

A METHOD FOR ADDITIVE CHARACTER RECOGNITION AND AN
APPARATUS THEREOF

Technical field

The present invention relates to a method for recognition of a handwritten pattern comprising one or more curves, as well as a module, an apparatus and a
5 computer program thereof.

Background of the invention

The recognition of handwriting is today in many aspects a mature research area with several industrial
10 applications. It has become an increasingly popular method for inputting data to data handling units, such as mobile phones and Personal Digital Assistants (PDAs). The recognition method is in most cases limited to recognition of single isolated characters, as for example
15 by Graffiti®, manufactured by Palm, Inc.

When it comes to on-line cursive word recognition progress has been much slower. Most such methods of today utilizes Neural Networks and statistical models based on Hidden Markov Models. However, extending the task to
20 recognition of cursive words introduces a difficult layer of complexity in the form of segmentation.

Summary

In view of the above, an objective of the invention
25 is to solve or at least reduce the problems discussed above. In particular, an objective is to make the interpretation of a handwritten pattern representing one or more symbols more effective.

The above objective is provided according to a first
30 aspect of the invention by a method for recognition of a handwritten pattern comprising one or more curves, said method comprising

receiving sample data representing the handwritten pattern,

segmenting the handwritten pattern by detecting segmentation points on each curve, and by dividing the
5 handwritten pattern into segments, and

comparing the handwritten pattern to templates wherein the comparing comprises

normalizing said segments according to a scheme which is independent of the templates to which the
10 segments are to be compared, and

determining matching measures for selecting at least one sequence of templates representing a recognition candidate of the handwritten pattern.

An advantage of this is that a single character
15 recognition method may be extended to treat cursive word recognition.

Further, the matching measures may comprise segmental matching measures comparing segmental features of the handwritten pattern to segmental features of the
20 templates, which means that the matching process may be made more efficiently.

Further, the matching measures may comprise connective matching measures comparing connective features between segments in the handwritten pattern to
25 connective features of templates, which also means that the matching process may be made more efficiently.

The method may comprise a step of compensating for translation, angle and length differences between the segments such that the segmental features are relative
30 within each possible segment, which is advantageous in that the features may be treated in the same way regardless of which template they are compared to.

The method may comprise a step of compensating for translation, angle and length differences between the
35 segments such that the connective features are relative between the adjacent segments, which is advantageous in

that the features may be treated in the same way regardless of which template they are compared to.

The segmental features may comprise a segmental distance between two segments or a distance component
5 between two pairs of attached segments, which is advantageous in that functional variables are used.

The connective features may comprise a distance component for non-connected segments or a distance component for a connection between two segments, which is
10 advantageous in that functional variables are used.

The step of determining matching measures may utilize an operator in order to determine the connection of templates that are to be used as a model for comparison with the connections between segments, which
15 is advantageous in that the functional variables are used by the operator.

The operator may be a linear function of the segmental distance between two segments and the distance component for a connection between two segments, which is
20 advantageous in that the operator is simple.

The method may comprise a step of detecting the segmentation points as local extreme points which are below a predetermined threshold, which is advantageous in that a segmentation frame is created in a simple way.

25 The method may comprise a step of parameterizing each segment by the Dijkstra Curve Maximization strategy with three intermittent points, which is advantageous in that the resulting curve length is maximized.

The step of comparing may utilize point-to-curve
30 matching, which is advantageous in that the method allows unevenly spaced points.

The method may comprise a step of associating an output weight to normalized segmental and connective features, which is advantageous in that that the features
35 may be balanced in a efficient way.

The above objective is provided according to a second aspect of the invention by a module for

recognition of a handwritten pattern comprising one or more curves, said module comprising

- a receiver configured to receive sample data representing the handwritten pattern,
- 5 a segmentation point detector configured to detect segmentation points on each curve,
- a divider configured to divide the handwritten pattern into segments,
- a normalizer configured to normalize said segments
- 10 according to a scheme which is independent of the templates to which the segments are to be compared,
- a determinator configured to determine matching measures for selecting at least one sequence of templates representing a recognition candidate of the handwritten
- 15 pattern, and
- a transmitter configured to output said matching templates.

The advantages of the first aspect of the invention are also applicable for this second aspect of the

- 20 invention.

The determinator may be configured to determine segmental matching measures.

The determinator may be configured to determine connective matching measures.

- 25 The module may comprise a compensator configured to compensate for translation, angle and length differences between the segments such that the segmental features are relative within each possible segment.

The module may comprise a compensator configured to

- 30 compensate for translation, angle and length differences between the segments such that the connective features are relative between the adjacent segments.

The determinator may be configured to determine a segmental distance between two segments or a distance

- 35 component between two pairs of attached segments.

The determinator may be configured to determine a distance component for non-connected segments or a distance component for a connection between two segments.

5 The determinator may utilize an operator in order to determine the connection of templates that are to be used as a model for comparison with the connections between segments.

10 The operator may be a linear function of the segmental distance between two segments and the distance component for a connection between two segments.

The segmental point detector may be configured to detect the segmentation points as local extreme points which are below a predetermined threshold.

15 The segmental point detector may be configured to parameterize each segment by the Dijkstra Curve Maximization strategy with three intermittent points.

The determinator may be configured to utilize point-to-curve matching.

20 The module may comprise an associator configured to associate an output weight to every normalized segmental and connective feature.

The above objective is provided according to a third aspect of the invention by an apparatus comprising a pen movement capturing device configured to receive
25 data representing a handwritten pattern,

a module according to claim 16 configured to receive said data from said pen movement capturing device and to output matching templates,

30 a symbol matcher configured to match said templates into symbols, and

a display configured to present said symbols.

The advantages of the first aspect of the invention are also applicable for this third aspect of the invention.

35 The pen movement capturing device may be a touch sensitive surface.

The apparatus may comprise a symbol set database comprising a number of reference template combinations and their associated symbols.

5 The above objective is provided according to a fourth aspect of the invention by a computer program arranged to perform the method according to the first aspect of the invention when downloaded into and run on a computational device.

10 Other objectives, features and advantages of the present invention will appear from the following detailed disclosure, from the attached dependent claims as well as from the drawings.

15 Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the [element, device, component, means, step, etc]" are to be interpreted openly as referring to at least one instance of said element, device, component, means, step, etc., unless
20 explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

As used herein, a symbol is any form that has a specific meaning, such as a character (e.g. Latin,
25 Chinese or other kind), a ligature between, before or after characters, a number, a punctuation mark, or a diacritic mark.

Brief description of the drawings

30 The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments of the present invention, with reference to the appended
35 drawings, where the same reference numerals will be used for similar elements, wherein:

Fig 1 generally illustrates a general principle of the present invention.

Fig 2 generally illustrates the segmentation of sample data in further detail.

5 Fig 3 generally illustrates the comparing and matching of sample data in further detail.

Fig 4a generally illustrates an example of a handwritten pattern with indicated segmentation points.

10 Fig 4b generally illustrates a second example of a handwritten pattern with indicated segmentation points.

Fig 4c generally illustrates the handwritten pattern illustrated in fig 4a divided into segments.

Fig 4d generally illustrates the handwritten pattern illustrated in fig 4b divided into segments.

15 Fig 5 schematically illustrates a module according to the present invention.

Fig 6 schematically illustrates an apparatus according to the present invention.

20 Detailed description of preferred embodiments

Fig 1 illustrates the general principle of the present invention, which is known from *J. Sternby. An Additive On-Line Single Character Recognition method. In Tenth International Workshop on Frontiers in Handwriting Recognition, La Baule, France, 2006*, and hereby
25 incorporated by reference. A method 100 for recognition of a handwritten pattern 124 comprises several steps, each step represented by a box in the figure. At step 120, sample data 122 representing a handwritten pattern
30 124 is received. The handwritten pattern 124 is segmented into several segments 126 at step 140, and at step 160 the segments 126 are compared and matched to templates 128.

The sample data 122 may be any type of digital data
35 representing a handwritten pattern 124 comprising one or more curves 130. The handwritten pattern 124 may form one

or several symbols. The templates 128 are each representing a symbol or a part of a symbol.

Fig 2 illustrates the segmenting step 140 in more detail. Considering the received sample data 122 as input data, a step 142 is performed for determining the writing direction of the handwritten pattern 124. Such determining step 142 may include a successive order of calculations or simply a validation of a default setting. By performing a step 144, a threshold is applied to the sample data 122. From this, segmentation points 132 are detected at step 146. The segmentation points 132 are placed on the curve as the local extreme points below the applied threshold, such that a gradient function of the curve in the local extreme points is exceeded. So far, the frame/segmentation 134 of the sample data 122 is produced by the steps 142, 144 and 146. An example of such segmentation is illustrated in fig 4c and 4d. A parameterizing step 148 may then be performed by executing the Djikstra Curve Maximisation strategy with three intermittent points, so that the segmentation points 132 are detected and placed on the curve 130 in such a way that the resulting curve length is maximized.

Fig 3 illustrates the comparing and matching step 160. Here, an extracting step 162 is performed, during which step segmental features 161 are extracted. In this step 162, a direction $a(s)$ is calculated for each segment 126. In this step 162, each subsequent pair of connected segments 126 also generates a length ratio λ and a connection angle φ . For non-connected subsequent segments 126, the length ratio λ is calculated as well as a vertical position κ and a segment gap δ . In another step 164 within the comparing and matching step 160, the extracted features 161 are normalized, resulting in a normalized direction $a(s)$, a normalized length ratio λ , a normalized connection angle φ , a normalized vertical position κ and a normalized segment gap δ . With reference

to fig 4a and 4b, the normalized direction $a(s)$ is defined as

$$a_j = \arg(\vec{v}_j), a_j \in [0, 2\pi],$$

the normalized length ratio λ is defined as

$$5 \quad \lambda(s_j, s_{j+1}) = \begin{cases} \frac{l_j}{l_{j+1}}, & \text{if } l_{j+1} \geq l_j \\ 2 - \frac{l_{j+1}}{l_j}, & \text{else} \end{cases},$$

the normalized connection angle φ is defined as

$$\phi(s_j, s_{j+1}) = \arg(\vec{\varphi}_{j(j+1)}) - \arg(\vec{\varphi}_{(j+1)j}) \mod 2\pi,$$

the normalized vertical position κ is defined as

$$\kappa(s_j, s_{j+1}) = \begin{cases} \frac{(h_{j+1} + b_{j+1})/2 - b_j}{h_j - b_j}, & \text{if } \frac{(h_{j+1} + b_{j+1})/2 - b_j}{h_j - b_j} \in [0, 1] \\ 0, & \text{if } \frac{(h_{j+1} + b_{j+1})/2 - b_j}{h_j - b_j} < 0 \\ 1, & \text{else} \end{cases},$$

10 and the normalized segment gap δ is defined as

$$\delta(s_j, s_{j+1}) = \begin{cases} \frac{dx_{j(j+1)}}{2(h_j - b_j)}, & \text{if } h_j - b_j \geq |dx_{j(j+1)}| \\ \text{sign}(dx_{j(j+1)}) - \frac{h_j - b_j}{2 \cdot dx_{j(j+1)}}, & \text{else} \end{cases}.$$

Again referring to fig 3, in a further step 166 a segmental curve distance function d_{DCM} is constructed in order to deal with the specific issues of discriminating between handwritten curves. Since translation, angle and length differences between the segments 126 have been removed due to the normalizing step 164, the segmental curve distance function d_{DCM} is measuring the distance between two curve segments aligned, so that the two segments 126 share start and end points. The segmental curve distance function d_{DCM} is a dynamic time warping influenced distance function made to discriminate well between curves 130 parameterized according to step 148. The points 132 placed during the step 148 are spaced unevenly on the curve, due to the fact that the method

focuses on retaining the shape information and not on providing a smooth parameterization. For this reason, the segmental curve distance function d_{DCM} allows point-to-curve matching in addition to traditional point-to-point matching. Furthermore, as the number of placed points are few compared to traditional arclength parameterizations, the directional vector used in prior art is not a stable feature.

The segmental curve distance function d_{DCM} can be defined as

$$d_{DCM}(P, Q) = \min_{\Phi} \sum_{i=1}^m g(p_{\phi_p(i)}, q_{\phi_q(i)})$$

where P and Q denote two different samples of a handwritten pattern, Φ is an alignment function of the normalized connection angles ϕ and normalization constants for balancing the angle distance with coordinate distance, and g is a basic distance function between two points p and q . This basic distance function g includes a weight function f in order to improve the fact that the matching of handwritten patterns suffers from over-fitting of the templates to the samples. This weight function f also considers the situation when the points differ. The weight function f can be defined as $f(x) = 0.2x^2 - 1.1x + 1$, $x \in [0, 1]$

and can be applied according to the minimal Euclidian distance of the point pair (x, y) to their common baseline defined by the start and end points. By defining the baseline as

$$b(t) = p_1 + \vec{v}t, \quad \vec{v} = p_n - p_1$$

and having defined $v_{x,y} = \arg \min_{v \in \{x,y\}} d_l(b, v)$, where d_l is the orthogonal distance between the point v and the line b , the basic distance function then equals

$$g_{DCM}(x, y) = f(\min(v_{x,y}, \|p_n - p_1\|)) \cdot (\|x - y\|^2 + k_{\theta} \|\theta_x - \theta_y\|^2).$$

The complete algorithm between two samples $P = \{p_j\}_{j=1}^n$ and $Q = \{q_j\}_{j=1}^n$ can then be formulated as:

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for  $i, j := 1, \dots, n$  do
    if  $i < n$  then
         $d(i_\xi, j) := g(x_{i,j}^{P,Q}, q_j) + \min \begin{cases} d(i, j-1) \\ d(i_\xi, j-1) \end{cases}$ 
    end if
    if  $j < n$  then
         $d(i, j_\xi) := g(p_i, x_{j,i}^{Q,P}) + \min \begin{cases} d(i-1, j) \\ d(i-1, j_\xi) \end{cases}$ 
    end if
     $d(i, j) := \min \begin{cases} d(i-1, j) + g(p_i, q_j) \\ d(i-1, (j-1)_\xi) + g(p_i, q_j) \\ d(i, j-1) + g(p_i, q_j) \\ d((i-1)_\xi, j-1) + g(p_i, q_j) \\ d(i-1, j-1) + 2g(p_i, q_j) \end{cases}$ 
end for
 $d_{DCM}(P, Q) := d(n, n) / 2n$ 

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Now referring to fig 3, the step 168 is performed in order to determine a linear distance function d_{FDE} of features 161. The linear distance function d_{FDE} is utilized in order to treat segments in an additive way and thereby bringing out the additive property of the character recognition method 100. The features 161 are divided into a segmental and a connective feature component d_s and d_c , respectively. The segmental component d_s compares two segments 126, and the connective component d_c compares the connection between two pairs of segments 126. The segmental distance component between two segments (s_1, s_2) has been defined as

15 $d_s(s_1, s_2) = \omega_A |a(s_1) - a(s_2)| + \omega_P d_{DCM}(A_{12}(s_1), A_{21}(s_2)),$

where one of the operators A_{12} , A_{21} is the identity operator and the other operator aligns the start and end point of the smaller segment to the longer segment.

A distance component d_A between two pairs of
 5 attached segments $(s_{11}, s_{12}), (s_{21}, s_{22})$ is similarly defined as

$$d_A((s_{11}, s_{12}), (s_{21}, s_{22})) = \omega_L |\lambda(s_{11}, s_{12}) - \lambda(s_{21}, s_{22})| + \omega_C |\phi(s_{11}, s_{12}) - \phi(s_{21}, s_{22})|.$$

Further, a distance component d_N for non-connected
 segments is derived from the normalized length ratio λ ,
 10 the normalized vertical position κ and the normalized
 segment gap δ , as

$$d_N((s_{11}, s_{12}), (s_{21}, s_{22})) = \omega_L |\lambda(s_{11}, s_{12}) - \lambda(s_{21}, s_{22})| + \omega_V |\kappa(s_{11}, s_{12}) - \kappa(s_{21}, s_{22})| + \omega_G |\delta(s_{11}, s_{12}) - \delta(s_{21}, s_{22})|.$$

The distance connective component d_c for a
 connection between two segments can then be defined as
 15
$$d_c(\cdot, \cdot) = \begin{cases} d_A(\cdot, \cdot) & \text{if segments are connected} \\ d_N(\cdot, \cdot) & \text{else} \end{cases}$$

The total additive distance function d_{FDE} between two
 samples with segmentations $S(X) = \{s_i^X\}_{i=1}^{|S(X)|}$ and $S(Y) = \{s_j^Y\}_{j=1}^{|S(Y)|}$
 such that $S(X) \sim S(Y)$ can then be stated as

$$d_{FDE}(X, Y) = \sum_{i=1}^{|S(X)|} d_S(s_i^X, s_i^Y) + \sum_{i=1}^{|S(X)|-1} d_C((s_i^X, s_{i+1}^X), (s_i^Y, s_{i+1}^Y)).$$

20 The additive distance function d_{FDE} is dependent on
 the weights ω_A , ω_P , ω_L , ω_V and ω_G , which are in this
 embodiment set to a predetermined value. The balancing of
 these weights may be done due to the differentiating of
 the distance function d_{FDE} into separate features 161. In
 25 one embodiment, this can be done by viewing the weights
 as a hyperplane and determining this hyperplane by a
 support vector machine. An initial value for all weights
 can be obtained by producing one positive element and one
 negative set of distance components for each sample 122.
 30 The positive element can be obtained as the set of
 distance components between a sample and the cluster
 center which the sample belonged to and correspondingly
 the negative element can be obtained as the distance

components between the sample and a neighbouring class. Further, the initial estimation of the weights can be obtained as the hyperplane obtained through a LinearSVC, which is a function that constructs a linear SVM
5 classifier, as implemented in an osu-svm package, such as the OSU SVM Classifier Matlab Toolbox (ver. 3.00) by Ma et al. Using a linear distance function with weights, it is possible to define secondary zoom functions to further differentiate in recognition between top candidates in
10 the recognition output.

A segment 126 of a handwritten pattern 124 may correspond to a sequence of possible segmentation points 132 from a first segmentation point to a second segmentation point. The segment 126 may thus comprise one
15 or more subsegments between adjacent intermediate segmentation points arranged in between the first and second segmentation points. The relative features of a segment 126 may be determined by comparing features 161 of adjacent sub-segments.

20 This implies that a handwritten pattern 124 representing several symbols may be quickly recognized. By using the possible segmentation points both for segmentation and for determining features 161 to be used in recognition of the handwritten pattern 124, the
25 calculations will simultaneously separate the handwritten pattern 124 and match the pattern 124 with templates 128. Thereby, the process of comparing of the handwritten pattern is very quick.

After all segmentation points have been analyzed,
30 cumulative matching measures may be assigned to the last segmentation point and may be associated with sequences of templates 128 that have been matched with the handwritten pattern 124. Thus, the information assigned to the last segmentation point could be used for
35 obtaining possible recognition results of the handwritten pattern 124.

A module 200 according to the present invention is illustrated in fig 5. The module may be a software implemented module, a hardware implemented module or a combination thereof, such as an ASIC.

5 Sample data 222 representing a handwritten pattern 224 which comprises one or more curves is received by a receiver 220 comprised within the module 200. The received sample data is thereafter transferred to a segmentation point detector 240, wherein segmentation
10 points 232 are detected on each curve.

Next, a divider 250 divides the handwritten pattern into segments 226 and a normalizer 264 normalizes said segments 226 according to a scheme 265. Said normalizer 264 may be of any suitable type, preferably a processor.
15 Said scheme 265 is independent of which sample 222 is to be normalized by the normalizer 264.

Further, a determinator 260 is configured to determine specific matching measures 266, 268 for selecting at least one sequence of templates 228
20 representing a recognition candidate of the handwritten pattern 224.

Finally, the selected sequence of templates 228 can be output from the module 200 by means of a transmitter 280.

25 The receiver 220 may be any known apparatus suitable for receiving data represented by any form, for example a voltage, a current, an optical signal, a magnetic signal or the like.

The transmitter 280 may be any known apparatus
30 suitable for transmitting data represented by any form, for example a voltage, a current, an optical signal, a magnetic signal or the like.

An apparatus 300 according to the present invention is illustrated in fig 6. The apparatus may be a communication terminal, such as a PDA ("Personal Digital Assistant"), a mobile phone or any other data handling
35 device.

The apparatus 300 may comprise a pen movement capturing device 310, such as a touch sensitive surface, configured for receiving sample data 322 representing a handwritten pattern 324. The sample data 322 received via
5 the pen movement capturing device 310 can be transferred to the module 200, as described above.

The reference templates 328 which are output from the module 200 can be transferred to a symbol matcher 350, which, in association with a symbol set database
10 352, can be configured to match a number of output reference templates to a symbol set.

When having found the symbol set, the corresponding symbol may be shown to the user on a display 390. If the pen movement capturing device 310 is embodied as a
15 touch sensitive surface, the touch sensitive surface may be combined with the display 390 of the apparatus.

Further, the symbol set may be transferred to an application 395, such as a messaging software application.

20 The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by
25 the appended patent claims.

CLAIMS

1. A method for recognition of a handwritten pattern comprising one or more curves, said method comprising
5 receiving sample data representing the handwritten pattern,
segmenting the handwritten pattern by detecting segmentation points on each curve, and by dividing the handwritten pattern into segments, and
10 comparing the handwritten pattern to templates wherein the comparing comprises
normalizing said segments according to a scheme which is independent of the templates to which the segments are to be compared, and
15 determining matching measures for selecting at least one sequence of templates representing a recognition candidate of the handwritten pattern.
2. The method according to claim 1, wherein said
20 matching measures comprise segmental matching measures comparing segmental features of the handwritten pattern to segmental features of the templates.
3. The method according to any of the claims 1 or 2,
25 wherein said matching measures comprise connective matching measures comparing connective features between segments in the handwritten pattern to connective features of templates.
- 30 4. The method according to claim 2, further comprising a step of compensating for translation, angle and length differences between the segments such that the segmental features are relative within each possible segment.
- 35 5. The method according to claim 3, further comprising a step of compensating for translation, angle

and length differences between the segments such that the connective features are relative between the adjacent segments.

5 6. The method according to claim 2, wherein said segmental features comprise a segmental distance between two segments.

10 7. The method according to claim 2, wherein said segmental features comprise a distance component between two pairs of attached segments.

15 8. The method according to claim 3, wherein said connective features comprise a distance component for non-connected segments.

20 9. The method according to claim 3, wherein said connective features comprise a distance component for a connection between two segments.

25 10. The method according to claims 6, 7, 8 or 9 wherein said step of determining matching measures utilizes an operator in order to determine the connection of templates that are to be used as a model for comparison with the connections between segments.

30 11. The method according to claim 6, 9 and 10, wherein said operator is a linear function of the segmental distance between two segments and the distance component for a connection between two segments.

35 12. The method according to any of the preceding claims, further comprising a step of detecting the segmentation points as local extreme points which are below a predetermined threshold.

13. The method according to claim 12, further comprising a step of parameterizing each segment by the Dijkstra Curve Maximization strategy with three intermittent points.

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14. The method according to any of the preceding claims, wherein said step of comparing utilizes point-to-curve matching.

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15. The method according to any of the preceding claims, further comprising a step of associating an output weight to normalized segmental and connective features.

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16. A module for recognition of a handwritten pattern comprising one or more curves, said module comprising

a receiver configured to receive sample data representing the handwritten pattern,

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a segmentation point detector configured to detect segmentation points on each curve,

a divider configured to divide the handwritten pattern into segments,

25 a normalizer configured to normalize said segments according to a scheme which is independent of the templates to which the segments are to be compared,

a determinator configured to determine matching measures for selecting at least one sequence of templates representing a recognition candidate of the handwritten pattern, and

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a transmitter configured to output said matching templates.

35 17. The module according to claim 16, wherein said determinator is configured to determine segmental matching measures.

18. The module according to claim 16, wherein said determinator is configured to determine connective matching measures.

5 19. The module according to claim 17, further comprising a compensator configured to compensate for translation, angle and length differences between the segments such that the segmental features are relative within each possible segment.

10 20. The module according to claim 18, further comprising a compensator configured to compensate for translation, angle and length differences between the segments such that the connective features are relative
15 between the adjacent segments.

20 21. The module according to claim 17, wherein said determinator is configured to determine a segmental distance between two segments.

22. The module according to claim 17, wherein said determinator is configured to determine a distance component between two pairs of attached segments.

25 23. The module according to claim 18, wherein said determinator is configured to determine a distance component for non-connected segments.

30 24. The module according to claim 18, wherein said determinator is configured to determine a distance component for a connection between two segments.

35 25. The module according to claims 21, 22, 23 or 24 wherein said determinator utilizes an operator in order to determine the connection of templates that are to be used as a model for comparison with the connections between segments.

26. The module according to claim 21, 24 and 25,
wherein said operator is a linear function of the
segmental distance between two segments and the distance
5 component for a connection between two segments.

27. The module according to claim 16, wherein said
segmental point detector is configured to detect the
segmentation points as local extreme points which are
10 below a predetermined threshold.

28. The module according to claim 25, wherein said
segmental point detector is configured to parameterize
each segment by the Dijkstra Curve Maximization strategy
15 with three intermittent points.

29. The module according to any of the claims 16 to
28, wherein said determinator is configured to utilize
point-to-curve matching.
20

30. The module according to any of the claims 16 to
29, further comprising an associator configured to
associate an output weight to every normalized segmental
and connective feature.
25

31. An apparatus comprising
a pen movement capturing device configured to
receive data representing a handwritten pattern,
a module according to claim 16 configured to receive
30 said data from said pen movement capturing device and to
output matching templates,
a symbol matcher configured to match said templates
into symbols, and
a display configured to present said symbols.
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32. The apparatus according to claim 31, wherein said pen movement capturing device is a touch sensitive surface.

5 33. The apparatus according to any of claim 31 or 32, further comprising
 a symbol set database comprising a number of reference template combinations and their associated symbols.

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 34. A computer program arranged to perform the method according to any of the claims 1-15 when downloaded into and run on a computational device.

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