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A methodology for hand and finger motion analysis using adaptive probabilistic models

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Abstract

A methodology for motion analysis and hand tracking based on adaptive probabilistic models is presented. This is done by integrating a deterministic clustering framework and a particle filter together in real time. The skin color of a human hand is firstly segmented. A Bayesian classifier and an adaptive process are utilized for determining skin color probabilities. The methodology enables us to deal with luminance changes. After that, we determine the probabilities of the fingertips by using semicircle models for fitting curves to fingertips. Following this, the deterministic clustering algorithm is utilized to search for regions of interest, and then the Sequential Monte Carlo is also performed to track the fingertips efficiently. Representative experimental results are also included to ensure workability of the proposed framework. Several issues about using the presented method in embedded systems are discussed. The method presented can be used to further develop the associated applications of embedded robotic and virtual reality.

Keywords: Motion analysis; Hand tracking; Extended sequential Monte Carlo; Finger tracking; Color segmentation; Bayesian classifier; Embedded system; Adaptive learning; Clustering algorithm

1 Introduction

Recently, embedded systems are beneficially applied to many autonomous and intelligent robotic fields. One of the possible keys is to make the embedded robot see and understand automatically. In many embedded systems, vision-based methods are used interestingly. Their algorithms are embedded in robots in both hardware and software, including a method about hand motion analysis. This is because if embedded robotic systems are able to recognize human organs automatically, they can apply to various related real-life applications practically. An example includes embedded robots used and researched after 9/11 which are designed to automatically operate and rescue humans within a challenging environment by recognizing human organs without using human eyes. Thus, it is very important to design the embedded robots that can recognize and analyze the motion of human organs in recent years. For this reason, researches about hand motion recognition based on digital image processing technology are becoming popular for embedded systems. This is because computer vision has been applied to many kinds of recent application to assist human motion tracking, especially fingertip tracking methodologies. Previous fingertip tracking methods were presented. For example, a correlation with pre-defined templates was presented in [1]. A chromatic distance was discussed in [2]. Mackie and McCane [3] also proposed image-division-based decision tree recognition. However, these aforementioned methods are not directly applicable to the self-occlusion fingertip tracking. Moreover, the background they used is usually uniform. As a result, it is more complicated to locate the fingertip positions correctly for self-occlusion and in non-uniform background. The proposed methodology for tracking the hand and fingertips solves these aforementioned issues.

To begin with, the hand is segmented in each frame from the background using an adaptive color detection algorithm. A Bayesian classifier is utilized during off-line phase [4]. An adaptive algorithm for determining skin probability is then applied to refine the classifier to train the system robustly [5]. Following this, we determine probabilities for fingertips by cropping the models of semicircle shape for a fit to the fingertip [6]. After superimposing the models on every candidate in the test

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