University of Engineering and Technology

Template Matching with Distortion

Class: INT3404 20

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I. Introduction

Template matching is a technique widely used for finding patterns in digital images. An efficient template matching algorithm should be able to detect template instances that have undergone geometric transformation or change of perspective.

This report will introduce a color template matching algorithm called Color-Ciratefi, which is a color-based algorithm invariant to rotation, scale, translation, brightnesss, and contrast that takes into account the color information.

This report based on the paper: “Color-Ciratefi: A color-based RST-invariant template matching algorithm”.

II. Algorithm Introduction

Color provides high discriminative power. However, the main problem of color template matching is how to extract color information that remains constant with the illumination change.

Based on the original Ciratefi technique, Sidnei Alves de Araújo and Hae Yong Kim introduce a new color template matching algorithm named Color-Ciratefi, which is invariant to rotation, scaling and translation, and robust to some common distortions such as blurring and minor viewpoint variations.

III. Ciratefi Technique

Ciratefi is a grayscale template-matching algorithm composed by three steps of filtering, Cifi, Rafi and Tefi that successively excludes pixels that have no chance of matching the query template.

The name Ciratefi can be easily seen as a combination of those three filters.

To shed some light on this algorithm, let A be the grayscale image to be analyzed and T the query grayscale template for instance. The goal of Ciratefi is to find all occurrences of T in A, with respective orientation angle and scale. The instances of T in A may appear rotated, scaled, shifted and with diverse brightness and contrast. Below we present a brief description of Ciratefi.

1. First Filter: Cifi – Circular sampling Filter

Cifi uses the projections of the images A and T on a set of circles to detect the "first grade candidate pixels". For each candidate pixel, the "probable scale factor" is also computed.

2. Second Filter: Rafi – Radial sampling Filter

This step uses projections of images A and T on a set of radial lines to upgrade some of the first grade candidate pixels to the second grade. Rafi also estimates the probable rotation angle for each second grade candidate pixel.

3. Third Filter: Tefi – Template matching Filter

This step filters the second grade candidate pixels using a conventional template matching with correlation coefficient as metric. This task is fast because Cifi and Rafi computed the probable scale and angle for each candidate pixel.

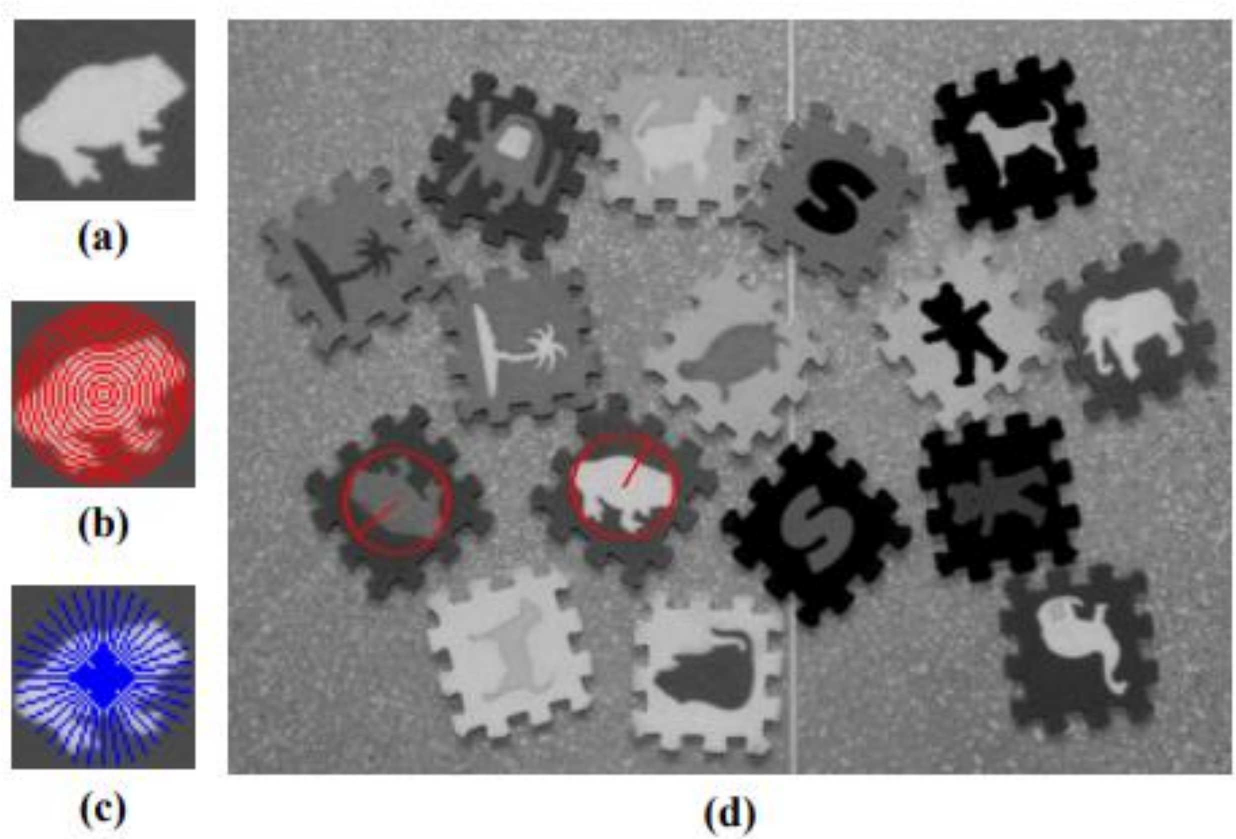

Figure 1. Usage of Ciratefi to detect template “frog”. (a) Query template T. (b) Circular projections in Cifi. (c) Radial projections in Rafi. (d) The circles indicate the matching positions.

IV. Color-Ciratefi

The goal of Color Ciratefi is: given a pair of color images A and T, detect all the instances of T that appear in A. The instances of T in A can be affected by different geometric and photometric transformations such as scale, rotation, minor viewpoint variations, blur and illumination.

To deal with illumination changes a similarity measure that uses CIELAB color space was proposed.

1. The CIELAB color space was designed to be a small perturbation to a color value produces a change of about the same perceptual importance across the range of all colors.

Moreover, CIELAB isolates the lightness L* from the chromaticity a*b*. This color space is especially suited to evaluate the similarity of two image patches, invariant to brightness and contrast changes.

In CIELAB:

- Lightness L*: from 0-100.
- Range of chromaticity components a*b*: depends on the original color space. In case of RGB, it would be from -100 to +100.

Chromaticity a*b* remains relatively constant under small changes of illumination temperature, intensity and direction. However, under a severe illumination variation, the chromaticity a*b* changes considerably.

2. The Similarity Measure

Color-Ciratefi use this similarity measure instead of the correlation coefficient, which uses a weighted composition of chromaticity and lightness components to evaluate the perceptual similarity between two color feature vectors, robust to brightness and contrast changes.

To shed some more light on the formula of this proposed measure, let x and y be two vectors of colors. Each component x_i or y_i is composed by a set of tristimulus values L*, a* and b* and are denoted, respectively.

- The proposed similarity measure (Sim) is a weighted geometric mean of S_C - similarity of chromaticity and S_I - similarity of intensity:

$$\mathrm{Sim}(\boldsymbol{x}, \boldsymbol{y}) = [S_C(\boldsymbol{x}, \boldsymbol{y})]^{\alpha} \cdot [S_I(\boldsymbol{x}, \boldsymbol{y})]^{\beta}$$

- For S_C, the Euclidean distance of components a* and b* is used:

$$S_C(\boldsymbol{x},\boldsymbol{y}) = 1 - \frac{\sum_{i=1}^{n} \sqrt{(x_{ia} - y_{ia})^2 + (x_{ib} - y_{ib})^2}}{200 \cdot \sqrt{2} \cdot n}$$

The distance is subtracted of one to obtain the similarity measure.

- For S_I, the correlation coefficient was employed, since it is invariant to brightness and contrast changes:

$$S_I(\boldsymbol{x},\boldsymbol{y}) = \frac{\sum_{i=1}^{n} (x_{iL} - \bar{\boldsymbol{x}}_L)(y_{iL} - \bar{\boldsymbol{y}}_L)}{\sqrt{\sum_{i=1}^{n} (x_{iL} - \bar{\boldsymbol{x}}_L)^2} \sqrt{\sum_{i=1}^{n} (y_{iL} - \bar{\boldsymbol{y}}_L)^2}}$$

Where $\bar{\boldsymbol{x}}_L$ and $\bar{\boldsymbol{y}}_L$ are, respectively, the mean lightness of x and y.

3. Experimental Results

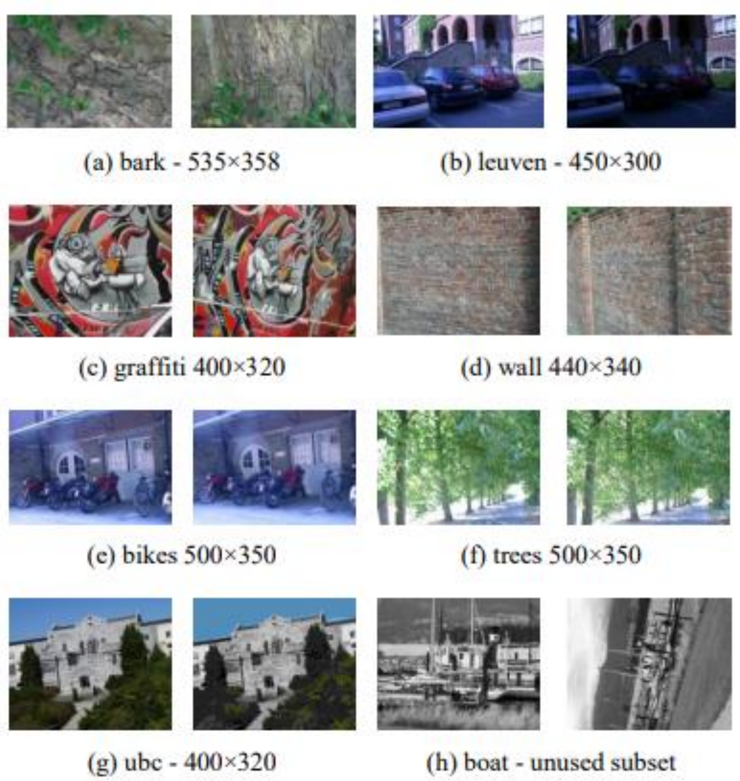

Figure 2. Images used for evaluating Color-Ciratefi.

In this experiment, 840 templates matchings were done. Color Ciratefi’s accuracy evaluation is 75%, compare to 63% of C-Color-SIFT.

So in average, Color-Ciratefi is more precise. However, SIFT is still faster.

V. Conclusion

Color-Ciratefi outperforms grayscale Ciratefi because of more advanced algorithm. However, Ciratefi is slower than the other algorithms.

VI. Reference

1. Sidnei Alves de Araújo and Hae Yong Kim. Color-Ciratefi: A color-based RST-invariant template matching algorithm. *IWSSIP 2010 - 17th International Conference on Systems, Signals and Image Processing*.