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Modified CAMshift Algorithm Based on HSV Color Model for Tracking Objects

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Abstract

Tracking objects in real time and exact tracking have long been challenging area in the field of computer vision. This paper describes a modified Continuously Adaptive Mean Shift (CAMshift) algorithm based on the Hue Saturation Value (HSV) color model for tracking an object in real time. The existing CAMshift can detect precisely when an object has a simple color. However, it has some disadvantages. When a CAMshift algorithm tracks an object, it does not consider direction and velocity, and it is difficult to track an object that has various colors and when the background contains color(s) similar to those of an object. In such case, CAMshift is worse than Meanshift. To overcome these disadvantages, a Kalman filter is used with CAMshift, as a Kalman filter can obtain direction vectors and it can make CAMshift exact, even under the aforementioned conditions.

Keywords: *CAMshift, HSV color model, Kalman Filter, Tracking*

1. Introduction

In recent years, many researcher developed many tracking algorithm to get exact and timely object location information [1, 2]. The representative algorithms are SURF (Speed-Up Robust Features) [3], SIFT (Scale-Invariant Feature Transform) [4], Meanshift [5], and Continuously Adaptive Mean Shift (CAMshift) [6, 7]. These have many applications, such as navigation, GPS, missile interception [8], crime detection through CCTV [9], and so on. Figure 1. Shows some tracking examples.

Figure 1. Tracking Examples

In this paper, a CAMshift algorithm with a Kalman filter is proposed. The CAMshift algorithm uses an HSV color model, and it can reduce computed value. In addition, it exhibits strong performance in terms of light. Through the Kalman filter, direction can be obtained and coordinates can be predicted.

This study consists of five chapters. Chapter 2 explains related theory, and Chapter 3 describes the proposed method. Chapter 4 presents results, and Chapter 5 concludes the paper and suggests future research topics.

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2. Related Theory

In this chapter, before explaining CAMshift and the Kalman filter, the color model Hue Saturation Value (HSV) is described.

2.1. HSV Color Model

The RGB color model is used for displays in devices; however, the HSV color model provides more eidetic color. The structure of the HSV model is shown in Figure 2. Unlike the white color (0, 0, 0) to black (1, 1, 1) in RGB, the HSV color model uses hue to add an extra dimension of identification.

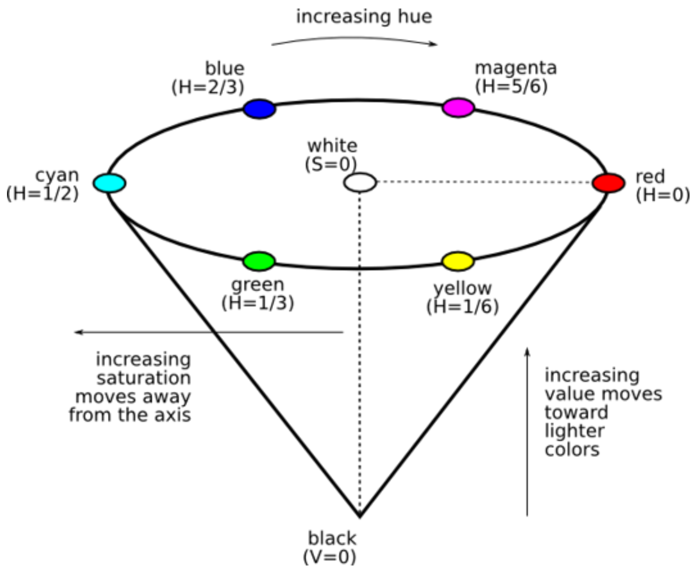


Figure 2. HSV Color Model Structure

The hue (H) of a color refers to which pure color it resembles. All tints, tones and shades of red have the same hue. Hues are described by a number that specifies the position of the corresponding pure color on the color wheel, as a fraction between 0 and 1 Value 0 refers to red, and 1/6 is yellow, 1/3 is green, and so forth around the color wheel. The saturation (S) of a color describes how white the color is. A pure red is fully saturated, with a saturation of 1, tints of red have saturations less than 1, and white has a saturation of 0. The value (V) of a color also called its lightness, describes how dark the color is. A value of 0 is black, with increasing lightness moving away from black.

2.2. CAMshift

The CAMshift algorithm is based on the Meanshift algorithm [10, 11]. The Meanshift algorithm works well on static probability distributions but not on dynamic ones, as in tracking movement. CAMshift is based on principles of Meanshift, but it also accounts for dynamically changing distributions. CAMshift is able to handle dynamic distributions by readjusting the search window size for the next frame based on the zeroth moment of the current frame’s distribution. This allows the algorithm to anticipate object movement to quickly track the object in Figure 3. Even during quick movements of an object, CAMshift is still able to track correctly.

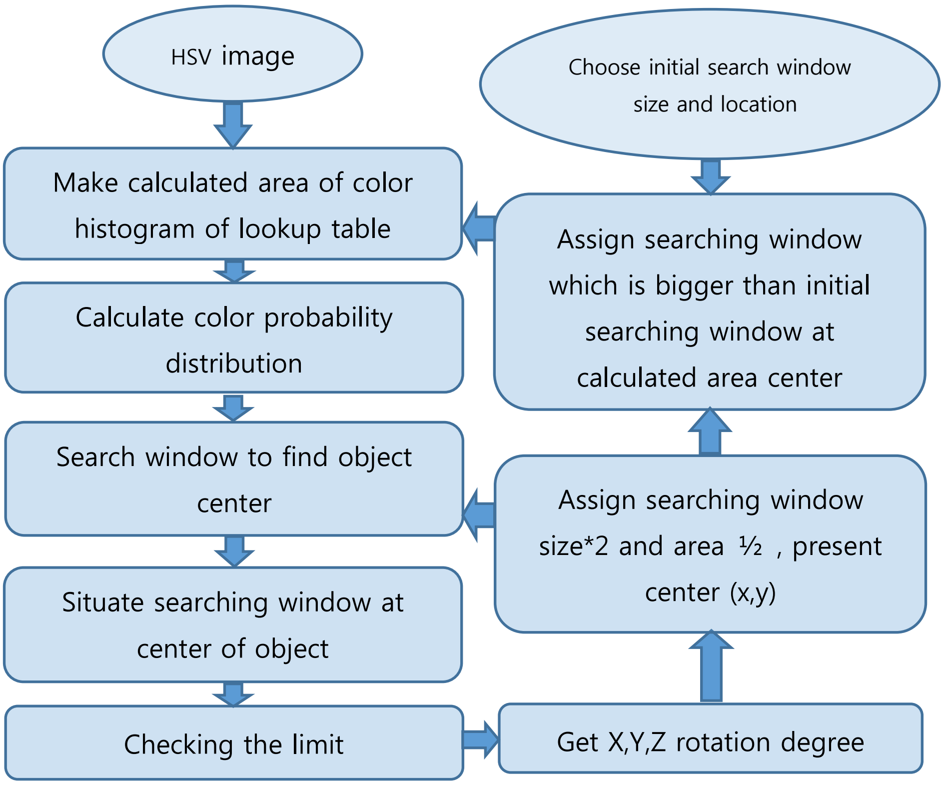


Figure 3. CAMshift Flowchart

The CAMshift algorithm is a variation of the Meanshift algorithm.

CAMshift can be summarized by the following steps (Figure 3). First, set the region of interest (ROI) of the probability distribution image to the entire image. Second, select an initial location of the Meanshift search window. The selected location is the target distribution to be tracked. Third, calculate a color probability distribution of the region center at the Meanshift search window. Next, iterate the Meanshift algorithm to find the centroid of the probability image. Store the zeroth moment (distribution area) and centroid location. Last, for the following frame, center the search window at the mean location found in Step 4, and set the window size to a function of the zeroth moment (then go to Step 3).

2.3. Kalman Filter

Kalman filtering, known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed over time, containing noise(random variations) and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone. More formally, the Kalman filter operates recursively on streams of noisy input data to produce a statistically optimal estimate of the underlying system state. The algorithm works in a two-step process. Figure 4 presents Kalman filter flow chart [12, 13].

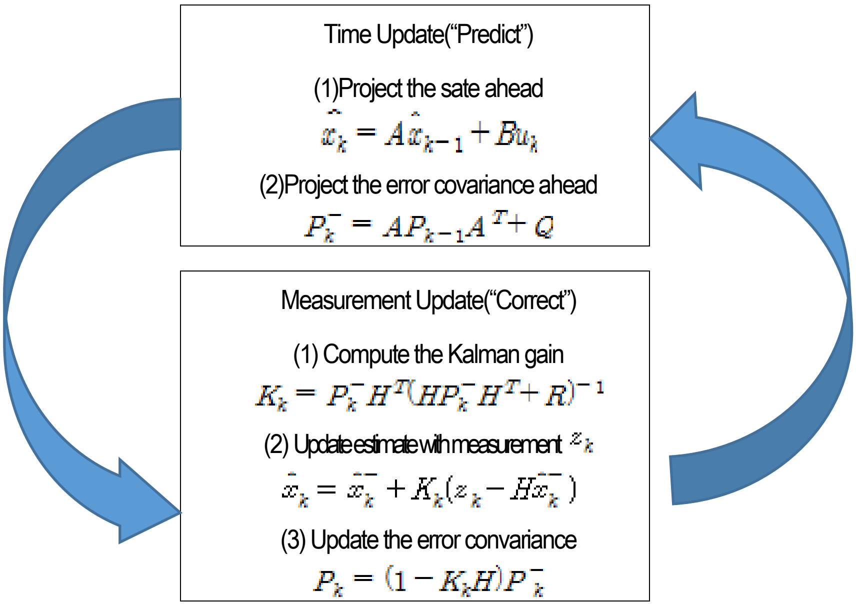


Figure 4. Kalman Filter Flowchart

The Kalman filter estimates a process by using a form of feedback control. The filter estimates the process state at some time and then obtains feedback in the form of measurements. As such, the equations for the Kalman filter fall into two groups [14], as shown in Figure 4: time update equations (prediction) and measurement update equations (correction). The time update equations are responsible for the feedback (*i.e.*, for incorporating a new measurement into the *a priori* estimate to obtain an improved *a posteriori* estimate). The time update equations can also be thought of as predictor equations, while the measurement update equations can be thought of as corrector equations. Indeed, the final estimation algorithm resembles that of a predictor-corrector algorithm for solving numerical problems, as shown in Figure 4.

3. Proposed Method

The proposed system algorithm is outlined in Figure 5.

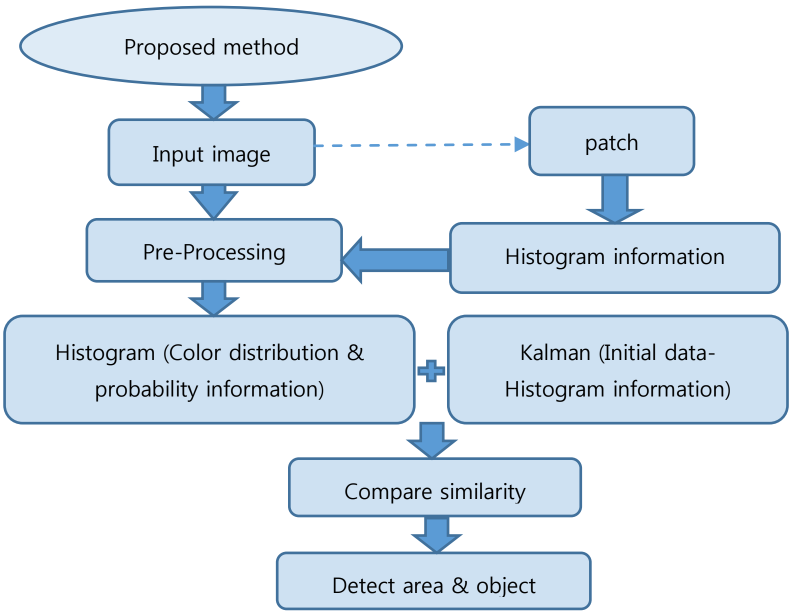
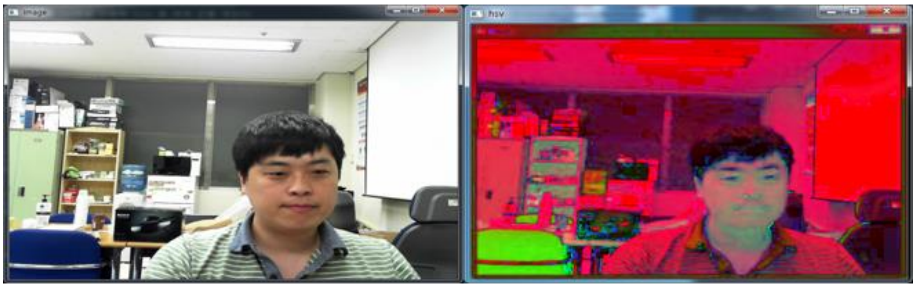


Figure 5. Proposed Algorithm Flowchart

First, we get input image through webcam. After do pre-processing to input image to remove noise. After it changes color model. When we get the image, it is RGB color model. So, it needs change HSV color model to make tough about light. HSV color model result is following Figure 6.



(a) Original image (b) HSV color model

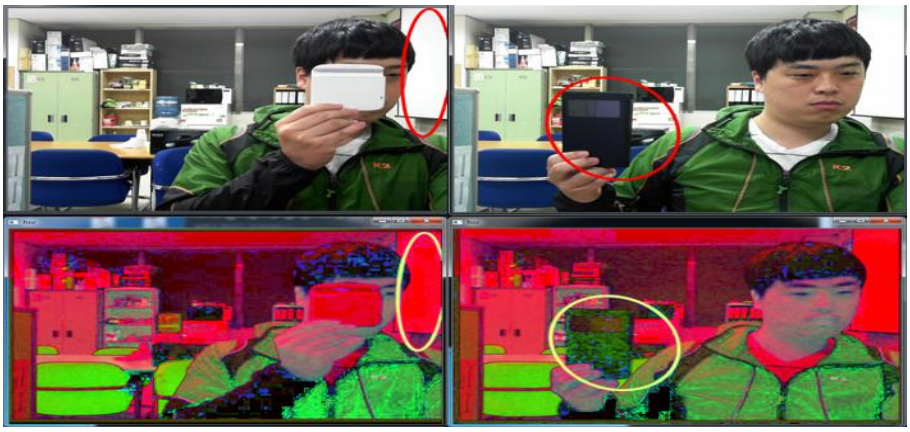
Figure 6. Comparison of RGB and HSV Color Models

After change color model from RGB to HSV, we use existed CAMshift to track object. Tracking result is Figure 7 and present HSV color model tracking result is Figure 8.

Figure 7. Existing CAMshift Algorithm Result

Figure 8. Existing CAMshift Algorithm Result in HSV Color Model

In Figure 9, the algorithm cannot detect objects because of color. In (a), the portable charger has a similar color to the background screen. In (b), the cellphone has a black color, so CAMshift detected it as a dark area. To overcome these disadvantages, a Kalman filter is used with CAMshift in this paper. Through Kalman filtering, we can even track an image that has strong light more exactly.



(a) Portable charger (b) Cellphone

Figure 9. Existing CAMshift Error Examples

4. Results

(a) Portable charger (b) cellphone

Figure 10. Final Results

Using the Kalman filter can help to predict coordinates by using object direction and velocity. From Figs. 8 and 9, it is shown that the modified CAMshift can detect objects more exactly, even where it could reduce the light effect. The red circle represents present coordinates, the gray rectangle represents correct coordinates, and the orange oval represents predicted coordinates. Tables 1 and 2 present Kalman filter coordinates for the two test cases.

Table 1. Kalman Filter Coordinates (Portable Charger)

count	Predict coordinates(x,y)	Correct coordinates(x,y)	Measure coordinates(x,y)
Time 1	(0,0)	(50,51)	(49, 48)
Time 2	(48,51)	(49,50)	(51,53)
Time 3	(49,53)	(49,50)	(49,52)
Time 4	(50,51)	(50,51)	(50,51)
Time 5	(53,51)	(52,52)	(53,53)
Time 6	(53,52)	(54,52)	(53,54)
Time 7	(55,56)	(55,54)	(55,55)
Time 8	(57,55)	(58,56)	(56,55)
Time 9	(58,52)	(58,53)	(57,54)
Time 10	(58,52)	(59,54)	(57,53)

Table 2. Kalman Filter Coordinates (Cellphone)

count	Predict coordinates(x,y)	Correct coordinates(x,y)	Measure coordinates(x,y)
Time 1	(0,0)	(53,54)	(54, 52)
Time 2	(52,53)	(52,53)	(51,54)
Time 3	(52,54)	(50,52)	(51,54)
Time 4	(53,54)	(51,53)	(52,55)
Time 5	(54,56)	(53,54)	(55,55)
Time 6	(56,54)	(55,55)	(56,55)
Time 7	(57,58)	(58,53)	(57,55)
Time 8	(59,54)	(58,53)	(56,58)
Time 9	(58,55)	(58,51)	(57,55)
Time 10	(56,54)	(59,54)	(57,53)

Using this table, object moving distance and direction can be obtained, and the next coordinates can be predicted. Times taken to track each object are given in Table 3.

Table 3. Time to Track an Object

	Time1	Time2	Time3	Time4	Time5	average
Portable charger	0.033sec	0.032sec	0.035sec	0.027sec	0.036sec	0.033sec
Cellphone	0.029sec	0.031sec	0.032sec	0.034sec	0.032sec	0.032sec

The average times for the portable charger and cellphone are 0.033sec and 0.032sec, respectively, which are sufficiently fast to be used in real time.

5. Conclusion

In this paper, a CAMshift algorithm based on the HSV color model with a Kalman filter was proposed. Through the Kalman filter, we can get direction vectors, from which we can predict the next object location and velocity. This can even track when an object has various features and when the background color is similar to that of the object.

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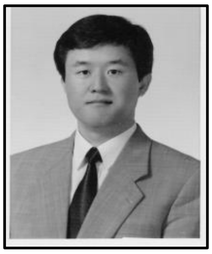

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