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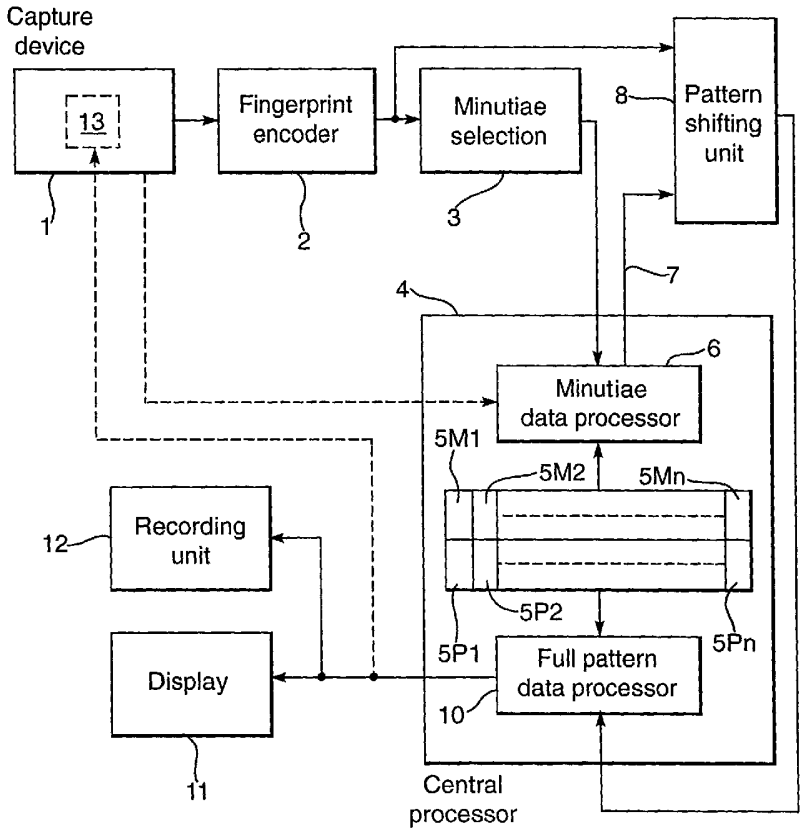
(54) Title: A SKIN RIDGE PATTERN IDENTIFICATION SYSTEM AND METHOD




(57) Abstract: A skin pattern identification system using a process in which a pattern is first captured (20), minutiae are then found (21), and the captured print is then aligned with a reference print on the basis of the relative positions of their minutiae (22, 23). Techniques in current use for the identification of fingerprints by comparison of minutiae sets are readily adaptable to yield the requisite alignment information. Once the subject and reference prints are aligned, a the pattern matching process (24) may be utilized on all or a significant part of the captured skin ridge pattern. with improved accuracy and speed, since no positional scanning is required.

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# A SKIN RIDGE PATTERN IDENTIFICATION SYSTEM AND METHOD

This invention relates to systems for identifying fingerprints, and it addresses particularly certain problems that can be encountered in such systems which utilize matching procedures based upon a significant part, at least, of the overall fingerprint pattern.

Such procedures are advantageous as compared with those which are based upon the recognition of specific localized features, such as minutiae or crease lines, in fingerprint patterns presented for identification (hereinafter called "subject patterns") and the comparison of such features with those previously derived from reference fingerprint images, principally because they are less susceptible to the effects of noise in, or localized changes to, the subject patterns. The term "noise" as used herein is intended to refer to any unwanted information that is incorporated in the subject patterns or in electrical signals derived from them and used in the recognition process. In this respect, it has to be borne in mind that the subject patterns are frequently obtained in circumstances that are significantly less than ideal, and in which the inclusion of noise, often in significant amounts, is unavoidable.

A disadvantage associated with pattern matching, however, is that the matching procedure depends quite critically upon the positioning and alignment of the subject pattern in relation to that of the reference images with which it is to be compared. Thus, whilst attempts have been made to physically constrain a subject's finger to adopt a particular position whilst a subject pattern is being taken, these have not proved wholly successful and it has frequently proved necessary to adopt computationally intensive operations to repeatedly shift and re-orientate a subject image relative to each reference image with which it is to be compared.

Even these operations are only partially successful, due to the fact that there are limits upon the number of attitudes and orientations that can be implemented in any system that is required to produce results within a reasonable time-frame, and that differences of scale, such as may be caused by plastic deformation of the subject's skin, are difficult to accommodate.

Despite these difficulties, pattern-based recognition procedures such as that described in European Patent No. 450,786, based upon auto-correlation, and incorporated in the applicant's fingerprint recognition system known by the Trade Mark VERID, are favoured in many circumstances, and the invention thus aims to address the above-mentioned difficulty.

According to a first aspect of the invention there is provided a fingerprint identification system as specified in claims 1 – 7.

Preferably the specific localized features utilized for comparison include minutiae such as ridge endings and bifurcations. Such minutiae lend themselves relatively well to automatic recognition and classification and thus constitute reliable mapping data.

Preferably also, the reference data are organized in paired and uniquely associated files, with the specific localized feature data, comprising a map of features tagged to reflect their types and referred to a standardized positional matrix in one file and the full pattern data in the other. By this means, the mapping data, derived from the features, are available for instantaneous comparison with similar data derived from the corresponding features of subject print patterns.

It is further preferred that full pattern matching is only carried out against those reference patterns whose specific localized feature maps show at least a reasonable correlation with the feature data derived from a subject print pattern. By this means, time and processing power is not wasted in attempting to compare patterns that are clearly incompatible.

It is preferred, but by no means essential, that the pattern matching procedure is based upon auto-correlation, as described in the aforementioned European Patent, whereby fingerprints can be encoded digitally and with economy of data.

According to a second aspect of the invention there is provided a method of identifying a skin ridge pattern such as a fingerprint, as specified in claim 8.

In order that the invention may be clearly understood and readily carried into effect, an embodiment thereof will now be described with reference to the accompanying drawings, in which:-

Figure 1 shows, in block diagrammatic form, a system according to the invention, and

Figure 2 shows, in block diagrammatic form, a method according to the invention..

Referring now to Figure 1, a fingerprint capture device 1 comprises, in this example, a station at which a person requiring access to some location or service presents their finger for identification. In other embodiments of the invention, the device 1 may comprise any arrangement for taking or obtaining prints, either directly from a finger or indirectly from a surface that a person may have touched. In any event, the entire print is scanned, and electronically encoded at 2 to provide print patterns for further processing. Scanning may be performed optically, or using other scanning means such as for example capacitive or pressure or thermal sensors.

The print patterns are applied, in this example, to a minutiae recognition and mapping stage 3 which can be configured to function in accordance with any of a number of techniques known in the art for recognizing minutiae and mapping their distribution relative to a predetermined framework or reference grid.

A central processor 4 incorporates paired stores 5M1, 5P1; 5M2, 5P2; up to and including 5Mn and 5Pn, where n represents the total number of reference fingerprints stored. The stores such as 5M1 store representations of minutiae, effectively mapped on the reference framework or grid, from respective fingerprints for comparison with similarly disposed representations relating to subject fingerprints and derived from the operational stage 3. The stores such as 5P1, on the other hand, store electronic representations of at least a significant part of the entire fingerprint pattern; the contents of a pair of stores such as 5M1 and 5P1, of course relating to the same fingerprint.

The minutiae data output from stage 3 are applied to a minutiae map data processor 6 incorporated within the central processor 4, where they are compared with the mapped reference minutiae data from one or more of the stores 5M1 to 5Mn, depending upon the nature of the system. In this respect, it may be for example that the person whose fingerprint has been captured at 1 is

one of a number of people having approved access to an area or to a service, and may identify themselves by means of a secondary method, such as by entering a PIN at the location 1. If that is the case, the processor 4 clearly does not need, at least in the first instance, to attempt to match the incoming subject minutiae data with all of its stored references, but merely with the single reference pertaining to the particular approved person. A dashed line connection for this purpose is shown in the drawing.

In any event, once a subject minutiae map is matched, at least to a reasonable degree of confidence with one or more reference minutiae maps, minutiae points identified in the subject map are effectively shifted, relative to the predetermined framework or grid to align them with apparently corresponding points on the reference map or maps. The positional and/or dimensional amounts of all shifts imposed upon the subject pattern to effect the alignment are derived and applied by way of a control line 7 to a pattern shifting unit 8, which receives the full pattern data relating to subject fingerprints from stage 2.

The unit 8 is thus effective to shift and/or orientate patterns applied to it so as to align them with the selected reference pattern or patterns, in dependence upon the comparison of the corresponding minutiae data.

The shifted and/or re-orientated patterns from unit 8 are applied to the full pattern processing unit 10, incorporated within the central processor 4, which utilizes any chosen pattern-matching procedure to compare the subject pattern with one or more of the stored reference patterns, as stored in stores 5P1 to 5Pn.

In this example, it is preferred to use the pattern recognition procedure described in the aforementioned European Patent, the full disclosure of which is hereby incorporated by reference; that procedure being based upon the autocorrelation of a true fingerprint image, with effective motion imparted to a replica of the original relative to the original itself; the "motion" being such as to cause the replica and original images to adopt a predetermined number (say six) of relative positions.

At each relative position, the overall white/black content of the superposed images in each of (say) four fixed measurement areas, defined in relation to the images, is detected, and electrical signals indicative of such

content are generated; the aforementioned measurement areas preferably covering in total all, or substantially all of the fingerprint area. Thus, in this example, a total of 24 signals, each indicative of the white/black content (or light intensity) measured in a respective one of the aforesaid (four) measurement areas with the original and replica images in a respective one of their (six) relative positions.

The 24 signals are found to accurately characterize the fingerprint, provided that the subject fingerprint pattern is sufficiently well aligned with the reference pattern(s), which alignment is effectively and efficiently achieved by means of the present invention.

The processor 10 is effective to drive an identification display 11 of any convenient form to present the results of the fingerprint comparison to an authorized user. The results presented upon display 11 may be applied also to a permanent recording unit 12 and/or to a local display 13 disposed at a point of entry, which may be where the fingerprint capturing device is located, and/or to generate a signal that automatically permits access to the requisite area or service once identification has been achieved.

It will be appreciated that the foregoing description is provided by way of example only and that various modifications may be made without departing from the scope of the invention. For example, pattern-matching techniques based upon procedures other than auto-correlation may be used and minutiae data other than, or in addition to, ridge endings and bifurcations may be used in the initial mapping and position/orientation adjustment phase.

It will be further appreciated that, although the processing components 6 and 10, and the paired stores 5M1-n and 5P1-n are shown as separate entities within the processor 4, they may be part of an integrated processing unit which may also incorporate the pattern shifting unit 8. In any event, it is preferred that the units 5, 6, 8 and 10 share timing and operational instructions generated under user control by the processor 4.

It will thus be appreciated that, in accordance with the invention, minutiae are first found and the subject print is then aligned with a reference print (or prints) on the basis of the relative positions of their minutiae. Techniques in

current use for the identification of fingerprints by comparison of minutiae sets are readily adaptable to yield the requisite alignment information.

Once the subject and reference prints are aligned, the pattern matching process (such as auto-correlation, as described above) may be utilized with improved accuracy and speed, since no positional scanning is required.

In contrast to the case where reliance for identification is placed solely upon minutiae matching, a substantial number of falsely identified minutiae, or minutiae which have failed to be identified, may be tolerated without complete failure of the recognition process. Thus reliable results can be achieved, even in circumstances dictating the use of either an inferior minutiae-finding algorithm or low quality fingerprint images. In the extreme event that the quality of a captured fingerprint image is too low to permit reliable minutiae matching to be achieved for alignment purposes, reliance can be placed wholly upon the pattern matching procedure which, as has been stated, is less sensitive than minutiae-based processes to localized characteristics of the fingerprint.

Use of the invention provides the capability of improving the False Accept Rate (FAR) associated with the pattern matching process by around an order of magnitude, whilst not deleteriously affecting its False Reject Rate (FRR) to any significant extent.

As has been stated, the alignment operation of the invention is not limited to the use of minutiae matching, and data relating to other specific localized features, such as crease lines, can be used instead of (or in addition to) minutiae if preferred. An advantage of using crease lines is that they represent readily identifiable features which can often extend in length to more than 10mm. Their identification is thus relatively straightforward and can be achieved with reduced computational power. It is known, however, that a small proportion of the population (believed to be between 5% and 10%) does not have crease lines. A preferred arrangement may therefore be to utilize crease lines where available but to utilize minutiae where crease lines are indistinct or non-existent.

In summary, a skin pattern identification system has been described which uses a process in which a pattern is first captured, minutiae are then found, and the captured print is then aligned with a reference print on the basis of the relative positions of their minutiae. Techniques in current use for the

identification of fingerprints by comparison of minutiae sets are readily adaptable to yield the requisite alignment information. Once the subject and reference prints are aligned, a pattern matching process may then be utilized on all or a significant part of the captured skin ridge pattern. with improved accuracy and speed, since no positional scanning is required.

A schematic diagram of the method of the present invention is shown in Figure 2, which shows a first block (20) which denotes capturing a subject skin ridge pattern, a second block (21) which denotes detecting the locations of specific localized features in the pattern, a further block (22) which denotes comparing the detected localized features with those of corresponding features in reference patterns, another block (23) which denotes using the comparison data to determine relative positions and/or orientations, as between the subject pattern and one or more reference patterns, at which a pattern-based recognition process is to be applied, and block 24 which denotes applying said a pattern-based recognition process (24) to all or a significant part of the captured skin ridge pattern.

## CLAIMS

1. A skin ridge pattern identification system, for comparing subject fingerprints with reference fingerprint data, the system including a skin ridge pattern capture device (1) and localized feature recognition and mapping means (3), wherein the locations of specific localized features in a subject pattern are first compared with those of corresponding features in reference patterns using data processing means (4, 6), and resulting comparison data are used to determine relative positions and/or orientations, as between the subject pattern and one or more reference patterns in a pattern shifting unit (8), at which a pattern-based recognition process is applied, characterised in that said pattern based recognition process is based on all, or a significant part of, the captured skin ridge pattern.
2. A system according to claim 1 wherein the specific localized features comprise minutiae.
3. A system according to claim 2 wherein the minutiae comprise ridge endings and/or bifurcations.
4. A system according to any preceding claim wherein the specific localized features comprise crease lines.
5. A system according to any preceding claim wherein reference pattern data are organized in paired and uniquely associated files, with the specific localized feature data, comprising a map of features tagged to reflect their types and referred to a standardized positional matrix in one file and full pattern data in the other.
6. A system according to any preceding claim wherein full pattern matching is only carried out against those reference patterns whose specific localized feature maps show at least a reasonable correlation with the corresponding feature data derived from a subject print pattern.
7. A system according to any preceding claim wherein the pattern-based recognition process is based upon a procedure of auto-correlation.
8. A method of identifying a skin ridge pattern such as a fingerprint, consisting of or including the steps of :- capturing a subject skin ridge

pattern (20), detecting the locations of specific localized features in the pattern (21), comparing the detected localized features with those of corresponding features in reference patterns (22), and using the comparison data to determine relative positions and/or orientations, as between the subject pattern and one or more reference patterns, at which a pattern-based recognition process is to be applied (23), and applying said a pattern-based recognition process (24) to all or a significant part of the captured skin ridge pattern..

Fig.1.

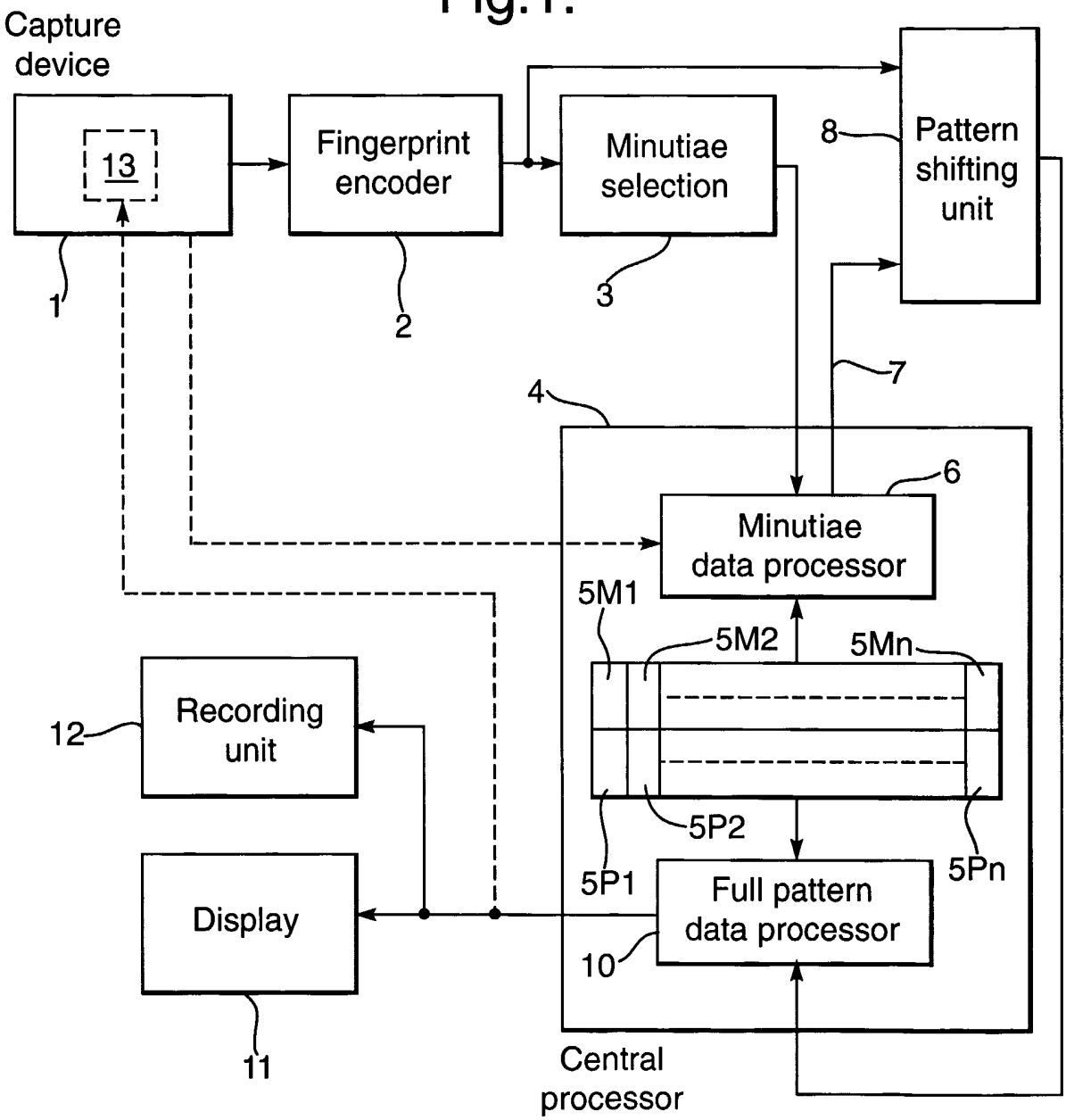
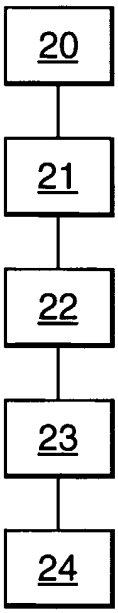

Capture device
13
1
Fingerprint encoder
2
Minutiae selection
3
8
Pattern shifting unit
7
4
6
Minutiae data processor
5M1
5M2
5Mn
5P1
5P2
5Pn
Full pattern data processor
10
Central processor
12
Recording unit
Display
11

Fig.2.



# INTERNATIONAL SEARCH REPORT

Inte ial Application No
PCT/GB 03/01265

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B5/117 G06K9/32

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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☒ Patent family members are listed in annex.

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