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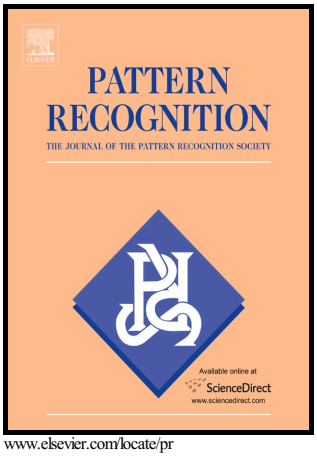


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# Signature Alignment based on GMM for On-Line Signature Verification

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**Abstract:**

On-line handwritten signatures are collected as real-time dynamical signals, which are written on collective devices by users. Since writing environments are always changed, fluctuations can be caused by signature size, location and rotation angle which being various at each inputting. Signatures should be effectively aligned before verification, which can diminish deviations caused by these fluctuations. In this study, we propose a method of signature alignment based on Gaussian Mixture Model to obtain the best matching. In verification, a modified dynamic time warping with signature curve constraint is presented to improve the efficiency. Weight factors are dynamically assigned to features, which depend on coefficient of variation, to improve the robustness. Several experiments are implemented on the open access on-line signature databases MCYT and SVC2004 Task2. The best performances can be provided with equal error rates 2.15% and 2.63%, respectively. Experimental results indicate the effectiveness and robustness of our proposed method.

**Keywords**：on-line signature verification; signature alignment; Gaussian Mixture Model; signature curve constraint; dynamic weight factor

## 1 Introduction

As requirements of information security and identity verification increase, biometrics is gaining popularity as a more trustable alternative to password based security systems. On-line handwritten signature verification is one of the most acceptable technologies of biometrics due to the fact that on-line handwritten signatures have long been established as the most widespread means of personal verification. The signatures are difficult to be imitated and forged because they are unique and consistent for a given period. Experimental results presented in relevant literatures have indicated that the accuracy of on-line signature verification is not lower than other biometrics [1, 2].

On-line signature verification could generally be divided into two groups, i.e., parametric approach and functional approach. In parametric approach, signatures are represented by series of parameters or vectors. Several common parameters most extensively used, such as position, displacement, numbers of pen ups and pen downs, speed, acceleration, pen down time ratio, aspect ratio, etc. [1, 2, 3, 4]. When functional approach is concerned, signatures are usually characterized in terms of time functions, some of most commonly used functions are position trajectory, velocity, acceleration, centripetal acceleration, pressure, direction of pen movement, azimuth angle and altitude angle etc. [1, 2, 5, 6]. Generally, it would obtain higher accuracy and reliability because the functional approach contains more dynamic information [2, 4, 6]. But functional approach often requires heavy computation during the process of matching or dissimilarity evaluation and it is less efficient in most cases.

In verification, the authenticity of test signature is evaluated by matching its features against those stored in knowledge base for given user. There are some commonly used verification methods, such as template matching methods [7, 8], statistics based methods [9, 10, 11], and structure based methods [12, 13, 14].

On-line handwritten signatures are collected as real-time dynamical signals and are presented as time series. During the process of collection, dynamic information of signatures is stored, such as position trajectory, timestamps, pen down and up status, pressure, azimuth and altitude angle, etc. By reasons of internal or psychological and external environments changes, there are fluctuations of size, location and rotation angle of signatures within the same user at different inputs. Furthermore, from the perspective of the kinematic, signatures are rapid and skilled human actions which mainly determined by the dynamics of muscle system. Signatures will not keep higher consistency for a long time since the writing habits and external environments changes. In this study, it is necessary to reduce the influence of fluctuations caused by variances of size, location and rotation angle, which could worsen the performance of verification. Thus, it is very important to effectively align the test signatures to references before verification.

The motivations of our work are emphasized on reducing the inconsistencies of signatures and improve the effectiveness of