

Introduction

This project tries to detect and analyze visual markers from images taken by a tiny camera embedded in cellular phones. We organized the process into three major steps: marker detection, coordinate mapping, and data analysis. In marker detection, we use the design elements of the visual marker to help identify visual markers in mediocre quality photographs produced by the cell phone cameras. These elements include three fixed corners and two fixed guide bars. In coordinate mapping, we must correct for the orientation of 2D visual markers, since while they may lie on planar surfaces, are usually not parallel to the image plane. Finally in data analysis, because of effects of noise and perspective, some amount of guess is required to extract data.

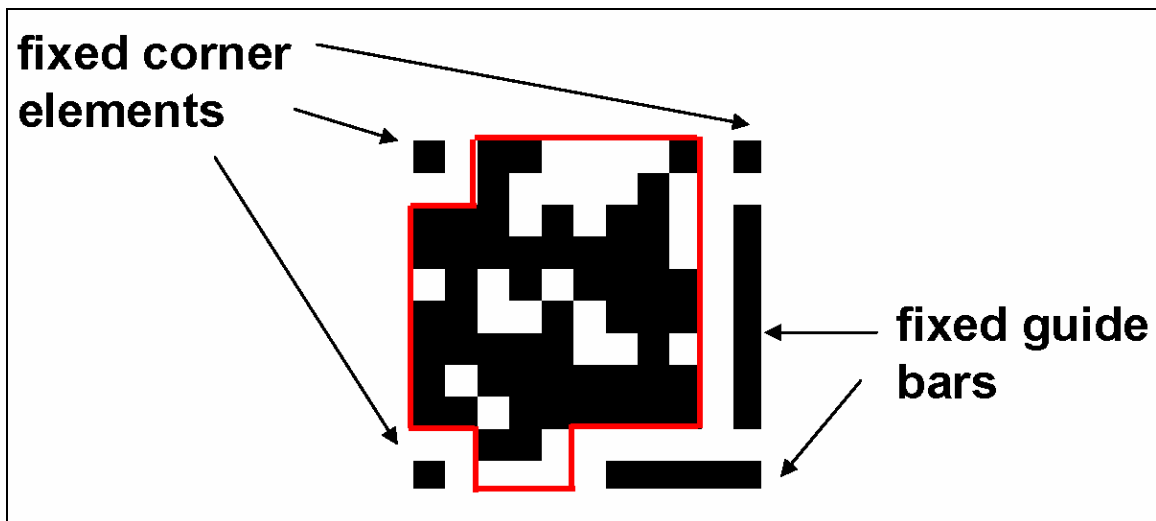


Figure 1 Marker Design

Marker Detection

The input images will be quite noisy, but the design elements should help in the detection process. First, there are three fixed corner elements. Since the marker is square, finding the locations of all three corners will give the location the marker's bounding box. There are several techniques that will work best in terms of robustness when used together. First, I thought of using edge detection and then finding circles using a Hough transform [Figure 2]. I look for circles since the squares will have their corners smoothed out in the input image. Even though there are many extraneous edges, the Canny edge detector is most reliable for these low quality images where the brightness and contrast and even focus are shaky.



Figure 2 Three Corners

Second, I use template matching after sharpening and thresholding the original image. Here's my b/w image and template:

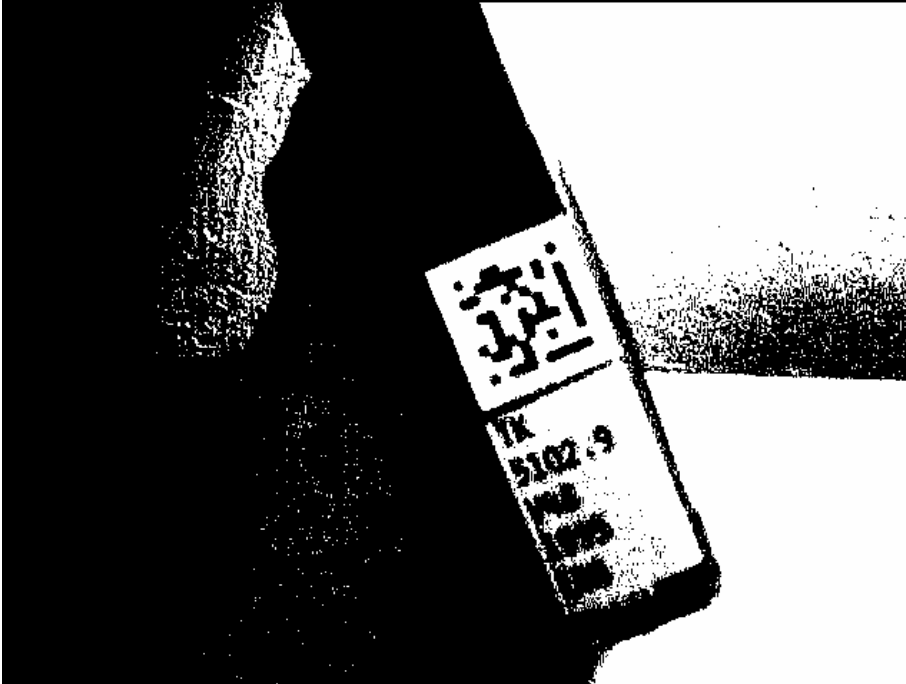


Figure 3 Template Matching



Figure 4 Template

Coordinate Mapping

Once we have the three fixed elements, we can draw the square bounding box around the marker. We would assume that while the plane that the marker sits is not parallel to us, it's pretty close. Thus, using the coordinates of the three fixed elements, we rotate the image until it's in home position. If necessary, we could calculate a more complex mapping using advanced techniques from camera calibration that would tell us exactly which pixels correspond in the data grid.

Data Analysis

Before data can be extracted, this region of the marker within the image should be sharpened further and partitioned into sections. Guessing based on each pixel individually would be difficult. We break the data section of each mark into rows and then columns. For each row and column, we would count pixels and try to match patterns. In this way, it would be easy to find rows and columns that were full or empty.

Conclusion

I ran out of time to complete the project, though I think my approach is sound. The majority of the issues that may cause problems with visual code markers have to do with how the input image is captured. Having a better cell phone camera would improve image focus and forcing the user to take pictures at a reasonable distance and orientation would greatly improve data analysis (you could do this by not showing the bounding box for marker detection until it's within limits).