# Recognition of Continuous Mouse Gesture Sequences

## I. Problem Statement

Gestures, ranging from simple mouse movement to complex full-body motion, are a common form of input in human-centric user interfaces [1]. However, a significant barrier to widespread use of gesture input is the problem of accurate gesture recognition, both in isolation and in sequence. Gesture recognition frequently involves solving two problems: segmentation of a gesture sequence and recognition of individual gestures.

In our work, we focus on the problem of segmenting sequences of user-defined (i.e., custom) symbols created via mouse gestures. Our work addresses one part of the larger problem of recognition of custom symbols, which is an important problem in law enforcement. The United States Federal Bureau of Investigation's Safe Streets and Gang Unit commonly encounters handwritten communication involving custom symbols [2]. To our knowledge, this problem has not been addressed in the literature.

## II. Related Work

Yang et al [3] present work on recognition of individual gestures in continuous gesture sequences, but unlike our work, they train Hidden Markov Models (HMMs) on continuous gestures; we view this as a deficiency due to the *a priori* definition of gesture sequences. The work most closely related to ours is focused on recognition of Chinese handwriting [4]. Hong et al use an iterative segmentation technique that uses whitespace separation to split character sequences into individual characters. Their approach is similar to ours, but their approach is intended to be suitable for both off-line and on-line recognition. As a result, their approach does not take advantage of the temporal data that we employ. To our knowledge, there is no directly comparable system in the literature.

## III. Proposed Implementation

Because our problem is segmentation of user-defined gestures, we cannot leverage grammar or other linguistic features, as was done successfully by Starner et al [5]. Additionally, we cannot assume the existence of any markers that separate gestures, as is typically found in Chinese writing [4]. Thus, we employ an approach based on an efficient "search" over the space of temporally segmented gesture sequences, aiming to find the most accurate gesture segmentation. We will build upon the mouse gesture recognition system developed by Tanguay [6], which performs on-line recognition of individual mouse gestures via HMMs. We will enhance his system by adding a segmentation routine that accurately splits a continuous gesture sequence.

In our approach, we first split the multi-gesture data stream temporally into N sub-streams (each corresponding to an individual gesture) of identical duration equal to the mean duration of gestures in the training set. The duration of each sub-stream can be conceptualized as a "window" overlaid on the complete data stream; N sub-streams correspond to N windows. After configuring the initial "window set", we calculate a "window set score", which is the mean of all the individual window scores; each window score, in turn, is equal to the maximum of the probabilities of a match between the window data and each trained HMM. We subsequently iteratively increase the window set score by independently increasing or decreasing the duration of each window by a delta based on the time variance of gestures in the training set. If the window score increased between iterations *k* and *k-1*, we repeat the previous action; otherwise, we try the alternate action. Our routine terminates when the delta change reaches zero.

## IV. Proposed Evaluation

Our approach consists of a segmentation routine, which is designed to be resilient to temporal variances in the input gesture sequence, and a HMM-based recognition routine, which is used to identify individual gestures. We propose to evaluate both the recognition success rate, defined as the percentage of correctly identified individual gestures, and the limitations on temporal variance for a correctly segmented gesture sequence. Because our problem and segmentation approach is comparable with the work by Hong et al [4], we will compare our success rates with their results, and quantify the maximum temporal variance for which segmentation is successful.

To avoid author bias during evaluation, we will conduct a micro-study involving one user. The user will arbitrarily create gesture sequences of lengths 1, 2, and 3. Gestures with length 1 serves to validate the system accuracy for individual gestures. Gestures of lengths 2 and 3 serves to quantify the success rate of our segmentation routine.

## V. References


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