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3—32

A Novel Feature Point Detection Algorithm based on Strips

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Abstract

Feature point detection plays a crucial role in shape representation and object recognition. A feature point set that can represent the shape honestly and consistently under different scale and environment is desired. The method used should be able to cater to these requirements as much as possible. Regretfully, no method has done completely well. Dynamic two-strip algorithm (Dyn2S) used the strip to extract features. Digitization noise can be tolerated because the strip has width and it can enclose points that can be approximated as a straight line. Unfortunately, its performance seems not very satisfactory on curves. In this paper, further investigation has been carried out along this direction. The proposed method, based on the long and narrow strips that are prominent and reliable, has been applied on logos with encouraging results. This approach is more capable of extracting consistent feature points from one instance of a model shape to another.

1 Dynamic two-strip algorithm [1]

Dyn2S is a curve representation method using feature points. The whole procedure has two stages. In the first stage, important properties of the data points are derived. Two strips are fitted to the left and right sides of each point on the curve respectively, and the points inside each strip are approximated as the left or right straight line. The best fitted strips are derived by adjusting the width of the strip and rotating it up or down dynamically using the starting point as the pivot. Longer and narrower strips are preferred. The ratio, which is called the **elongate value** of a strip, is defined as ***E=L/W*** of its length *L* over its width *W* to represent the merit of fit. The merit *f* for a point can be computed as $f = E^{left} S^{\theta} E^{right}$, where E^{left} and E^{right} are the elongate values of the left and right strips, and $S^{\theta} = |180^{\circ} - \theta|$ is the acuteness of the angle θ between the two strips. In the second stage, a subset of the most representational points is selected based on the local maximum of point merits.

One example is illustrated in Figure 1 where the minimum and maximum strip widths can be easily pre-selected as 1 and $0.1 \times D$ pixels, where 1 is considered small enough while *D* is the length of the image diagonal. Let P_0 be the current point to be processed, L_i (i=1, 2,..., 6) be points on P_0's left side and R_j be points on P_0's right side. An initial strip of minimal width would first extend from P_0 to encompass as many points as possible to its left side (i.e. the dashed-line box). Its width is then increased and its orientation is adjusted to include as many points as possible, until the maximum strip width is reached (i.e. the left solid-line box). The measure of fit (i.e. elongate value) is recorded for each strip as a function of strip width but only the strip with the highest value is marked and used. The same procedure is applied to the other side of the point.

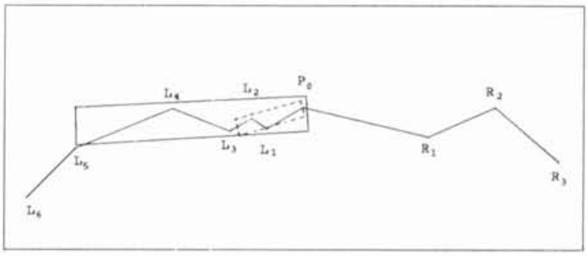

Figure 1. The illustration of the dynamic two-strip algorithm.

There are advantages using strips to extract local features. First, digitization noise can be tolerated because the strip has width and it can enclose points that can be approximated as a straight line. Then the support region of one point can be reflected honestly by the strips.

However, the Dyn2S does not work well on curves with no obvious sharp points or corners. This gives rise to inconsistent point sets being generated on different instances of the same model. Here, the robust shape feature (i.e. the long and narrow strip) is retained and further developed into a new approach to extract feature points.

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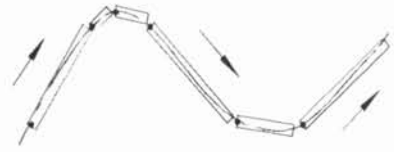
2 The proposed method

Teh and Chin [2] indicated that feature point detection relies more on the determination of a local support region rather than on the estimation of discrete curvature. A novel feature point extraction technique based on the local support region (i.e. strip from dyn2S) is proposed here. Instead of starting from a point and looking for support regions from its left and right sides, the proposed method looks first for the supports (i.e. the strips) and then computes the location of the feature point. Strips have the good property of tolerating noises as described in Dyn2S. In addition, one can sort all the strips according to their elongate values and start searching for feature points based on strips of the largest local elongate values i.e. the long and narrow strips that are prominent and reliable. This approach is more capable of extracting consistent feature points from one instance of a model shape to another since it relies on the local most reliable strips. It also allows labeling feature points according to their important attributes, i.e. the strip elongate value.

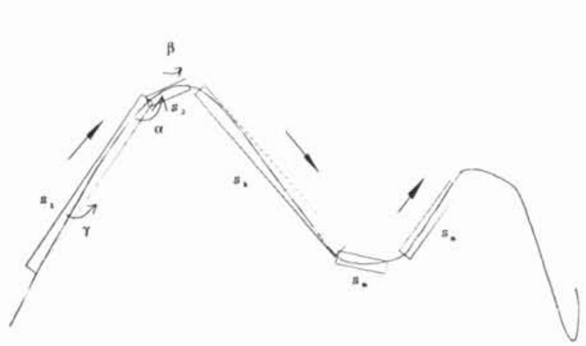
Some characteristics of strips can be observed from Figure 2 (a) where the strip lengths and elongate values become smaller and smaller when one goes up-hill. The values start to become larger and larger when the strips are heading down the hill. In addition, the rotation directions of the strips also change from clockwise to counter-clockwise. This direction change can be detected as shown in Figure 2 (b) where the intersecting angles (α and β) from strip S_1 to strips $S_2, S_3, \ldots, S_k$ are changing in a monotonous manner. In this case, it is decreasing monotonously. The angle starts to change in different direction (see angle γ) when one considers S_m which rotates in counter-clockwise manner.

The feature point (e.g., point D in Figure 3) can then be located by two nearest maximal strips (e.g., S_1 and S_k in Figure 2 (b)) whose elongate values are local maxima. At the same time, the rotation direction after S_k should turn to the other direction. Hence, one has two indicators for manipulation. The next step in computing a feature point can be illustrated as shown in Figure 3. First, one needs to build a triangle ΔABC by extending the center lines going through the strips S_1 and S_k. The base, BC, is then moved up until it touches the curve at only one point at D. Point D would be declared as the feature point.

Here, the feature point detected from the above process is declared as major feature point.



(a) Changing pattern of the strip lengths.



(b) Changing pattern of the strip angular difference.

Figure 2. The illustration of the proposed concept for detecting feature point.

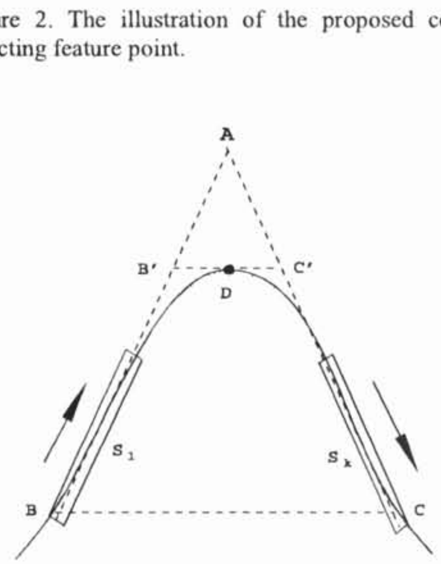
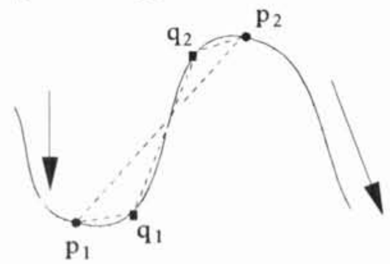


Figure 3. The illustration of feature point location.

The main concern of feature point detection is whether the detected points are good enough to represent the shape of a curve. For example, in Figure 4, point p_1 and p_2 are detected from curve to represent the curve segment from p_1 to p_2 as line $\overline{p_1 p_2}$ (the dashed line). Obviously, deviations from points on the curve to $\overline{p_1 p_2}$ are large. In this case, it might be appropriate to add supplementary point, such as q_1 and q_2. In this study, iterative polygonal approximation method [3] is used to add supplementary feature points. Since major feature points have been detected in the previous process, supplementary feature points can be properly computed from these good starting points.



p1, p2 : major feature points.
q1, q2 : supplementary feature points.

Figure 4. Sample of major and supplementary feature points.

3 Results

The proposed method has been applied to logos from the University of Maryland[3]. Examples of the comparison results against Dyn2S are shown from Figure 5 to Figure 7. The three logos used in these examples are selected according to their different complexity (see Table 1).

Logo name	Contour points	Contour number
logo9	1038	3
logo21	1611	13
logo50	2857	16

Table 1. The complexity of the three logos.

From these results, one can see that

- The Dyn2S method has more redundant points than the proposed method (see below). This means that the proposed method is more effective in data reduction.

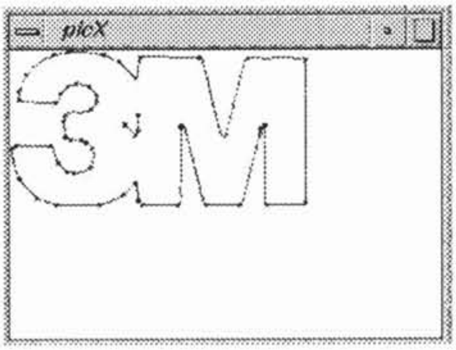
Logo name	Feature point number	
	Dyn2S method	The proposed method
logo9	57	37
logo21	95	56
logo50	205	142

Table 2. The feature point number of the three logos by the Dyn2S and the proposed method.

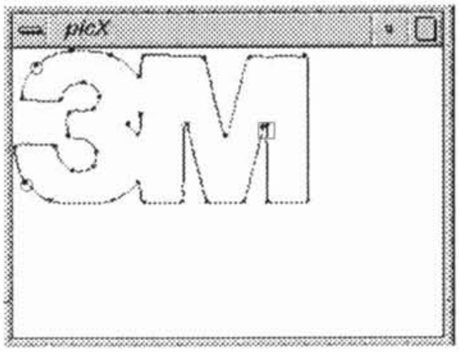
[3]http://document.cfar.umd.edu/pub/contrib/databases/umdlogo_database.tar

- The proposed method can detect feature points that conform to human perception, such as the feature points detected along the circular segments in Figures 5 (b) – 7(b), while the Dyn2S cannot make it.
- The proposed technique can generate consistent feature points around the same location as it is designed for. This is shown in Figure 7 where symmetric feature points were generated on both the left and right sides regardless of the scale. However, the Dyn2S detected many inconsistent feature points, e.g. the feature points detected along the circular segments in Figure 7(a). These results show that feature point detection relies heavily on the accurate determination of the local region of support, but not on the accuracy of discrete curvature estimations [2].

Hence, the intended improvements based on Dyn2S have been successfully achieved.

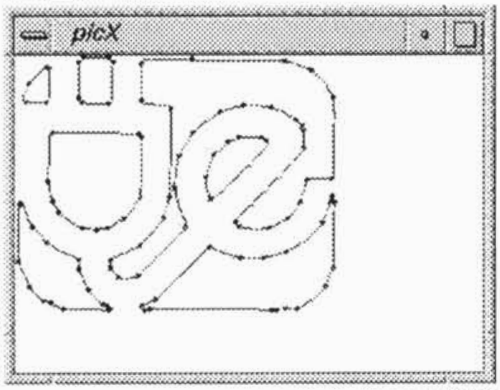


(a) Result obtained from Dyn2S

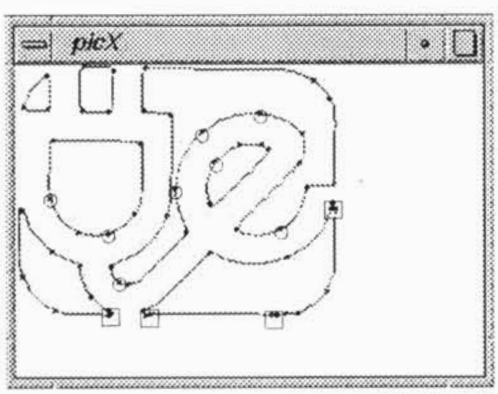


(b) Result obtained from the new method

Figure 5. Comparison of the results using Dyn2S and the proposed technique on logo9. Where • and ⊙ represent the major and supplementary feature points, and the points in □ are the starting and ending points of a non-closed curve.



(a) Result obtained from Dyn2S



(b) Result obtained from the new method

Figure 6. Comparison of the results using Dyn2S and the proposed technique on Logo21. Where • and ⊙ represent the major and supplementary feature points, and the points in □ are the starting and ending points of a non-closed curve.

4 Summary

A novel feature point detection scheme has been proposed in this paper. Instead of starting from a point and looking for support regions from its left and right sides, the proposed method looks first for the supports (i.e. the strips) and then computes the location of the feature point. The proposed method provides the major and supplementary feature points that are consistent and conform to human perception of feature point.

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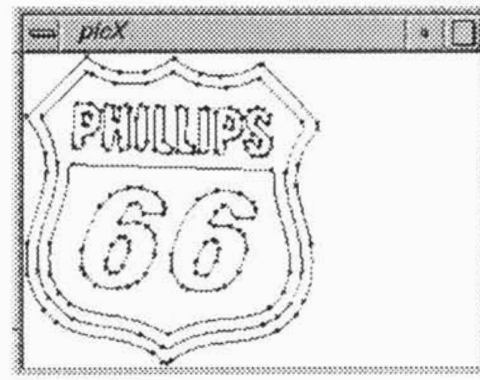
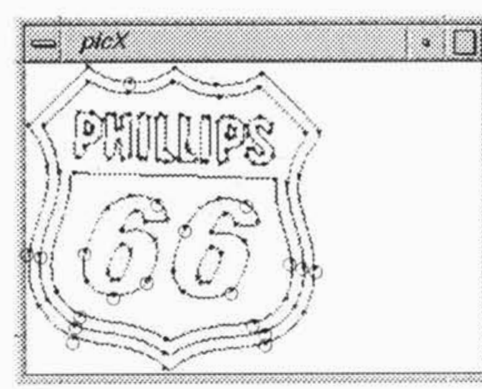


(a) Result obtained from Dyn2S



(b) Result obtained from the new method

Figure 7. Comparison of the results using Dyn2S and the proposed technique on Logo50. Where • and ⊙ represent the major and supplementary feature points, and the points in □ are the starting and ending points of a non-closed curve.

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