

# Chinese Acupuncture Expert System (CAES)—A Useful Tool to Practice and Learn Medical Acupuncture

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**Abstract** This paper describes the development of a Chinese Acupuncture Expert System (CAES) that will assist the learning and practice of medical acupuncture. This was the development of a Chinese Acupuncture Expert System which incorporated eight functional modules. These modules were 1) Add Patient Record subsystem; 2) Diagnosis subsystem; 3) Acupuncture Prescription subsystem; 4) Needle Insertion Position Animation subsystem; 5) Acupuncture Points Usage Statistic subsystem; 6) History Query subsystem; 7) Acupuncture Points Query subsystem and 8) Diagnosis Remarks and Diagnosis Record Save subsystem. Two databases were built—Patient Record database and Diagnosis (Acupuncture) Knowledge database. All the Traditional Chinese Medicine (TCM) knowledge and acupuncture treatment prescriptions were extracted from officially used TCM textbooks and received guidance and expert advice from two acupuncturists working in this project. A Chinese Acupuncture Expert System (CAES) was built, which after the input from users of any Chinese disease symptoms and signs, it can provide a list of related TCM syndrome diagnoses based on the

patients' disease symptoms and signs, and at the same time it can offer advice of the appropriate Chinese acupuncture treatment to the users. CAES also provided text descriptions and acupuncture animations showing the acupoint locations and the direction and depth of the needle insertion technique. Therefore users can easily learn acupuncture and practice it. This new acupuncture expert system will hopefully provide an easy way for users to learn and practice Chinese Acupuncture and establish its usefulness after it was fully evaluated.

**Keywords** Acupuncture expert system · Acupuncture learning · Acupuncture treatment · Medical acupuncture

## Introduction

Chinese Acupuncture is a medical treatment using fine filiform needle insertions or/and moxibustion on the acupuncture points and meridian system (Jing Mai) in our bodies. It is a traditional medical treatment developed in China many thousands years ago, and has now gained worldwide recognition in Western World. The Consensus for Acupuncture at the National Institutes of Health (NIH) in 1997 stated that acupuncture is “widely” practiced by physicians, dentists, acupuncturists, and other practitioners for pain and for various other health conditions [1]. However, the theory and principle of Acupuncture practice is totally different from existing western medical practice. There are more than 350 acupuncture points and 14 regular meridians with different functionalities [2]. Like anatomy in western medicine, a lot of these acupuncture points and meridians are hard to memorize as there is no underlying logic or known mechanism of actions to make it scientifically easier to understand and remember. Thus, it is

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difficult for students and beginners in Traditional Chinese Medicine (TCM) to be proficient in acupuncture treatment after short course training without much practical experience. The understanding of Chinese Medicine on how body acupuncture work is built on the ancient Chinese philosophical thinking, e.g., yin and yang. Acupuncture treatment is aimed to tonify/reduce the qi (vital energy) at various organs or meridians in order to treat the underlying conditions. Body acupuncture and ear acupuncture are used widely as the treatment for various medical conditions. Body acupuncture involves stimulation of body acupuncture points through different sized sterile needles while ear acupuncture, in which the acupuncture points on the external ears are stimulated either by needles or pellets accordingly. Unlike the detailed anatomical finding and functionalities demonstrated by organs in Western Medicine. There were no scientific recognized structures or anatomical organs for the acupuncture points or meridians. Moreover, Acupuncture and Chinese Medicine adopt a holistic treatment approach, while Western Medicine defines diseases as disorders, dysfunction or damages of a structure or organs, its treatment aims to restore the functional imbalance, remove and repair the diseased structure or organ.

Numerous TCM books were written to help people to memorize acupuncture points and practice acupuncture. Some books used writing in verses that used rhythm, imagery and even poetic language to assist easy learning of acupuncture. The Chinese terminologies associated with every acupuncture point were still hard for westerners or beginners to remember. Although names of acupuncture points can now be replaced as a numerical with their meridian abbreviations, thus obviating the need to remember Chinese names of the acupuncture points or meridians, the repetitive numbers and their locations still remain a difficult learning task for beginners and the inexperienced practitioners. Pioneering teaching materials and improved science of acupuncture prescription from Chinese Medicine universities and colleges had established some logical thoughts on acupuncture prescriptions.

In clinical practice, acupuncture practitioners are the ones who know how to perform Chinese acupuncture. However, these practitioners have to rely on their experience and memory to perform acupuncture treatments. Patients may suffer from serious side effects if acupuncture needle was inserted at wrong body site. Although very uncommon, severe adverse effects due to acupuncture treatment had occasionally happened, they had given acupuncture an undeserved bad image [2].

In order to provide the possible best care to patients receiving Chinese Acupuncture, we had developed a computer system named Chinese Acupuncture Expert System (CAES) in 2007. The CAES is a system that can

analyze patients' presenting symptoms and signs and provides an appropriate Chinese disease syndrome differentiation based on the Chinese Medicine theory extracted from the recommended TCM medical textbooks. CAES would then prescribe the most appropriate Chinese acupuncture treatment for a particular disease syndrome. It can provide both text and animation instructions describing the location and insertion techniques of the acupuncture needle for the treatment.

This paper will present the development of this Chinese Medicine Expert System and illustrate its functionalities.

### The developments of system modules

The Chinese Acupuncture Expert System (CAES) was developed at the Department of Computer Science and Engineering at the Chinese University of Hong Kong after their previous interests and works in medical consultation experts system [3–6] in the 1990's. The CAES has incorporated eight functional subsystems. All the TCM knowledge and acupuncture treatment prescriptions were extracted from a commonly used Chinese textbook "Acupuncture & Moxibustion" [7]. Any uncertainty or ambiguity in the TCM nomenclature or symptoms, we made further reference to various Chinese TCM textbooks and received expert guidance and advice from two experienced acupuncturists who were registered TCM practitioners working in this project.

In this expert system, it incorporates eight functional modules which are

#### Module 1- *the "Add Patient Record" subsystem*

"Add Patient Record" subsystem consists of two parts—they are system interface and a record database. The main function of this subsystem is to create new patient records to the Patient Record database. These records saved can be used in Diagnosis subsystem or Diagnosis History Query subsystem for making appropriate acupuncture prescriptions and retrieving the past diagnoses/treatment for any patient. In the Add Patient Record Subsystem interface, there are several pieces of patient personal information that users have to input into the subsystem. Personal information includes name, gender, date of birth, and hospital/clinic/ID number of the patient. After ensuring the above information are correctly keyed in, pressing the "Add Patient" button will store the patient's information into the record database and then this subsystem will generate a unique Patient ID for the new patient.

Module 2- *the “Diagnosis” subsystem*

“Diagnosis” subsystem had been previously reported by our group [8]. It has three functional blocks: 1) an Intelligent Fuzzy Petri Net (IFPN) that represents the relationship between symptoms and diseases, and performs inference operations to obtain a Chinese disease syndrome; 2) a disease-acupoint database that contains a number of combination grouping between different disease syndromes and treatment acupoints; and 3) a self-learning subsystems that uses a back propagation algorithm to learn the weights in IFPN via a set of training rules.

The Diagnosis subsystem derives the most appropriate Chinese disease syndrome for the reported symptoms and signs and then offers a recommended acupuncture prescription to that particular disease syndrome. It analyses step by step according to the recorded inputs by the user. These inputs are:

- 1.) Preliminary Diagnosis component: it collects and analyses clinical information of the patient’s symptoms and signs and it then provides a list of possible Chinese disease syndromes that the patient may be suffering from.
- 2.) Supplementary Information component: Ten questions are then asked according to the result of the Preliminary Diagnosis. After analyzing the additional information from answers to these ten questions, a diagnosis of the Chinese disease syndrome based from Chinese Medical diagnosis will be suggested and presented to the user.
- 3.) Based on the preliminary diagnosis, a list of subsequent questions is presented in Table 1 as examples.

Module 3- *the Acupuncture Prescription subsystem*

The Diagnosis subsystem provides a list of appropriate disease syndromes that a patient may suffer. The acupuncture prescription system will list a number of acupoints that can be used as principal acupuncture points to treat this disease syndrome. The treatment parts were divided into two tables. The upper one contains the recommended principal acupoints, and the bottom one contains some supplementary acupoints that may enforce the effectiveness of the primary acupuncture treatment. The principal acupuncture points suggested are based on the traditional therapy for the particular sickness. The supplementary (additional) acupuncture points (peixu (配穴) in

**Table 1** A list of additional information questions—10 of the below questions will be asked based on the preliminary diagnosis

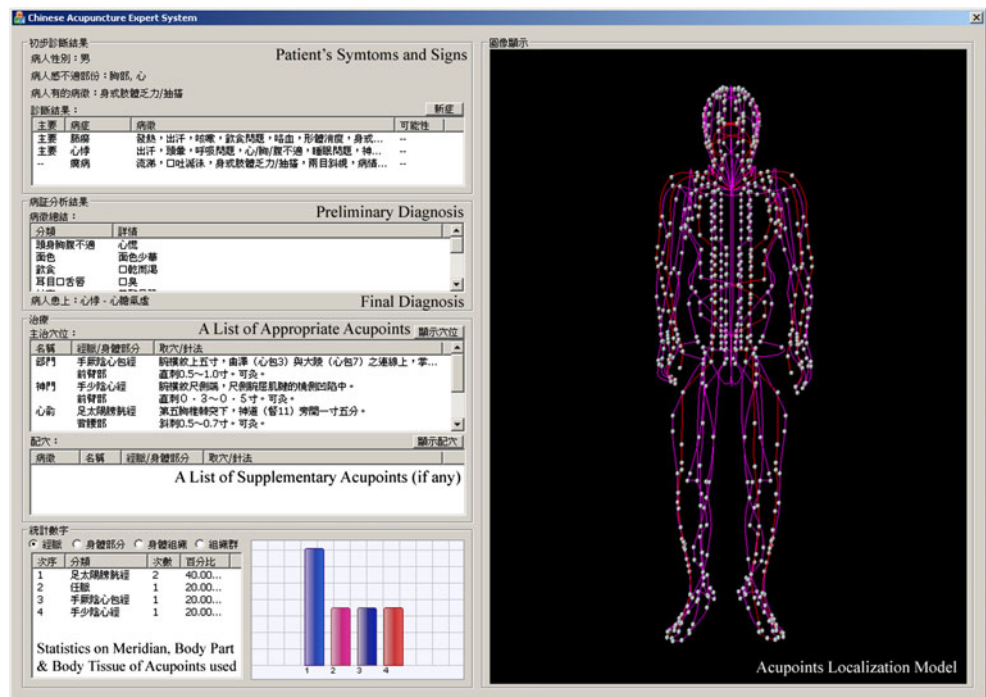
Question no.	Question
1	Is the patient’s body temperature normal?
2	Is the patient’s breathing normal?
3	Is the patient’s tongue normal?
4	How is the patient’s pulse?
5	Is there any discomfort in the patient’s head, body, chest and abdomen?
6	Does the patient’s body shape change?
7	Has the patient felt pain?
8	Does the patient sleep well?
9	Does the patient in good mind condition?
10	Are the patient’s eyes, ears and lip in normal condition?
11	How is the patient’s facial condition?
12	Whether the patient has felt sick in the nose or throat?
13	How is the patient’s sputum look like?
14	Does the patient have runny nose?
15	Does the patient have cough?
16	Does the patient have excessive sweating?
17	Has the patient’s eating habits changed?
18	Does the patient have vomiting?
19	Is the patient’s urine or faecal excretions normal?
20	Does the patient have gynecologic symptoms?
21	Does the patient have mense-related symptoms?
22	Has the patient had other unusual circumstances?

Chinese) are targeted to some specific symptoms that the patient suffered from. Given the wide possibility of acupoint selection from each syndrome, the ten questions we used are extracted from our reference TCM textbook which would guide us the principal and supplementary acupoints selection. Figure 1 showed the names of acupoints, positions of the acupoints on the body and the method of inserting the acupuncture needles.

Module 4- *the Needle Insertion Position Animation subsystem*

After all the analyzing process on the left hand side of CAES screen, CAES can provide teaching animation of each acupoint position that is recommended [Fig. 2]. The locations of acupoints as recommended by the CAES treatment system are shown as a red spot on acupoints in the animation models. There are four types of animations for needle insertion position—Skin Model Animation, Muscle Model Animation, Bone Model Animation

**Fig. 1** The table showed both the diagnosis subsystem and the acupoints prescription subsystem. The first box showed the patients' symptoms and signs; the second box gave a list of the preliminary and the final diagnosis; the third box contains the most appropriate acupoints for a disease syndrome, and the fourth box contains some supplementary acupoints (if any) that can enforce the effectiveness of the primary acupuncture treatment. The lowest box showed the user statistics of the acupoints used in the patient



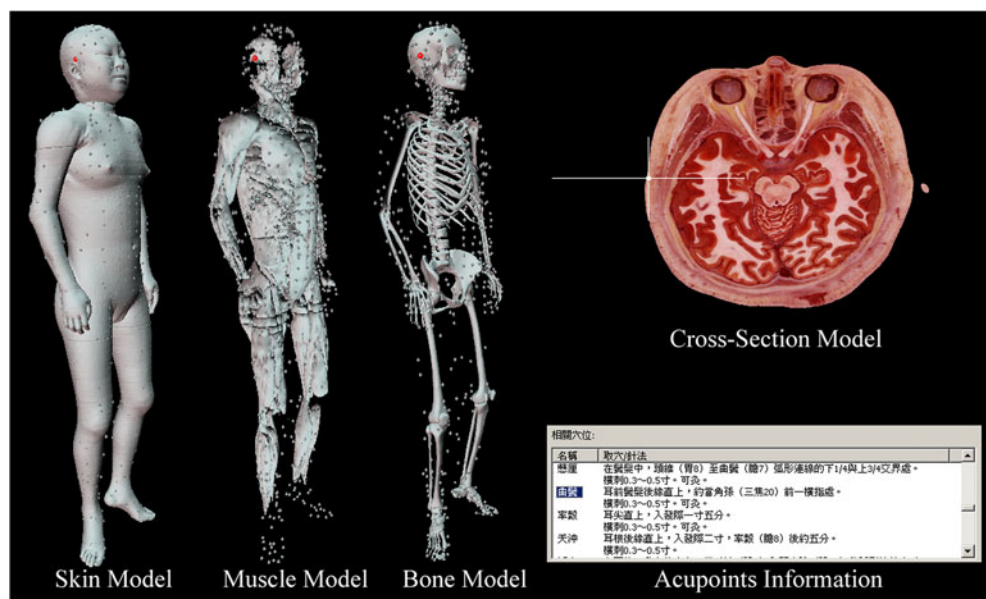
and Cross Section Layer Animation. These models will assist users to identify the exact location of the acupoints by animation pictures. With the help of these needle insertion cross section layer animations, it would be more accurate and easier to identify the correct acupoints by the users in any treatment process.

In its further development during the construction of CAES, the following subsystems were developed to enhance the functionality of CAES as well as to tailor it for future evaluation.

**Module 5- the Acupuncture Points Usage Statistic subsystem:**

The purpose of this Acupuncture Points Usage Statistic subsystem is to audit the number of times of any acupuncture point is used as recommended from various acupuncture prescriptions for any disease syndromes. These numbers are represented in a Bar Chart for any disease syndromes as shown in Fig. 1. These statistics can provide assistance to investigate the frequency of various combination acupoints used in any disease, and

**Fig. 2** The needle insertion position animation subsystem





hopefully it will provide a reliable evidence of various acupuncture treatments in a particular disease. This outcome analysis will be very useful through future data mining of these data to provide evidence of the useful acupuncture points.

Module 6- ***the Diagnosis History Query subsystem***

This subsystem is designed for practitioners who would like to look back into any patient's diagnosis histories, acupuncture treatment histories and outcome histories, so as to select those useful acupuncture treatments or adjust to more appropriate treatments by referencing to the past acupuncture treatment. Practitioners can retrieve his/her patients' diagnosis histories conveniently through this Diagnosis History Query System.

Module 7- ***the Acupuncture Points Query subsystem***

Acupuncture Points Query subsystem is to target either TCM students or beginners practicing Chinese Medicine. This subsystem is a search engine that can provide detailed information and locations about all acupoints and provide cross section layer animation pictures to show the technique of needle insertion as in Fig. 2. Beginners and students then can learn all the acupuncture points conveniently without only referring to the textbook.

Module 8- ***the Diagnosis Remarks and Diagnosis Record Save subsystem***

Outcome, side effects, and complications can be input into the expert system by the user through this subsystem. Practitioners can jot down useful notes and remarks for the specific treatment for further use by pressing the "Diagnosis Remarks" button. By pressing the "Diagnosis Record Save" button, the system will save the diagnosis result for the patients according to the patient ID input on the starting of the diagnosis.

The diagrammatic design of the Chinese Acupuncture Expert System is shown in Fig. 3. After new patient data are keyed into the Expert System, a new patient record will be formed. Old patient will be retrieved by searching the patient record database which will provide the previous diagnosis history. Any new symptoms and signs as well as specific supplementary answers will help the diagnosis database with reference to the TCM knowledge base and past diagnosis history to derive the most appropriate Chinese disease syndrome and then offers a recommended acupuncture prescription to the disease. It also analyzes step by step any previous recorded input by the user.

## Results

The CAES is a system that can deduct and list the possible Chinese diseases or sickness based of a number of symptoms and signs input from a user. There are two important features incorporated into the CAES system. The first feature is the disease's Chinese medicine syndrome generation. Chinese medicine requires a practitioner to examine a patient's signs and symptoms through four diagnostic methods—inspection (wàng), olfaction (wén), inquiry (wèn), and palpation (qiè). In the preliminary diagnosis stage, CAES analyses input from these methods from the practitioner or user, and makes a diagnosis according to the presenting symptoms and signs from patients. After a preliminary diagnosis, users need to answer ten tailor-made relevant questions. Diagnosis of a possible disease or sickness would then be deducted from the CAES. Here is an example of how it works in a diagnosis:

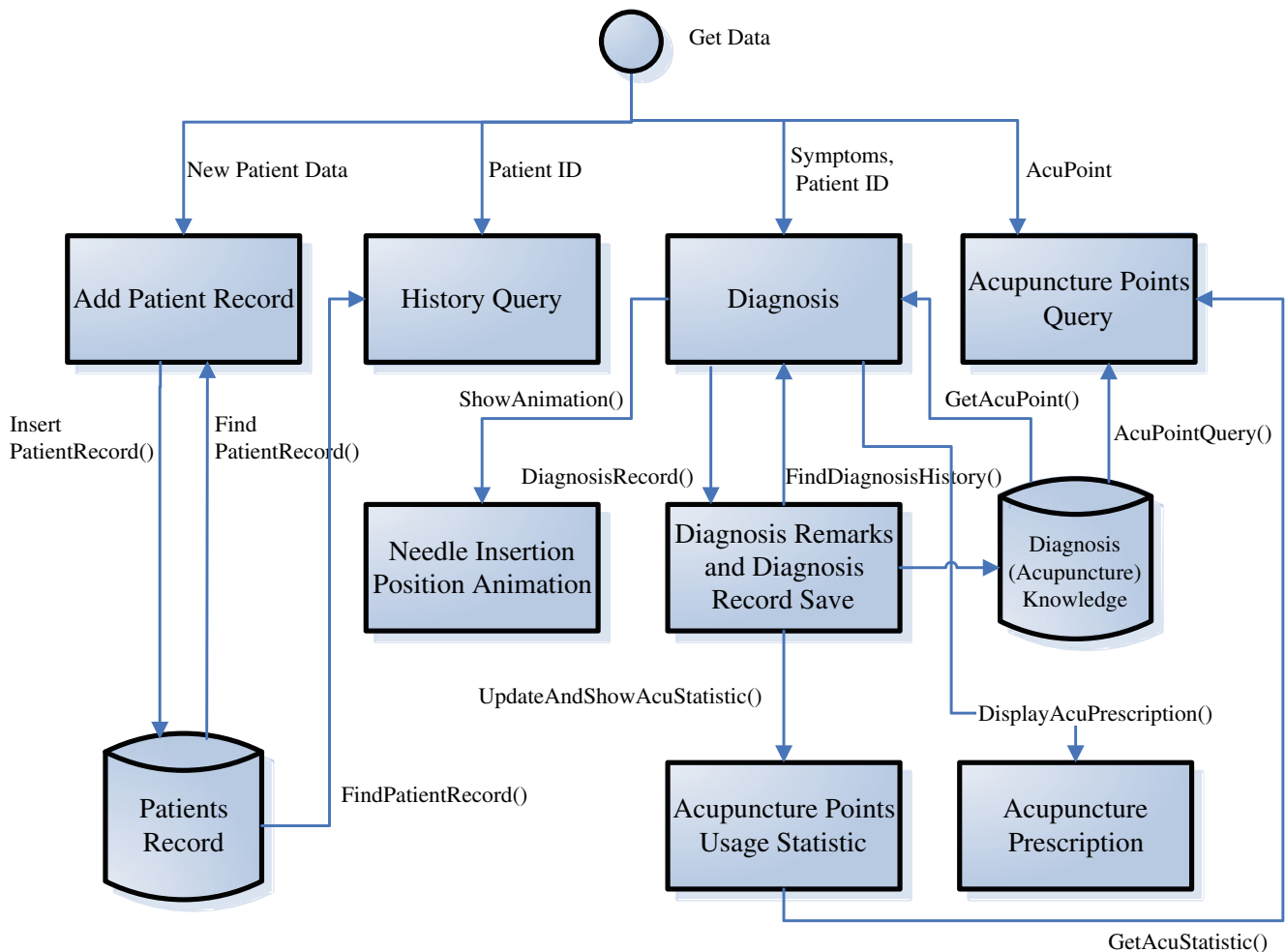
- 1) After basic clinical information are collected, CAES system will create a cluster tree classifying the syndrome in the data pool into different groups, the group that gets the high possibility from our scoring system will be further analysed.
- 2) CAES system will calculate the statistical data among all the disease syndromes in the chosen clustering group. Based on the statistic results, then, ten questions will be asked by the CAES system one by one which can help to derive the final disease syndrome. There are over 180 disease syndromes in the knowledge pool.

As it is impossible to demonstrate all on this paper, we have, therefore, chosen an unusual diagnosis as part of the discussion on our analysis to illustrate the mechanism of diagnosis deduction.

Details with example: Pulmonary disease

We chose chest weakness as our targeted disease. We knew that the patient of chest disease would feel pain on his chest, feel tired all the time and have difficulty breathing. In order to limit the clustering tree size, we chose "feeling tired" as the diagnosis. We assume the situation is a male patient feeling discomfort on the chest and always feeling tired. Information input to CAES would be: Male for gender, Chest problem for main symptom, Languid and Twitch for signs. Initial consulting would be performed to select all possible diseases out from the knowledge pool by statistic. Statistical result showed that in this case, the diagnoses could possibly be 1) pulmonary disease, 2) cardiac palpitation and 3) epilepsy, as all three of them will lead the patient to have tired feeling.

In case of pulmonary disease, together with other signs like fever, sweating, coughing, poor appetite, blood



**Fig. 3** The diagrammatic design of CAES

in phlegm, skinny, languid and twitch, the syndrome could be:

PT1: Hyperactivity of fire due to yin deficiency

PT2: Deficiency of both yin and yang

In case of cardiac palpitation, together with other signs like sweating, dizzy, respiratory problems, pain feeling on heart, chest and abdomen, sleeping problems, mental problem, languid and twitch, the syndromes could be:

PA1: Heart-gallbladder vacuity

PA2: Dual vacuity of the heart and spleen

PA3: Hyperactivity of fire

PA4: Heart yang deficient

PA5: Stasis obstruction of the heart vessels

In case of epilepsy, together with running nose, leaking of saliva, languid and twitch, cannot concentrate on sightseeing, the syndromes could be:

EP1: Phlegm turbidity congestion

EP2: Wind-phlegm congestion

As epilepsy is not a disease that belongs to the category of chest problem, only pulmonary disease and cardiac palpitation will be counted as key factors with high impact to affect the further analysis, however epilepsy will be counted as a minor factor and still has a certain level of influencing power.

The name of the most appropriate disease syndrome, acupoints for treatments are displayed in the diagnosis box (see Fig. 1) in word with a statistic showing commonly used acupoints for that disease as extracted from the literature. The locations of acupoints are also displayed in any of the animation models. Other text information provided are the type of needle and the depth of the needle insertion based on acupuncture prescription for the disease.

The second important feature of CAES is acupuncture treatment animation. CAES offers correct acupuncture needle insertion position information for the practitioners. The available format is in a software-form which can allow the users to perform CAES with both text analysis and animation support on the same software browser. This

enhances the users to gain better understanding of the proposed treatment.

After the development of the CAES, both the acupuncture practitioners in our team had a test run of the system and found its performance very satisfactory. Nevertheless, a formal evaluation will be needed to assess its practicality and validity.

## Discussions

The CAES system provides Chinese disease syndrome diagnosis based on the Chinese medicine knowledge reported in the Chinese literature. The acupuncture treatment subsystems will advise relevant acupuncture treatments to the diagnosed disease syndrome with the help of needle insertion information and animation models. The CAES not only can analyse the input data with relevant to the TCM knowledge database, it can also provide a recommendation of the acupuncture prescription. CAES is able to list all the acupuncture points for any diagnosed disease syndromes. Its query subsystem allowed users to retrieve patients' information to guide their treatments of any specific disease over time. Despite the syndrome differentiation of a disease based on patient's presenting symptoms and the ten auxiliary questions can meet with strong criticism about its accuracy, the syndrome diagnosis is based on knowledge obtained from various TCM textbooks and expert advice from experience acupuncturists. The operational definitions for the questions are defined by the textbook we mentioned. "Normal" stands for the patient without the symptom in that specific category. It is true that the operational definitions are hard to be interpreted by general users since the variations bounded by one symptom are hard to distinguish (such as there are at least three operational definitions for describing the whiteness of facial colour). Our system is suggested to be used by TCM beginners for verification purposes, the diagnosis results / treatments generated from the CAES system should be served as reference only. The interpretation reliability and inter rater reliability testing had not been done in this CAES system. Hopefully these refined tests in the future will improve the diagnostic accuracy of this CAES system. In addition, the IFPN subsystem with its self learning subsystem will ensure further accurate refinement of the disease-acupoints treatment recommendation to treat disease. The detail of IFPN inference subsystem has been reported by our group in 2006 [9]. Hopefully this IFPN subsystem will provide a continuous self-learning ability for the CAES system to resolve one of its limitations. As at the early development of this system, it is essentially based on interpreting data form a base set

of text books and then perpetuating these same data by a small number of TCM practitioners to provide logic information for the computer decision making process. We could not have a huge amount of clinical data from a large variety of TCM practitioners in its early development. Without this self-learning subsystem, CAES system will always be self-limiting. Hopefully the computer will continue to learn not only diagnostic data from a single hospital or clinic, it may acquire data from a variety of clinics and a large number of participating TCM practitioners. The larger the data set, it will have a more refined and more accurate decision making process.

This new Chinese Acupuncture Expert System will facilitate the learning and practice process of:

### 1) Students studying Chinese medicine

Students using this Chinese Acupuncture Expert System will find it easier to assist their memorization of all the acupoints on the body, while at the same time relating to the real time clinical case scenario. Learning from the animation of the acupuncture treatment can provide the best studying environment for students to gain observational trainings prior to treatment, which can effectively ease students' stress during their studying. Nevertheless, there has been no evidence that the use of point location dvd's has improved student learning, therefore our system will only make it a less painful task for the student to memorize all these acupuncture points, the design of the 3D animation is to help the beginners to strengthen their learning without referring to their textbook. It must be stressed that all memorizations of acupuncture points have to be built up by repeated practices.

### 2) Junior Chinese acupuncture practitioners—beginners

Beginners in the Acupuncture field are certainly lack of valuable experience as well as frightened by the several hundreds of acupoints on the body to be memorized. It could be dangerous if the Chinese acupuncture practitioners made mistakes on selecting the wrong acupoints. If due to a lack of experience, beginner practitioners might confine themselves to a small number of well known acupuncture points in their practice to treat any disease. This will reduce the effectiveness of acupuncture treatment. Thus, CAES can assist inexperienced practitioners to verify their diagnosis and to practise the most appropriate acupuncture prescriptions, together with a demonstration by the location and insertion of needles by text and animations. Therefore the system can help to verify the provisional diagnosis made by the beginner practitioners and the 3D animation of the system is for increasing the confidence of the practitioners on applying needle insertion treatment.

### 3) Anyone who are interested

Although Chinese medicines and herbs are now popularized, the practice of Chinese acupuncture is broad, inconsistent and difficult. It will be difficult for the public to understand acupuncture. Therefore not only students and practitioners, the public can benefit from this CAES to gain a better understanding of their diseases and the relevant acupuncture treatment when it can be available over the internet for their references. This is important to know that the purpose of this CAES system is not to preplace medical decision making or make this easier for beginner TCM practitioners, rather it is a system which may provide data that might assist the decision making process by providing more information based on patients' morbidity. We fully understand the limitation of this system which based on information from textbook, and on the computer logic derived from information input, it cannot account for the vagaries of clinical practice. Therefore the computer generation diagnosis is not to replace traditional medical diagnosis. We therefore recommend anyone using CAES must have basic Chinese Acupuncture and TCM knowledge prior to using the system. As long as users can use CAES wisely and correctly, they will benefit from its user-friendly design and advice given.

We will continue to upgrade the CAES on many aspects including a web-based personal CAES system for registered users. We also would like to develop a portable user friendly acupuncture treatment and acupoints query system for practitioners. We are in the process of designing a 3D perimysium model of the whole body. This perimysium model of the whole body can give us a better understanding of the relationship between Chinese Acupuncture Treatments and the connective tissues related to the meridians. After building the perimysium model, we hope to do data-mining of the body tissues against acupoints. After these data-mining, we may be able to provide any supportive evidence of the tissue responsible for the function of acupuncture meridians. From the acupuncture points usage statistics, we can also investigate the most appropriate combinations of Chinese acupuncture treatment to any disease for any particular user, data-mining of these data can give us a correlation of the outcome and recommended acupuncture treatment.

To learn Acupuncture, it is important not only to have the right acupoints location or depth of needle insertion, needle manipulation is also very important to improve efficacy by obtaining the de-chi sensation. We plan to build into this CAES system a real time virtual reality

practicing environment and data collection subsystem during acupuncture manipulation, which will allow us to quantitatively analyze the acupuncture manipulation techniques. Finally, the reasons of building this acupuncture expert system is to target TCM students and beginners to use it as a teaching aid throughout their early career development. We believe this user-friendly CAES system will be very useful for learning and practicing acupuncture. Hopefully the Acupuncture Points Query System within CAES can provide the best studying environment for students and beginners to utilize as it can provide useful information of acupoints, their locations, techniques for needle insertion, depth of insertion and other specific information ...etc.

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**Conflict of Interest** Nil

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