2014 IEEE International Conference on Systems, Man, and Cybernetics
October 5-8, 2014, San Diego, CA, USA

Hybrid Model of Human Hand Motion for Cybernetics Application

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***Abstract*—One of the major unsolved problems in the field of image processing is to recognize human hand motion robustly in many real circumstances and unpredictable scenarios. Understandingly, this problem is not a trivial task. In this paper, a hybrid methodology for motion analysis and hand tracking based on adaptive probabilistic models is presented in this paper. This hybrid model is composed of a deterministic clustering framework and a standard particle filter. We search for regions of interest before distributing particles into each region to determine the fingertips. This is definitely different from any previous particle filter system. It is not only performed in real-time, but also adaptively based on skin color probabilities. This means that the amount of lighting may change, the tracker still performs accurately. Finally, experimental work demonstrates that the proposed method of human hand motion is able to track and recognize successfully and robustly. This presented hybrid model is able to further and potentially implement the systems and applications of cybernetics.**

Keywords—cybernetics; human motion; man hand; probabilities; motion tracking; image processing; region of interest

I. BACKGROUND

Intelligent human motion is widely applied to various cybernetics areas, so that researches about hand motion recognition are becoming popular for cybernetics systems. To achieve the hand motion recognition, image processing technology is usually used to assist human motion tracking, especially fingertip tracking methodologies. In recent years, previous fingertip tracking methods were proposed such as in [1], [2], [3], [4] and [5]. Zhou et al. [1] discussed the method using the combination of mean shift and scale-invariant feature transform (SIFT) features for object tracking in challenging scenarios. They use similarity search between two neighboring frames based on color histograms and probability distributions. They use an expectation–maximization algorithm to determine a maximum likelihood estimate by integrating mean shift and SIFT together. More recently, Zhanga et al. [2] presented a method using the assumption that is about sparse representation in conventional sequential Monte Carlo method. They activate the background templates using the linear system to differentiate the tracked object from the background. Also, one of the classic hand tracking methods is to use minimization of an objective function presented by De La Gorce et al. [3] and [4]. A similar work to our work is also the one of Wang et al. [5]. In their method, they use a scale factor with a standard particle filter. They use the assumption based on color local entropy (CLE) for object tracking dynamically.

Nonetheless, these aforementioned methods are not straightforwardly applicable to the self-occlusion fingertip recognition. 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 computational time of the method is also an important issue to apply it to cybernetics applications.

In this paper, we present a hybrid model of human hand motion by integrating a clustering framework and sequential Monte Carlo framework together to solve the aforementioned problems. We overcome these problems by attempting to segment the skin color of hand robustly and effectively. To solve this issue, it is important to understandably address a problem to control the lighting. The levels of light between off-line and online phases are important for getting the correct registration. A major decision has to be made when deriving a model of color. By simply setting the threshold in color model, the accurate and robust results are rarely obtained. Another method [6] presented by Asthana et al. is to use histogram models. Still, it cannot perform adaptively when the levels of light between off-line and online phases are totally different. In the proposed method here, the hand segmentation is performed based on a Bayesian framework adaptively [7]. This segmentation step is critical before proceeding to the next step. By using Bayes' rule, the hand segmentation is achieved adaptively and robustly. We use the models of semicircle shape for a fit to the fingertip [8] to determine probabilities. Template matching is performed to refine the probabilities. After superimposing each semi-circular model on each region, we use a clustering framework [9] to determine

978-1-4799-3840-7/14/$31.00 ©2014 IEEE