# Design and evaluation of an intelligent physical examination system in improving the satisfaction of patients with chronic disease

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**Research**

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# Abstract

Background: The doctor-patient relationship is very important for healthcare quality. Improving the patients satisfaction is important for doctor-patient relationship. The relationship between patients with chronic disease and doctors often established in the process of physical examination in outpatient clinics. The use of artificial intelligence (AI) in the Internet of Health Thing (IoHT) introduce the possibility of developing an intelligent system in hospital to establish a good doctor-patient relationship through improving the satisfaction of patients. We aimed to establish an intelligent physical examination system and preliminarily investigate its effect on improving the satisfaction of patients with chronic disease.

Methods: An intelligent chronic disease management system based on the AI in the internet of health things was established. This system was combined with traditional Chinese medicine and western medicine. A total of 115 patients with chronic disease, who underwent physical examination in our hospital from August, 2019 to November, 2019 were enrolled in this study. Among them, 55 patients were in the intelligent system (intelligent group) and 60 patients were in the traditional system (control group). We collected the satisfaction questionnaire of patients who took physical examination in these two systems. Satisfaction score between intelligent group and control group was compared.

Results: A total of 106 patients were finally taken into analyzed . There was no statistical difference in age, gender , education or income level between intelligent group and control group. We found significant differences in the five aspects of satisfaction (1 . the physical examination environment; 2.the attitude and responsiveness of doctors; 3.the attitude and responsiveness of nurses 4.the effectiveness of getting results; 5.the information of physical examination and medical advices) (p 0.05). Moreover, in the logistic regression, the differences were still statistically significant after adjusting age, gender, education and income level.

Conclusions: The intelligent physical examination system might be an effective tool in improving the satisfaction of patients with chronic disease. This could play an important role in establishing a good doctor-patient relationship .


# Background

The doctor-patient relationship is very important for healthcare quality. The satisfaction of patients has a vital impact on the doctor-patient relationship. For patients with chronic disease, the relationship between them and doctors often established in the process of physical examination in outpatient clinics [1–3]. Therefore, improving the patients satisfaction when they undergo physical examination may have an positive effect on the management of chronic disease.

Internet of Thing (IoT) is one of the most emerging wireless network technology in which objects can communicate with each other through Internet to establish different unified systems [4]. Coupled with the use of artificial intelligence (AI), it has been applied in many fields to provide intelligent services, especially in the age of 5th generation mobile networks (5G). Internet of Health Things (IoHT) is the

concept combined IoT with medicine and health, AI in the IoHT typically employ cloud computing, which has a strong data processing capability and the availability of big data in health to realize intelligent medical services [5–8]. The use of AI in the IoHT introduce the possibility of developing an intelligent system in hospitals to predict the risk of patients health problems, and to further optimize hospital resources through anticipating the requirements of patients [5, 9].

In this article, we described the appliance of an intelligent system based on the IoHT in the field of physical examination of patients with chronic disease, and this system was combined with Chinese medicine and Western medicine to offer intelligent health services. All approaches for optimizing the process of patients healthcare were emphasized, and the effect of this intelligent system on improving the patients satisfaction was discussed.

## Methods

# The structure of the intelligent system

The structure of the intelligent system for patients in outpatient clinics based on the IoHT is shown in Fig. 1, including physical examination and health intervention. Patients can quickly get both the accurate results of physical examination and the comprehensive medical advices through electronic and paper versions.

The most obvious advantage of the physical examination in this intelligent system is quick, comprehensive, and low-invasive. The physical examination contains Chinese medicine part and Western medicine part (Fig. 1). Each part contains 6 methods of examination, and all data can be transferred to big data through different equipment for cloud computing

Traditional Chinese medicine part: Traditional Chinese medicine (TCM) was the major treatment for various diseases among Chinese population for thousands of years. Even in nowadays, TCM is still considered as an important option for disease prevention and treatment. In the past, since the data of patients was often recorded subjectively by TCM doctors, lacking of objective data and scientific standardized language, it was difficult to analyze TCM information scientifically. However, with the development of IoT, the establishment of big data in TCM has been promoted greatly, leading to the well appliance of AI in TCM. In addition, most of the TCM examinations are non-invasive or low-invasive, it can effectively predict the health condition of patients, which can be used as an effective supplement for traditional physical examination.

In the Chinese medicine part, the examinations are mainly based on the theory of Yellow Emperor's Inner Canon (Huangdi Neijing), which is one of the most influential book in the field of Chinese medicine, establishing a fundamental theory basis of TCM[10]. All the examinations in this part are non-invasive. A TCM doctor complete the inquiry-feature and palpation-feature examination by recording information of patients through voice-input equipment. Two pictures of patients' tongue are taken for tongue-feature (color, size, coated tongue) examination. The pulse-feature examination, cupping-feature examination,

and eye-feature examination can be complicated by medical instruments. We take cupping-feature examination and eye-feature examination as examples to show the modernization of TCM. Cupping is a common methods of therapy and examination in the field of TCM with a long history, different local site skin pigmentation would be left after cupping, which can reflect the features of patients [11, 12]. In this intelligent system, the cupping features are recorded and uploaded by cups with special sensors which can distinguish the color and temperature of particular skin point to reflect the health conditions of different viscera (Fig. 2A). Examination based on eye-feature is a method of TCM for many diseases. It includes observing the blood vessels, fog, and spots [13]. Different variations in different sites of the eyes can reflect the health status of viscera [14]. In this intelligent system, a novel askiatic imaging method free from an illumination source's reflection shadow and complex manipulations is used for eye-feature examination [15]. Ten pictures of the white part of the eyes are taken for analyzing the viscera condition and the risk of multiple diseases (1: stomach; 2 and 15: spleen; 3: large intestine; 4: small intestine; 5: heart; 6: breast; 7: lung; 8 and 10: kidney; 9: bladder; 11: ovary (testis); 12 and 14: liver; 13: gallbladder; 16: brain; 17: lumbosacral) (Fig. 2B). All these data are recorded and uploaded to big data through IoHT for AI cloud computing, and to further provide comprehensive medical advices. The process of all these 6 methods of examination only takes less than half an hour, and all the results can be obtained in a few minutes.

The Western medicine part: In the Western medicine part, the examination of ultrasound,

computed tomography, electrocardiogram and other technologies (metabolomics diagnosis, pharmacogenomics diagnosis, genomics diagnosis, physiological and biochemical diagnosis, and immunology diagnosis) are connected with the intelligent system, and the images can be read by AI. In addition, many patients with chronic disease are asked for regular blood test, especially the glucose, triglyceride and total cholesterol. This may increase the discomfort and reduce the compliance of patients. However, in this intelligent system, only one drop (12 microliters) of fingertip blood is needed for testing the blood glucose, triglyceride and total cholesterol, and the results can be accurately and automatically get within 15 minutes (Fig. 3A). Moreover, many blood parameters can also be detected through electro interstitial scan (EIS). EIS is a non-invasive examination, using the theory of bio-impedance, electrochemistry, and physiology to produce reproducible measurements of conductance for use as markers of disease or indicators of treatment response [16]. Also, the data of EIS can be sent to big data for AI analysis (Fig. 3B).

# Study population

We performed a prospective cohort study. We prospectively enrolled 55 patients (intelligent group) who underwent the physical examination in the intelligent system from August 2019 to October 2019. Another 60 patients (control group) who took the physical examination in the traditional system were also enrolled from August 2019 to November 2019. The inclusion criteria: 1) age 18–80; 2) with one or more chronic health problems (such as hypertension, diabetes, coronary heart disease,hyperlipidemia);3) without acute health problem; 4) inform consent. The exclusion criteria: 1) with serious primary disease (such as cancer, systemic lupus erythematosus diseases require major surgery); 2) unwillingness to

provide written informed consent. We recorded the basic information of all participants. Participants were free to choose which questions they wanted to answer. This study was approved by the Ethics Committee of Shanghai East Hospital, Tongji University School of Medicine.

# Satisfaction score

We collected the satisfaction questionnaire of patients who took physical examination in intelligent system and traditional system. The satisfaction questionnaire mainly contained five aspects: 1) the physical examination environment; 2) the attitude and responsiveness of doctors; 3) the attitude and responsiveness of nurses 4) the effectiveness of getting results; 5) the information of physical examination and medical advices. The score of satisfaction ranged from 1 to 5 (1: very dissatisfied; 2: dissatisfied; 3: medium; 4: satisfied; 5: very satisfied) (**Additional file 1**).

# Statistical analyses

We performed the analysis using Software of SPSS22.0 (IBM SPSS, Armonk, NY, USA).The continuous variables fitting the normal distribution were expressed as mean ± standard deviation (SD), and the statistical analyses were conducted by student's t test or Mann-Whitney u test. The categorical variables were expressed by number and percentage, and tested with the Chi-squared test or Fisher's exact test. Parameters with P  0.3 in above analysis were taken into multivariate logistic regression to test the association between satisfaction score and different groups. $P < 0.05$ was considered to be statistically significant.

## Results

# Baseline information

A total of 106 patients (51 patients in the intelligent group and 55 in the control group) who fulfilled the inclusion criteria were finally taken into analyzed, 9 patients were excluded due to incomplete information. The reliability of the satisfaction questionnaire was 83.70% and the validity of the satisfaction questionnaire was 85.76%.

# Comparison of basic information between intelligent group and control group

There was no statistical difference in age ($p = 0.839$), gender ($p = 0.881$), education ($p = 0.297$) or income ($p = 0.123$) level between intelligent group and control group (Table 1).

Table 1
Comparison of basic information between intelligent group and control group

| Parameters | All subjects (n = 106) | Intelligent group (n = 51) | Traditional group (n = 55) | P value |
|---|---|---|---|---|
| Age(year) | | | | 0.839 |
| ≤ 30 | 13(12.3%) | 8 (15.69%) | 5 (9.09%) | |
| 31–40 | 21(19.8%) | 10 (19.61%) | 11 (20.00%) | |
| 41–50 | 31(29.2%) | 15 (29.41%) | 16 (29.10%) | |
| 51–60 | 31(29.2%) | 13 (25.49%) | 18 (32.73%) | |
| ≥ 60 | 10(9.4%) | 5 (9.80%) | 5 (9.09%) | |
| Sex | | | | 0.881 |
| Male | 34(32.1) | 16 (31.37%) | 18 (32.73%) | |
| Female | 72(67.9) | 35 (68.63%) | 37 (67.27%) | |
| Education(year) | | | | 0.297 |
| ≤ 12(Senior high school) | 26(24.5%) | 12 (23.53%) | 14 (25.45%) | |
| 13–16(Junior college/undergraduate) | 65(61.3%) | 29 (56.86%) | 36 (65.45%) | |
| ≥ 17(Postgraduate) | 15(14.2%) | 10 (19.61%) | 5 (9.09%) | |
| Income (yuan/month) | | | | 0.123 |
| 5000 | 2(1.9%) | 0 (0.00%) | 2 (3.64%) | |
| 5000–10000 | 23(21.7%) | 10 (19.61%) | 13 (23.64%) | |
| 10000–20000 | 57(53.8%) | 25 (49.02%) | 32 (58.18%) | |
| 20000 | 24(22.6%) | 16 (31.37%) | 8 (14.55%) | |

# Comparison of satisfaction score between intelligent group and control group

We found significant differences in the five aspects of satisfaction (1. the physical examination environment; 2. the attitude and responsiveness of doctors; 3. the attitude and responsiveness of nurses 4. the effectiveness of getting results; 5. the information of physical examination and medical advices) (all values of p  0.001), and the p value of total score was also under 0.001(Table 2). Moreover, in multivariate logistic regression, after adjusting education and income level whose p values were under

0.3 in above analysis, the differences were still statistically significant (all values of p  0.001), and the p value of total score was 0.004 (Table 3).

Table 2
Comparison of satisfaction score between intelligent group and control group

| Satisfaction measures | All subjects (n = 106) | Intelligent group (n = 51) | Traditional group (n = 55) | P value |
|---|---|---|---|---|
| Environment | 4.46 ± 0.758 | 4.94 ± 0.238 | 4.02 ± 0.805 | 0.001 |
| Attitude and responsiveness of doctors | 4.49 ± 0.746 | 4.96 ± 0.196 | 4.05 ± 0.803 | 0.001 |
| Attitude and responsiveness of nurses | 4.48 ± 0.746 | 4.96 ± 0.196 | 4.04 ± 0.973 | 0.001 |
| Efficiency of obtaining physical examination results | 4.48 ± 0.771 | 4.94 ± 0.238 | 4.05 ± 0.848 | 0.001 |
| Information of physical examination results and medical advices | 4.55 ± 0.500 | 4.90 ± 0.300 | 4.22 ± 0.417 | 0.001 |
| Total score | 22.46 ± 2.768 | 24.71 ± 0.502 | 20.38 ± 2.345 | 0.001 |

Table 3
Association between satisfaction score and different groups

| | Unadjusted | | Multivariate adjusted | |
|---|---|---|---|---|
| Satisfaction measures | OR (95% CI) | P value | OR (95% CI) | P value |
| Environment | 0.051 (0.014, 0.178) | 0.001 | 0.032 (0007, 0.147) | 0.001 |
| Attitude and responsiveness of doctors | 0.036 (0.008, 0.161) | 0.001 | 0.012 (0.001, 0.112) | 0.001 |
| Attitude and responsiveness of nurses | 0.033 (0.007, 0.148) | 0.001 | 0.016 (0.002, 0.107) | 0.001 |
| Efficiency of obtaining physical examination results | 0.069 (0.020, 0.231) | 0.001 | 0.047 (0.011, 0.191) | 0.001 |
| Information of physical examination results and medical advices | 0.030 (0.010, 0.093) | 0.001 | 0.013 (0.002, 0.065) | 0.001 |
| Total score | 0.025 (0.003, 0.189) | 0.001 | 0.012 (0.001, 0.251) | 0.004 |

# Discussion

In this article, we introduced an intelligent system for chronic disease management based on the AI in the IoHT. The combination of traditional medicine and western medicine was one of the important advantages of this system. We highlighted the intelligent system with quick, comprehensive and non-invasive/ low-invasive examinations. Furthermore, we found higher satisfaction scores could be obtained among patients taken physical examination in the intelligent system.

Chronic diseases are important risk factors for acute cardiovascular events. Many hospitals have to spend a lot of resources to improve patient education and discharge planning. But outpatient support may have higher patient satisfaction which is beneficial for further diseases management. A study conducted on all participating hospitals of the Hospital Consumer Assessment of Healthcare Providers and Systems patient survey reported that higher patient satisfaction was associated with better stroke outcomes [17]. Another study carried out in outpatient clinics showed that patients satisfaction was an important part of consultation quality. Consultation quality improvement can develop physicians' clinical competence and skills, which can in turn promote the consultation quality improvement [18]. These results all confirmed the importance of patients satisfaction in diseases management. Improving patients satisfaction with reducing cost might be the direction of future researches. Combining with the development of science and technology may be an effective way to achieve the goal.

With the development of AI and IoT, the collection of data could be totally automatized, which make it possible to analyze information quickly and accurately in big data of health. Previous studies have proven that AI could be widely used in healthcare, nursing and physical examination, especially for patients with chronic disease [19–21]. Guided by relevant clinical questions, powerful AI techniques can unlock clinically relevant information hidden in the massive amount of data, which in turn can assist clinical decision making [22, 23]. Although human physicians cannot be totally replaced by AI, AI can assist physicians to make better clinical decisions or even replace human judgement in certain functional areas of healthcare. This might be an important factor for the higher satisfaction scores of the effectiveness of getting the results in the intelligent group. Moreover, this could improve the efficiency and reduce the degree of crowding in the physical examination environment. The AI technology could significantly diminish the burden imposed on doctors for recording and analyzing the information of patients, allowing doctors to have more time to effectively communicate with patients. So patients in intelligent group were more satisfied with the attitude of doctors. In addition, the big data of health which connected with this intelligent system can provide detailed and personalized medicine advices for each patient based on their examination results. The medical advices contain many aspects, such as diet, emotional regulation, acupoint pressing, medicated bath, and further physical examination. Moreover, we added the application of TCM in the intelligent system and all TCM examinations were non-invasive. This also might be an important reason for higher satisfaction score in intelligent group. With the long historical use, TCM has been considered as a safe therapy for chronic disease. But due to the lack of objective data and standardized scientific language, the information of TCM processing is difficult. TCM has its own characteristics: phenomenon information, epistemological information, time information and

overall information, these are consistent with the characteristics of " Big Data": integrity data, correlation data and fuzzy data [24], so the intelligent system which combined the "Big Data" with TCM, can create new opportunities for the TCM development. Moreover, the system transfers the TCM information into scandalized data to evaluate the condition of patients' health. This can provide qualified information to analyze the development of disease and help doctors to make comprehensive medicine advices. In this intellectual system, we combined the theories of TCM and western medicine. It can not only promote the development of TCM, but also improve the satisfaction of patients. Higher patients satisfaction is very important. Firstly, it is good for the doctor-patient relationship, which can increase the enthusiasm of doctors. Secondly, it is beneficial to improve patient compliance, which is good for chronic disease management.

In this study, we mainly described the structure of this intelligent system and the effect of this system on improving satisfaction scores of patients. More data are still needed to support other functions of this system, such as the effectiveness of managing chronic disease, and the effectiveness of improving satisfaction of doctors and nurses. In addition, the popularization of this intelligent system should also be evaluated. As the questionnaire study was conducted entirely on the voluntary basis, the authenticity might not be guaranteed, especially the income data which might be a sensitive issue in China. Moreover, although we explored the effect of this system on improving the satisfaction of patients preliminarily, the sample size was small and the questionnaire didn't contain more detailed items (such as disease distribution, course of disease and etc.) which might be important factors for the results. Therefore, in future studies, we will further collect more information to solve the above problems and measure the effectiveness of this system more quantitatively and scientifically.

## Conclusions

The intelligent physical examination system might be an effective tool in improving the satisfaction of patients with chronic disease. This could play an important role in establishing a good doctor-patient relationship.

## Abbreviations

IoT: Internet of Thing AI: Artificial Intelligence; IoHT: Internet of Health Thing; TCM: Traditional Chinese medicine; SD: standard deviation; OR: Odd Ratio

## Declarations

# Ethics approval and consent to participate

This study was approved by the Ethics Committee of Shanghai East Hospital, Tongji University School of Medicine. All participant were informed consent.

# Consent for publication

All authors in the manuscript have agreed to submit it to this journal.

# Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

# Competing interests

The authors declare that they have no competing interests.

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# Author Contributions

XC wrote the manuscript; XC and RX D analyzed the data and created the figures; XC, RX D and YS collected the data; HJ devised the study.

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None declared.

## References

1. Janati A, Hasanpoor E, Aslani F, HaghGoshayie E, Hassanzadeh E. "Evaluating visit quality in plan of health sector evolution in Iran: A local survey from Tabriz," (in en). International Journal of Epidemiologic Research. 2017;4(1):69–77.
2. Hasanpoor E, Bahadori M, Yaghoubi M, Haghgoshayie E. and A. J. B. E.-B. M. Mahboub-Ahari, "Evidence-based management as a basis for evidence-based medical consultation.".
3. kalateh sadati A, Tabei S, Lankarani K. "A Qualitative Study on the Importance and Value of Doctor-Patient Relationship in Iran: Physicians' Views". Open Access Macedonian Journal of Medical Sciences. 2018;6:09/26.

4. Davoli L, Belli L, Cilfone A, Ferrari G. "From Micro to Macro IoT: Challenges and Solutions in the Integration of IEEE 802.15.4/802.11 and Sub-GHz Technologies" *IEEE Internet of Things Journal*, vol. PP, pp. 1–1, 09/01 2017.
5. Andreu-Perez J, Poon CC, Merrifield RD, Wong ST, Yang GZ. "Big data for health," (in eng), *IEEE J Biomed Health Inform*, vol. 19, no. 4, pp. 1193 – 208, Jul 2015.
6. Mell PM, Grance T. *SP 800 – 145. The NIST Definition of Cloud Computing*. 2011.
7. o. KJJ, Rasch AI, Environments S. "An unsupervised recommender system for smart homes" vol. 6, no. 1, pp. 21–37, 2014.
8. Jones NJN. "Computer science: The learning machines" vol. 505, no. 7482, pp. 146–148, 2014.
9. Da CCA, Bj?rn PCFE, Bandeira dSD. and d. R. R. R. J. A. I. i. Medicine, "Internet of Health Things: Toward intelligent vital signs monitoring in hospital wards" pp. S0933365717301367-.
10. Ni MJSP. "The Yellow Emperor's Classic of Medicine: A New Translation of the Neijing Suwen With Commentary" 2015.
11. Lowe, Pract DTJCTC. "Cupping therapy: An analysis of the effects of suction on skin and the possible influence on human health" p. S1744388117304024.
12. Qureshi NA, Ali GI, Abushanab TS, El-Olemy AT. and A. M. N. A.-B. J. J. o. I. Medicine, "History of cupping (Hijama): a narrative review of literature" vol. 15, no. 3, pp. 172–181, 2017.
13. "Research Status and Thinking of Traditional Chinese Medicine on Vascular. Dementia %J Continuing Medical Education," 2006.
14. Huang H, Shujuan HU, QJ C. A. o. T. C. M. Peng, "Research Progress and Review of Eye Diagnosis of Chinese Medicine," 2013.
15. N Xue et al., "Original askiatic imaging used in Chinese medicine eye-feature diagnosis of visceral diseases" vol. 11, no. 04.
16. Maarek A. "Electro interstitial scan system: assessment of 10 years of research and development" vol. 5, no. 1, pp. 23–30, 2012.
17. Xiang X, Xu WY, Foraker RE, "Is higher patient satisfaction associated with better stroke outcomes?," (in eng), *Am J Manag Care*, vol. 23, no. 10, pp. e316-e322, Oct 1 2017.
18. Bahadori M, Yaghoubi M, Haghgoshyie E, Ghasemi M, Hasanpoor E, "Patients' and physicians' perspectives and experiences on the quality of medical consultations: a qualitative evidence," (in eng), *Int J Evid Based Healthc*, Nov 12 2019.
19. F Jiang et al., "Artificial intelligence in healthcare: past, present and future," (in eng), *Stroke Vasc Neurol*, vol. 2, no. 4, pp. 230–243, Dec 2017.
20. Clancy TR, "Artificial Intelligence and Nursing: The Future Is Now," (in eng), *J Nurs Adm*, vol. 50, no. 3, pp. 125–127, Mar 2020.
21. Berzin TM, Topol EJ, "Adding artificial intelligence to gastrointestinal endoscopy," (in eng), *Lancet*, vol. 395, no. 10223, p. 485, Feb 15 2020.

22. Murdoch TB, Detsky AS, "The inevitable application of big data to health care," (in eng), *Jama*, vol. 309, no. 13, pp. 1351-2, Apr 3 2013.
23. Dilsizian SE, Siegel EL. "Artificial intelligence in medicine and cardiac imaging: harnessing big data and advanced computing to provide personalized medical diagnosis and treatment," (in eng). Curr Cardiol Rep. Jan 2014;16(1):441.
24. Cui M, Li H, Hu X, "Similarities between "Big Data" and traditional Chinese medicine information," (in eng), *J Tradit Chin Med*, vol. 34, no. 4, pp. 518 – 22, Aug 2014.

# Figures

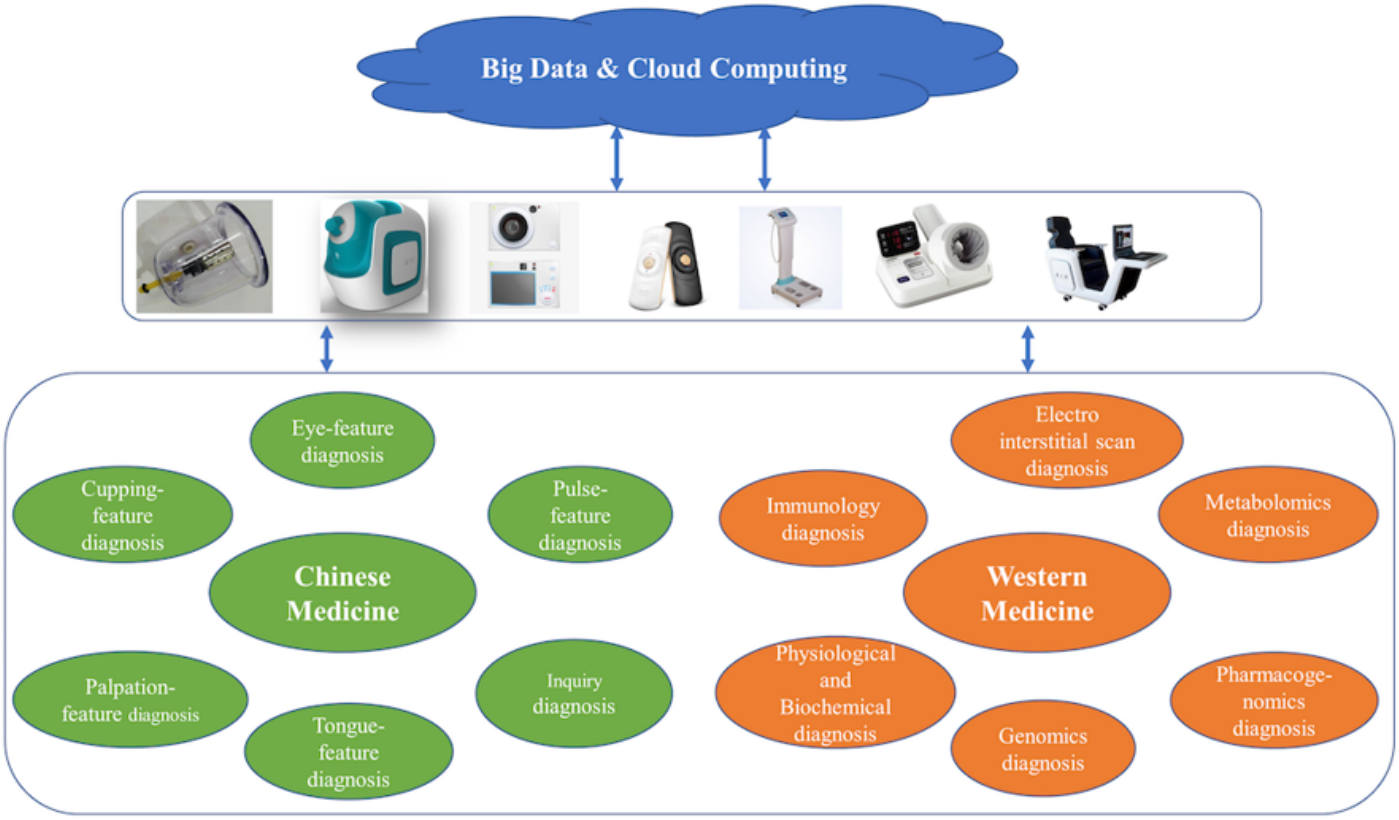
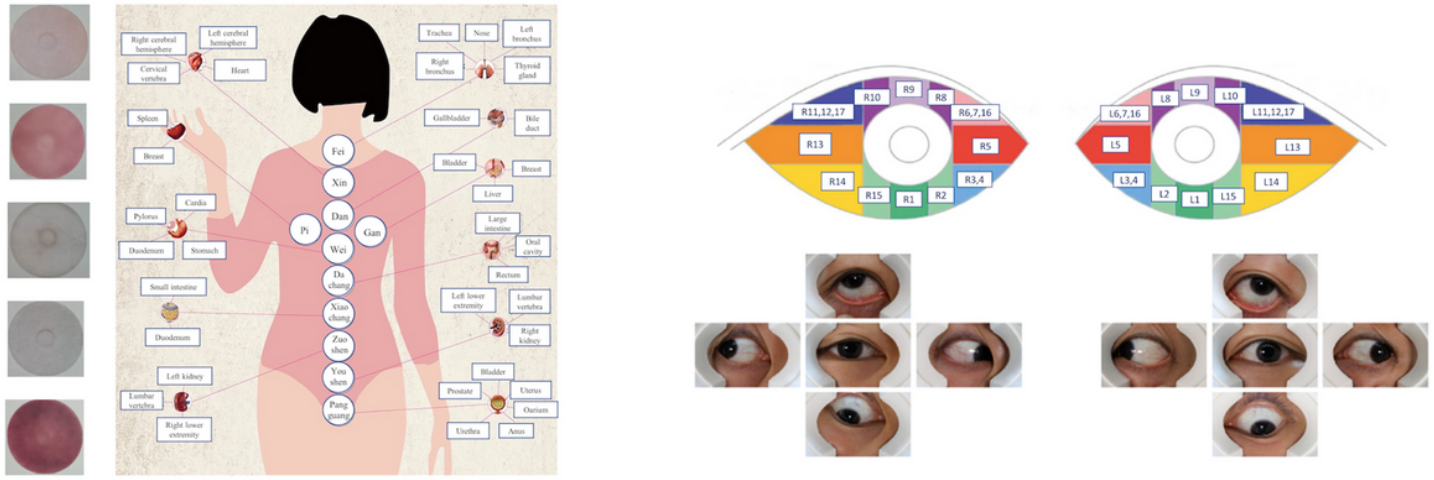



**Figure 1**

The structure of the intelligent system



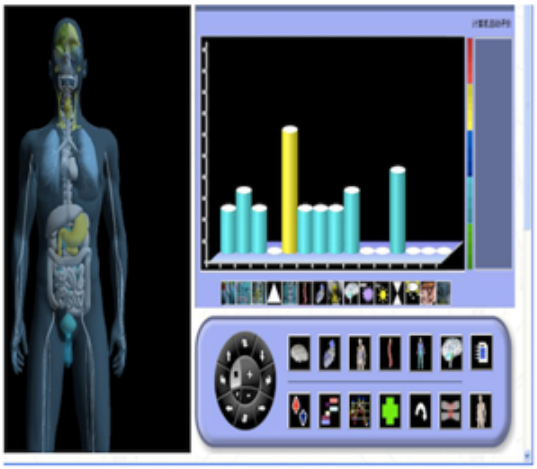

**(A) Cupping features recorded and uploaded by cups**

**(B) Schematic diagram of eye-feature and eye-feature images**

## Figure 2

(A) Cupping features recorded and uploaded by cups. (B) Schematic diagram of eye-feature and eye-feature images

**Figure 3 (A) Automatic biochemical analyzer**



| Parameters | |
|---|---|
| Biochemical parameters | Triglyceride, glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, alkaline phosphatase, transpeptidase, blood glucose, low density lipoprotein |
| Electrolyte parameters | Potassium ion, sodium ion, chloride ion, calcium ion, magnesium ion, iron ion, phosphorus ion |
| Blood gas parameters | carbon dioxide partial pressure, partial pressure of oxygen, residual alkali, pH value, hydrogen ion, bicarbonate ion |
| Hormone parameters | Thyroid stimulating hormone, follicle stimulating hormone, dehydroepiandrosterone, cortisol, aldosterone, adrenomedullin, interstitial testosterone, insulin, parathyroid hormone, thyroid hormone, antidiuretic hormone, and adrenocorticotropic hormone |
| Oxygen free radical parameters | Peroxynitrous acid, small molecule free radical, hydrogen peroxide free radical, superoxide anion radical, hydroxyl radical |
| Neurotransmitter parameters | acetylcholine, catecholamine, dopamine, serotonin |

**Figure 3 (B) Parameters of electro interstitial scan system**

### Figure 3

(A) Automatic biochemical analyzer. (B) Parameters of electro interstitial scan system

## Supplementary Files

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