摘 要

全手行为跟踪是实现手势交互的重要技术之一，在人机交互的诸多场景中展现了应用价值。目前手部跟踪技术仍存在运动导致佩戴错位等问题，同时手势交互技术也面临 MidasTouch 等问题。在全手行为跟踪技术中，由于通过加速度计获取空间位置存在漂移问题，因此，本文面向基于姿态的全手行为跟踪与手势交互技术，开发手部约束特性以优化全手行为追踪技术，研究震颤信息区分交互意图以探究更自然的空中手势交互方法。

本文主要工作如下：

1）研究了一种全手行为跟踪优化方法。首先，本文依据传感器姿态估计方法，构建全手行为跟踪算法。其次开发手部约束特性，将手部约束作为先验知识融合进全手行为跟踪算法中，作为全手行为跟踪优化算法。最后通过实验验证在对 PIP 姿态求解中优化算法相较于未优化算法的$q_3(F_{1,33}=396.4，p<0.001，\eta^2=0.46)$和$q_4(F_{1,33}=396.3，p<0.001，\eta^2=0.46)$误差存在显著差异，表明姿态优化方法结果更加贴近真实手部姿态。

2）研究了一种基于姿态的手势集与实现方法，分析了基于震颤的交互意图识别方法。首先，基于以用户为中心的设计方法研究了一种基于姿态的手势集合；然后，分析了空中手势交互坐标映射方法与手势实现方法；最后，通过设计实验，提取用户震颤信息以识别用户交互意图行为，为空中手势交互中的 MidasTouch 问题提出一种解决方法。实验结果表明，通过震颤特征区分用户行为有无交互意图达到了 97%的准确率。

3）设计并实现了基于姿态的空中手势交互原型系统 iGestureGlove。在该交互系统中，实现了空中手势交互的五类基本功能：平移、选择、抓取、旋转和缩放，并且针对该空中手势交互系统设计了无线传输数据手套，为基于姿态的空中单手手势交互提供支持。

本研究面向基于姿态的全手行为跟踪与手势交互技术，通过开发手部约束特性以提高姿态跟踪的准确度，本研究所提方法可扩展到更多的约束维度，最终提高姿态估计方法的性能和可用性；本研究分析了行为震颤与交互意图的关系，本方法通过行为获取用户更多维度的信息，可以提高空中手势交互的自然性，这对于全手行为跟踪技术以及空中手势交互技术具有参考意义。

关键词： 人机交互；手势交互；手部姿态；行为跟踪；交互意图

Abstract

The whole-hand behavior tracking is one of the important technologies to realize gesture interaction, which shows its application value in many human-computer interaction scenes. At present, there are still some problems in hand tracking technology, such as misplacement caused by movement, and the hand gesture interaction technology also faces MidasTouch and other problems. Because of the serious drift problem in obtaining spatial position by acceleration integration, this paper develops hand constraint feature to optimize the whole hand behavior tracking technology for gesture-based hand tracking and gesture interaction, in order to explore a more natural method of air gesture interaction, vibration information is used to distinguish the intention of interaction.

The main work of this paper is as follows:

1) A whole-hand behavior tracking optimization method is studied. Firstly, the whole-hand behavior tracking algorithm is constructed based on the sensor attitude estimation method. Secondly, the hand constraint is fused into the whole-hand behavior tracking algorithm as a prior knowledge and used as the optimal algorithm of whole-hand behavior tracking. Finally, the experimental results show that there is a significant difference between the optimal algorithm and the non-optimal algorithm $q_3(F_{1,33} = 396.4，\ p < 0.001，\ \eta^2 = 0.46)$ and $q_4(F_{1,33} = 396.3，\ p < 0.001，\ \eta^2 = 0.46)$.

2) The user-centered method is used to design the gesture set based on the gesture, and the coordinate mapping method and the gesture implementation method in the air gesture interaction are proposed. Finally, the user experiment is designed to use the extracted tremor information to identify the user interaction intention, and a solution to the MidasTouch problem in air gesture interaction is proposed. The experimental results show that the accuracy of the extracted tremor features is 97%.

3) An air gesture interaction prototype system iGestureGlove based on attitude is designed and implemented. In this interactive system, five basic functions of air gesture interaction are realized: translation, selection, grasping, rotation and zooming, provides support for gesture-based air-to-air single-hand gesture interaction.

This research is aimed at gesture-based whole-hand behavior tracking and gesture interaction technology. By developing hand constraint features to improve the accuracy of gesture tracking, the proposed method can be extended to more constraint

dimensions, finally, the performance and usability of the attitude estimation method are improved, and the relationship between behavior tremor and interaction intention is analyzed, it can improve the naturalness of air gesture interaction, which has reference significance for the whole hand behavior tracking technology and air gesture interaction technology.

Key words: Human-Computer interaction;Gesture recognition; Hand attitude; Motion tracking; Interaction intention