Robot-Assisted Acupuncture

Kun-Chan Lan
Department of Computer Science and Information Engineering
National Cheng Kung University
Tainan, Taiwan
klan@csie.ncku.edu.tw

Guan-Sheng Li
Department of Computer Science and Information Engineering
National Cheng Kung University
Tainan, Taiwan
samlee1008@gmail.com

Jun-Xiang Zhang
Institute of Medical Informatics
National Cheng Kung University
Tainan, Taiwan
king841231@gmail.com

***Abstract*—An acupuncture points localization method is implemented on an Android platform. Such a system can be used to locate the relevant acupuncture point and/or drive a robot arm for the purpose of symptom relief (e.g. through acupressure).**

Keywords—Augmented reality, Acupuncture point estimation, 3D morphable model, Robot arm

I. Introduction

Acupuncture therapy is one of the main modalities of treatment in Traditional Chinese Medicine (TCM). Based on the different symptoms of the patient, needling or massaging is applied to the corresponding acupuncture points to relieve the symptoms. However, unless one has been trained for a long period of time, it is hard to remember all of the acupoint locations and corresponding symptoms, due to the complexity and diversity of the acupoints. We designed and implemented an acupoint localization system with a high accuracy through integrating multiple techniques including landmark detection, image deformation and the 3D morphable model (3DMM). In the case of mild symptoms (e.g. headache, sleep disorder), with the aid of our proposed system, the patient can quickly locate the corresponding acupuncture points for the application of massage, and relieve his/her symptoms without the help from TCM physicians.The proposed system includes four stages: symptom input (in which the user interacts with a chatbot to describe his/her symptom), symptom search (according to the symptom described by the user, a TCM database is mined and symptom-related acupuncture points are retrieved), acupuncture point localization and massage with the robot arm, as shown in Figure 1. Due to the space limitation, in this poster we focus on the description of acupoint localization and robot arm control. In addition, we explain our acupoint localization scheme based on a face model.

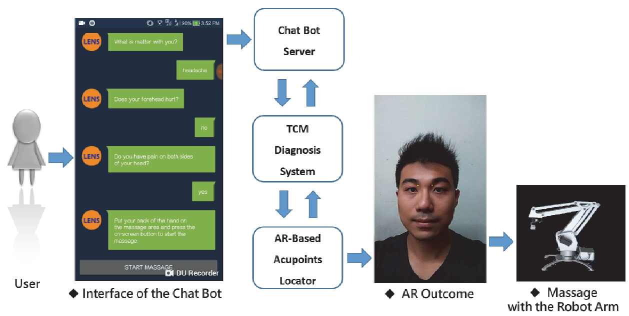

Fig. 1. Structure chart of the system

II. Related Work

H. Jiang et al. proposed Acu Glass [1] based on Google Glass, their system draws the acupoints on top of the input face based on the height and the width of the user's face and the distance between the eyes. However, their system can't adapt to different face shapes and their results are sensitive to the angle of frontal face. Some acupoint probing devices are available in the market by measuring the skin impedance at acupoints, based on the assumption that acupoints generally have a lower impedance compared to the skin areas around. However, Pearson et al. and Mist et al. [2] [3] suggested results from such electrodermal screening devices might not be reliable since the skin impedance could be affected by other factors (e.g. different operators, probe size, skin dryness).

III. Acupoint Localization and Robot Arm Control

Our acupoint localization system can be divided into offline (shown in dark gray) and online (shown in gray) processes as shown in Figure 2. We fit a 3D Morphable Face Model (3DMM) [4] to a 2D image, and combine facial landmarks and image deformation to estimate acupoints. Since the estimation is based on the fitted model, the estimation of acupoints are consistent across different users. During the offline processes, we annotate facial landmarks and acupoints on the mean model of a 3D morphable model. Then in the online processes, we perform face detection on the input image and landmark detection, and fit a 3DMM to get a 3D model which can be matched with the input face. By estimating the pose with 3D and 2D landmark points, the orientation of current 3D face is obtained. We then rotate the 3D face and project landmarks and acupoints into 2D space. Two sets of landmark points are used as control points to perform image deformation [5] and estimate the acupoints. Finally, the estimated acupoints can be visualized on the input face. In order to implement our acupoint localization system on an embedded system , the complexity of the algorithms is considered in our system. We adopted a real time face alignment algorithm developed in [5] and a recently-proposed 3DMM fitting framework [6] to improve the speed of our system.

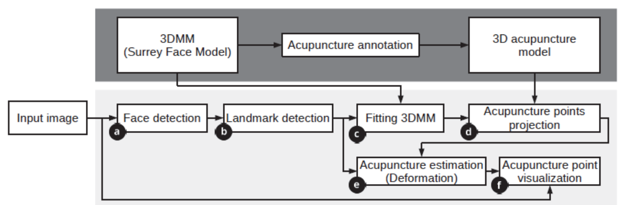

Fig. 2. Flow chart of 3D acupuncture point estimation

Once the coordinate of acupoint image is estimated, the next step is to convert it into the coordinate of the robot arm, which is formulated as a hand-eye calibration problem [7], as shown in Figure 3. The perspective transformation method [8] is used to convert the image coordinate into the robot arm coordinate. Due to that we use a 2D camera to implement our system, the height of the acupoint needs to be considered separately when performing the transformation of coordinates between the image space and the robot arm space.

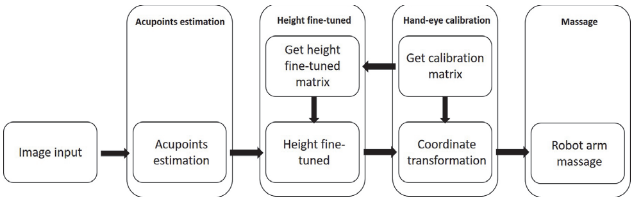

Fig. 3. The process of massage with the robot arm

IV. Results

Fig. 4 shows the impact of face angle to the accuracy of acupoint estimation. We can see that with the 2D based method (as the one used by Acu Glass [1]), the error is higher when the input face is not frontal, the error is up to 11.36 pixels at 30-degree side face.

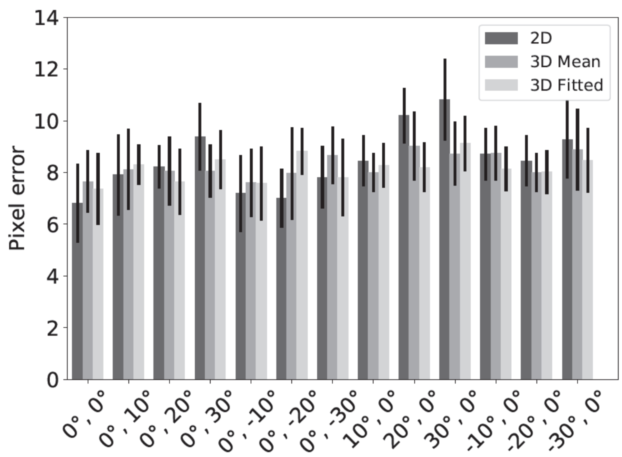

Fig. 4. Different face angels

Fig. 5 shows the impact of different face shapes to the accuracy of acupoints estimation. The mean error of estimation using 3D fitted model is 8.16 pixels. Overall speaking, the 3D based method is slightly better than the 2D based method because of the fitting.

Figure 6 (in which x-axis indicates different acupoints) shows the localization errors of the robot arm with and without considering the height of acupoint. The average error is reduced to 2.6mm when the height is considered during the transformation of coordinates from the image space to the robot arm space. A demo video of our system can be found at https://youtu.be/MGYsAQoaIAM

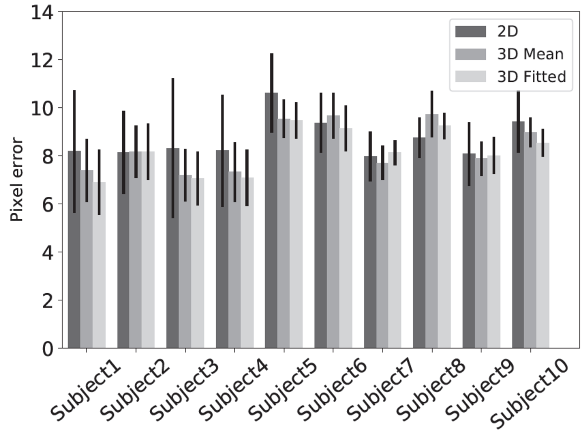

Fig. 5. Different face shapes

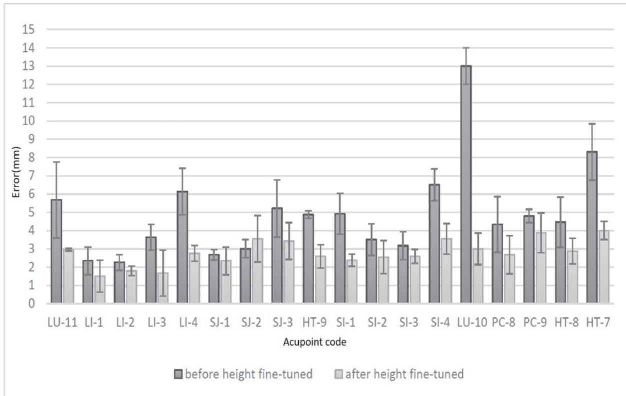

Fig. 6. The localization errors of the robot arm

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