3D Gesture Recognition Based on Handheld Smart Terminals

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ABSTRACT

With the popularity of smart devices, it has become impossible for traditional human-computer interaction techniques to accommodate people’s needs. This article proposes an iOS-based three dimensional (3D) gesture recognition system, gathering users’ specific gestures from their handheld smart terminals to judge implications of these gestures, so to control other smart terminals with more natural human-computer interactions. In this article, gestures were recognized by reading data about corresponding 3D gesture data with motion sensors of smart terminals using optimized dynamic time warping (DTW) algorithm. As to this algorithm, curve paths were delimited via slope based on features of mobile devices and dynamic programming. Meanwhile, this algorithm reduced computational load for template matching and costs of gesture recognition by preliminarily storing upper and lower boundaries of delimited areas with linked lists or setting distortion thresholds. In this article, efficiency and precision of recognition schemes were tested and verified on cellphones. The results suggested that the improved algorithm was less time-consuming than classical algorithms, and required less time for computational load for template matching. Furthermore, it was demonstrated that the gesture recognition based on dynamic template matching algorithms, with higher recognition efficiency and precision, could bring better experiences of human-computer interactions.

KEYWORDS

Dynamic Template Matching Algorithm, Dynamic Time Warping, Gesture Recognition, Handheld Smart Terminals, Human-Computer Interactions

INTRODUCTION

With the development of computer technologies and maturity of recognition techniques, gesture has tended to become a part of human-computer interactions and gesture recognition techniques have received increasingly widespread concerns. Nowadays, more and more applications have been developed basing on mobile platforms, made a growing amount of more convenient services available for users. In daily life of human beings, gesture interaction has become one of common natural and intuitive communications that can convey special meanings under many particular scenes. Compared with keyboards, micees and remote controllers of conventional human-computer interactions, the proposed method of this paper for making gestures with handheld smart terminals can improve human-computer interactions, thus make free natural interactions possible for users.

At present, some research outcomes have been achieved in sensor-based gesture recognition. Hiyadi, Ababsa, Montagne, Bouyakhf, and Regragui (2015) propose a recognition technique of 3D dynamic gesture for human robot interaction (HRI) based on depth information provided by Kinect.
sensor. Ding, Zhang, Chen, Chen, and Wu (2015) used Hidden Markov Model (HMM) algorithm to model and classify gestures. Sudha, Sriraghav, Sudar, Jacob and Manisha (2017) designed a 14-patch gesture partition method, integrated into the vision-based gesture recognition framework to develop desktop applications, tracking hand gestures in three-dimensional space and using simple contour models to match gestures, and thus supporting complex real-time interactions. Acharjya and Anitha (2017) proposed an algorithm framework for processing acceleration and surface electromyography (SEMG) signals for hand gesture recognition. Ikeda, Araki, Dey, Bose, Shafique, and Elbaz, et al. (2014) proposed a novel gesture recognition scheme for Leap Motion data. A feature set based on the position and orientation of the fingertip is computed and sent to the SVM classifier in order to identify the executed gesture. Acharjee, Chakraborty, Karaa, Azar and Dey (2014) proposed an algorithm, using the 3D convolutional neural network challenge, the depth and intensity data of the driver gesture recognition algorithm were implemented on the VIVA challenge dataset with a 77.5% correct classification rate. Surekha, Nazare, Raju and Dey (2017) described a template-based recognition method that uses sequential Monte Carlo inference techniques to align input gestures at the same time. Contrary to the standard template-based approach based on dynamic programming (such as dynamic time warping), their algorithms have the adaptive process of real-time tracking hand gesture changes. Hore, Chatterjee, Santhi, Dey, Ashour and Balas, et al. (2017) proposed a novel and effective descriptor, the Histogram of 3D Facets (H3DF), to encode the 3D shape information explicitly using depth maps. Tsai et al. (2015) proposed a system designed to easily access daily information without the need for mouse and keyboard operations to reduce the step of receiving information. And in 2016, Cheng, Yang, and Liu presented a survey of some recent works on 3D depth hand gesture recognition. For the time being, research on sensor-based gestures has mostly focused on sending collected data about gestures to PC and then recognizing gestures using light-weighted equipment. However, this recognition model is too dependent upon PC in data processing and classification, as a result of which application of gestures is restricted.

This paper innovatively proposed 3D gesture recognition on mobile terminals without the aid of PC for data processing, and this 3D gesture recognition can be realized anywhere without any limit of network and place. Thus, this recognition model may greatly expand the application of gestures. For instance, it is applicable to PPT presentation for lectures, control over smart home appliances and even flight trajectories of unmanned aerial vehicles. Besides, all people have personal unique habits of gestures, which is especially true for complicated ones. Thus, unique features of each person's gestures can be extracted to create a trajectory fingerprint for cellphone unlocking and simple identity authentication. Different from vision-based gesture recognition, the proposed gesture recognition method of this paper is impacted by environmental backgrounds and lighting conditions. This method can be even adopted during walking without greatly impacting its recognition rate, which is more or less advantageous than vision-based gesture recognition.

Therefore, this paper greatly expanded the application of 3D gesture recognition basing on previous studies and made it possible to study, test or realize 3D gesture recognition based on handheld smart terminals.

GESTURE RECOGNITION METHODS AND OPTIMIZATION

In this paper, gestures were recognized by DTW algorithm, which was optimized and thus improved efficiency of gesture recognition (Senin, 2008). The core idea of DTW algorithm is to match input primary data with preliminarily stored templates and to fulfill the recognition tasks by measuring similarity between two templates (Plouffe & Cretu, 2015). In consideration that duration of a gesture changes at random, for template matching, it is necessary to cope with consistencies between input data and preliminarily stored templates in length of time series (Wang and Li, 2016). In this respect, DTW algorithm has some strengths. Data preprocessing and recognition with DTW algorithm were included in the proposed recognition method of this paper.
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