Chapter 8
Hand Gesture Recognition Using Multivariate Fuzzy Decision Tree and User Adaptation

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ABSTRACT

As an emerging human-computer interaction (HCI) technology, recognition of human hand gesture is considered a very powerful means for human intention reading. To construct a system with a reliable and robust hand gesture recognition algorithm, it is necessary to resolve several major difficulties of hand gesture recognition, such as inter-person variation, intra-person variation, and false positive error caused by meaningless hand gestures. This paper proposes a learning algorithm and also a classification technique, based on multivariate fuzzy decision tree (MFDT). Efficient control of a fuzzified decision boundary in the MFDT leads to reduction of intra-person variation, while proper selection of a user dependent (UD) recognition model contributes to minimization of inter-person variation. The proposed method is tested first by using two benchmark data sets in UCI Machine Learning Repository and then by a hand gesture data set obtained from 10 people for 15 days. The experimental results show a discernibly enhanced classification performance as well as user adaptation capability of the proposed algorithm.

INTRODUCTION

Human computer interaction (HCI) technology has been widely used in various assistive systems for the disabled and the elderly. One of the recent highlighted topics is "understanding a user's intention" from natural human signals such as voice or gesture. Those signals, if successfully recognized, can provide a comfortable and convenient means for the user to interact with an engineering system.

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For example, a vision-based hand gesture recognition technique can be used to control a multitude of home appliances. Do et al. (2005) developed the Soft Remote Control System which enables the disabled user to control various home appliances using a set of simple hand gestures. Positions of a face and one hand are calculated using images obtained by stereo cameras. A concatenation of those positions constitutes a 3D trajectory of hands, from which the system recognizes those user's commands.

Critical factors that affect the performance of such systems are known to be false positive errors and inter-person variation / intra-person variation. False positive errors are caused by hand gestures that are meaningless but similar to some hand command gestures. To cope with this problem of false positive error, Yang (2007) proposed a gesture spotting method using the fuzzy garbage model in which an input gesture is classified either as a command gesture or a garbage gesture. The experimental results of the study shows that the command gestures such as "up" or "left" are effectively distinguished from the garbage gestures such as "eating" or "reading". In this paper, we deal with the latter problem of inter-person variation and intra-person variation.

When multiple users access to the system, the user independent (UI) recognition algorithms cannot compete with the user dependent (UD) recognition algorithms in the recognition rate. Furthermore, even for the same user, some characteristics of hand motion vary over time, which results in degradation of performance. The inter-person variation problem can be tackled by properly invoking some of the UD model techniques, model selection methods, or user adaptation strategies. The intra-person variation problem can be tackled by using fuzzy logic owing to its robustness property against uncertainty and ambiguity of human motion.

In particular, fuzzy decision tree learning has been widely used in classification problems due to its two merits: (1) interpretability of the decision tree and (2) capability of fuzzy logic in handling uncertainty and ambiguity (Janikow, 1998). Though the fuzzy decision tree is known to show a good performance in learning and classification tasks, however, it can be vulnerable to an overfitting situation that degrades prediction and adaptation performance. The higher the degree of overlap among membership functions is, the bigger the structure of the fuzzy decision tree becomes.

In this paper, we propose a multivariate fuzzy decision tree (MFDT) structure which effectively prunes the decision tree so as to enhance the classification and adaptation performance. The fuzzy decision tree model can be simplified by using a multivariate concept. Specifically, several recognition models are first built, and the best model that fits a new user is selected by using the maximum likelihood model comparison. Subsequently a user adaptation algorithm is presented, based on the gradient descent method.

To demonstrate the performance of the proposed algorithm, we use IRIS and WINE data set in UCI Machine Learning Repository (Merz et al., 1996) and a hand gesture data set which is collected from 10 people for 15 days. The experimental results show that the classification and user adaptation performances of the proposed method are better than those of other well-known fuzzy decision tree techniques.

VISION-BASED HAND GESTURE RECOGNITION FOR THE SOFT REMOTE CONTROL SYSTEM

Vision-based hand gesture recognition for the soft remote control system (Do et al., 2005) is carried out in the following steps:

1. Face and hand "region of interests" (ROI) are extracted from camera images.
2. A trajectory of the hand position relative to the face position is calculated.