Automated Tracking of Marks on Moving Objects

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Abstract - **The problem of the automated tracking of marks, placed on moving objects, is discussed. Different techniques for localization of the marks are pointed out. Experiments with human body parts tracking have been carried out. The approach could be used for tracking of moving objects and evaluation of their kinetic characteristics.**

Keywords - **Tracking, Marks, Moving Objects, Human Motion**

I. INTRODUCTION

Object tracking in a sequence of images is an important task in the field of computer vision. Different techniques have been developed for estimation of the movement of vehicles, indoor and outdoor tracking of humans, analysis of motion in biomedicine, etc. Tracking results are mathematically analyzed and thus movement dynamics description is obtained.

The algorithms for objects' tracking are based on either optical flow or localization and tracking of features. *Optical flow* represents a displacement vector field in the image plane induced by the motion of objects, by the observer or both. Optical flow methods can be divided into three groups [2]: differential methods – they compute image velocity with spatio-temporal derivatives of the intensity; frequency methods – using information about the energy and the phase in the image spectrum; matching methods – calculating the displacements of tokens matched in small series of images. The goal of the *feature-based* tracking methods [4, 8] is to discriminate the moving features from the static ones and to calculate the point correspondences in a sequence of images. The correspondence techniques are based on tracking pixels and tokens – point, line or region.

The human motion analysis lies on the assumption that the body movement can be considered as a movement of articulated objects. The study of such motion is related to kinematics, which is concerned with the geometry of the object, its position, orientation and deformation. The *2D human tracking methods* are appearance-based (using texture, color, shape, etc.), or model-based (using preliminary information about the motion) [10]. A certain part of the methods use only one camera, but build 3D human body model [5]. They can be called *pseudo-3D methods*. Actual *3D methods* are used when two or more cameras, placed in different positions are working at the same time [6].

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In many cases the study of the movement of specific body parts such as face, hands, fingers, legs, etc. is needed. Human limbs can be modeled as a system of rigid objects connected with articulations with one or more degrees of freedom. In case of tracking, markers and constant background are often used. Many applications are developed in the area of security, motion estimation of physical exercises, etc. [7, 9].

II. ALGORITHMS FOR AUTOMATED TRACKING OF MARKS

In this study two methods for tracking, based on the localization of areas with specific light intensities, are investigated: localization of the marks in a region and with the assistance of a kinetic model.

According to the first method the moving marks in the *n*-th image are supposed to be located in a region near their centers of gravity in the previous image *n-1* from the sequence. The size of the search region (square or circle) is set according to the dimensions of the marks, their speed and computation time. The search is accomplished around predicted positions of the marks, calculated according to the equations:

$$\hat{x}_n = x_{n-1} + (x_{n-1} - x_{n-2}), \quad \hat{y}_n = y_{n-1} + (y_{n-1} - y_{n-2}), \tag{1}$$

where (x_{n-1}, y_{n-1}) and (x_{n-2}, y_{n-2}) are the coordinates of the corresponding mark in the previous two images. The coincidence of the light intensities of the pixels and the marks is determined by an admissible deviation for the components of the digital image – red, green and blue, expressed with three conditions related with the logical function "AND":

$$|R_n - R| < \theta \wedge |G_n - G| < \theta \wedge |B_n - B| < \theta, \tag{2}$$

where R_n, G_n and B_n are the color components of the current pixel, *R*, *G* and *B* determine the color of the mark and θ is a number between 0 and 255, which gives the maximal admissible deviation. The approach is appropriate for cases when the marks are clearly different from the other objects in the scene, no matter if the objects are moving or not. Problems can occur when two marks with identical light intensities get very close to one another or when one mark overlaps the other.

The description of the movement of connected objects can be based on certain kinetic model. The presence of such a model can facilitate the algorithm of tracking, as in that case the movement of the marks can be restricted to some determined trajectories – circles, for example. In case of marks placed on object's axes of rotation, such as human joints, the distance between marks placed on consecutive joints can be considered constant and the trajectory of one of them can be fixed on a circle centered at (α, β) in the previous and with radius *R* equal to the distance between them. To avoid some fluctuations, a certain thickness *r* at these circles is assumed. The condition for a pixel to be on the circle is:

$$(R-\frac{r}{2})^2 < (x-\alpha)^2 + (y-\beta)^2 < (R+\frac{r}{2})^2 \quad (3)$$

Such motion model is idealized so its realization is restricted to the case when the camera is positioned perpendicularly to the examined object. Even in that particular case moving objects may not lie in the same plane, which will produce some offset from the position expected.

III. EXPERIMENTAL RESULTS


Frame 1


Frame 15


Frame 30


Frame 60

Fig. 1. Frames from the recorded sequence

In the experiments, a real indoor scene with a human arm movement has been investigated. Color rectangles have been pasted at the location of the three joints – shoulder, elbow and wrist, and used as marks. A movie in *AVI* file format, 25 frames per second, with consecutive positions of the arm has been recorded with a static Sony USB color camera and then has been divided in images in *BMP* file format, with resolution 640x480 and 24 bits per pixel. Using the described approaches, separated frames, containing the consecutive positions of the person's arm, have been processed (Fig. 1).

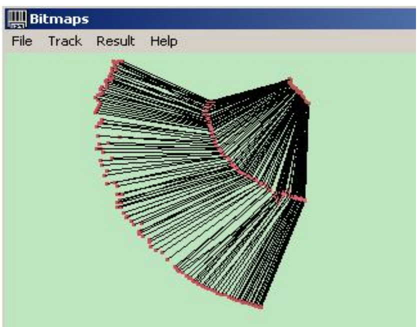

Fig. 2. Positions of the human arm in the image sequence

The best results have been obtained with the method of searching within region, using a square with size of 40 pixels and setting the admissible deviation for the color components to 10. In Fig. 2 the consecutive positions of the three marks are given, the marks in each frame being connected with lines, showing the current position of the arm. Tracking with the assistance of a kinetic model using a thickness of 20 pixels for the circles gives similar results.

IV. CONCLUSION

An automated tracking of colored marks on moving objects is realized with the help of different methods for localization of the positions of the marks in sequential images. The scene used in the experiments consists of a person with markers on his moving arm. Problems can occur if different marks get very close to one another or if one mark overlaps the other. A solution can be found using different colors for the marks or studying the trajectories and the velocities of movement of the marks. The developed algorithms are realized in a software program using Microsoft Visual C++. Possible applications can be found in the area of analysis of human motion when performing sport exercises (darts, boxing, cycling), biomedicine, gait recognition, security, etc.

ACKNOWLEDGEMENTS

This work is supported by the Institute of Information Technologies of BAS and by the Ministry of Education and Sciences under contract I-1302/2003.

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