Development and Application of Mobile Phone Micro-Assisted Photography and Inspection System

Binfeng Xu*, Zijian Chen, Xiaoai Ma and Yarong Hu
The department of Medical Device, Guangdong food and drug vocational college, Guangzhou, China
*Corresponding author e-mail: xubf@gdyzy.edu.cn

Abstract. With the rapid development of modern technology, people's lives have become more and more convenient, but the grasp of physical health is still stuck in a traditional stage. If the body is uncomfortable, most people will go to the hospital for treatment or buy drugs at will to solve the problem. The efficiency of solving physical diseases is not high. This article describes a disease diagnosis system consisting of a mobile phone and a microscope. The system can initially diagnose the patient's condition based on the results of the microscope and give a certain diagnosis report to help the patient more clearly understand his physical condition.

Keywords: Cell Phone, Microscope, TCM Diagnosis

1. Introduction
The fast pace of life in modern society, fierce competition and busy work make most people's bodies in a sub-healthy state. Therefore, everyone is very concerned about their health. However, because of busy work, high costs of medical treatment, and privacy issues related to illness (such as urine, feces, semen, etc.), many people have no way or do not want to go to the hospital for examination. The patient only treats the disease based on past experience, which leads to misjudgment and misses the best treatment time. Some privacy issues cannot be resolved. At the same time, smart phones have played an increasingly important role in people's lives. The improvement of mobile phone hardware performance and the rapid development of 5G network technology have made the application of mobile phones more and more extensive. Therefore, it is becoming possible to realize portable medical diagnosis using mobile phones [1].

As we all know, Chinese medicine is divided into four aspects in medical diagnosis, "look, smell, ask, and cut”. The project team focused on the "Look" part of Chinese medicine. Using innovative microscopy technology combined with the powerful image processing capabilities of the smart phone platform, the team designed a smart phone-based "inspection system". After application, the system can realize the initial diagnosis of the user's condition and at the same time monitor the patient's condition, which has far-reaching application significance in sub-health control [2].

2. Structural Design of the Inspection System
The inspection system is mainly composed of hardware and software. A block diagram is shown in Figure 1. The hardware system collects image data with high magnification microscope and sends it to smartphone. The software system compares the collected image with the image of database, and makes a possible diagnosis suggestion to the user [3].

3. The design of the Hardware System
The hardware system mainly includes two parts, the microscope and a smartphone. According to the design requirements of system, the team uses a high-power microscope which is improved. The additional device can easily install and fix the microscope on the mobile phone. The data collection can be realized through the front camera and the rear camera of the mobile phone by manually adjusting the device. The structure of mechanism is shown in Figure 2. The device uses metal slides rail to adjust the position of Micro-lens for different kinds of mobile phones to apply. In order to prevent the device from blocking out the flashing light of the mobile phone, the device has designed a light source beside the microscope, which is powered by the battery [4].

![Figure 1. Block diagram of the system](image)

![Figure 2. Mechanical structure of the hardware](image)

![Figure 3. Structure of the optical part](image)
The optical part of the system uses aspheric lens which is high-quality and slightly distorted. Furthermore, the lens has a very high resolution. The tiniest distance between the lines is only 3 µm with the observation of the test drawings. The optical structure of the system is illustrated in Figure 3.

Nowadays configuration of the mainstream smart phone has reached an extremely high standard, which means its performance is equivalent to a minicomputer. Thus, the hardware part of the system directly uses smart phone platform to realize capabilities for speeding up the development and reducing the cost as well as easy to promote [5].

4. The Design of the Software System
This inspection system has designed a software system based on the Android platform. The software system is mainly divided into two parts, image photographing and diagnostic analysis, which respectively corresponds to two keys in the software. The user selects the appropriate options according to their requirement [6]. In the first part, the camera lens of smart phone is used to acquire the data obtained by the microscope. The user can directly analyze the image magnified by 400 times and get the diagnosis results. In the second part, the system analyzes the image data and offers some helpful suggestions after analysis. As shown in Figure 4, the user can complete the process according to the system prompts.

![Figure 4. Application flowchart](image)

The medical image processing part of the system is the key portion in the project. As shown in Figure 5, the teams use the diagnostic technology of TCM image in the preliminary research [7].

![Figure 5. The design idea of image processing algorithm](image)

In image processing, in order to analyze and identify the image better, usually preprocess the image to reduce noise impact for the after work of image processing, and make the image easier for image segmentation and feature extraction. In this context, the common processing methods of image include image noise reduction, image smoothing, image enhancement, pseudo color technology, etc. The image processing algorithm which is used to filter and denoise the image effectively, improving the contrast and color of the image and bringing greater convenience for the next work [8].

Image segmentation is the most important part of quantitative analysis in the whole system. Because of the irregular structure image that obtained by microscope, such as tongue and face, using the rectangular image acquisition method will inevitably contain many useless image regions. Therefore, it is necessary to use image segmentation algorithm to extract region of interest (ROI). The algorithm used in the system is to map the collected RGB image to HSV space for generating the corresponding gray image.
The gradient edge detection algorithm based on Laplace, Canny operator and Sobel operator is used to extract the strong edge with gradient, and then the edge pixels are distinguished according to the contour generated by filtering for obtaining the tonal range of ROI pixels. Then a hue threshold range is set for the H-channel image, so that the region in the hue threshold range of the whole H-channel image is the reserved region, and the other tonal regions will be deleted. Finally, the precise ROI contour is obtained by searching the contour and connecting the region.

After getting the ROI of diagnostic image, we need to extract its features. The feature extraction of this system mainly includes two aspects: one is ROI color feature extraction, which according to the TCM diagnostic theory (different colors represent different pathology like tongue color and facial expression), and the other is geometric characteristics of ROI (different geometric appearance and shape represent different pathology). With regard to feature extraction of color, the channel value of RGB space is directly used as the value range of color. However, using the edge detection algorithm mentioned above can also obtain the appearance and shape features of ROI by receiving the parameters like area, skew angle, length, width, circularity and rectangularity in geometric feature extraction.

In the end, the relevant diagnosis suggestions to user will make when the characteristic data obtained by the application compare with the existing data.

5. Application of Inspection System

After the design of the system is completed, the preliminary application is represented by Figure 6 which is the user interface of the software system.

![Software interface of inspection system](image)

**Figure 6.** Software interface of inspection system

Traditional Chinese medicine (TCM) has formed an important theory of TCM diagnostics through holistic concept and syndrome differentiation. According to the experience of Chinese people, TCM diagnosis mainly includes four aspects, "look, smell, ask and cut". Inspection is the first in the four methods of diagnosis, observing the patient's external expression and other diagnostic methods to diagnose the disease. The main contents of inspection are face examination and tongue examination. "Look" refers to judging the health of the whole person and the corresponding internal organs by observing the color change of the facial features of the patient, which is the basis for diagnosis and treatment.

The application of this system mainly has two aspects, one is to analyze the sample of the tested organ, the other is to give the diagnostic suggestions combined with the TCM theory.
5.1. Bacterial Analysis
In the application of software system, the inspection system uses someone's hair as a experimental sample and gets a good display result. During camera shooting, which is non-contact type, we mainly focus on the morphological structure of four parts, which include hair stem, hair follicle, and skin surface and capillary. The micro-graph of hair is illustrated in Figure 7, the automatic diagnosis function of the system can conclude that the volunteer's hair is healthy on the basis of the corresponding hair color. For example, dark red indicates that the hair is dyed or the hair is caused by insufficient nutrition, and the white spots on the sample are dandruff. It is suggested that the volunteer should strengthen hair nutrition and shampoo in time [9].

5.2. Condition Diagnosis
About the functional of the system, the software part is mainly combined with the diagnostic theory of TCM, and uses the test results of face and tongue to analyze and diagnose.

The observation of face is an important part of TCM syndrome differentiation. The face is the place where the meridians and blood vessels gather, so the pathological state of the five internal organs in human body can be reflected by the properties of the face, such as complexion, luster, eyes, skin pigmentation and lip color. Many important information of clinical diagnosis exists in the facial image of human body. According to the theory of TCM, the viscera correspond to the color of the face, which is green, red, yellow, white and black. Blue and black can indicate the pain, red and yellow can indicate heat syndrome, white can indicate cold syndrome, for instance. In the context, the observation of face plays an important role in the judgment of abnormal organs. The face inspection system combines with the dermo copy technology, which is a kind of microscopic image analysis technology to observe the micro-structure and pathological changes of human skin, and its observation range is from the epidermis to the deep dermis. The technology has high clinical application value and potential experimental research space because it can observe the invisible parts of the skin without damaging the skin unnecessarily. Human skin is not absolutely smooth, and the scattering of light by a large number of furrows and ridges is the main obstacle to observe skin. Therefore, we must deal with the optical problems such as absorption coefficient and reflection coefficient. The skin color observed under the microscope is formed by the reflection of melanin in different layers and depths of skin. From the black of the superficial cuticle to the blue of the deep dermis gradually transition, when the multiple layers of the lesions contain pigment, they can also appear black after overlapping. Increased or dilated blood vessels are shown in red, and issue degeneration or scar area showed in white. The facial skin image is shown in Figure 8. After automatic diagnosis, the system shows that there are acne on the face, which may be caused by excessive sebum secretion [10].
One of the most important and pervasive diagnostic methods in TCM is Tongue diagnosis. Tongue diagnosis has not only the advantages of simplicity and immediacy but also the high value in clinical application and self diagnosis. Whenever there is a complex disease diagnosis full of contradictions, tongue examination can quickly clarify the main pathological process and syndrome type. The images of tongue usually reflect the real situation of patients, and the variation of tongue image is equivalent to the variation of health status of the viscera. According to the theory of TCM, human tongue can be divided into five parts, which correspond to the five internal organs. This concept is illustrated in Figure 9. Because of the complexity of the surface structure, the tongue image mainly includes tongue coating and tongue texture. The tongue coating is mainly distinguished by color, such as gray, white, yellow and black. However, the color of tongue texture includes deep-red, red, purple, white, light red, etc. For example, the system draws a conclusion that the volunteer is in a healthy state when the tongue is light red according to the image of the tongue texture.

To sum up, this project designs the inspection system based on the microscopic technology with mobile phone, which makes a preliminary significance to the system, and proves that the system has a good practical significance and is worthy to popularize.

Acknowledgments
This work was financially supported by the 2019 "Climbing Plan" Guangdong University Science and Technology Innovation Cultivation Special Fund Project (No. pdjh2019b0761).

References
[1] Song Haibei, Wen chuanbiao. Research progress on automatic recognition method of TCM face
diagnosis information [J]. Journal of Chengdu University of traditional Chinese medicine, 2019,41 (1): 5-8. (in Chinese)

[2] SCULLY C G, LEE J, MEYER J, et al. Physiological parameter monitoring from optical recordings with a mobile phone [J]. IEEE Trans Biomed Eng, 2012, 59(2): 303-306.

[3] Wang Lin, Hu Jie, Li Fei, etc. The latest development of smart phones in modern medical applications [J]. Journal of Biomedical Engineering, 2014, 31 (1): 222-227. (in Chinese)

[4] HSU RL, ABDEL-MOTTALEB M, JAIN AK. Face Detection in Color Images [J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2002, 24(5): 696-706.

[5] MIYAMOTO K, TAKIWAKI H, HILLEBRAND GG, et al. Development of A Digital Imaging System for Objective Measurement of Hyperpigmented Spots on the Face [J]. Skin Research and Technology, 2002, 8(4): 227-235.

[6] Zhang Guangyu. Research on tongue image segmentation and feature extraction algorithm based on tongue diagnosis of traditional Chinese medicine [D]. Jiangxi: Jiangxi University of science and technology, 2018. (in Chinese)

[7] Hamuda E, Ginley B M, Glavin M, et al. Automatic crop detection under field conditions using the HSV colour space and morphological operations [J]. Computers & Electronics in Agriculture, 2017, 133: 97-107.

[8] Yoshinara K, Taguchi A. Color Image Enhancement in HIS Color Space without Gamut Problem [J]. IEEE Transactions on Fundamentals of Electronics Communications & Computer Sciences, 2015, E98.A(2): 578-581.

[9] Xiong Yueling, Ye Mingquan, Yao Chuanwen, etc. The auxiliary diagnosis system of dermatosis based on mobile medical [J]. China Digital Medicine, 2019, 14 (11): 21-2. (in Chinese)

[10] Chen Mengzhu. Face color recognition of traditional Chinese medicine based on skin color detection [D]. Beijing: Beijing Jiaotong University, 2018. (in Chinese)