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Author: Ki-Sang Hong; Zhengyou Zhang; Asian Federation of Computer Vision Societies.; Han'guk Pangsong Konghakhoe.

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All Authors / Contributors: Ki-Sang Hong; Zhengyou Zhang; Asian Federation of Computer Vision Societies.; Han'guk Pangsong Konghakhoe.

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A METHOD FOR RIDGE EXTRACTION

Thanh Hai TRAN THI and Augustin LUX

Project PRIMA
INRIA Rhone-Alpes
655 Av. de l'Europe
38330 Montbonnot-St. Martin
FRANCE

ABSTRACT

Current methods of object recognition require generally a feature extraction phase. Several feature types have been studied. In this article, we suggest using ridges. Our purpose is to study a simple, but robust method which allows to extract the ridges in an image at several scales. These ridges are used to build object models. The experiments show that our ridge extraction method based on differential geometry performs well on several kinds of real images.

1. INTRODUCTION

Generally, feature extraction is a necessary phase for further image processing such as object recognition, image retrieval, etc. In the literature, many kinds of feature such as segments, outlines, corners, interest points have been studied. However, these features are highly sensitive to noise and do not describe the local structures of object which are widely useful for generic object recognition.

The goal of our research is to recognize object classes. So we tend to look for the features which, on the one hand, are robust to noise and to the changes in viewpoints, scale and illumination. On the other hand these features should allow us to construct a significant shape description of object. Ridges satisfy these demands. This article presents a new method for ridge detection. This method can be considered as wedding of one method based on the study of geometrical properties and an another one concerning the derivatives of image signal. We produce the more flexible criteria from mathematical ridge definition and then combine them to detect and localize ridges in images.

Ridges will be detected at several scales. We shall keep only those which are the most significant. The ridge significance is measured by a weighted function of the length, the contrast and the lifetime of ridge via scales. The artifacts (called in the following "false ridge") detected due to the weakness of the calculation method will be studied and removed. The "false ridge" problem was never mentioned in the literature.

This article is organised as follow: In the section 2 we present the existing ridge detection methods. In the section 3, we explain our own method and discuss about the false ridge problem. In the section 4, we expose some results of extraction of ridge made on different images. The section 5 presents the measuring of ridge significance that will be used to follow mobile objects in a video sequence.

2. EXISTING RIDGE DETECTION METHODS

Different definitions of ridges have been studied by mathematicians since the second half of the 19th century, and by image processing researchers over the last decades.

In one of the oldest studies of this kind, Saint-Venant identified ridges as loci of minimum gradient magnitude along level curve of a relief [11]. This approach arises from a deep mathematical study, but its immediate application to images produces discontinuous ridges.

Saint-Venant's condition was later reformulated by Haralick for applications in vision [3]. A ridge is detected at loci of extrema of the image function in the direction along which the second order directional derivative has the greatest magnitude. In Haralick's approach, the image function is approximated by a cubic polynomial which, sometimes, produces an image that is completely different from the original image, consequently distorts the detection.

Other methods detect ridges in image by using differential geometric properties [9]. Ridges have been found at points where one of the associated principal curvatures assumes a local extremum. With these criteria, unfortunately, all points on the surface of a cylinder are ridge points, while we would like to detect a single ridge at the top of the surface.

In all the above studies, ridges are defined with respect to a surface given by a function, without any consideration of scale. In reality, we don't know which scale is appropriate and ridges do not always exist at a single scale. Lindeberg [8] proposed to detect ridge point at its characteristic scale. In this way, the scale can vary along ridge. However, at the intersection of several structures, one point can have several characteristic scales and the selection of the optimal scale is not a simple problem.

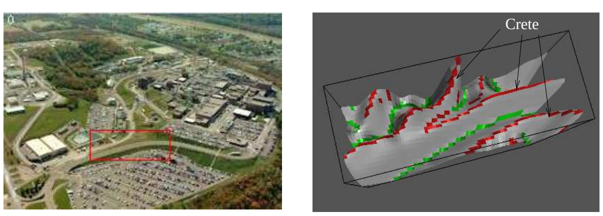
3. PROPOSED METHOD FOR RIDGE EXTRACTION

To remedy the handicaps of the previous methods we propose a new method to extract ridge in image. Instead of adopting only the results of differential geometry or the calculation of derivatives, we look for criteria in both. These criteria complement each other which allow to detect ridges more robustly even in poor quality image, but they also imply false ridges. We are going to present in detail how to detect ridges and eliminate the "false".

3.1. Ridge definition

Various mathematical definitions of ridge exist [2, 3, 1, 6]. In this article, we want to give a simple and intuitive vision of ridges, but sufficient to detect them. Our definition arises directly from what we see in the image.

Intuitively, a ridge is to be thought of as the path you follow on a mountain, where there's always a drop both to your left and to your right. In an image, a ridge occurs when there is a connected sequence of pixels having intensity values which are higher(lower) in the sequence than those neighbouring the sequence (figure 1). With this intuitive definition, a ridge can be considered as an approximate medial axis of an oblong object such as a road in a satellite image, a blood vein in a medical image, etc.



(a) (b)

Fig. 1. (a) An aerial image. (b) 3D representation of the rectangle of the image at left

Now we would like to introduce some notations. Given a two-dimensional image signal $I(x, y)$. $L(x, y; \sigma)$ the corresponding image function in the scale-space, where x and y are coordinates of a point, and σ is a scale. In practice, $L(x, y; \sigma)$ is almost the result of convolution of the image signal $I(x, y)$ with a filter $F(x, y; \sigma)$: $L(x, y; \sigma) = F(x, y; \sigma) * I(x, y)$. Ridges are the curves on the top(bottom) of the surface associated to the image function. The type of filter $F(x, y; \sigma)$ and the scale σ play an important role in the decision of the presence of a ridge.

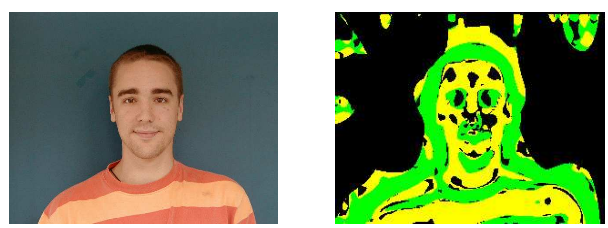
3.2. Geometrical properties of the surface of a ridge point

Suppose that we have an image $I(x, y)$. At scale σ, we try to look for the geometrical properties of the local surface of a ridge point.

Let us consider the local surface associated to a point (x, y) in an image. The surface is characterized by two main curvatures λ_1, λ_2, according to two main directions w_1, w_2. These curvatures are in fact the eigenvalues of the Hessian matrix, two corresponding directions are its eigenvectors. The Hessian matrix approximates locally the surface to a quadric. The relations of sign and greatness of the curvatures decide whether the point (x, y) is a ridge point, a peak or a saddle point, etc.

Ideally, the main curvature in direction of a ridge should be null at all points on the ridge. However, this one exists only in mathematic. To adapt to different cases in practice where ridges can take any form, we replace this condition with an another: both curvatures of the surface associated to a ridge point have the same sign and the one dominates strongly the other one. The main direction corresponding to the smallest curvature is the local direction of the ridge at this point.

Moreover, according to our intuitive definition, the curvatures along a ridge can change sign when the ridge passes by a "col" (which corresponds to a saddle point) (figure 1). It really seems that the criterion about sign relation of curvatures is still too strict. It gives experimentally discontinuous ridges. We thus decide to use only the criterion about greatness relation of curvatures or we consider that all curvatures superior to ϵ are positive, inferior to $-\epsilon$ are negative, the others in the interval $[-\epsilon, \epsilon]$ are equal to zero.



(a) (b)

Fig. 2. (a) Image of a face. (b) Points satisfying the criteria of curvature are gris, the black points are not characteristic points.

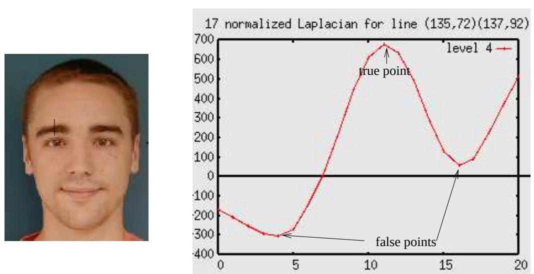
The figure 2 shows the detection of points which satisfy criteria of curvatures. We notice that the ridge points are numerous which form multiple regions.

3.3. Different choices of filter

We have just studied the geometrical properties of the surface of a ridge point. Satisfying only these properties does not give us expected ridges. In fact, as we spoke previously, multiple points with constant curvature were detected. Therefore, it produces regions, not ridges (figure 2). To obtain desired ridges, we must add some other criteria about the image function.

The image function in the scale-space is the result of convolution of image signal with a filter. The filter is chosen such that it represents best the structure of an object. As ridge points lie on the top(bottom) of an oblong object, the filter should give the strongest response at a ridge point. We use this property to detect a ridge when a local extremal in the direction perpendicular to the ridge is found. We propose in our work using the Gaussian filter, the Laplacian filter and the curvature filter.

Gaussian is a smoothing filter. At a some scale, its shape is locally very close to the physical shape of object. At a ridge point it assumes an extremal response in the direction perpendicular to the ridge. We also noticed that the Laplacian and curvature filter give the strongest response at a ridge point in the direction perpendicular to the ridge. However, these two last ones produce ”false” ridges.



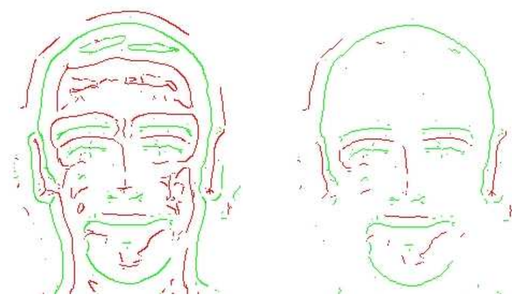
(a) (b)

Fig. 3. (a) Image of a face. (b) Laplacian of points on the line passing by eyebrow of the man in the image at left at $\sigma = 4$

The figure 3 shows an example of false ridges produced by using the Laplacian operator. In fact, when we apply this operator to the image of a single long spot, we obtain 3 extrema: one inside the spot, corresponding to a ”true” ridge point, and 2 outside, provoking 2 false ridge points. This problem is also present when using the curvature operator.

The literature has never discussed about this problem of “false” ridge. In fact, they detect either ridge or valley, but not both at the same time. (A valley is considered as a upturned ridge). For a general detection, false ridges must be removed.

To remove the false ridges, we verify if there is a change in the sign in the direction perpendicular to the ridge of the Laplacian at a ridge point. The interval on whom we verify this change of sign must be adapted to the scale. An another measure can be proposed to remove false ridge points is the directional gradient magnitude. However, for real images, these criteria can also eliminate ”true” ridge points, which provokes the discontinuousness of the ridge.



(a) (b)

Fig. 4. (a) Image of ridges detected at scale $\sigma = 4$ without eliminating false ridges (b)with elimination of false ridges. Note that almost false ridges have been removed

We propose to remove only ridges that have more than a certain percentage of ridge points are false points. With this criterion, we obtain the good results (see the figure 4). However, the results depend extremely on the ratio between the number of points to be removed and the total number of ridge points. A threshold for this ratio should be automatically chosen or fixed at a value without any influence on the extraction results.

3.4. Outline

Ridges are detected at all scales in the considered scale interval. At every scale, the process of image ridge detection is as follows [12]:

1- Compute the Gaussian, the Laplacian of Gaussian, the curvatures of the image and normalize them to scale factor. Specifically, the Laplacian and the curvatures are multiplied by the square of the scale.

2- For each pixel (x, y) in image, verify the condition of the greatness of 2 curvatures and the condition of the response of image function. A ridge point is a point that the ratio of its two main curvatures is superior to a threshold and the image function assumes a local extremal in the direction corresponding to the biggest curvature.

3- Link the ridge points and label ridges. To label ridges, we research the connected components satisfying constraints of ridge point directions. The algorithm begins by labeling a ridge point P_1. One 8-neighbourhood point is set the same label if the difference of angle of two local ridge directions at these two points is inferior to a threshold.

4. EXPERIMENTAL RESULTS

The experiment is made on different real images such as satellite image, face image, animal image, football image.... These images are sometimes noisy that can perturb the detection. The scale interval used is [0,10]. The spacing between scales is exponential of $\sqrt{2}$. In all case, we consider only points whose Laplacian is larger than a threshold. This threshold is manually chosen and depends on images. For example, we chose 5 for the foot image (figure 7), and 10 for the face image (figure 4). The threshold for the ratio of two main curvatures is set to 1.5.

The figure 5 shows the results of ridge detection by using various types of filter: the Gaussian (fig5 a), the Laplacian of Gaussian (fig5 b), the curvature (fig5 c). We notice that the Gaussian gives worse results than the Laplacian and the curvature. Note here also that the scale of Gaussian used to obtain the extraction result comparable with the extraction results obtained by applying the Laplacian or the curvature filter is smaller than the scale used by these two ones. Sometimes, the Gaussian does not detect desired ridges or returns discontinuous ridges. The Laplacian and the curvature filter give the similar results. With others tests we find that the curvature filter gives slightly less continuous ridge than the Laplacian filter because of its more complex calculation. See the images overlapped by ridges in the figure 6, we note that ridges are continuous and localized at desired positions.

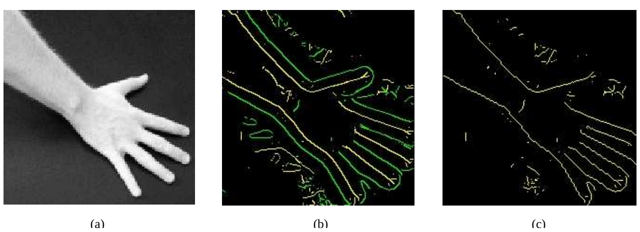


Fig. 8. Ridge detected at $\sigma = 4\sqrt{2}$. (a) Image of a hand. (b) Image of ridges detected without eliminating false ridges. (c) With elimination of false ridges

The figures 8c and 9b show the result obtained after removing false ridges of the image at left. The threshold for ratio of the number of false ridge points and the total number of ridge points varies from 0.3 to 0.9 depending on images. We find that the false ridges were not entirely removed. In fact, it exists several ridges which do not correspond to any structures of the object(called non-desired ridges), but analytically, they satisfy all criteria needed for a ridge. This is a weakness in the filter and scale selection.

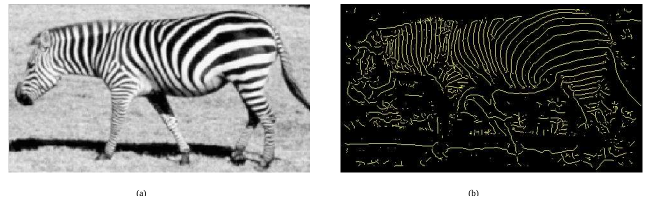


Fig. 9. (a) Image of a zebra. (b) Ridges detected at scale $\sigma = 4\sqrt{2}$ by using the Laplacian operator with elimination of false ridges.

5. FOLLOWING MOBILE OBJECTS IN A VIDEO SEQUENCE

5.1. Measuring ridge significance

In our method, ridges are detected at all scales. It is possible that two ridges at two different scales represent the same structure of object. So, we want to judge whether a ridge existing at coarse level of scale can be regarded as more significant or less significant than a ridge at fine level of scale.

We define the significance of a ridge as a weighted function of its contrast, its length and its lifetime. The contrast of a ridge is the total sum of contrast of all points of the ridge. The length of a ridge is the number of points of the ridge. The lifetime is the number of scales at which the ridge exists. This measure is derived from the idea in [7]. Given a ridge R_i at scale i. We say that the ridge R_{i+1} represents the same structure that the ridge R_i does at scale i+1 if they are similar.

We introduce the measure of similarity of two ridges. To measure the similarity of two ridges, we consider a ridge as a set of points and use the measure proposed in [5] with the weights are equally distributed. The larger significance measure is, the more ridge is significant. This significance measure is useful in some applications where we want to eliminate the ridges detected due to the noise and keep the only that represent the structure of the object.

5.2. Tracking significant ridge with Kalman filter

The object following in a video sequence is very useful for applications such as video-surveillance and gesture identification. Several methods for object following have been proposed. Some of them are based on the subtraction of consecutive frames [10] in a sequence. This method cannot be applied to case in which the camera moves because of change of the context. A method based on the correlation [4] works well when there is a movement of the camera. However, following of an object is difficult if its appearance changes. We present in this section one application of us-

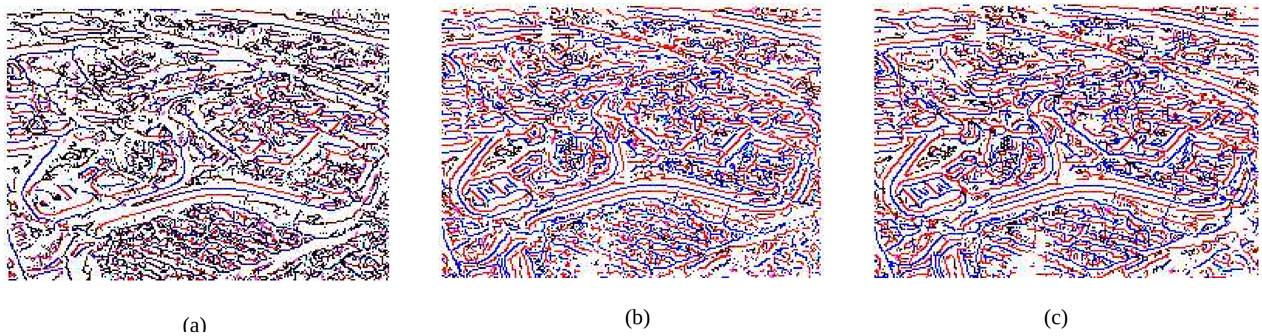


Fig. 5. Ridges detected from the aerial image in the figure 1a. (a) by using the Gaussian filter at scale $\sigma = \sqrt{2}$. (b) The Laplacian filter at $\sigma = 2$. (c) The curvature filter at $\sigma = 2$

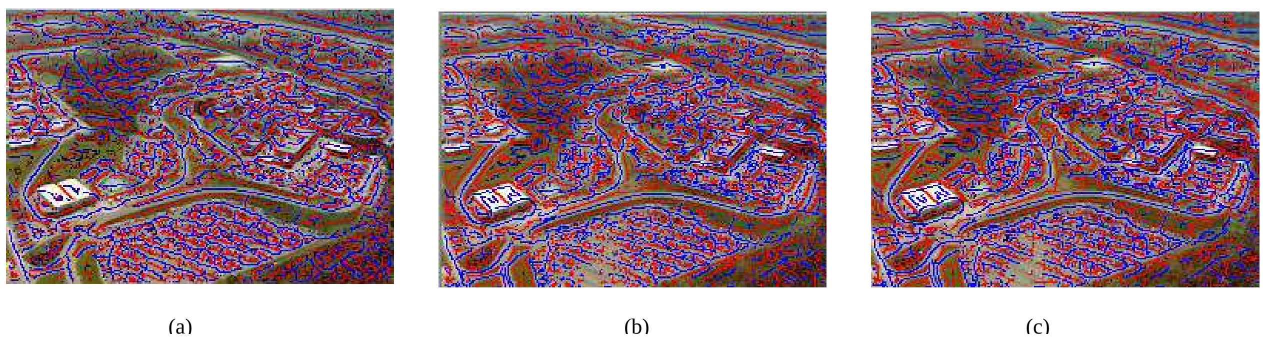


Fig. 6. Ridges overlap the original image. 1a. (a) by using the Gaussian filter at scale $\sigma = \sqrt{2}$. (b) The Laplacian filter at $\sigma = 2$. (c) The curvature filter at $\sigma = 2$

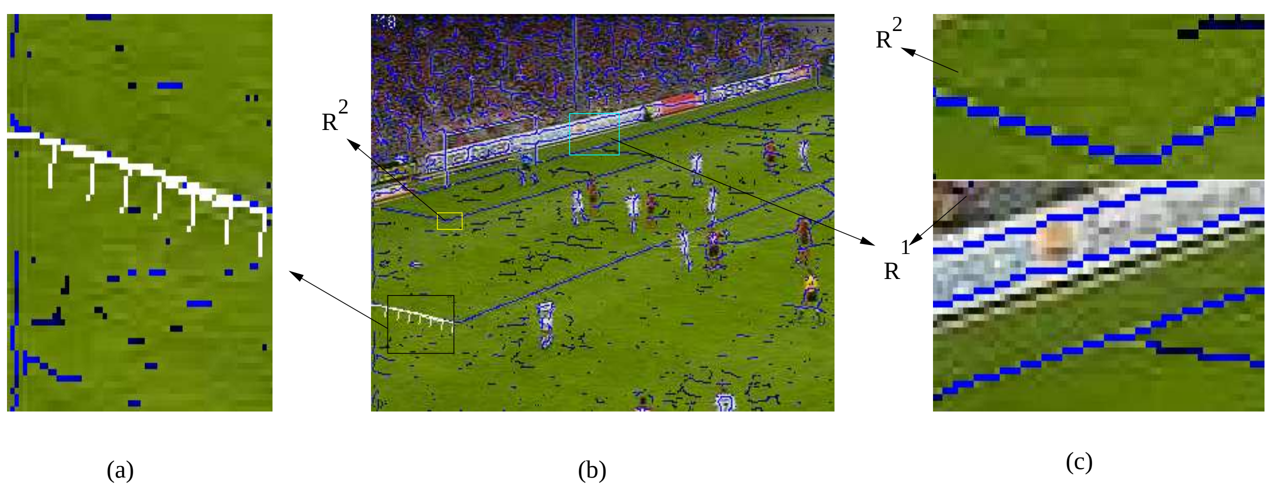


Fig. 7. (b) The original image overlapped by ridges detected at $\sigma = \sqrt{2}$ by using the Laplacian filter. Note the continuousness of the ridges (zoom of two rectangle (a) and (c). In the figure (a), the white lines are eigenvectors corresponding to the local main directions of the ridge

ing ridge to follow an object. The idea is to model every object to be followed by one or some significant ridges and follow these ridges by using the Kalman filter. The calculation of lifetime is very expensive. It can not be realized in real time. We propose to evaluate the significance of a ridge based only on its length and its contrast.

The Kalman filter allows to predict the position as well as the speed of a point in the following image of the sequence [13]. How this filter is used to follow ridges, which are a sequence of points? We suggest applying this filter at the gravity center of a ”main” ridge in the region of the object. Its predicted position in succeeded image allows to determine a rectangle centered at this point. We discover then ridges in this rectangle and select a ridge which looks like most the previous ridge (the most similar). The process repeats in the same way for every image of the sequence. As an object is characterized by ridges, following of an object consists in following of its ridges.

We make the tests on a video sequence of a football match (see an image extracted from the football match sequence in figure 7b). Our purpose is to follow players during the match. Every player is represented by the most significant vertical long ridge. The derivatives are calculated by making the convolution the derivatives of corresponding Gaussian with the component C_2 in the colour space YC_1C_2. Using C_2 instead of the intensity allows to distinguish well the red players from the lawn.

The experiment shows that we can follow players in the football match sequence until they are outside the view of camera. When there is a movement of the camera, the Kalman filter predicts badly the position of the players. We recognize this event by comparing the measure of similarity of ridges with a threshold. We decide in that case not to use what is supplied by the Kalman filter, but to use the current position and to widen the considered zone. The size of image in the sequence is 352x288, the following speed is 20 images/sec. We find that, in this particular application, following of a single ridge does not depend on player’s appearance. In fact in this sequence the players appear rather vertically at a scale, he is thus represented by a long vertical ridge. His details are not very important.

6. CONCLUSION

This article has presented a new method for ridge extraction. Our method is robust to noise and to different transformations such as rotation, translation, change of luminosity and change of scale [12]. Our first contribution is producing the more flexible criteria of ridge and combining them to detect ridge at several scales. The second contribution is introducing and solving the false ridge problem, although it does not perfectly work for all real images. The third contribution is measuring the ridge significance that allows to eliminate ridges detected due to the noise. Ridges following supplied by the Kalman filter prediction is promising to track mobile objects in a video sequence. The feature work is using ridges to construct object models for recognition and more efficient object tracking.

7. REFERENCES

[1] D. Eberly and C. Scrlach S. Pizer. Ridges for image analysis. *Journal of Mathematical Imaging and Vision*, 4:353–373, 1994.

[2] Jonh M. Gauch and Stepen M. Pizer. Multiresolution analysis of ridge and valleys in grey-scale images. *IEEE Trans. Pattern Anal. Mach. Intell*, 15(6):635–646, June 1993.

[3] Robert M. Haralick. Ridges and valleys on digital images. *Computer Vision, Graphics and Image Processing*, 22:28–38, 1983.

[4] H. Inoue and M. Inaba T. Tachikawa. Robot vision system with a correlation chip for real-time tracking, optical flow and depth map generation. In *Proc. IEEE Int. Conf. on Robotics and Automation*, pages 1621–1626, 1992.

[5] F. Kanters and L.Florack B.Platel. Content based image retrieval using multiscale top points. Spinger, 2003.

[6] Jan J. Koenderink and Andrea J. van Doorn. Two-plus-one-dimensional differential geometry. *Pattern Recognition Letters*, 15:439–443, May 1994.

[7] T. Lindeberg. Detecting salient blob-like image structure and their scales with a scale-spaces primal sketch: A method for focus-of-attention. *International Journal of Computer Vision*, 11(3):283–318, 1993.

[8] T. Lindeberg. Feature detection with automatic scale selection. *International Journal of Computer Vision*, 30(2):79–116, 1998.

[9] Antonio M. Lopez and Juan J. Villanueva Felipe Lumbreras, Joan Serrat. Evaluation of methods for ridge and valley detection. *IEEE Trans. Pattern Anal. Mach. Intell*, 21(4):327–334, April 1999.

[10] M.Yachida and S. Tsuji M. Asada. Automatic analysis of moving image. *IEEE Trans. Pattern Anal. Mach. Intell*, 3(1):12–20, 1981.

[11] M. De Saint-Venant. Surface à plus grande pente constitué sur les lignes courbes. bulletin de la Soc. Philomath. de Paris, pp. 24-30, 1852.

[12] H. Tran and A. Lux. Local feature extraction for object representation. *RIVF , Hanoi, VietNam*, 2003.

[13] G. Welch and G. Bishop. An introduction to the kalman filter. Technical Report No 95-041, University of North Carolina at Chapel Hill, 1995.