Chapter IV
An Automatic Off-Line Signature Verification and Forgery Detection System

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ABSTRACT

This chapter presents an off-line signature verification and forgery detection system based on fuzzy modeling. The various handwritten signature characteristics and features are first studied and encapsulated to devise a robust verification system. The verification of genuine signatures and detection of forgeries is achieved via angle features extracted using a grid method. The derived features are fuzzified by an exponential membership function, which is modified to include two structural parameters. The structural parameters are devised to take account of possible variations due to handwriting styles and to reflect other factors affecting the scripting of a signature. The efficacy of the proposed system is tested on a large database of signatures comprising more than 1,200 signature images obtained from 40 volunteers.

INTRODUCTION

A handwritten signature can be defined as the scripted name or legal mark of an individual, executed by hand for the purpose of authenticating writing in a permanent form. The acts of signing with a writing or marking instrument such as a pen or stylus is sealed on the paper. The scripted name or legal mark, while conventionally applied on paper, may also be accomplished using other devices that capture the signature process in digital format.

Hilton (1992) discusses what a signature is and how it is produced. He notes that the signature
has at least three attributes: form, movement, and variation. Since signatures are produced by moving a pen on a paper, movement perhaps is the most important aspect of a signature. Movement is produced by muscles of the fingers, hand, wrist, and, for some writers, arm; these muscles are controlled by nerve impulses. Once a person is used to signing his or her signature, these nerve impulses are controlled by the brain without any particular attention to detail.

The variations in handwritten signatures are quite immense, both within samples from the same individual and to an even larger degree across the population of individuals. The susceptibility of a signature to false imitation is clearly a function of the nature of the signature itself. In a broad sense, signatures can be classified as simple, cursive, or graphical based on their form and content, as shown in Figure 1.

A simple signature is one where a person scripts his or her name in a stylish manner. In this type of signature, it is very easy to interpret all the characters in the name. Cursive signatures, on the other hand, are more complex. Though the signatures still contain all the individual characters within the name, they are, however, drafted in a cursive manner, usually in a single stroke. Lastly, the signatures are classified as graphical when they portray complex geometric patterns. It is very difficult to deduce the name of the person from a graphical signature, as it is more of a sketch of the name of the signer.

**HANDWRITTEN SIGNATURES**

It is a well-known fact that no two signatures, even if signed by the same person, are ever the same. However, if two signatures are *exactly* alike, then one of them is not a genuine signature but rather a copy of the other—either a machine copy such as one produced by a computer or photocopier, or a manually produced copy such as tracing. In addition, simulation must be taken into account, where an individual copies the signature of another using a genuine signature as a model. In these cases, the simulated writing usually exhibits an incorrect interpretation of inconspicuous characteristics of a genuine signature, which are quite hard to recognize by a nonexpert.

Osborn (1929), one of the earliest experts in the field of document examination, observed that variations in handwriting are themselves habitual. This is clearly seen in any collection of genuine signatures produced at different times and under a great variety of conditions. When carefully examined, these signatures show that running through them is a marked, unmistakable individuality even in the manner in which the signatures vary as compared with one another. He

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**Figure 1. Types of signatures**

<table>
<thead>
<tr>
<th>Type</th>
<th>Genuine</th>
<th>Skilled forgery</th>
<th>Unskilled forgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple</td>
<td>[Signature Image]</td>
<td>[Signature Image]</td>
<td>[Signature Image]</td>
</tr>
<tr>
<td>Cursive</td>
<td>[Signature Image]</td>
<td>[Signature Image]</td>
<td>[Signature Image]</td>
</tr>
<tr>
<td>Graphical</td>
<td>[Signature Image]</td>
<td>[Signature Image]</td>
<td>[Signature Image]</td>
</tr>
</tbody>
</table>
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