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Shape matching with geometric primitives

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Abstract—**We propose to represent objects with parabola segments with an algorithm that allows us to fit parabola segments real-time to edge pixels. Parabola offer a good description for the many edges in the object, which is advantageous for several applications. We use parabola segments for face recognition and vehicle tracking, which is done by a technique that matches parabola segments based on distance and intensity.**

Keywords— **Geometric Primitives, Parabola, Matching, Face Recognition, Vehicle Tracking.**

I. Introduction

Real-time object recognition and tracking is the critical task in many computer vision applications such as surveillance. We explore the domain of the geometric low-level features, such as lines and parabola. In a first stage we test parabola features for face recognition, in a second stage we use them for vehicle tracking.

II. Face Recognition

Several applications such as access control, behaviour observation and videoconferencing require a real-time method for face recognition. We developed a compact face feature, the Parabola Edge Map (PEM) [1], which extracts parabola segments from a face edge map as features. For the segmentation we use an algorithm that allows us to fit parabola segments in real-time to edge pixels [2]. Figure 1 shows the parabola segments for a face of the Georgia Tech. Face Database [3].

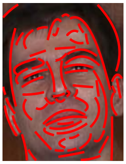

Figure 1. A parabola segmented face

We propose parabola-based face coding and parabola matching techniques to integrate geometrical and structural features in the template matching. The PEM approach not only has the advantages of geometric feature-based approaches, such as invariance for illumination and low memory requirement, but also has the advantage of high recognition performance of template matching.

To represent a face we need far fewer parabola segments than line segments, which leads to larger more stable features. In fact, many parabola segments correspond to physically meaningful features such as eyebrows, cheekbones or lips, which is advantageous for several applications such as recognition of the facial pose and the facial expression. Furthermore, since a parabola segment has a more distinctive shape than a line segment, matching parabola segments is more reliable.

The recognition system matches the PEM of the query image with the PEM of the model image. For the matching we developed the Parabola Distance Function (PDF). We extend the PDF so that it also takes into account the intensity differences along a parabola segment. In fact, each parabola segment defines a convex region, so that it makes sense to compute the average intensity difference between the inner and outer side of a parabola.

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We show that the recognition rate improves considerably by the introduction of intensity variations in the distance function. The system performances are compared to existing methods by testing different face databases. It is an encouraging finding that the proposed face recognition technique performs consistently superior to (or equally well as) existing methods in all comparison experiments.

III. VEHICLE TRACKING

In surveillance systems moving object, such as vehicles, have to be detected and tracked. Tracking uses temporal correlation to locate the object in a video sequence. With temporal information, we can narrow down the search range significantly and thus make real-time tracking possible.

For the detection we let the user demarcate the vehicle with a bounding box in the first frame of the video sequence. The edges within the bounding box are segmented in parabola features (PEM) as shown in figure 2. We search the vehicle in a new incoming frame, by matching the PEM of the vehicle in the previous frame with the parabola segments in the current frame, using the PDF.

The motion vector of the bounding box is estimated by statistical analysis of the PDF. The global direction of the motion vector, in which the vehicle moved, is estimated from the histogram of the directions in which the parabola segments individually moved. The length of the motion vector is estimated from the histogram of the distances in which the parabola segments individually moved, projected perpendicular on the axis in the earlier estimated direction of the motion vector.

The motion vector can be made more accurate. The previous PEM is moved to the current PEM according the motion vector. We calculate the mean distance between the moved previous PEM and the current PEM for shifted versions of the previous PEM. We keep the location that minimizes the mean distance between all corresponding parabola. The same is done for enlarged and reduced versions of the previous PEM. We now have a more accurate location and size of the bounding box of the vehicle in the new frame.

Figure 2. A parabola segmented vehicle

For the prediction of the motion vector, we can use more history. This is done by the use of the estimated directions and lengths of previous motion vectors. They are taken into account with different weight factors.

The results on different video sequences are promising, they prove the stability and robustness of parabola features. This kind of tracking is advantageous for solving problems with occlusion.

IV. CONCLUSION

In this work we recognize faces and track vehicles with parabola features collected in a Parabola Edge Map (PEM). We developed a technique of shape matching for parabola segments, based on distance and intensity. Parabola segments are robust describing low-level features, they are a good description for the many edges in an object, which is advantageous for several applications. In the future parabola features are useful for describing all kind of rigid objects.

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