

METHOD FOR RECOGNIZING HANDWRITTEN INPUT

Field Of The Invention

This invention relates generally to handwriting
5 recognition, and more particularly to recognition of individual words.

Background of the Invention

10 Machine recognition of human handwriting is a very difficult problem, and with the recent explosion of pen-based computing devices, has become an important problem to be addressed. Machine recognition of human handwriting has various present applications.

15 One example of the current application for machine recognition of human handwriting is found in personal digital assistants, such as the EO and Newton products. Typically these type of products have a touch sensitive screen upon which a user can impose handwriting. These devices then function to
20 digitize the handwritten input, such as alphanumeric input, and thereafter process the input in an attempt to recognize the information content of the handwriting.

Pursuant to one prior art handwriting recognition technique, one makes a best determination as to the identity of
25 each alphanumeric character in sequence, with the resulting string of characters comprising the result of the recognition activity. There are a variety of drawbacks to this approach. It is hindered by the difficulty of identifying spatial boundaries of the candidate inputs (in this case alphanumeric characters to be
30 recognized. When these boundaries are not located correctly, it is impossible to recognize the character accurately, since it will either be lacking pieces or will incorporate extraneous material from adjacent characters.

One significant problem with machine recognition of human handwriting is the ability to recognize the end of one input and the beginning of the next input. For example, a significant problem exists in locating the end of one
5 handwritten input segment, word, or alphanumeric input, from the beginning of the subsequent handwritten input segment, word, or alphanumeric input. Poor recognition of such breaks in the handwritten input results in poor, inaccurate
10 interpretation of the information content of the handwritten input.

Accordingly, a need exists for a handwriting recognition technique that can detect the end of a first handwritten input segment from the beginning of a second handwritten input segment. in the handwritten input and thereby provide a more
15 accurate interpretation of the information content of the handwritten input.

Brief Description of the Drawings

20 FIG. 1 Illustrates a flow diagram of operation in accordance with a preferred embodiment of the present invention.

FIG. 2 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the
25 present invention.

FIG. 3 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the present invention.

30 FIG. 4 Illustrates a graphical view of an illustrative display in accordance with an alternative preferred embodiment of the invention.

FIG. 5 Illustrates a graphical view of an illustrative display in accordance with a preferred embodiment of the
35 present invention.

Detailed Description of the Preferred Embodiments

Typically, handwritten character input is collected from the user in the form of discrete continuous segments. A
5 discrete continuous segment consists of one or more pen strokes, where a pen stroke is the mark left by a pen during its period of contact with an input device such as a digitizing tablet or paper. A stroke is represented as a sequence of
10 points sampled at approximately regular intervals by the input device. Each point is described at minimum by an X coordinate and a Y coordinate. Strokes may be captured electronically using a digitizing tablet, or in an alternative embodiment may be derived from a scanned or faxed image through a process of line detection in the image; such methods of capturing input
15 electronically are understood in the art.

Generally, the present invention as disclosed determines whether two discrete continuous segments form part of the same handwritten character input or part of more than one handwritten character input. In the present invention one or
20 more discrete continuous segments are the units of handwritten input being recognized. Handwritten input is input which is captured electronically that includes but is not limited to the following: handwritten input; electronic input; input captured through pressure, such as stamped input; input
25 that is received electronically, such as via facsimile, pager, or other device. For example - the present invention determines whether two discrete continuous segments form part of the same word or whether they form part of separate words. In a preferred method, the present invention calculates one or more
30 substantially parallel distances disposed substantially parallel to the writing axis, and compares these distances to one or more predefined thresholds. The predefined thresholds specify minimum distance measures which must be exceeded by the substantially parallel distances for the discrete
35 continuous segments to be judged as belonging to separate

handwritten input, for example separate handwritten words. The writing axis is the line along which the handwritten input is added. The writing direction is the direction in which each subsequent handwritten input is added. In English,

5 handwritten input is added typically along a horizontal writing axis with each subsequent alphanumeric input following horizontally after the previous input in a writing direction that is left to right. Various other writing axis and writing directions alternatives are possible with implementation of the
10 teachings of the present invention.

In a preferred embodiment, the handwriting axis is horizontal and the handwritten input forms a series of words. In this preferred embodiment, the substantially parallel distances are calculated horizontally, and the output tells whether discrete
15 continuous segments belong to separate words. In an alternative preferred embodiment, the handwriting axis is horizontal and the handwritten input forms a series of separate characters, which may be alphanumeric characters, ideographic characters as found in languages such as Chinese, or other
20 forms of characters or symbols of written communications. In this alternative embodiment, the output tells whether the discrete continuous segments belong to separate characters. In another preferred embodiment, the handwriting axis is vertical and the handwritten input forms a series of separate
25 characters, which may be alphanumeric characters, ideographic characters, or other handwritten text. In this preferred embodiment, the writing axis is vertical and the substantially parallel distances are aligned vertically; the output tells whether the discrete continuous segments belong to separate
30 characters. In yet another preferred embodiment, the handwriting axis is vertical and the handwritten input forms a series of separate words, alphanumeric input, or other handwritten input, such as a vertical list of words, or numbers. In this preferred embodiment, the writing axis is vertical and
35 the substantially parallel distances are aligned vertically; the

output tells whether the discrete continuous segments belong to separate handwritten input, such as separate words. As disclosed above and as will be discussed further, the present invention demonstrates through the disclosure of several of the preferred embodiments that the writing axis may exist at any angle and the handwritten input may be interpreted more generally as corresponding to discrete elements (including but not limited to characters and words) containing one or more discrete continuous segments. The application of the methods described herein to any of various preferred embodiments requires only a change in the coordinate system used and such modifications can be made in accordance with the teachings presented.

Referring now to FIG. 1, a preferred method of the present invention is illustrated. The present invention is applicable to one or more handwritten inputs of discrete continuous segments. The preferred embodiments of the present invention, are applicable to two or more handwritten inputs of discrete continuous segments. The use of only two discrete continuous segments S_1 and S_2 is for illustrative purposes. In the preferred method illustrated in FIG. 1, handwritten input consisting of two discrete continuous segments S_1 and S_2 (110) is accepted by a device, such as a PDA, or other device. Other devices which function to receive handwritten input include but are not limited to the following: computers, modems, pagers, telephones, digital or interactive or other televisions, devices having a digitizing tablet, facsimile devices, scanning devices, and any device with the ability to capture handwritten input. Preferably, upon acceptance of the handwritten input the substantially perpendicular boundaries b_1 and b_2 between the discrete continuous segments S_1 and S_2 are identified (120). The boundaries b_1 and b_2 which are substantially perpendicular to the writing axis are determined by finding the point in the stroke sequence S_1 that has the largest displacement along the writing direction and the point

in the stroke sequence S_2 that has the smallest displacement along the writing direction (120). The substantially perpendicular boundary b_1 is the displacement values of the point in the stroke sequence S_1 that has the largest displacement along the writing direction. The substantially perpendicular boundary b_2 is the displacement values of the point in the stroke sequence S_2 that has the smallest displacement along the writing direction. By calculating the displacement in the writing direction of each point in S_1 in turn and comparing that value to a stored value that is initially a very large negative number, the substantially perpendicular boundary b_1 that has the largest displacement along the writing direction can be determined. If the calculated displacement value is larger than the stored value, the stored value is replaced with the calculated displacement value. Once all the points have been examined, the stored value will contain the value of the largest displacement value found in the stroke sequence. A similar procedure, starting with a large positive initializing value, can be used to discover the point in S_2 that has the smallest displacement along the writing direction by calculating the displacement in the writing direction of each point in S_2 in turn and comparing that value to a stored value that is initially a very large positive number. If the calculated displacement value is less than the stored value, the stored value is replaced with the calculated displacement value. The preferred method then calculates a first substantially parallel distance d' , where $d' = b_2 - b_1$ (130).

Referring to FIG. 1, the first substantially parallel distance d' is compared to a first predetermined threshold t' . If d' is greater than or equal to ($\geq$) t' the preferred method concludes that the first continuous discrete segment S_1 and the second continuous discrete segment S_2 belong to different segments of handwritten input (145). By way of example if d' is greater than ($>$) t' the preferred method concludes S_1 and S_2 are different words, characters, or other elements of

handwritten input. The selection of a predetermined threshold t' is a value made in accordance with the specific embodiment. Choice of a threshold t' will be discussed in further detail elsewhere.

- 5 If the value of d' is smaller, or less than, the threshold value t' further processing occurs. To determine if the discrete continuous segments S_1 and S_2 form separate discrete continuous segments of handwritten input, such as separate words, characters, or other elements, a second substantially
- 10 parallel distance d'' is calculated. The second substantially parallel distance d'' is found by calculating several substantially parallel distances and choosing the shortest of those distances. In a preferred embodiment, this is done by first calculating the maximum extent perpendicular to the
- 15 writing axis subtended by S_1 and S_2 together (150). The extent is then divided into a number of bands of equal height substantially parallel to the writing axis (160). The substantially parallel distance between S_1 and S_2 for each band (170) is then found. The smallest or shortest
- 20 substantially parallel distance between S_1 and S_2 from among the plurality of bands is selected as d'' (180). In the preferred method represented in FIG 1, once the substantially horizontal distance d'' is found, the distance d'' and the first substantially horizontal distance d' are combined to aid in making a final
- 25 decision that S_1 and S_2 are part of the same handwritten input or are parts of separate discrete continuous segments of handwritten input. A weighted average of d' and d'' is calculated. A preferred weighted average equation is $q'd' + q''d''/(q' + q'')$. It has been found by empirical tests on actual
- 30 handwriting data that a weighted average of d' and d'' is more accurate than either alone. In one preferred embodiment, $q' = q''$, but it may be possible to optimize this further by a judicious choice of q' and q'' which are not identical. Additionally, q' and q'' can each be equal to zero, but not at the
- 35 same time.

The weighted average is compared against a second threshold t'' . If the weighted average is less than or smaller than t'' the preferred method concludes that S_1 and S_2 are part of the same segment of handwritten input (197). If the weighted average is larger than or equal to t'' the preferred method concludes that S_1 and S_2 are different continuous discrete segments of handwritten input and the preferred method concludes with that result (199).

The preferred method of selecting t' and t'' is a detail of the specific embodiment. In one embodiment, t' may be set by measuring the value of d' across a large set of data and choosing the value that best distinguishes real dividing points from false choices. In another preferred embodiment, t' may be set to a constant value that corresponds to some fraction of the distance between input guides on the input device. In another preferred embodiment, t' may vary dynamically as a fraction of the measured extent of S_1 and S_2 perpendicular to the writing axis. In another embodiment, t' may be set explicitly by the user before the method is invoked. In the preferred embodiment illustrated, t' is set to be $1/3$ of the measured extent of S_1 and S_2 perpendicular to the writing axis, which gives a good result for English, alphanumeric text. Many other ways of setting t' may be considered and may be optimal for different solutions. The various ways of determining t'' in different embodiments are similar to those described for determining t' .

In FIG. 2, a graphical representation is given, for a preferred embodiment. In this embodiment, the discrete continuous segments, S_1 (210) and S_2 (220), correspond to English words, the writing axis (230) is horizontal, and the writing direction (270) is left to right. In this preferred embodiment, the displacement along the writing direction for any point is simply the value of the X coordinate for that point, so the substantially perpendicular boundary b_1 (240) is the value of the X coordinate of the rightmost point in S_1 (210)

and the substantially perpendicular boundary b_2 (250) is the value of the X coordinate of the leftmost point in S_2 (220). The substantially parallel distance d' (260) is the distance extending between b_1 and b_2 .

5 Alternatively, as illustrated in FIG. 3, the discrete continuous segments S_1 (310) and S_2 (320) correspond to Chinese characters, the writing axis (330) is vertical, and the writing direction (370) is top to bottom. In this embodiment, the displacement along the writing direction (370) for any
10 point is simply the value of the Y coordinate for that point multiplied by -1 (assuming a standard coordinate system in which Y increases as one moves from bottom to top), so the substantially perpendicular boundary b_1 (340) is the value of the Y coordinate times -1 of the bottommost point in S_1 (310)
15 and the substantially perpendicular boundary b_2 (350) is the value of the Y coordinate times -1 of the topmost point in S_2 (320).

In other embodiments, the values for b_1 and b_2 can be calculated by applying a simple geometric rotation of the
20 handwritten input to line up the writing axis with one of the cardinal axes of the coordinate system, and then applying the procedure just described. This is a straightforward operation that will be understood by persons in conjunction with the teachings presented here. Alternatively, other embodiments
25 may calculate the displacements of the points along the writing direction, when the writing direction does not line up with one of the cardinal axes of the coordinate system, by a simple geometric projection of the discrete continuous segments onto the writing axis and then using trigonometry to calculate the
30 displacement of the projected points from the origin of the coordinate system. This is a well-understood mathematical procedure that can be applied to the teachings herein.

As stated previously, if d' is smaller than t' , the processing continues. In many cases, segments that do in fact
35 belong to separate words or characters are positioned in such a

way that d' is small or even negative, but it is still possible to determine that S_1 and S_2 belong to different words or characters. FIG. 4 shows an example of this situation for an embodiment in which S_1 (410) and S_2 (420) are English words.

5 In this example, d' (460) is actually negative, and b_1 (440) is larger than b_2 (450). In this example, the writing axis (430) is horizontal and the writing direction (470) is left to right.

In one embodiment in which the writing axis is horizontal, the maximum extent perpendicular to the writing axis subtended by S_1 and S_2 is calculated by finding the minimum and maximum Y coordinate values present in S_1 and S_2 . To find the minimum Y coordinate value, a stored value is initialized with a very large positive value, and then every point in S_1 and S_2 is examined in turn, and if its Y coordinate value is smaller than the stored value, the stored value is assigned that Y coordinate value. A similar method is used to find the maximum Y coordinate value. By subtracting the maximum and minimum Y coordinate values, the extent perpendicular to the writing axis can be calculated. All points in S_1 and S_2 lie within this extent.

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In a preferred embodiment, this process can be made more efficient by considering only a subset of the points in S_1 and S_2 such that only a fixed number of points near the boundary in question are considered, since these are the ones most likely to affect the measure being derived.

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In an alternative embodiment, in which the writing axis is vertical, the maximum extent perpendicular to the writing axis subtended by S_1 and S_2 is calculated by finding the minimum and maximum X coordinate values present in S_1 and S_2 . To find the minimum X coordinate value, a stored value is initialized with a very large positive value, and then every point in S_1 and S_2 is examined in turn, and if its X coordinate value is smaller than the stored value, the stored value is assigned that X coordinate value. A similar method is used to find the maximum X coordinate value. By subtracting the

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maximum and minimum X coordinate values, the extent perpendicular to the writing axis can be calculated.

5 In an alternative embodiment, where the writing axis is neither horizontal nor vertical, the image plane can be rotated to align the writing axis with the X or Y axis of the coordinate system, as described above in the calculation of the substantially parallel distance d' when the writing axis was neither horizontal nor vertical.

10 Once the extent perpendicular to the writing axis has been found, a preferred embodiment divides this extent into bands substantially parallel to the writing axis, such that each band describes a narrow slice through S_1 and S_2 . Within each band, the point in S_1 with the largest displacement in the writing direction is found, and the point in S_2 with the smallest
15 displacement in the writing direction is found. This can be done efficiently with respect to S_1 by initializing a stored value for each band to a very large negative number. Each point in S_1 is checked in turn. First, its displacement perpendicular to the writing axis is checked to see which band it lies in. Since
20 the bands span the entire extent of S_1 and S_2 perpendicular to the writing axis, it is guaranteed that a band can be found for any point in S_1 and S_2 . If the preferred embodiment described above for calculating the perpendicular extent by considering only a subset of points in S_1 and S_2 , the perpendicular extent
25 may not contain all points in S_1 and S_2 , and so each point must be checked to ensure that it lies within a band. If it does not, it is not considered further. Once the band is identified, the displacement of the point in the writing direction is compared to the stored value for that band, and if the displacement is
30 larger, it is assigned to the stored value. Once all of the points in S_1 have been checked in this way, the stored value in each band will contain the largest displacement of the point with the largest displacement encountered in that band in S_1 . If there were no points in S_1 lying within a given band, the stored
35 value will remain as the very large negative initializing value.

A similar procedure, using a second stored value in each band initialized to a large positive number, is used with respect to S_2 to find the minimum displacement of the point with the minimum displacement in the writing direction within each band in S_2 . If there are no points for a given band in S_2 , the second stored value for that band remains at its large initialized value.

At the end of this operation, for each band there are two stored values corresponding to the largest displacement in the writing direction of S_1 in the band and the smallest displacement in the writing direction of S_2 in the band. If either stored value has not changed from its very large negative or positive initializing value, then the information for that band is not used in any further calculations. Otherwise, a distance is calculated for each band by subtracting the stored value for the displacement of the point in S_1 from the stored value for the displacement of the point in S_2 . The smallest of these distances is found by examining the distance for each band in turn and storing the smallest one found. This smallest distance is the substantially horizontal distance d'' . If d'' is less than 0, which can occur if S_1 and S_2 touch or overlap, it is assigned the value 0.

One embodiment in which the writing axis is horizontal and the writing direction is left to right is shown in FIG. 5. In this embodiment, the number of bands (510) is 10. The rightmost point of S_1 lying within each band is found (520) and the leftmost point of S_2 lying within that band is also found (530). This is done with respect to S_1 by initializing a stored value for each band to a very large negative number. Each point in S_1 is checked in turn. First, its Y coordinate is checked to see which band it lies in. Since the bands span the entire height, extent (540) of S_1 and S_2 , it is guaranteed that a band can be found for any point in S_1 and S_2 . Once the band is identified, the X coordinate of the point is compared to the stored value for that band, and if the X coordinate is larger, it

is assigned to the stored value. Once all of the points in S_1 have been checked in this way, the stored value in each band will contain the X coordinate of the rightmost point encountered in that band in S_1 . If there were no points in S_1 lying within a given band, the stored value will remain as the very large negative initializing value. A similar procedure with respect to S_2 , using a second stored value in each band initialized to a large positive number, is used to find the X coordinate of the leftmost point in each band in S_2 .

As described previously, the value of d'' is computed from the stored locations for each band. The smallest, or shortest, substantially parallel distance between S_1 and S_2 from amount the plurality of bands is selected as d'' . The distance d'' is then combined with d' via a weighted average and compared to t'' . Upon comparison with t'' the method of the present invention concludes whether the discrete continuous segments S_1 and S_2 belong to the same handwritten input or separate handwritten inputs.

It will be apparent to those skilled in the art that the disclosed invention may be modified in numerous ways and may assume many embodiments other than the preferred forms particularly set out and described above. Accordingly, it is intended by the appended claims to cover all modifications of the invention that fall within that fall within the true spirit and scope of the invention and its equivalents.

I Claim:



is assigned to the stored value. Once all of the points in S_1 have been checked in this way, the stored value in each band will contain the X coordinate of the rightmost point encountered in that band in S_1 . If there were no points in S_1 lying within a given band, the stored value will remain as the very large negative initializing value. A similar procedure with respect to S_2 , using a second stored value in each band initialized to a large positive number, is used to find the X coordinate of the leftmost point in each band in S_2 .

As described previously, the value of d'' is computed from the stored locations for each band. The smallest, or shortest, substantially parallel distance between S_1 and S_2 from amount the plurality of bands is selected as d'' . The distance d'' is then combined with d' via a weighted average and compared to t'' . Upon comparison with t'' the method of the present invention concludes whether the discrete continuous segments S_1 and S_2 belong to the same handwritten input or separate handwritten inputs.

It will be apparent to those skilled in the art that the disclosed invention may be modified in numerous ways and may assume many embodiments other than the preferred forms particularly set out and described above. Accordingly, it is intended by the appended claims to cover all modifications of the invention that fall within that fall within the true spirit and scope of the invention and its equivalents.

I Claim:



1. A method comprising the steps of:
receiving handwritten character input, which handwritten character input is comprised of at least a first and a second discrete continuous segment;
- 5 calculating at least on substantially parallel distance between the first and second discrete continuous segments;
using the substantially parallel distance to determine whether the first and second discrete continuous segments belong to separate handwritten character input.

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2. The method of claim 1 wherein at least one of the following:
- a) the step of calculating at least one substantially parallel distance includes the step of calculating a plurality of substantially parallel distances between the first and second discrete continuous segments and,
- 5 where further selected the step of calculating a plurality of substantially parallel distances further includes the step of identifying the substantially parallel distance having smallest value and,
- 10 where further selected the step of using the parallel distance to determine whether the first and second discrete continuous segments belong to separate handwritten inputs includes the step of using the substantially parallel distance having the smallest value to determine whether the first and
- 15 second discrete continuous segments belong to separate handwritten inputs;
- b) further including the steps of:
- identifying a substantially perpendicular boundary for each of the first and second discrete continuous segments;
- 20 calculating a distance between the substantially perpendicular boundary for the first and second discrete continuous segments and,
- where further selected the step of using the parallel distance to determine whether the first and second discrete continuous segments belong to separate handwritten inputs
- 25 includes the step of also using the distance between the substantially perpendicular boundary for the first and second discrete continuous segments to determine whether the first and second discrete continuous segments belong to separate
- 30 handwritten inputs.

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3. A method comprising the steps of:
receiving handwritten input, which handwritten input is comprised of at least a first and a second discrete continuous segment;
- 5 identifying a substantially perpendicular boundary for each of the first and second discrete continuous segments;
calculating a first distance between the substantially perpendicular boundary for the first and second discrete continuous segments;
- 10 when the first distance does not at least exceed the first predetermined threshold, calculating at least one substantially parallel distance between the first and second discrete continuous segments;
using the first distance and the substantially parallel
- 15 distance to determine whether the first and second discrete continuous segments belong to separate handwritten inputs.
4. The method of claim 3, wherein the step of using the first distance and the substantially parallel distance to determine
- 20 whether the first and second discrete continuous segments belong to separate handwritten inputs includes the step of adding a weighted first distance and a weighted substantially parallel distance together to obtain a result and dividing the result by two to obtain a final result, and comparing the final result with a
- 25 second predetermined threshold.
5. The method of claim 4, wherein at least one of the following:
- 30 a) the first and second predetermined thresholds are identical to one another;
- b) the first and second predetermined thresholds are different from one another;
- c) a weighting factor, as applied to both the first distance and the substantially parallel distance to obtain the weighted first
- 35 distance and the weighted substantially parallel distance,





respectively, is one, such that the first distance is equal to the weighted first distance and the substantially parallel distance is equal to the weighted substantially parallel distance.

- 5 6. The method of claim 3, wherein the step of calculating a first distance between the substantially perpendicular boundary for the first and second discrete continuous segments includes the steps of:

10 when the substantially parallel distance is positive in value, using the substantially parallel distance as the substantially parallel distance;

when the substantially parallel distance is negative in value, using a predetermined value as the substantially parallel distance and;

15 where further selected the predetermined value is zero.

7. The method of claim 3, wherein the step of calculating at least one substantially parallel distance includes the step of calculating a plurality of substantially parallel distances between
20 the first and second discrete continuous segments.

8. The method of claim 7, wherein the step of calculating a plurality of substantially parallel distances further includes the step of identifying the substantially parallel distance having a
25 smallest value and;

where further selected the step of using the first distance and the substantially parallel distance to determine whether the first and second discrete continuous segments belong to separate handwritten inputs includes the step of using the substantially
30 parallel distance having the smallest value and the first distance to determine whether the first and second discrete continuous segments belong to separate handwritten inputs.





9. A method comprising the steps of:
- receiving handwritten input, which handwritten input is comprised of at least a first and a second discrete continuous segment that are disposed substantially parallel to a writing axis;
 - 5 identifying a boundary that is perpendicular to the writing axis for each of the first and second discrete continuous segments;
 - calculating a first distance between the boundary for the first and second discrete continuous segments;
 - when the first distance at least exceeds a first
 - 10 predetermined threshold, concluding that the first and second discrete continuous segments belong to separate handwritten inputs;
 - when the first distance does not at least exceed the first predetermined threshold, calculating at least one substantially
 - 15 perpendicular distance between the first and second discrete continuous segments, which substantially perpendicular distance is substantially perpendicular to the writing axis;
 - using the first distance and the substantially parallel distance to determine whether the first and second discrete
 - 20 continuous segments belong to separate handwritten inputs.
10. A method of determining that two discrete continuous segments belong to separate handwritten inputs, comprising the steps of:
- 25 receiving handwritten input, which handwritten input is comprised of at least a first and a second discrete continuous segment;
 - identifying a substantially perpendicular boundary for each of the first and second discrete continuous segments, which
 - 30 substantially perpendicular boundaries are those boundaries that are most adjacent to one another;
 - calculating a separation distance between the substantially perpendicular boundary for the first and second discrete continuous segments;





when the separation distance at least exceeds a first predetermined threshold, concluding that the first and second discrete continuous segments belong to separate handwritten inputs;

- 5 when the separation distance does not at least exceed the first predetermined threshold, calculating a plurality of substantially parallel separation distances between portions of the first and second discrete continuous segments;

- 10 using the separation distance and a smallest one of the substantially parallel separation distances to determine whether the first and second discrete continuous segments belong to separate handwritten inputs.

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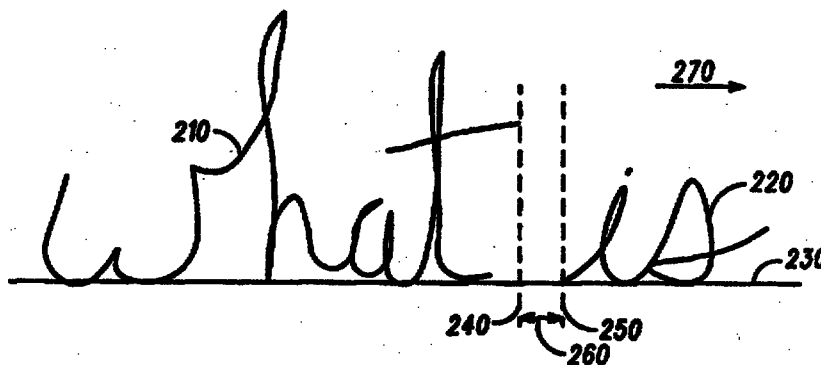
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(57) Abstract

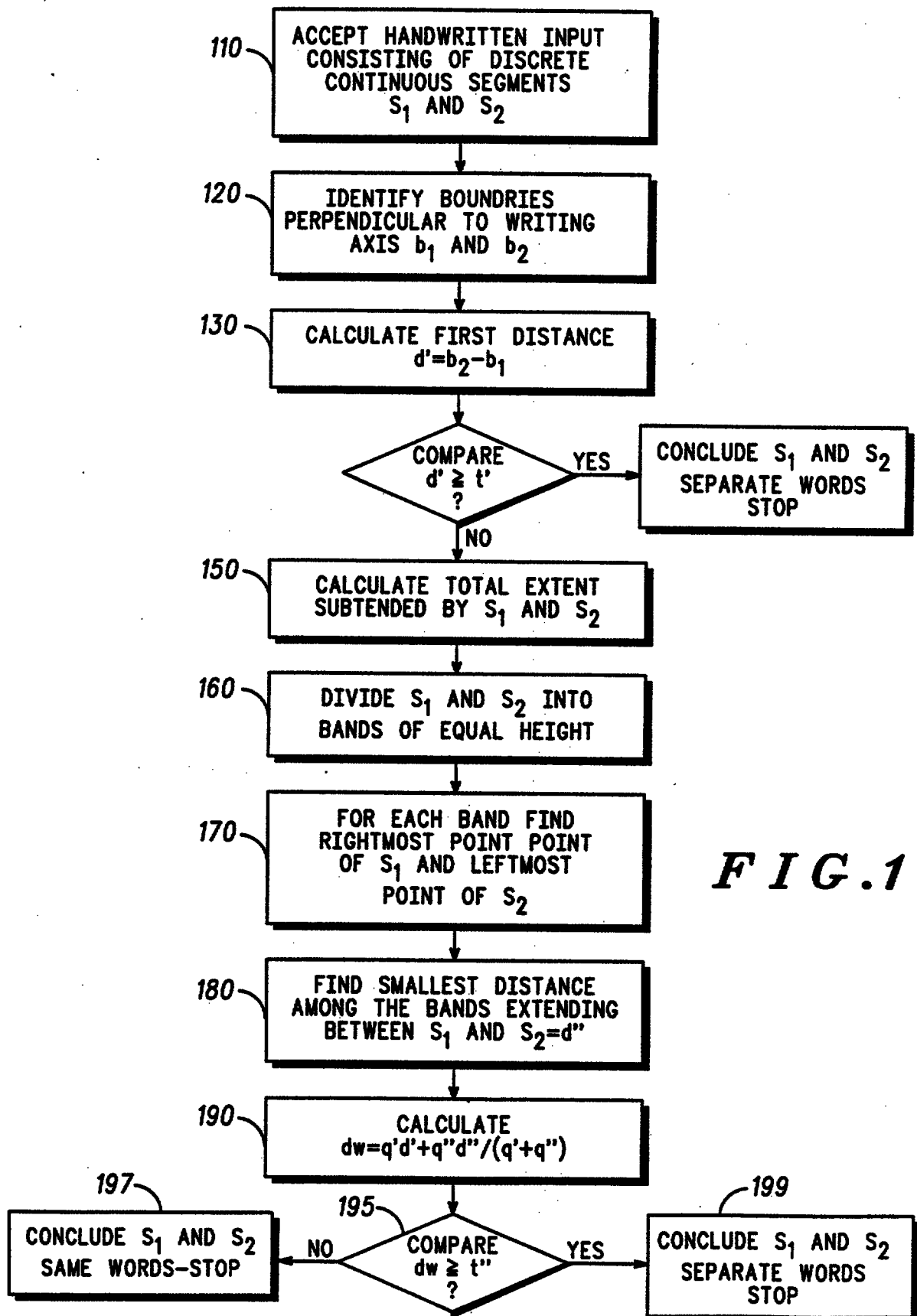
The present invention determines whether two discrete continuous segments of handwritten input S_1 (210) and S_2 (220) form part of the same handwritten input or are part of more than one, separate handwritten inputs. The present method calculates one or more substantially parallel distance (260) disposed substantially parallel to the writing axis (230) and compares these distances to one or more predefined thresholds. The predefined thresholds specify minimum distance measures which must be exceeded by the substantially parallel distances (260) for the discrete continuous segments (210, 220) to be judged as belonging to separate segments of handwritten input.

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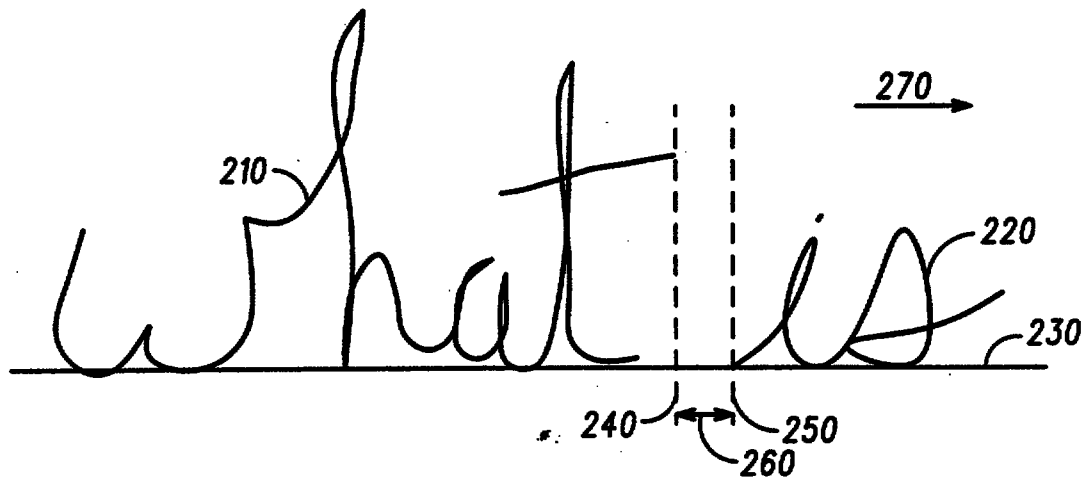
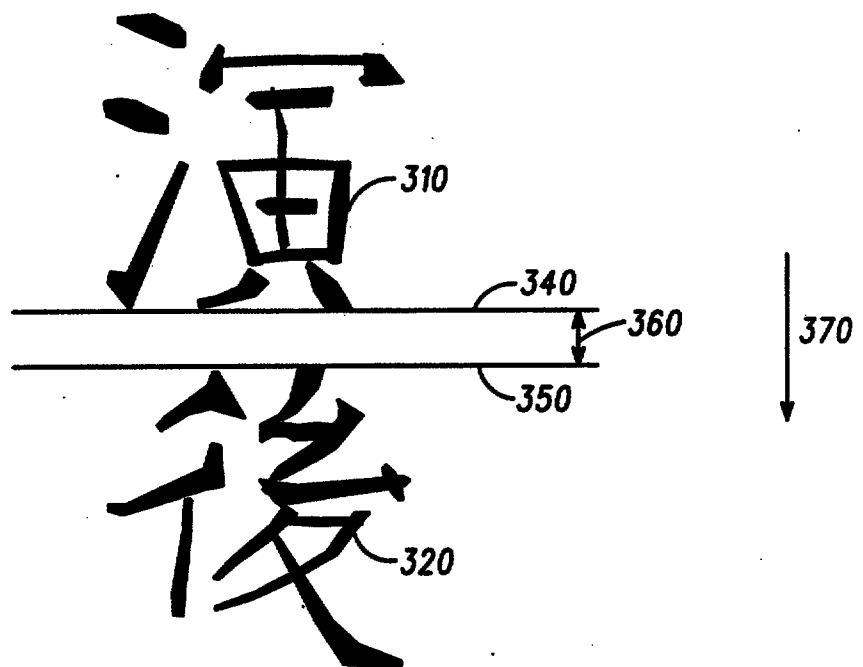
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CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

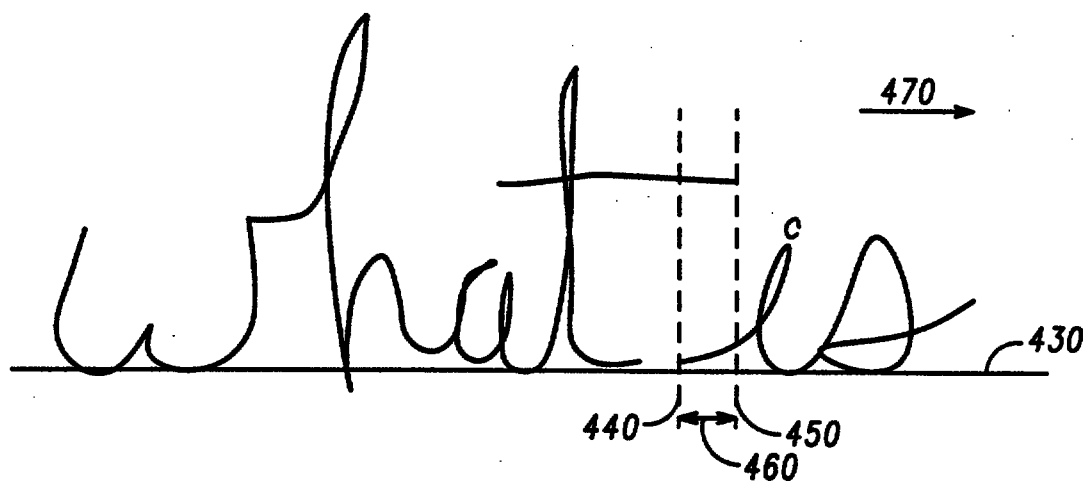
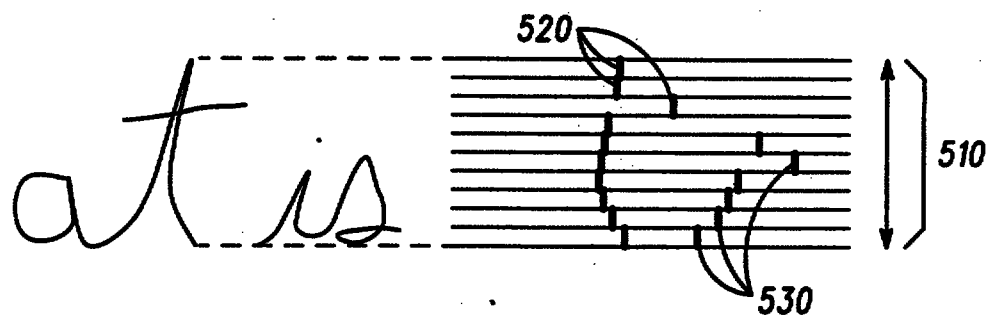
1 / 3

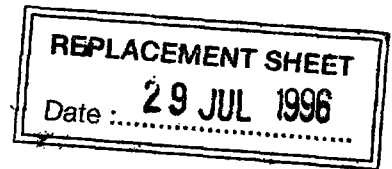


2/3

**FIG. 2****FIG. 3**

3/3

**FIG. 4****FIG. 5**



1. A method comprising the steps of:

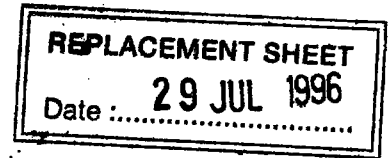
receiving handwritten character input, which handwritten character input is comprised of at least a first and a second discrete continuous segment;

calculating at least one distance between the first and second discrete continuous segments, the distance being substantially parallel to a writing axis of the first and second discrete continuous segments including the steps of:

calculating a plurality of distances between the first and second discrete continuous segments which are substantially parallel to the writing axis of the first and second discrete continuous segments;

identifying which of the plurality of distances has a smallest value; and
using the distance to determine whether the first and second discrete continuous segments belong to separate handwritten character inputs.

2. The method of claim 1, wherein the step of using the parallel distance to determine whether the first and second discrete continuous segments belong to separate handwritten inputs includes the step of determining whether the first and second discrete continuous segments belong to separate handwritten inputs based upon the smallest value of the plurality of distances.



3. A method comprising the steps of:

receiving handwritten character input, which handwritten character input is comprised of at least a first and a second discrete continuous segment;

calculating at least one distance between the first and second discrete continuous segments, the distance being substantially parallel to a writing axis of the first and second discrete continuous segments;

identifying a boundary for each of the first and second discrete continuous segments, which boundary for each of the first and second discrete continuous segments is substantially perpendicular to the writing axis;

calculating a distance between the boundaries for the first and second discrete continuous segments; and

using the distance between the boundaries for the first and second discrete continuous segments to determine whether the first and second discrete continuous segments belong to separate handwritten inputs.



Date : 29 JUL 1996

4. A method comprising the steps of:

receiving handwritten input comprising first and second continuous segments, the handwritten input having a first axis defined along a direction of writing of the handwritten input;

determining a boundary for each of the first and second continuous segments, the boundary for each of the first and second continuous segments being defined along a second axis perpendicular to the first axis through a point along the first axis for each of the first and second continuous segments nearest the boundary of the other of the first and second continuous segments;

calculating a distance parallel to the first axis between the boundaries; and

determining from the distance whether the first and second continuous segments are separate handwritten inputs, including the steps of:

comparing the distance to a first predetermined threshold;

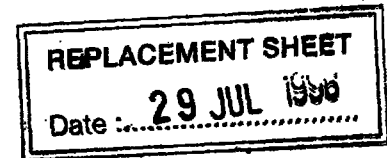
determining that the first and second continuous segments are separate handwritten inputs when the distance is greater than the first predetermined threshold;

separating each of the first and second continuous segments into a plurality of sections when the distance is not greater than the first predetermined threshold;

analyzing each of the plurality of sections to determine which of the plurality of sections has a portion of each of the first and second continuous segments;

for each of the plurality of sections where the portion of each of the first and second continuous segments has been found, calculating a segment distance between the portions of the first and second continuous segments that are nearest to each other; and

determining from the distance and the segment distance whether the first and second continuous segments are separate handwritten input.



5. A method according to claim 4 wherein the step of determining from the distance and the section distance whether at least first and second continuous segment are separate handwritten input comprises the steps of:

calculating a weighted average of the distance and the segment distance;

comparing the weighted average to a second predetermined threshold;

determining that the at least first and second continuous segment are separate handwritten input if the weighted average is greater than the second predetermined threshold; and

determining that the at least first and second continuous segment are not separate handwritten input if the weighted average is not greater than the second predetermined threshold.

6. A method according to claim 4 wherein the sections are distributed in a direction perpendicular to the writing axis.

7. A method according to claim 6 wherein the sections are of equal breadth in a direction perpendicular to the writing axis.



REPLACEMENT SHEET
Date : 29 JUL 1996

8. A method, comprising the steps of:

processing first and second discrete continuous segments representing handwritten input entered along a writing axis to identify a first boundary for the first discrete continuous segment and a second boundary for the second discrete continuous segment, the first boundary representing a greatest displacement of the first discrete continuous segment from a reference and the second boundary representing a least displacement of the second discrete continuous segment from the reference;

calculating a first distance between the first and second boundary, the first distance being substantially parallel to the writing axis;

determining that the first and second discrete continuous segments represent a separate handwritten character when the first distance exceeds a first threshold;

determining a second distance when the first distance does not at least exceed the first threshold, the second distance being substantially parallel to the writing axis and selected as a minimum distance from a plurality of distances between left-most points of the first discrete continuous segment and right-most points of the second discrete continuous segment in a like plurality of bands being substantially parallel to the writing axis; and

determining that the first and second discrete continuous segments represent a separate handwritten character when the second distance exceeds a second threshold.

Date ... 29 JUL 1996 ...

9. A method comprising the steps of:

receiving handwritten character input, which handwritten character input is comprised of at least a first and a second discrete continuous segment positioned along a writing axis;

defining a first and a second boundary which are substantially perpendicular to the writing axis;

calculating the first boundary by finding the point in the first discrete continuous segment that has the largest displacement from a reference point along the writing axis;

calculating the second boundary by finding the point in the second discrete continuous segment that has the smallest displacement from the reference point along the writing axis;

determining that the largest displacement of the point in the first discrete continuous segment is greater than the smallest displacement of the point in the second discrete continuous segment;

calculating a negative value by subtracting the smallest displacement of the point of the second discrete continuous segment from the largest displacement of the point of the first discrete continuous segment; and

using the negative value to determine whether the first and second discrete continuous segments belong to separate handwritten inputs.

