编码：10384　　分类号 TP391.4 密级_____
学号：23020060153369　　UDC_____

厦门大学

博 士 学 位 论 文

基于视觉特征与一致性检测的中医察目望神客观化若干关键技术研究

Study on Several Key Technologies of Spirit Diagnosing by Eye Features Based on Visual Features and Consistency Detection in Traditional Chinese Medicine

郭 锋

指导教师姓名：　李 绍 滋　教授
专 业 名 称：　人工智能基础

论文提交日期：　2011　年　　月
论文答辩时间：　2011　年　　月
学位授予日期：　2011　年　　月

答辩委员会主席：_____
评　　阅　　人：_____

2011 年　月

申请厦门大学博士学位论文

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作　　者：郭　锋

指导老师：李绍滋　教授

专　　业：人工智能基础

信息科学与技术学院

2011 年　月

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摘要

中医诊断客观化研究是中医信息化领域的热门研究课题。多年来，该领域的研究工作主要集中在面色、舌像和脉诊等信息获取和利用方面，而在中医察目望神客观化研究方面则基本处于空白。针对这种现状，本文进行了基于视觉特征与一致性检测的中医察目望神客观化若干关键技术研究，对于填补中医察目望神客观化诊断研究的空白，进一步完善中医诊断客观化研究的理论体系，丰富该领域的研究成果，促进中医诊断信息化的早日实用及应用推广，具有重要的理论意义和良好的应用价值。本文的主要创新性工作概述如下：

（1）论文首次提出了一种利用眼部视觉信息的察目望神客观化诊断模型，并围绕该模型进行了一系列创新性研究。首先给出了专门针对中医察目望神客观化诊断模型的人脸与眼部视觉数据采集方法。目前，还没有专门针对眼部视频信息的数据库，也没有将眼部图像与中医诊断相关联的先例。我们拍摄了若干受试者在不同时期、不同健康状态情况下眼部图像和视频数据，为中医察目望神客观化的研究提供了实验数据基础。

（2）提出了一种快速有效的视觉注意机制将计算焦点集中在面部区域，并首次提出了基于 Block 对的改进 Hog 特征用于眼睛候选区域分类。本文的眼睛定位分为三个层次，首先利用视觉注意机制将焦点集中在面部区域，降低了系统复杂度；第二层根据 Haar 特征和 AdaBoost 算法速度快的特点，在上一层得到的兴趣图上搜索出大量眼部候选区域；第三层使用改进的 Hog 特征排除非眼睛候选区域，Hog 特征速度较慢但精确度高，在候选区域不多的情况下对计算的要求大大降低。

（3）提出了一种基于多特征的中医察目望神客观化特征表示方法。国内外目前还没有中医察目望神的研究，本文根据中医望眼神的望外形、望眼球灵动程度、望血络和望眼睛光泽等理论知识，将白睛血丝、眼睛反光度、眼形、眼睛闭合速度、眼动速度和注意力等指标进行量化，形成察目望神客观化的多特征表示方法。

（4）提出了将 SIFT 特征用于光流场的眼睛运动检测新算法。基于内容的光流场假定时间相隔很短的两帧图像对应点的内容保持不变，为光流发展的一个趋

势。本文将 SIFT 特征用于光流计算，假定相邻两帧间对应点的 SIFT 特征相同，从而将 SIFT 特征尺度不变的优点带入光流场中，相比仅使用 SIFT 匹配的方法，本文方法的匹配点检出数目更多，光流信息更丰富。

（5）根据医生在诊断中存在主观性和擅长领域不同的特点，本文首次提出了一致性的概念，用于衡量医生诊断中偏好的特征列及其所擅长的结论。改进的云模型关联规则挖掘能够进行类似模糊集的关联计算，很适合于中医理论，其缺点在于获取的规则有很大冗余。本文提出了一种综合方法对挖掘出的关联规则进行裁剪，进而得到精简的从眼部特征推导出人体“神”的状态。

（6）提出了一个利用人体面部特征、眼部特征、情绪和客观身体自检等信息进行亚健康状态和中医证候推测的原型系统，该系统中的眼部特征采集以及多特征情况下的规则挖掘和诊断与本文察目望神模型中的方法相同。为了验证眼部特征对亚健康和中医证候的作用，本文比较了使用和不使用眼部特征两种情况下的诊断准确率。通过实验证明，亚健康状态推测在这两种情况下的准确率分别为 91%和 87%，基本实现了中医亚健康的客观化与自动推导，中医证候诊断的准确率分别平均为 56%和 52%，眼部特征在诊断亚健康和中医证候时具有一定作用。

总之，在中医察目望神的客观化研究领域，本文首先提出了一种利用眼部视觉信息的客观化诊断模型，进行了多种新的尝试并取得了一定的实际成果。从提出脸部与眼部视觉数据采集方法构建研究所需的视觉数据库，到利用视觉注意机制、结合 Haar 特征和改进的 Hog 特征进行眼睛的精确定位，紧接着对各项与望眼神有关的眼部特征进行量化，并将 SIFT 特征用于光流场的新算法用于眼动检测，再使用云模型进行关联规则挖掘从眼部特征推导出人体“神”的状态，利用一致性检测整合多名医生诊断信息，最后为了消除冗余的规则，使用了一种综合方法对挖掘的规则进行裁剪。实际挖掘出的规则表明：这一系列工作能够比较精确地根据眼部的视觉信息推导出当前人体“神”的状态，对中医诊断的客观化研究具有重要的理论意义和应用价值。同时本文用了一章的篇幅将眼部特征引入到亚健康和中医证候自动诊断原型系统中，比较了使用和不使用眼部特征情况下，诊断准确率的变化，从而得出了眼部特征能够提高诊断精度的结论，同时也说明本文的数据采集及处理模型不单适用于察目望神客观化，还能够应用在亚健康状态和中医证候的诊断中。

关键字：察目望神；视觉注意机制；Hog 特征；SIFT 光流场；Block 对；云模型；一致性检测

Abstract

The objectification Of TCM diagnosing is a hot research topic in the field of TCM information. Researches have been carried for many years, but mainly focused on the access and usage of the information about facial color, tongue images and pulse diagnosis. Till now TCM automatic extraction of diagnostic information in the area of eye features computation in the spirit diagnosing is almost blank. Aim to this situation, this paper focus on the study of the several key technologies about the TCM objectification of eye features computation in the spirit diagnosing based on feature integration and consistent inference, which has important theoretical and practical significance in the aspect of filling in the blank of TCM automatic extraction of diagnostic information in the area of eye features computation in the spirit diagnosing, the further improvement of the theoretical system of objective research in TCM diagnosis, the enrichment of the researching results in this area, and the aspect of the early implementation and application of TCM diagnosis objectification. The main innovations are summarized as follows:

(1) This paper has proposed a spirit diagnosing model used the visual eye information for the first time. At first, a data collection model devoted to the objectification eye features computation in the spirit diagnosing in TCM has been proposed. Nowadays, there is still no specific eye video information database, nor the precedent about the association between eye images with TCM diagnosis. At the same time, a number of testers' eye images in different time with different health situations have been collected, which provides experimental data to the study of eye spirit in TCM.

(2) A fast and effective visual attention has been proposed to make our computation focuse on the facial region. And improved Hog features based on the Block pairs has also been presented for the first time, which are used for the classification of the eye candidate region. Eye location is divided into three steps in

this paper. Firstly, visual attention mechanism is used to make the facial region become the focus, which can reduce the system complexity. Secondly, Haar features and the AdaBoost algorithm are used to obtain a number of candidate eye regions from the interest pictures received in the first step; At last, improved Hog features are used to exclude the non-eye regions. So in this way, speed and accuracy can be both ensured.

(3) A multi-feature representation for the objectification of eye features computation in the spirit diagnosing in TCM has been proposed in this paper. There is still no research about eye features computation in the spirit diagnosing in TCM. According to the knowledge in TCM eye spirit inspection about eye shape inspection, eye moving speed inspection, venation and conjunctiva inspection, eye gloss inspection and meaningful glance inspection etc, features about venation and conjunctiva, the degree of the eyes' gloss, eye shape, eye closure speed, eye moving speed, and attention degree have been quantified, which compose the multi-features.

(4) A new algorithm used to the detection of eye's movement has also been proposed. The algorithm's main idea is about the using of SIFT features in the optical flow. Content-based optical flow assumes the content invariance between corresponding points of the two images during a very short time interval, which is the tendency of optical flow. In this paper, SIFT features are used for the calculation of optical flow. Assuming that corresponding points of the two adjacent images have the same SIFT features, thus scale-invariant advantage of SIFT features is taken into the optical flow field. Compared to the method that only uses SIFT, our method can detect more matching points, which contains the more optical flow information.

(5) A comprehensive approach used for the pruning of association rules, which are mined base on the cloud model, has been proposed. Therefore, human "spirit" state can be derived from the reduced eye features. Mining association rules based on cloud model can be associated with a similar calculation of fuzzy sets, which is suited to TCM theory, but its' disadvantage lies in the great redundant rules. So a more general rule choosing, lazy pruning and database coverage pruning are used in this paper in order to gain the real sense of derivation rules.

(6) This paper has also proposed a prototype system which can auto speculate the sub-health state and the TCM syndrome by using of the facial features, eye characteristics, emotional and objective physical self-state suggested information. This system uses the same methods to collect eye features, mine rules and estimate sub-health state as our eye features computation in the spirit diagnosing model. In order to verify the advantages that the eye features can bring to sub-health and TCM syndrome, this paper has compared the speculation accuracies under the situations of using and non-using eye features. In experiments, accuracies of the sub-health state speculation are 91% and 87%, and accuracies of TCM syndrome diagnosing are 56% and 52% under these two situations, which shows that the eye features can help in the speculation of sub-health state and the TCM syndrome.

All in all, in the researching area of the objectification of eye features computation in the spirit diagnosing in TCM, this paper has carried out a variety of new attempts and has gained some practical results. Our work starts from the construction of the video database, and then comes to the exact eye location by the using of the visual attention mechanism and the combination of Haar features and Hog features. Next, eye features corresponding with the eye spirit inspection are quantified, and a new algorithm about applying SIFT features into optical flow is used to the detection of eye movement. In the end, association rules mining based on the cloud model is used to get the human “spirit” state from eye features, at the same time, in order to the elimination of redundant rules, a comprehensive approach is used for rule pruning. From the final rules shows that these series of work can help for the correct derivation of human “spirit” state from the eye videos, which has important theoretical significance and application value to the objectification of TCM. At the same time, this paper devotes a chapter to introduce eye features into the prototype system of automatic diagnosis of sub-health and TCM syndrome, and then compare the accuracies under the two situations of using and non-using eye features, which shows the conclusion that eye features can help to improve the accuracy. Our data colleting and processing model can not only used for eye features computation in the spirit diagnosing, but also used for the diagnosing of sub-health state and TCM syndrome.

Keywords: Spirit diagnosing by eye features; Visual attention mechanism; Hog features; SIFT optical flow; Block pairs; the Cloud model; Consistent detection

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