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## An expert system for supporting Traditional Chinese Medicine diagnosis and treatment

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### Abstract

Portugal has recently become one the few European countries to fully acknowledge Traditional Chinese Medicine (TCM); this substantial paradigm shift calls for novel tools for TCM practitioners, students and patients alike. This paper describes an Expert System for supporting the TCM consultation process – both in terms of gathering and managing the patients' personal and symptomatic data, and of obtaining accurate diagnoses and treatments under regulated and reviewed protocols. The proposed tool was designed and is being developed with the support of two TCM therapists, which act as experts and provide aid to the processes of building the knowledge base and the automatic diagnosis system. In terms of architecture, the current version of the framework includes a mobile client application for the Android platform, integrated with an online spreadsheet. A survey was conducted in order to assess some of the needs of the community of TCM practitioners, and allowed gathering information on their needs.

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## 1. Introduction

Traditional Chinese Medicine (TCM) is the name commonly given to the set of practices of traditional medicine in use in China. Those practices were developed over thousands of years and are considered one of the oldest forms of Oriental medicine. TCM encompasses seven main methods of treatment: Tui-na; Acupuncture; Moxibustion; Cupping; Phytotherapy; Chinese food therapy; Physical practices.

The main goal of this research is the creation of an expert system capable of helping therapists reach a diagnosis and establish a treatment plan. In order to do so, the expert system must guide the therapist in the data entry process by presenting the most relevant questions in an adequate sequence. Moreover, the expert system must use that data to find the most adequate diagnosis hypothesis and present them to the therapist. In addition, we are using a Google Spreadsheets to store all relevant information, including the knowledge necessary to reach a diagnosis and suggest a treatment plan. This option eases the creation of both desktop and mobile applications while also simplifying the fine tuning of the system. All TCM diagnosis and acupuncture treatments included in the expert system were collected from experts and are supported by B. Auteroche e P. Navailh book [1].

This paper focuses on presenting the TCM-SIS (Traditional Chinese Medicine – Support Information System) framework, while providing the background underlying this research and proving the pertinence of this study; also, we intend to introduce the technical and architectural approaches proposed for implementing the framework.

### 1.1. Traditional Chinese Medicine

Traditional Chinese Medicine cannot be understood without a basic understanding of holistic medicine. Holistic medicine views the body as a whole, and tends to believe that “imbalances” in the body manifest as symptoms. Holistic medicine believes that, in the long term, it is not efficient to suppress symptoms (e.g., by means of aspirin for headaches), as these symptoms will keep returning until the body is restored into balance. Traditional Chinese medicine is based on the theory of holistic medicine, and this can be seen through remedies such as herbal medicine, acupuncture, massage (Tui na), exercise (qigong), and dietary therapy. TCM diagnosis aims to trace symptoms to patterns of an underlying disharmony, by measuring the pulse, inspecting the tongue, skin, and eyes, and examining the eating and sleeping habits of the patient among many other things [1].

The theoretical framework of TCM has a number of key components. The Yin-yang theory is the concept of two opposing – yet complementary – forces that shape the world and all life, and is central to TCM. In the TCM view, a vital energy or life force called *qi* circulates in the body through a system of pathways called meridians. Health is an ongoing process of maintaining balance and harmony in the circulation of *qi*.

The TCM approach uses eight principles to analyse symptoms and categorize conditions: cold/heat, interior/exterior, excess/deficiency, and yin/yang (the chief principles). TCM also uses the theory of five elements – fire, earth, metal, water, and wood – to explain how the body works; these elements correspond to particular organs and tissues in the body [2,3].

### 1.2. The Portuguese Reality

The law bill n. ° 71/2013 published on September 2013 [13] is a milestone of the Portuguese TCM history, as Portugal will be one of the few European countries to fully acknowledge TCM and its practitioners. This paradigm shift increases the relevance of software solutions as the one presented in this paper.

With the purpose of getting to know some of the TCM therapists' needs as related to the information technologies in their professional settings we conducted a survey during a 3-day TCM post-graduation session that had 220 therapists in attendance. The participation in the survey was completely voluntary and of those 220 therapists we had 55 answering the survey.

The first question asked in the survey was “What would you value the most in a computer application tool developed with the purpose of assisting you in your professional TCM practice?”. The answers are detailed in Table 1. The second question asked in the survey was “Do you presently use any kind of information system to support your therapeutic practice?”; we have obtained 34 negative answers and 21 positive answers.

Table 1 – Question 1

	What would you value the most in a computer application tool developed with the purpose of assisting you in your professional TCM practice?*						Total
	No answer	Least valued				Most valued	
		1	2	3	4	5	
Automatic diagnostic support	1	8	5	14	9	18	55
Patient Clinical record	1	2	0	5	12	35	55
Remote access to clinical information	4	3	2	9	12	25	55
Information data security	1	0	1	2	8	43	55
Quick access to external entity information	4	2	1	9	17	22	55
Prescription	5	2	3	12	10	23	55
Human anatomy aid on acupuncture points	1	2	5	11	15	21	55
Billing	3	5	11	11	12	13	55
<i>Total</i>	20	24	28	73	95	200	

The answers to these two simple questions reinforce the well known facts: that in all health related information systems, the data security is of paramount importance and that professionals in this area are eager to have Electronic Health Records available to them. Other than that, they show a degree of distrust on “Automatic diagnostic support” tools that is to be expected from people that still do not use any form of information system in their therapeutic practice (only 21 in 55 respondents use some kind of information system).

Also, the survey contained one open-ended question: “Please specify the Information Systems you use”. Of the 21 therapists that use some kind of information system in their therapeutic practice, 17 stated that the information system they use is a simple word processor and/or a spreadsheet that they use to register their patients’ clinical records.

## 2. Methodology and Technical Approach

This work focuses on developing an Expert System for assisting TCM therapists with the process of efficiently and assertively diagnosing and treating patients. The idea of having automated decision support tools supporting clinicians is very compelling and several such systems have been created. Some of the best known are MYCIN [6], CASNET [7] and CADUCEUS [8], just to name a few.

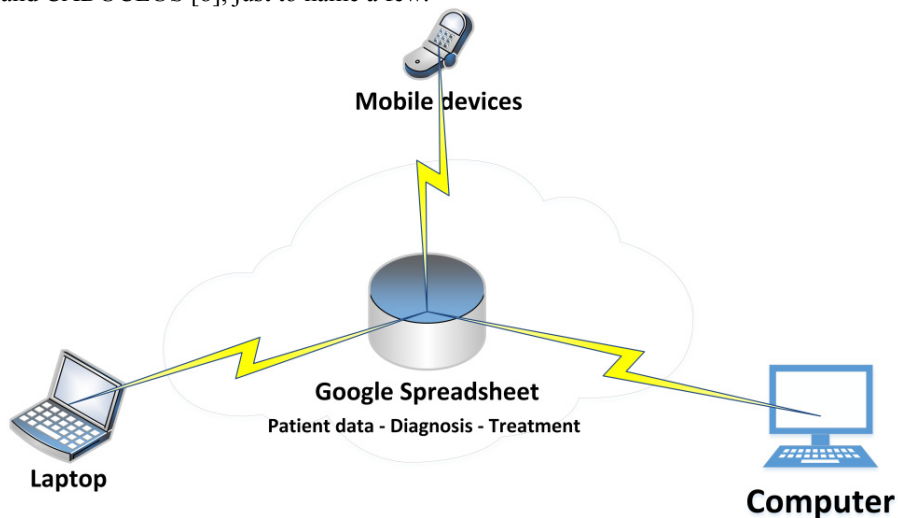


Figure 1 - Architecture of the proposed framework.

The Expert System's knowledge base is being built with the aid of two TCM therapists; their expertise is the main support for the processes of constructing and validating the framework. The TCM experts will be utilizing the B. Auteroche e P. Navailh reference book [1] as the preferred source for clarifying any doubts or acquiring specific information.

The knowledge base containing symptoms and diagnosis information, as defined by the experts and required by the Expert System's algorithm to produce an outcome, will be stored in "the cloud", in an online spreadsheet (namely, a Google Spreadsheet), which is accessible to the client application via a web API (Application Programming Interface) provided by the Google Spreadsheets platform. A mobile application for the Android platform was implemented for supporting the consultation process; this will allow the therapist to gather and upload patient data during the consultation itself, allowing for a less disruptive consultation process. The architecture proposed for the TCM-SIS platform is shown in Figure 1.

Commonly, the TCM diagnosis process is performed as the result of a clinical consultation and examination, in which the TCM therapist examines the patient and indicates the most suitable treatment. During this consultation, various questions are posed (e.g., "do you have heart problems?", "do you have hearing problems?"); the TCM-SIS client application provides support for selecting a valid choice among those defined by the experts. All the observations performed by the therapist can be added in the same way, resulting in a set of symptoms which will be the basis for the Expert System's diagnosis process. The set of symptoms will then be uploaded to the remote online spreadsheet – i.e., to the Google Spreadsheet – at the client application user's command which will, in turn, return the diagnosis yielded by the implemented Expert System and the suggested treatment.

Utilizing Google Spreadsheets for storing and managing both symptomatic and diagnosis data brings several advantages. It should be noted that building and fine tuning an Expert System is an iterative process, which requires a significant amount of inputs from the experts in order to achieve a quality system; the fact that the knowledge base is stored in an online spreadsheet, accessible via a web API, allows for continuous adaptations and improvements with basis on the therapists' feedback. Moreover, it is possible for the therapists to fine-tune the knowledge base themselves – in order to improve its outcome or to adapt it to their specific needs, sensibilities or experience – given that the online spreadsheet is manageable by any user with basic computer skills. Also, and given that the online spreadsheets used are part of Google's application ecosystem, the proposed framework will benefit from all the conditions offered by this enterprise in terms of security and reliability.

### 2.1. The Expert System

The Expert System works with basis on three sources of information stored in the online spreadsheet, which are accessible to the client programs (namely, to the mobile client application) via its web API, and allow managing patient, symptoms, diagnosis and treatment data:

- **Patient Data** – contains patient information (e.g., name, height, weight, birth date, address, etc.).
- **Validation Data** – contains the options available for the client application's user (i.e., the therapist) to annotate the patient's symptoms. Each column represents a symptom, and for each symptom a series of possible values are defined in accordance to the specifications provided by the experts. The client application's interface is generated dynamically with basis on the parameters defined in this spreadsheet, so as to provide the therapist with the current symptoms set and the array of possible values for each symptom [Figure 2].
- **Diagnosis and treatment data** – contains the diagnosis information, as defined by the experts, and encompasses the set of possible outcomes of the Expert System's diagnosis process; the goal of the Expert Systems will thus be that of returning a list of suggested diagnoses, ordered by accuracy, as the result of the application of the Expert System's algorithm to the symptoms provided as input. It also contains the set of acupuncture points associated with treating the pathology diagnosed by the Expert Systems.

The Graphical User Interface of the mobile application is intended be simple, efficient, and follow the Springboard model [5], which is characterized by having a menu page which includes the application's main functionalities; also, as was above mentioned, the symptoms' input view is extremely customizable, as it is dynamically generated from the data in the Validation Data spreadsheet.

Figure 2 showcases the information flow in the TCM-SIS framework.

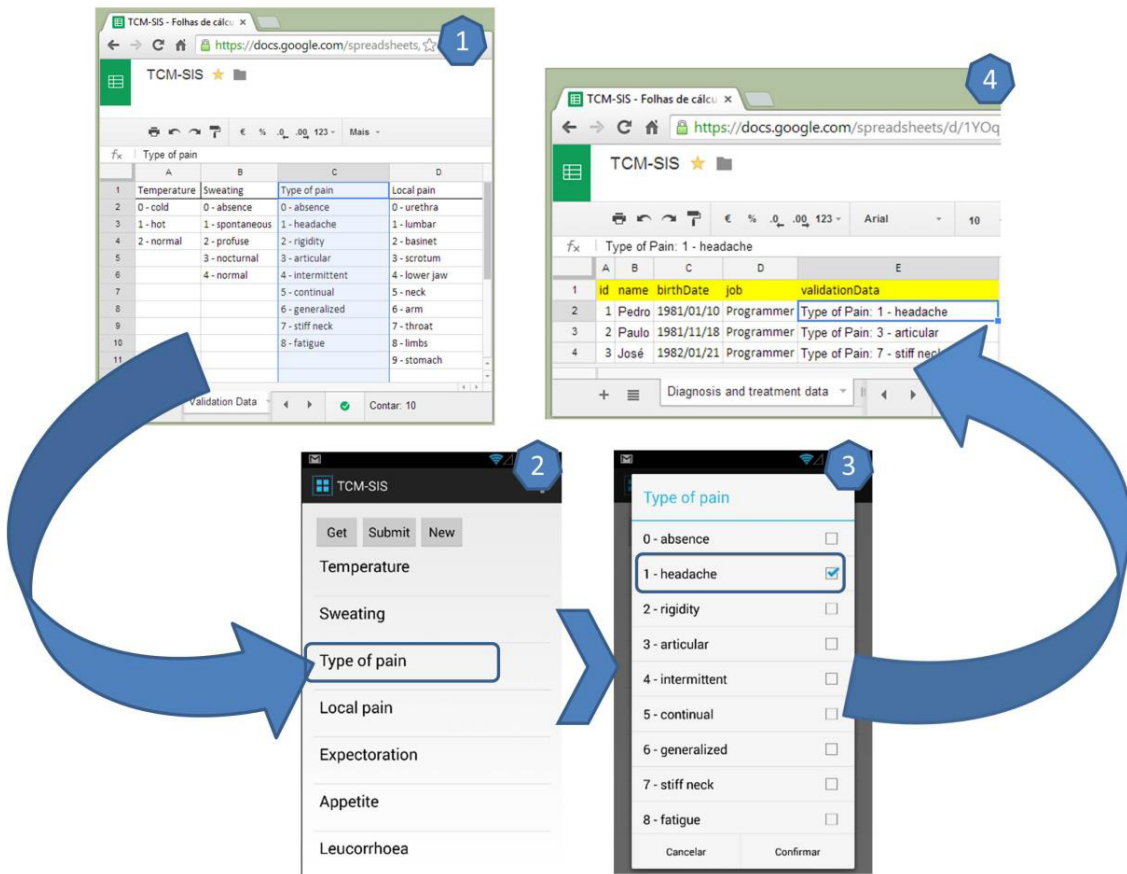


Figure 2 - Information Flow in the TCM-SIS framework. Step 1 depicts an example “Validation Data” spreadsheet, where a set of symptoms and a list of possible values for each symptom. Step 1 shows a view of the Android Client application in which a list of symptoms is filled automatically with basis on the data defined in the “Validation Data” spreadsheet. Step 3 shows the set of possible values for the “type of pain” symptom. Step 4 exemplifies the “Diagnosis and treatment data spreadsheet” filled out with sample patient information.

### 3. Related Work

Existing frameworks in the TCM fields are mainly of educational nature and/or generic Electronic Health Records management systems; examples include ShenProfessional [9], AcuBase [10], AcuPartner [11]; moreover, they are commonly commercial tools, which are not publicly available for researchers to experiment with.

The Chinese Acupuncture Expert System (CAES) [4] and the ACE - Acupuncture Expert [12] are, to the best of our knowledge, the tools that most closely resemble the proposed TCM-SIS framework. CAES is a very comprehensive information system, encompassing several modules (e.g., patient record, needle insertion position animation, acupuncture points usage statistic, etc.) in addition to the diagnosis and acupuncture prescription subsystems; ACE is a commercial information system, which focuses on automating the diagnosis process using an Expert System. The knowledge base is, in both cases, built with the aid of experts in the field. The main differences between these and TCM-SIS reside in the availability of a simple and effective means for therapists to manage the knowledge base (the online spreadsheet), the mobile nature of the proposed client application, and the inherently distributed architecture which allows its extension with additional modules and client applications.

#### 4. Conclusions and Future Work

Portugal has recently become one the few European countries to fully acknowledge Traditional Chinese Medicine; this substantial paradigm shift calls for novel tools for TCM practitioners, students and patients alike. This paper describes a framework for supporting the TCM consultation process – both in terms of gathering and managing the patients' personal and symptomatic data, and of obtaining accurate diagnoses and treatments under regulated and reviewed protocols.

The proposed tool was designed and is being developed with the support of two TCM therapists, which act as experts and provide aid to the processes of building the symptoms knowledge base and the automatic diagnosis system. In terms of architecture, the current version of the framework includes a mobile client application for the Android platform, integrated with an online spreadsheet. A Google Spreadsheet is utilized as: a knowledge base of symptomatic diagnosis and treatment information; a backoffice for managing the knowledge base; a database of patient data; and a web service which allows for the client application to remotely access and modify the stored data.

A survey was conducted in order to assess the needs of the community of TCM practitioners, and allowed gathering information on their needs. It also permitted reaching a better understanding of the new business perspectives set off by the recent advances in terms of legislation.

The main hindrance posed to this research is related with the nonexistence of norms that regulate TCM practice (such as those that exist for conventional Medicine), which complicates the search for diagnoses and treatments associated with a specific disease; the experts must constantly resort to specific literature resources, and the Expert System must be subjected to constant validations and parameterization; this is the main reason for designing the TCM-SIS framework in a way that enables the constant update of the knowledge base, and the immediate mirroring of any changes made to the knowledge base to the client application. Future work involves defining the Expert System's algorithm with basis on the information gathered from the experts, and integrating those advances into the final product. Also, we expect to be able to introduce additional modules into the framework (e.g. billing, fitotherapy prescription, etc.) in order to provide therapists with a all-in-one solution for their MTC needs.

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