

Integrated Application Platform of TCM Diagnosis and Treatment Equipment based on the Integration of Hardware and Software

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Abstract: In terms of hardware, the integrated application platform of TCM diagnosis and treatment equipment is based on TCM diagnostic equipment such as telescopic apparatus, pulse diagnostic apparatus, infrared apparatus and meridian apparatus from different manufacturers, and the laboratory of key TCM technology and equipment is established to carry out empirical research on the dismantling and rearrangement of TCM basic theory concepts, and to provide TCM diagnosis for TCM clinical trials based on the integrated application and data collection of TCM diagnosis equipment. In terms of software, the platform establishes the data interface of each device and the multi-source information fusion algorithm that simulates the four diagnoses of TCM with the ontology of TCM engineering field as the core; it is valuable for the collection of TCM objective diagnosis information, efficacy evaluation and big data analysis.


1 INTRODUCTION


Traditional Chinese medicine emphasizes "four-diagnosis integration", in which inspection, listening and smelling, inquiring and pulse diagnosis are all important elements of Chinese medicine diagnosis and inheritance. In ancient times, Chinese medicine practitioners did not have modern testing technology, so they used to diagnose and judge the efficacy of the treatment based on their experience with the four-diagnoses of inspection, listening and smelling, inquiring and pulse diagnosis. With the development of modern science and technology, researchers hope to use TCM diagnostic equipment to help TCM doctors diagnose diseases and objectively record the information of the process. TCM diagnostic equipment refers to instruments, equipment, apparatus, materials and other items (including the required software) applied under the guidance of TCM theory, and is medical equipment developed by applying modern science and technology and methods (Cui, Xu 2018). Its R&D activities are closely related to the demand situation of TCM clinical use.

Since the 1970s, the research on the objectification and instrumentation of diagnosis methods such as pulse diagnosis and tongue diagnosis in TCM was started in China, which laid an important foundation for TCM equipment-assisted diagnosis (Zhuo, Zhang 2014). At present, there are a total of 14 enterprises producing TCM diagnostic equipment in China, and the listed products that have gotten the approval include tongue instrument, pulse instrument, infrared instrument, meridian detector, etc. Since TCM is concerned with holistic concept, it needs to synthesize and integrate new results of various diagnostic studies, and adopt some new diagnostic algorithms to integrate multiple sources of information together to achieve intelligent four-diagnosis integration, or four-diagnosis fusion, which is a model more in line with traditional TCM theory.

At present, the objective information collection technology of four-diagnosis of TCM and the corresponding intelligent devices have made great progress, and the combination with artificial intelligence technology is an inevitable trend, but there are still many problems to be solved: most algorithms are based on single source information,

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such as facial diagnosis, tongue diagnosis or pulse diagnosis to make analytical judgments; a large number of excellent cutting-edge deep learning methods are applied due to the lack of objective collection data difficulties. This may be due to the lack of subjective understanding of the holistic view of TCM theory by the developers of smart devices, or to the lack of standard high-quality labeled TCM data with multiple sources of information, resulting in poor accuracy in the integrated processing of multiple sources of information (Qi, Li 2017). The collection of TCM diagnostic learning samples requires finding suitable automated methods, such as using portable devices, to facilitate the collection of large data training samples and to promote the objective collection of information from the four TCM diagnoses as well as to simulate the traditional TCM thinking pattern of the four-diagnosis integration.

Based on the TCM diagnostic equipment such as telescopic apparatus, pulse apparatus, infrared apparatus, meridian apparatus, etc. from different manufacturers, this study establishes a laboratory for key TCM technology and equipment, and develops a software platform to link the communication interfaces of each equipment to form an integrated software and hardware TCM diagnostic equipment application platform; and carries out data-based empirical research based on the dismantling and rearrangement of basic TCM theories and concepts. Meanwhile, we provide technical support in TCM diagnostic equipment for TCM clinical trials.

2 THEORETICAL RESEARCH: RESEARCH ON OBJECTIVE MEASUREMENT

The theoretical basis of the integrated application of TCM diagnosis and treatment equipment is to propose a TCM engineering concept system that can be measured by modern science and technology, so that the measurement signal of the instrument can be interfaced with the basic theoretical system of TCM through the interface of measurement elements and evidence, in order to solve the problem of difficult interface between the theoretical system of TCM and modern science and technology.

In this study, we reviewed the literature related to TCM diagnosis, sorted out the TCM basic theories and diagnostic concepts such as etiology, pathogenesis, location and nature of disease, and acupuncture concepts such as meridians and acupoints, selected appropriate measurement objects,

and established a system of measurement variables. The instrumental measurement objects of TCM symptoms are defined as the smallest measurement units, described as measurement elements in TCM language and as measurement variables in engineering language. The measurement variables are logically independent and have clear boundaries, and the measurement variables and values are distinguished.

Based on the concept of "evidence element" in modern TCM diagnosis, we systematized the types of TCM evidence variables in the literature and constructed a system of five types of measurement variables: positioning variables, physiological variables, pathogenic variables, school measurement variables and specialist measurement variables, as shown in the following table.

Table 1: The system of TCM concepts used for measurement.

Variable type	Measured Variable
Variable type 1	Heart, liver, spleen, lung, kidney, stomach, gall bladder, small intestine, large intestine, bladder, triple jiao,
Variable type 2	Essence, spirit, qi, blood, fluid, yin, yang
Variable type 3	wind,cold, heat, humidity, dryness, fire,epidemic,phlegm, food, insects
Variable type 4	Wei, Qi, Ying, and Blood components; Chest and diaphragm [upper jiao], lesser abdomen [lower jiao], spleen and stomach [middle jiao];
Variable type 5	eyes (meatus, blood, qi, wind, and water chakras), ears, nose, pharynx, and teeth;
Added Variable

3 SOFTWARE PLATFORM: TCM MULTIMODAL DATA COLLECTION SYSTEM

A TCM multimodal data acquisition system PC and APP for doctors and a WeChat app for patients were developed to collect data and signals measured by TCM diagnostic equipment and various instruments.

3.1 Multimodal Data Acquisition System PC Side and APP (Physician Side)

The PC side and APP of the multimodal collection system include several basic functions such as case management, decision support, data statistics, and physician information on the one hand, and on the other hand can link the communication ports of TCM diagnostic equipment such as camera, microphone, pulse diagnostic instrument, and can support sub-visit case management such as initial consultation and follow-up consultation.

The diagram shows the home page with four modules: camera, microphone, pulse diagnostic instrument, and case; the device then takes pictures of the designated areas to complete the collection of data in order to provide good conditions for treatment, such as eyes, ears, and tones. Finally, the pulse instrument is connected to upload the collected signal data and display it to form the overall information to complete the final data collection.

The TCM multimodal APP can be downloaded at:
<http://124.70.72.144:802/download/download.html>

Homepage of TCM multimodal data acquisition system physician website can be visited at:
<http://124.70.72.144:802>

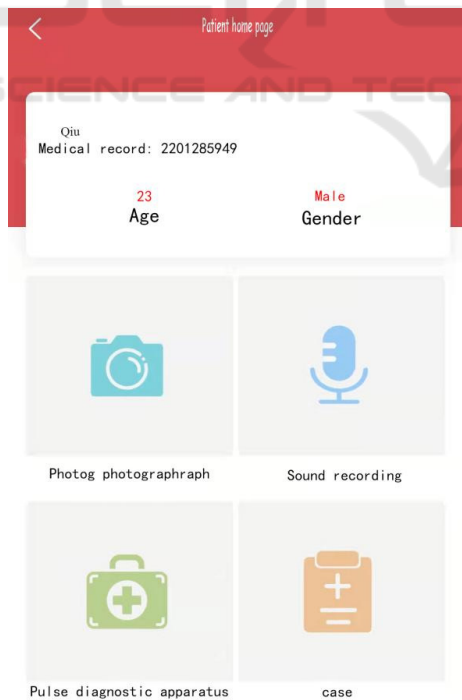


Figure 1: The whole process of TCM multimodal data acquisition system APP.

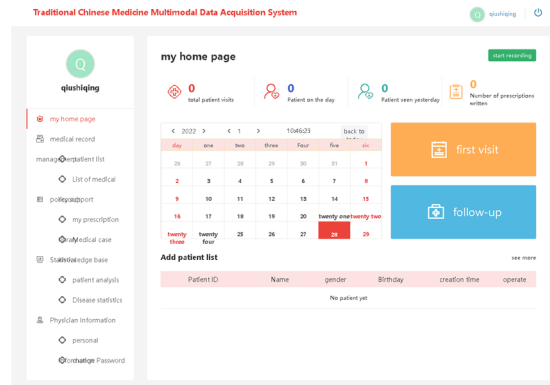


Figure 2: Homepage of TCM multimodal data acquisition system physician.

3.2 Data Collection Applet (Patient Side)

After the patient logs into the applet, the tongue image, facing and voice are captured and submitted for analysis according to the standard practices provided by the system, and a self-assessment questionnaire is also provided for the patient to record and report symptoms. The applet side can be a complement and extension of the physician side, allowing the collection of tongue image, facing and voice in an out-of-hospital setting, and in clinical studies, saving the time of filling out questionnaires on site.



Figure 3: Diagnosis and Methodology Hessian Applet.

4 HARDWARE SELECTION: INTEGRATED APPLICATION OF TCM DIAGNOSIS EQUIPMENT

In terms of hardware, the TCM diagnosis equipment integrated application platform is based on TCM diagnostic equipment such as telescope, pulse diagnostic instrument, infrared instrument and meridian instrument from different manufacturers to carry out research on TCM diagnosis equipment integrated application, and at the same time to provide technical support in TCM diagnosis equipment for TCM clinical trials.

At present, the platform has established a TCM key technology equipment laboratory in the basic theory research of TCM at the Chinese Academy of Traditional Chinese Medicine, and replicated this laboratory as a model and center to establish a sub-center in the Wuhan Hongshan District Chinese Hospital. The sub-center is configured with the same equipment according to the demand and carries out clinical trials or accumulation of clinical real-world data simultaneously.

4.1 Platform Hardware: Testing Principle and Algorithm Model of TCM Diagnostic Equipment

4.1.1 Visual Diagnosis Instrument

Thanks to the rapid development of Computer Vision (CV) technology, tongue, face, and eye diagnostic instruments are more frequently used, and their detection principles are mostly based on the theory of TCM holographic partition diagnosis to analyze the photos taken by the instruments and provide reference for disease diagnosis by identifying disease characteristics under specific holographic partitions. It provides reference for disease diagnosis by identifying disease characteristics in specific holographic zones. Due to the intuitive features and high consensus of tongue analysis, the accuracy of the intelligent model can reach 85%; however, due to the existence of different TCM diagnostic theories, further data collection is needed to train the intelligent model for facial diagnosis and visual diagnosis.



Figure 4: Facial diagnostic instrument.

4.1.2 Pulse Detection

Compared with the lookout type instruments, the pulse instrument differs greatly in various aspects such as the principle. Based on pressure-pressure detection, as well as different detection principles such as photoelectricity and ultrasound and different sensors, respectively, a variety of pulse diagnosis instruments have appeared on the market, such as the BYS-14 four-conductor pulse instrument, YGJ medical manager multi-functional identification instrument and so on. The current application is the pressure type pulse diagnosis instrument which is similar to the intuitive feeling of Chinese medicine. Its algorithm principle is based on the pressure-pressure signal collected by the sensor for time domain and frequency domain analysis, and is classified and calculated by calculating pulse position, pulse rate, pulse rhythm, pulse force, tension, fluency, and other characteristic indicators, using the 28 pulse signs of Chinese medicine such as floating and sinking latency as labels.



Figure 5: Instrument of pulse.

4.1.3 Infrared Meter

The detection target of infrared meter is human body surface temperature, which performs computerized thermal state analysis and image processing on the collected infrared images of human body to achieve rapid spatial localization and quantification of TCM organs, meridians and acupuncture points. Its algorithm model first divides the five internal organs and twelve meridians areas on the human body surface according to the TCM holographic theory, and then analyzes the temperature distribution. At present, the clinical application of infrared instrument includes "treating the untreated disease", primary screening of major diseases, monitoring of chronic diseases, special examination, and observation and evaluation of therapeutic efficacy.



Figure 6: Human body infrared detector.

4.1.4 Meridian Instrument

Due to the slow progress of meridian research, there are concerns about the testing principle of meridian instrument in TCM. However, this does not seem to affect the use of meridians by TCM doctors to guide clinical diagnosis and perform efficacy evaluation. The meridian point diagnostic model of the TCM meridian instrument diagnoses the status of qi, blood, yin and yang, physiology and pathology of human organs and determines the functional and pathological changes in the human body by measuring the bio-current values and integrating index information of specific meridian points in the human body. The information that can be collected

and analyzed includes the changes of resistance, voltage, capacitance and temperature values of 48 holographic points, such as the 12 original meridian points and the 'holographic naked points' of human organs and organs (such as the sensitive points on the inner and outer back of the feet).



Figure 7: TCM meridian detector.

5 PLATFORM SERVICE: OBJECTIVE MEASUREMENT INDEX OF TCM

Starting from the existing equipment, the integrated application platform of TCM diagnosis and treatment equipment compares and fuses the objective testing information with the original four diagnostic information subjectively observed and textually recorded by doctors, so as to increase the objective testing indicators for TCM diagnosis, identification and efficacy evaluation on the one hand, and to establish an engineering interface suitable for cross-fertilization of medical industry for TCM equipment research on the other hand. The objective indexes supporting the collection include:

Table 2: Objective measurement index of TCM.

Information source	Collection tool	Collection of information	Collection of indicators
Face diagnosis image	Intelligent Body Recognition Instrument (Dawson)	Frontal human face, each gender, age, unobstructed color image	Face-hand holographic zoning colors: heart, liver, spleen, lungs, kidneys;
Tongue Diagnosis Images	Tongue Diagnostic Instrument (Dawson)	Frontal tongue image, sublingual ligament image	Color of tongue, redness at the tip, petechiae and petechiae, moss color, moss thickness, moss greasiness,

			moss decay, moss peeling, tongue fatness, tooth marks, punctures, cracks, etc.
Pulse Information	Pulse Diagnostic Instrument (Dawson)	Sensor array type and number of points, pulse cycle waveform pattern (data length is about 10s)	Pulse position, pulse rate, pulse rhythm, pulse force, tension, fluency
Meridian Information	Meridian Detector (Hainda)	Electrical impedance value of acupuncture points	12 meridian acupuncture point electrical impedance
Infrared thermal image	Infrared detector (Jiangshan)	Infrared thermal image of face or whole body	Face-hand holographic zoning temperature: heart, liver, spleen, lung, kidney; whole body to be zoned by meridian points.

Using these research indicators shown in Table 5, clinical real-world researchers of TCM can collect evaluation indicators suitable for the characteristics of traditional Chinese medicine to evaluate the curative effect of traditional Chinese medicine diagnosis and treatment in order to guide disease diagnosis and treatment activities, or as evidence-based evidence. Researchers can choose an appropriate one according to their needs, and then select one or several indicators. Or they can also choose to comprehensively utilize several equipment or all equipment, and then select some indicators of different equipment for joint diagnosis. These devices makes the objective quantification of TCM diagnosis possible.

6 CONCLUSIONS

At present, the development of traditional Chinese medicine is at a great opportunity of "climate, favorable location, and harmony", and the development of clinical diagnosis and treatment equipment of traditional Chinese medicine will also usher in a period of opportunity for leapfrog development.(Yang, Hu 2021).Modern TCM equipment can detect more and more information, fuse subjective and objective multi-source information together, interpret the collected signals in accordance with the TCM way of thinking, and establish an information-comparison assisted diagnosis model, which is more in line with the holistic concept of traditional TCM. It is expected to promote TCM equipment to truly add objective testing indicators for TCM doctors to diagnose diseases, identify and classify or evaluate the efficacy (Wang 2021); at the same time, it also facilitates TCM doctors to accumulate objective data and provide objective tools for the research of TCM efficacy evidence. It is more conducive to processing

and analyzing the "big data" generated by the increasing number of new devices in the future.

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