Pores appear as round features with a diameter varying between 88 and 220 mm and can thus be detected from the binary fingerprint by connected-component (or 'blob') analysis. A blob—defined as a set of white pixels in which every pixel is 4-connected to at least one other pixel—is considered to be a pore if its area is smaller than 0.2 mm. The position of a pore is determined by computing its center of mass using grayscale intensity values from the foreground image.

Next, a thinning operation reduces the remaining valley pattern to a width of 1-pixel while maintaining its topology. The number of 8-neighbors of skeleton pixels is then used to determine their classification. The orientation of nearby valleys is used to obtain distinguishing minutia characteristics. Pores do not have distinguishing features.

The feature extraction process often results in fingerprint skeleton artifacts. Syntactic editing rules adapted from Roddy and Stosz (1999) are applied to eliminate the four common defects shown in FIG. **26**. Short valleys **321**, bridges **322** and spurs **323** are replaced by pores. Broken valleys **324** are bridged. Two additional filtering operations are applied to reject unreliable features. The first operation discards features in regions of high feature density. The second operation rejects features near the outer border of the fingerprint. FIG. **27** shows how a grey level image **341** is processed into a simplified version **342** where the valleys and hence the valley bifurcations (triangles), and the pores (circles) are identified.

Next, skin strain measurement consists of three steps. The first step matches features in pairs of consecutive frames. The second step assembles matches into smooth and reliable feature trajectories. The third step infers changes in skin strain from the relative changes in edge length in a triangulation of tracked features. Feature matching from frame to frame relies on the assumption that the image acquisition rate is sufficiently high to ensure that feature displacements are much shorter than inter-feature distances. For each pair of frames, an attempt is made to match as many features as possible from the first frame to the second. Matching is performed by searching for the best match near a feature's expected position as predicted from its previous displacement, if available. Any feature of the same type (valley ending, valley bifurcation or pore) within a given radius (approx. 0.3 mm) is considered a candidate match and given a confidence rating that decreases with the distance from the feature's expected position and with the minutia orientation error, if applicable. Matches are selected so as to maximizes the sum of confidence ratings without matching the same feature twice.

Fingerprint feature extraction algorithms are not sufficiently reliable to insure the stability of features. As a result, the matching algorithm is generally capable of tracking features continuously only for a number of frames. The result is a set of disjoint feature trajectories starting and ending at different frames. To improve the quality of measurements, features trajectories that do not span a minimal number of frames (approx. 30) are assumed to be unreliable and rejected. The discrete nature of the image grid as well as minor feature extraction errors also result in jagged feature trajectories. This is corrected by smoothing trajectories, resulting in subpixel feature coordinates.

Changes in local skin strain are estimated by observing changes in a triangulation of tracked features. The subset of features of a frame that are tracked in the subsequent frame is used to construct a Delaunay triangulation as exemplified by FIG. **28** with nodes **291** and edges **290**. The change in local skin strain is evaluated by measuring the change of edge lengths as illustrated in FIG. **29** where feature **331** is matched to the same relocated feature **333** and feature **332** is matched to the same relocated feature **334**. Each pair of successive images is analyzed, yielding a map of relative changes in skin strain over time. For purposes of illustration, skin strain measurements can be represented by variations in the grayscale intensity of edges from black (maximum relative decrease in length) to white (maximum relative increase) as shown by FIG. **30**. Measurements can also be made over a span of more than one frame.

Having described the processing steps in their broad outlines, additional details are now are provided with the help of FIGS. **31**, **32**, and **33**.

FIG. **31** summarizes a preferred method to accomplish step **420** or **520**. At step **610** natural or artificial features are extracted from an image. At step **620** each of these features is tracked from frame to frame into long sequences. A criterion for deciding that a same feature appears from one frame to the next may be based on the observation that the speed of skin sliding on a surface is bounded and hence that a given feature will appear in the next frame within a radius smaller than the minimum distance between two features of the same fingerprint. At step **630** the variations in distances between each features is recorded. This may be accomplished by determining a triangulation between these features. For example, a Delaunay triangulation may be conveniently used. Then sequences of skin strain variation can be computed by determining the area of each triangle or by determining the lengths of their edges.

FIG. **32** show in greater details steps which mat be taken to accomplish step **610**. At step **710** a process of low pass filtering is used to reduce the noise in the image. At step **720**, the intensity of pixels in small windows is average to determine an average grey level. This information is used to compensated for the imperfections of the sensor, be it optical, thermal, or ultrasonic. At step **730**, the background image is removed from further consideration. This may be conveniently accomplished by discarding all pixels whose intensity deviate significantly from the average found at step **720**. At step **740**, the image is simplified by marking the pixels which can reliably be considered to arise from contact and discarding the others. At step **750** features arising from the presence of pores may be extracted on the basis of their morphology. A pore for example will correspond to a set of connected pixels in a small radius. At step **760** thinning is employed to simplify the image even further. This is accomplished by repeated deletion of connected pixels as is well know. At step **770**, other features such as valley endings and bifurcations may be conveniently detected. Finally at step **780**, errors made during the entire process may be corrected on the basis of prior knowledge of the morphology of fingerprints.

FIG. **33** show an alternate method to accomplish the computation needed to needed to accomplish steps **420** or **520**. As it is known from those skilled in the art that sequences of images may be processed directly to compute a vector field know as the image flow by using the intensity differences of each pixel from one frame to the next. These vectors may be used as indication of skin relative deformation at each location of the image.

The unit **5** may be implemented as one or several programs running in a computer (not shown), such computer having one or several arithmetic and logic units (ALU) and having a memory which stores program instructions for the operation of the ALU. The program instructions could be stored on a medium which is fixed, tangible and readable directly by the processor, (e.g., removable diskette, CD-