学校编码：10384　　分类号 TP391.4 密级_____
学　　号：B200428003　　UDC_____

厦门大学

博 士 学 位 论 文

面向中医面诊诊断信息提取的若干关键技术研究

Study on Several Key Technologies of Diagnostic Information Extraction for Face Diagnosis in Traditional Chinese Medicine

吴 暾 华

指导教师姓名：　周 昌 乐　教授
专 业 名 称：　基 础 数 学

论文提交日期：　2008　年　3 月
论文答辩时间：　2008　年　5 月
学位授予日期：　2008　年　　月

答辩委员会主席：_____
评　　阅　　人：_____

2008 年 3 月

申请厦门大学博士学位论文

面向中医面诊诊断信息提取的若干关键技术研究

作　　者：吴暾华

指导老师：周昌乐 教授

专　　业：基础数学

信息科学与技术学院

数学科学学院

2008 年 3 月

厦门大学学位论文原创性声明

兹呈交的学位论文，是本人在导师指导下独立完成的研究成果。本人在论文写作中参考的其他个人或集体的研究成果，均在文中以明确方式标明。本人依法享有和承担由此论文产生的权利和责任。

声明人（签名）：

2008 年　　月　　日

厦门大学学位论文著作权使用声明

本人完全了解厦门大学有关保留、使用学位论文的规定。厦门大学有权保留并向国家主管部门或其指定机构送交论文的纸质版和电子版，有权将学位论文用于非赢利目的的少量复制并允许论文进入学校图书馆被查阅，有权将学位论文的内容编入有关数据库进行检索，有权将学位论文的标题和摘要汇编出版。保密的学位论文在解密后适用本规定。

本学位论文属于

1.保密（　），在　　年解密后适用本授权书。

2.不保密（　）

（请在以上相应括号内打“√”）

作者签名：　　日期：　2008 年　　月　　日

导师签名：　　日期：　2008 年　　月　　日

摘要

面诊是中医望诊的重要内容，为中医临床必察之项。中医学认为，人体是一个有机的整体，面部犹如反映人体生理病理的一面镜子，望五官神色变化，可直接诊察脏腑病变。

面诊的优点在于它的方便和快捷：无论多么复杂的病症，通过查看患者的面部，就能快速地阐明主要的病理过程。因此，在临床应用、自我诊断方面具有重要的价值。按照 21 世纪医学最有前景的诊断方向：无痛、无伤，面诊是很少的诊法之一。

然而，传统的面诊方法依赖于医生直观的定性观察。人眼难以分辨细小的差异，判断结果容易因人而异，具有主观性，重复性也差。这些缺点给面诊的进一步发展带来严重的困难。因此，对中医面诊的客观化进行研究，对于中医辩证规范化，及中医教学、科研手段的现代化，具有重要的理论和实际意义。

中医面诊客观化在本文中具体指的是对面色与眼神这两种主要的面诊诊断信息的自动识别、量化及其辩证推演。本研究意在填补国内在中医诊断信息自动提取中有关头面望诊方面的空白。研究的目标是建立自动提取面色和眼球运动信息的计算方法，为中医面诊诊断信息的量化、分析与处理提供理论和方法上的支持。研究内容为面色、眼神信息自动提取中涉及的若干关键技术，主要包括：多姿人脸检测、人脸特征定位、中医面色识别和针对面诊的眼动跟踪。

主要研究成果归纳如下：

(1) 提出了一种在复杂背景下的多姿人脸检测方法。该方法直接利用角点构造疑似人脸窗口，避免了因角度估计失败带来的检测率下降。在检测方法上还做了以下改进：(*a*) 引入目标物体边缘先验规则，加快了检测速度；(*b*) 利用 LAB 颜色空间的 *L* 分量对图像做光线校正。在 CMU 正面和平面旋转测试集上分别取得了 95.1%和 94.6%的检测率，误检窗口数分别为 43 和 24，在 Feret 侧转测试集上取得了 89.7%的检测率，误检窗口数 15。实验结果表明，该方法解决了正面、平面旋转和侧转人脸的检测问题，同时还在遮挡、光照、图像分辨率等多方面具有较高的鲁棒性。另外，在中医面诊人脸库中的检测率达到了 100%、误检窗口 0 个，表明该方法可用在中医面诊图像处理与分析上。

(2) 提出了一种称为 FC-ASM 的物体轮廓提取方法。该方法首先以 FCM 聚类结果作为 C-V 分割模型的初始位置，加快了 C-V 模型的收敛速度，同时提高了准确性；其次，改进了 ASM 模型：将由 C-V 模型分割出的物体局部轮廓作为匹配过程中的固定点，得到物体的全局轮廓。该方法充分利用了物体的几何信息和统计模型的先验知识，对于几何信息较强的区域做精确分割，而对于几何信息较弱的区域利用统计知识有目的地获取轮廓。该方法成功地应用于人脸特征轮廓提取，在正面人脸图像上，定位精度较目前主流的 AAM 模型高出 27.2%，且具有较高的鲁棒性，这为中医面色信息的自动提取提供了准确的参考位置。

(3) 根据中医面色脏腑分属图，首次提出中医面色识别的方法并取得了 84.6%的识别率。该方法在标准化的条件下，以面色脏腑分属图上特征点的 LAB 颜色作为面色特征，通过 FCM 聚类区分基色和面色，从图像上自动提取面诊特征向量并利用支持向量机自动归类识别，为面诊自动逻辑推理提供依据，也具有一定的临床诊断参考价值。

(4) 建立了一个面向中医面诊的眼动跟踪模型。该模型在标准化的光照条件下，以鼻孔作为参考点，充分利用 Camshift 跟踪算法和 Lucas-Kanade 光流的实时性，快速地计算眼球运动速率和轨迹。在分辨率为 640×480 的视频上，取得了 25 帧/秒的跟踪速度，该研究成果为中医眼神分析奠定了基础。

各项实验结果表明，本文提出的解决方法是有效的，基本达到了预期的研究目标。该研究对于扩大四诊客观化研究的范围、丰富中医诊断信息提取方法有着重要的科研研究价值，对于推动中医诊断信息技术的应用前景同样有着重要的实际应用意义。另外，在模式识别领域，与人脸相关的技术如人脸检测、识别、特征定位和跟踪等，因其难度大、应用面广，一直是近年来的研究热点，本文的研究成果还可为其它相关的应用研究提供借鉴。

关键字：面诊；AdaBoost；水平集；C-V 模型；ASM；Hough 变换；FCM 聚类；支持向量机；Mean-Shift；光流

Abstract

Face diagnosis is an important part of the inspection in Traditional Chinese Medicine (TCM). It's a necessary component in clinical diagnosis. TCM considers the body of human as an inseparable whole and the face is just like a mirror that reflects physiological function and pathological changes. The pathological changes of viscera can be directly diagnosed by inspecting the changes of complexion and eye expression.

The beauty of face diagnosis lies in its simplicity and immediacy: whenever there is a complex disorder full of contradictions, examination of the face instantly clarifies the main pathological process. Therefore, it's of great value in both clinic applications and self-diagnosis. Moreover, Face diagnosis is one of the few diagnostic techniques that accord with the most promising direction in the 21st century: no pain and no injury.

Traditional face diagnosis has inevitable limitations that impede its medical applications. First, the clinical competence of face diagnosis is determined by the experience and knowledge of the practitioners. Second, Face diagnosis is usually based on the detailed visual discrimination. Therefore, it depends on the subjective analysis of the examiners, so that the diagnostic results may be unreliable and inconsistent. These disadvantages bring difficulties to the further development of face diagnosis. Therefore, the objective research of face diagnosis is of great significance to the dialectical standardization, teaching and research methods of modernization of TCM.

In this theis, the objectification of face diagnosis is specifically referred to the automatic recognition, quantification and dialectical deduction of two main facial diagnostic informations: complexion and eye expression. This research was to fill the blank on the technologies for automatically extracting facial diagnostic information in TCM. More specifically, this research aimed at building several computational methods for automatically extracting the information of complexion and eye movements. And the methods will provide theoretical and methodological support for the quantification, analysis and processing on the diagnostic information of face diagnosis in TCM. The contents of this research are several key technologies for automatically extracting the information of complexion and eye movements,

including multi-view face detection, facial feature localization, complexion recognition in TCM and face diagnosis oriented eye tracking.

The main research results were summarized as follows:

Firstly, a method for multi-view face detection under complex background was proposed. The corners were utilized to directly extract candidate face regions from images, and consequently, the decline in detection rate caused by false estimations on the inclination of faces was avoided. Besides, two revisions to the detection procedure are as follows: (*a*) accelerate object detection by applying a rule of image edges; (*b*) utilize the *L* component of LAB color model to correct light variations in the images. The experiments on CMU frontal face and rotated face test sets result detection rates of 95.1% and 94.6% with 43 and 24 false alarms respectively. The experiment on a Feret profile test set result an 89.7% detection rate with 15 false alarms. Results show that the method not only realizes the detection of frontal, plane rotated and profile faces, but also has high robustness to occluding, light variations, image resolutions, etc. In addition, the experiment on the face database for face diagnosis in TCM results a 100% detection rate with 0 false alarms, which means that the method can be used to process and analyze the images for face diagnosis in TCM.

Secondly, a method named 'FC-ASM' for object contours extraction was proposed. First, the results of FCM clustering on images were taken as the initial position of C-V segmentation model, and consequently, the convergence of C-V model was accelerated. Second, the classic ASM matching procedure was revised by taking the partial contours that extracted by C-V model as fix points. The object's geometric information and statistical model's prior knowledge were fully utilized. Exact segmentation was made to the regions that have relative strong geometric information. And for the regions that have relative weak geometric information, statistical knowledge was utilized to extract contours purposefully. The method was successfully implemented to facial feature contour extraction, and the accuracy surpasses AAM which is the mainstream method for facial feature localization by 27.2%. The accuracy and robustness of the method are so good that it can be used to provide accurate reference positions for automatically extracting complexion in TCM.

Thirdly, based on complexion-viscera diagram in TCM, a method for complexion recognition in TCM was proposed for the first time which achieves an accuracy of 84.6%. First, the environment of shoot was standardized. Second, the complexion features in LAB color model were extracted from the corresponding feature points on

complexion-viscera diagram by FCM clustering which separates the complexion from skin color. Third, the complexion features were classified by SVM automatically. Results of the method not only can be served as a basis for the automatic logic inference of face diagnosis, but also have reference value for clinical diagnosis.

Finally, a face diagnosis oriented eye tracking model was constructed. First, the lighting condition was standardized. Second, the nostrils were localized and taken as reference points, and the left eye's relative movements to the nostrils were taken as the real movements of the eyes. Third, the Camshift algorithm and Lucas-Kanade optical flow algorithm were respectively utilized to track the face and nostrils real-timely. Finally, the rate and trajectory of eye movements were calculated. The experiments on a video of resolution at 640*480 result a tracking speed of 25 frames per second. Results of the model lay a foundation for eye expression analysis in TCM.

All the experimental results proved the efficiency of the proposed methods, and the goal of this research was mainly achieved. In sum, this research has significantly scientific study value that will expand the study on the objectification of Four Diagnosis and will also enrich the technology for extracting diagnostic information in TCM. In addition, face related technologies, such as face detection, face recognition, facial feature localization, face tracking and so on, are research hotspots in the field of pattern recognition for the difficulties in realization and their wide application. So, the research results could also be the reference for other related application researchs.

Keywords: Face diagnosis; Level set; C-V model; ASM; Hough transform; FCM clustering; SVM; Mean-Shift; Optical flow.

目录

Table of Contents