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# K-means Tracker-based Object Tracking Method for Digital Camera

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*Abstract* — **An automatic object tracking technology is developed for a digital camera. We have developed a new modified object tracking algorithm based on K-means Tracker algorithm that is adaptive to the change of the object shape and appearance. Several modifications for higher tracking performance and lower computation cost are introduced for the digital camera application.**

## I. INTRODUCTION

Advanced camera control technologies such as face detection have been developed to improve usability of a digital camera. An object tracking capability is a next promising technology. This enables a user to shoot a photo containing a moving object only by indicating the position on a monitor at the beginning. The camera automatically tracks the object and the user shoots the photo at an arbitrary timing. This paper describes the details of the tracking capability.

## II. PREVIOUS WORK

Template matching[1], Mean-shift[2], Particle filter[3] and K-means tracker[4] are representative object tracking algorithms. Among them, the template matching method is the most conventional and often used for a high precision positioning of electric and mechanical parts. However, the algorithm doesn't achieve sufficient performance for the digital camera application.

On the other hand, Mean-shift, Particle filter and K-means tracker are known to have high performance for scenes taken by a digital camera. However, Mean-shift is not robust enough for scale and appearance changes of an object. The computation cost of Particle filter is high so that it is difficult to apply for a digital camera.

We selected K-means tracker as the object tracking algorithm because the algorithm is applicable for wide variation of scale and appearance change with reasonable computation cost.

## III. K-MEANS TRACKER ALGORITHM

K-means tracker detects a region having the similar color information along sequential frames using the color information of a target area that corresponds to the moving object. The main features of the algorithm are as follows:

### *A. 5D uniform feature space*

Pixels in a target area are clustered to K classes. Color information (R, G, B) and a position (x, y) of a pixel are treated equally as feature values in the 5 dimensional coordinate. A distance between two pixels in the space is defined as a Euclidean norm.

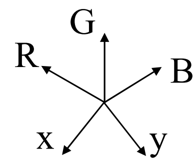


Fig.1 5D feature space

### *B. K-means clustering*

When clustering the pixels in the target area, K-means clustering algorithm is used. K clusters are created and a representative color is assigned for each cluster. In each cluster, the mean color and center position of each cluster are calculated and renewed continuously.

### *C. Concept of background colors*

To detect target object correctly, a background color near the target object is used. This is because not only the target color but also the background color is important for the object detection.

### *D. Elliptical target and search area*

Both of the target area and the search area are defined as elliptical areas. Pixel values on the elliptical contour of the search area are treated as background colors.

### *E. Coarse and fine sample points*

Not all points in the search area are checked for the clustering. Only sample points of them are checked. The sample points are dense around the center of the search area and sparse at the periphery of the area in the original K-means tracker algorithm.

## IV. NEW MODIFIED OBJECT TRACKING METHOD

Although original K-means tracker algorithm has high performance to detect a target object, it needs high computation costs. We modified several items to improve the tracking performance with limitation of CPU's processing ability on a digital camera as follows:

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### A. Representative color

One or plural representative colors are selected in the original method. However, it is not easy for a user to select multiple colors on a monitor of a digital camera. Therefore, we limited the number to only one.

### B. Color distance

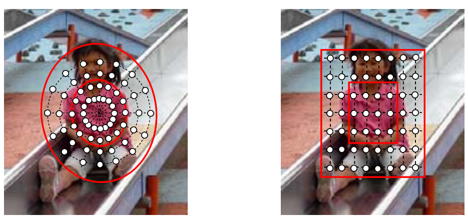
A Euclidean norm is used to measure a distance between two color pixels in the original method. The method with norm is not robust for luminance variation of an object. To solve the problem, we use a color angle between the pixels.

### C. Shape of search and target area

The shape of a search area and a target area were ellipses in the original algorithm. The shapes of them were changed to rectangles to reduce the computation cost.

### D. Distribution of sample points

The original method generates sample points from the center of the target area ellipse in a radial pattern. The density of the sample points becomes higher at the center of the ellipse. As shown in Fig.2, the distribution was changed to be uniform in the search area.



(a) Original method (b) Modified method

Fig.2 Shape of search areas (outside red lines) and sampling points (small white dots).

The modified method was implemented into a prototype digital camera and verified to track objects correctly.

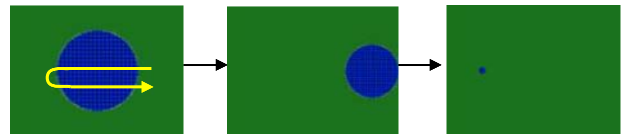
## V. EVALUATION OF TRACKING PERFORMANCE

To measure objective performance of the modified method on the prototype camera, we prepared several computer generated movies. They were designed to simulate real scenes by considering practical and critical conditions that have higher possibility of failure in object tracking. Those shooting scenes were classified to six representative scenes as follows.

1. Hue and luminance of an object change, such as when the object moves from the shade to sunlight.
2. Luminance of the background changes, such as when the object moves and the background changes.
3. Size of an object changes, such as when the object moves forward or backward.
4. Occlusion of an object occurs, such as when the object moves behind a blocking item.
5. Large uniform plane of an object appears, such as when the object is bigger than the possible tracking region.
6. Quick lateral movement of an object happens, such as when the object moves rapidly in the screen.

All evaluation results showed that the performance of the modified method has sufficient performance for the practical use.

(a) Real scene (walking person)



(b) Computer-generated movie for evaluation

Fig.3 Example in the case of the representative scene, No.3

TABLE 1
Example of results of the performance evaluation

| Representative scenes | Conditions(extracted from real scenes) | Object Tracking Results |
|---|---|---|
| 1. Hue and luminance change of an object | Hue change from 180-degree to 150-degree | Success within all degrees |
| 3. Size change of an object | Object size reduction from 100% to 10% | Success within 100% to 40% |

## VI. CONCLUSION

We proposed a new modified object tracking algorithm based on K-means tracker and implemented it on a prototype digital camera. The tracking performance was evaluated by using six computer-generated movie sequences simulating critical conditions of real scenes. Consequently, we confirmed that the performance of the modified method was high enough for the practical use.

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