Fall 2004 ECE598YM Project Proposal
Geometrically Consistent Contour Extraction

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1 Objectives

Making a nice 3d model of an object has always been a important goal of Computer Vision. A lot of methods have been proposed for different kind of settings for 3d model construction, but in this project we assume that 1. an object is rigid, 2. all the cameras are calibrated. Even on these settings, various methods have been proposed to build a 3d model, and they can be classified into 2 categories: ones that explicitly extract and use apparent contours to build a model [1] and ones that do not [2, 3, 4].

One of the biggest advantages of the first approach over the second is that we have apparent contours that does not tell everything about the object, but gives us a lot information about it. For instance, only from apparent contours, a descent 3d model can be already obtained by computing the intersection of all the cone strips, namely *Visual Hull*. On the other hand, the biggest disadvantage is that extracting contours robustly are not easy and manual intervention are usually necessary. Even with the latest contour extraction algorithms, it is very difficult to make this process fully automatic.

There are 2 objectives in our method:

1. Suppose really good initializations of contours are given, but those apparent contours must satisfy some equations to be geometrically consistent with each other, which is detailed in the next section. So the first objective is to make the extracted contours very accurate. Note that local minima are not problems in this situation, and we only slightly deform apparent contours slightly to satisfy geometric constraints.

2. Second objective of this project is to reduce the amount of human intervention. Suppose we try to extract a contour in a single image, say by using snake, but local minimum is always a big problem and if the initialization is far from the real contour, it may not reach the true solution. So in most contour extraction algorithms, good initialization were necessary. We try to resolve these local minimum problems by taking into accout the geometric and photometric consistencies over multiple images.

Next section details in the consistencies of multiple apparent contours, which are key ideas of our method, and actual approaches are discussed in the last section.

2 Consistencies Over Multiple Apparent Contours

2 kind of consistencies will be used to help extracting multiple contours, geometric consistencies and photometric consistencies.

2.1 Geometric Consistency

Firstly, we define that multiple apparent contours are *consistent* with each other if and only if there exists some 3d solid that generates exactly the same set of apparent contours. Note that this consistency is purely geometric and we do not care about textures of an object.

It is well known that a set of points on apparent contours that are tangential to the epipolar lines, namely *frontier points* must satisfy some conditions. Although constraints on frontier points alone are not sufficient for apparent contours to be consistent, it probably helps to extract apparent contours more robustly.

2.2 Photometric Consistency

We can further enforce some consistencies over multiple contours by taking into account the texture information. Since this is not purely geometric, we need to have some assumptions on surface properties, typically lambertian assumption, but in practice they should be very helpful.

Of course, we cannot simply check photo consistencies, because we do not know the surface of an object; the best surface approximation we can get is the visual hull. However, there exists some points on the surface of an object, where we can compute the 3d coordinates only from apparent contours. Such special points are again visible as frontier points in images, and photo consistencies can be enforced at those points.

3 Approaches

Firstly, our algorithm will be image based, although we recover 3d coordinates of frontier points and check photo consistencies there, we do not explicitly use 3d volume as in [3, 4]. The main reason is the speed; totally image based algorithms should be much faster. However, it is important to note that even without recovering 3d solid, we can enforce a lot of constraints on apparent contours in images.

Our approach will probably an extension of existing snake algorithms: normal snakes, gradient vector flow, and etc. We define new energy functions that take into accout the geometric and photometric consistencies we introduced in the previous section, and add them to the existing enery functions of some snake algorithm.

References

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