors call for a government driven strategy to champion the development of decision support systems may be critical however, much of the reluctance to embrace these technologies may derive from issues more fundamental to the nature of clinical practice. (Kay and Purvis 1996) claim that diagnostic reasoning is largely narrative based characterised by the reliance on case studies for initial acquisition of diagnostic skills followed by years of experience with patients and their stories to further the skills. By focussing on the automation of diagnostic algorithms, and ignoring the narrative context of the reasoning, clinical decision support systems often fail to find a place within clinical practice.

The current study is positioned to explore the deployment of a decision support system for training of practitioners. By embedding the system in a narrative based "make your own case study and learn" intelligent interactive learning environment, a major obstacle to the deployment of decision support systems is hoped to be overcome. The domain of TCM diagnoses directed toward arthritis conditions presents complementary and alternative medicines as a new and promising application area for health informatics research.

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