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Objects Detection and Extraction in Video Sequences Captured by a Mobile Camera

Raida Charfi, Mbainaibeye Jerome

Abstract— **Detection and extraction of objects in images and video sequences is an important and intensive activity in the researcher's community. The most important applications concern industrial activities, civil and military tasks. This paper presents an approach for the detection and the automatic extraction of the objects in video sequences captured by a mobile camera. The approach is based twice on the optimal orientation vision angle and on the camera movement model. Furthermore, we have proposed a new algorithm to overcome the drawbacks of the Active Edge method which permits us to recover the lost points on the object edge. The simulations are operated on some standard video sequences and using Matlab software. The obtained results show that our approach is very encouraging.**

Index Terms— **Object detection, automatic object extraction, mobile camera, orientation vision angle, movement model.**

I. INTRODUCTION

Mobile objects detection and extraction is a fundamental aspect in many applications such as robot navigation, video surveillance, video indexation, etc. While static object detection has reached maturity because a lot of works are already done in the literature and many systems are already realized, detection and extraction of moving objects stay a difficult task and this domain is subject of intensive research activities now. Different approaches are proposed in the literature to realize this task. Many of these approaches are based on pixel classification techniques exploiting a local measure linked to apparent movement such as moving image difference called Displaced Frame Difference (DFD). Pixel classification procedure in static and dynamic zones uses the thresholding [1]-[3] or Bayesian techniques [4]-[6]. Some approaches operate by iterative processing on pixels or on regions [6].

Extraction of initial spatial partition is also exploited for the segmentation in term of image sequence movement from the movement criteria [7], intensity information, texture or color [8]-[10]. These methods offer the best precision of the movement localization frontiers in terms of intensity, texture or color. From this initial segmentation, 2D parametric model of movement is associated with each spatial region and the segmentation in terms of movement consists to the realization of fusion regions. It can exploit the techniques of the classification of movement parameter's space or the Bayesian approaches such us the using of Minimum Description Length (MDL) [7], or the Markovian techniques of contextual labeling on a graph's regions [9]. One of the limits of these approaches is the fact that they cannot exploit the fine spatial partition for obtaining the movement parametric model and so presents the high probability to lose some movement frontiers where many points defining the object edge may be lost. This paper presents an approach for detection and extraction of objects in video sequences captured with a mobile camera; this approach is based on optimal orientation vision angle and camera movement model. The remaining of this paper is organized as fellow: section II presents the state of the art; section III presents the development of our contribution; section IV and section V present the obtained results and discussions; finally section VI presents the conclusion and the perspectives of this work.

Raida Charfi, Engineering High School of Tunis, Tunisia
Mbainaibeye Jerome, University of Doba, Chad

II. STATE OF THE ART IN OBJECT DETECTION AND EXTRACTION

Detection and localization of objects for extraction in digital image and video sequence has become one of the most important applications for industrial use to ease user and save time. The techniques of detection and extraction of objects has been developed many years ago but improvement of them, in particular for mobile object, is still required in order to achieve the targeted objective in more efficient and accurately. Many applications in this domain exist and the literature is most abundant.

In robotic application, the moving object is tracked by utilizing a mobile robot with sensors. In [11], the authors have developed a system where the robotic platform uses a visual camera to sense the movement of the desired object and a range sensor to help the robot to detect and ovoid obstacles in real time while continuing to detect and follow the desired object.

In [12], the authors have developed a method for detection of mango from mango tree. Their method uses color processing as primary filtering to eliminate the unrelated color or object in the image, edge detection and Circular Hough Transform.

Image and video segmentation and edge detection techniques are widely used in object detection, information retrieval by several authors such us [13]-[17].

In [18], author has developed a perfect method for object recognition with full boundary detection. His method is based on the combination of Affine Scale Invariant Feature Transform (ASIFT) and a region merging algorithm.

In [19], authors have presented a system for the detection of static objects in crowded scenes. In their method, based on the detection of two background models learning at different rates, pixels are classified with the help of finite-state machine. The background is modeled by two mixtures of Gaussians with identical parameter except for the learning rate.

In [20], authors have proposed a method for the detection of moving object based on the combination of adaptive filtering technique and Bayesian change detection algorithm. An adaptive structure firstly detects the edges of motion objects; then the Bayesian algorithm corrects the shape of detected objects.

III. PROPOSED OF OBJECT DETECTION AND EXTRACTION SYSTEM

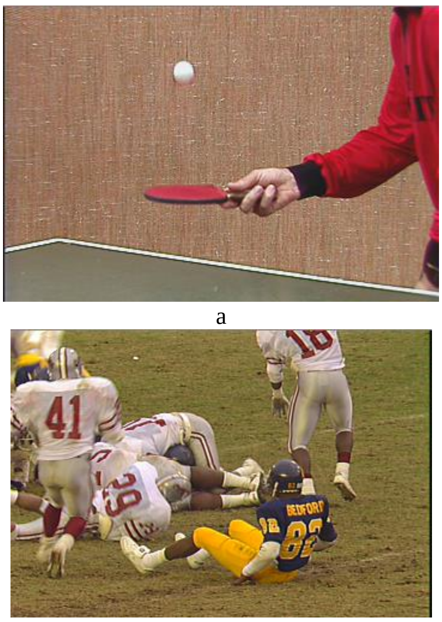
Our contribution in object detection and extraction is divided in two stages: optimal orientation vision angle and camera motion modeling.

A. *OPTIMAL ORIENTATION VISION ANGLE*

We consider three successive frames in the video sequence for the estimation of the orientation vision angle. These successive frames are I_{n-1}, I_n, and I_{n+1} corresponding to the images at times *n-1*, *n* and *n+1* respectively. Objects of the first frame (I_{n-1}) are compared to the objects of the second frame (I_n) and the objects of the second frame (I_n) are compared to the objects of the third frame (I_{n+1}). We obtain two compensated frames describing the movement which we call first order movement. We compared the objects of the two compensated frames and the result of this comparison is one compensated frame noted ΔI describing the movement which we call second order movement. The second order movement is the result of the global movement between the first frame (I_{n-1}) and the third frame (I_{n+1}). The orientation vision angle consists to apply to ΔI a geometric transform for the determination of the vision angle. The geometric transform is the rotation with angle Θ and Θ is considered here as a field vision of the observer. The difficulty is how to obtain the optimal vision angle Θ_{opt}. To resolve this difficulty, we have developed an algorithm to estimate Θ_{opt}. This algorithm is described below:

1. *Divide ΔI in blocks of n x n pixel with n odd*
2. *For each block, apply a rotation with variable angle from 0 to 360°*
3. *For each block, compare the object in ΔI to object in I_{n-1}, I_n or I_{n+1} and calculate the difference number using a threshold*
4. *Optimal vision angle Θ_{opt} is the angle for wich the similarity of the compared objects is maximal.*

To evaluate this algorithm, we use the following standard video sequences: Tennis and Football video sequences for which the frames are captured by a mobile camera.



a

b

Fig. 1 Test video sequences: a) Tennis, b) Foot ball

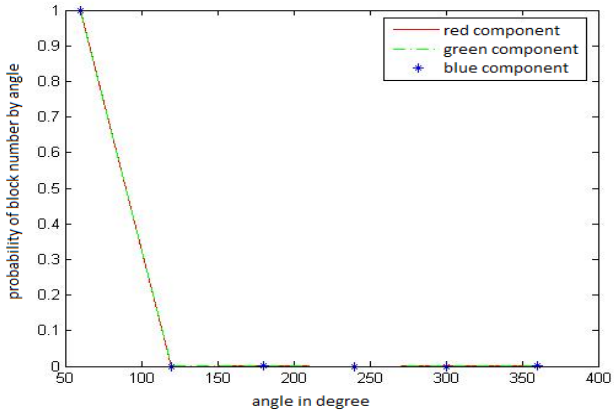
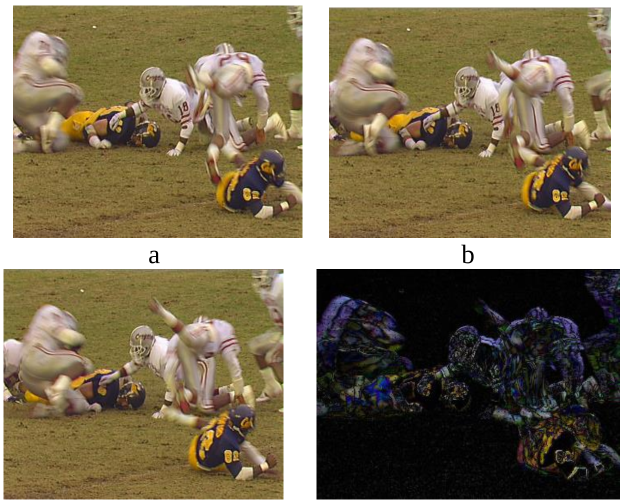


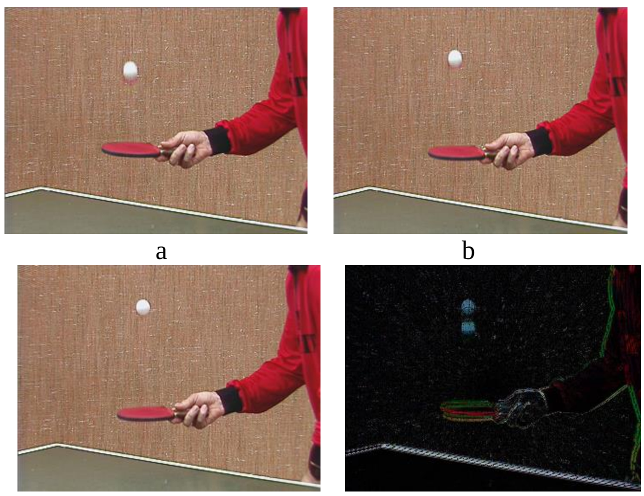
Fig.2 Vision angle analysis

The above algorithm is applied on the two standard video sequences. The statistics which we have obtained have shown that 98 % of the blocs were obtained for an average optimal vision angle $\Theta = 60°$ for the red, green and blue frame components as showed in figure 2. Furthermore, figure 2 shows that the probability to obtain frame blocs for the vision angle greater than 120° is equal to zero. Figures 3 and 4 present respectively the results obtained in term of objects detected (frame ΔI).



a b c d

Fig. 3 Football video sequence: a) frame I_{n-1}, b) frame I_n, c) frame I_{n+1}, d) frame ΔI



a b c d

Fig.4 Tennis video sequence: a) frame I_{n-1}, b) frame I_n, c) frame I_{n+1}, d) frame ΔI

B. CAMERA MOVEMENT MODELING

The estimation of the camera movement is a difficult task because the movement of a pixel between two successive images depends not only of the camera parameters but depends also of the depth of the captured scene point. The camera movement model used in this work is based on the model presented in [21]. This model is the affine movement and describes the relation between the movement of objects and the movement of the observable domains using a parametric expression. This model can describe the movements such as rotation, translation, and zoom using six parameters which are the element of the vector *a* defined by equation 1:

$$a = (a_1, a_2, a_3, a_4, a_5, a_6)^T \quad (1)$$

This movement model is defined in horizontal and vertical directions respectively by equations 2 and 3:

$$m_x[a, x, y] = \frac{w-1}{2}\left[a_1c_1 + a_2c_2\left(x - \frac{w-1}{2}\right) + a_3c_3\left(y - \frac{h-1}{2}\right)\right] \quad (2)$$

$$m_y[a, x, y] = \frac{h-1}{2}\left[a_4c_1 + a_5c_2\left(x - \frac{w-1}{2}\right) + a_6c_3\left(y - \frac{h-1}{2}\right)\right] \quad (3)$$

Where w and h are respectively the width and the height of a video frame.

The coefficients c_1, c_2 and c_3 are defined by equations 4, 5 and 6 respectively:

$$c_1 = \frac{1}{\sqrt{wh}} \quad (4)$$

$$c_2 = \sqrt{\frac{12}{wh\,(w-1)(w+1)}} \quad (5)$$

$$c_3 = \sqrt{\frac{12}{wh\,(h-1)(h+1)}} \quad (6)$$

A picture captured by a camera may contain many moving objects combining with focal movement of the camera. In this work, we have partitioned the video frame at time *n* in *N blocks* where the size of each block is *m x m* with *m* =16. For each block, the movement parameters are estimated. This estimation permits the description of the movement inside each block between the video frame captured at time *n-1* and another captured at time *n*.

In the camera movement modeling, we have used two steps which are: first, the determination of initial motion vector and second, the estimation of the motion parameters.

C. INITIAL MOTION VECTOR

We define the initial motion vector using m^I by equation 7:

$$m^I = \left(m_x^I, m_y^I, m_t^I\right) \quad (7)$$

Where m_x^I , m_y^I represent the spatial movements and m_t^I represents the temporal motion.

To obtain the initial motion vector, the cost of the estimation is given by the Lagrangian defined by equation 8:

$$m^I = \arg\min\left\{MSE(S_{k,l}, m) + \lambda R(S_k, m)\right\},\ m \in M \quad (8)$$

Where $MSQ(S_{k,l}, m)$ is the distortion for the block S_k of size 16 x16. It is calculated between two successive frames using the least squares method defined by equation 9:

$$SQM(S_{k,l}, m) = \frac{1}{32}\sum_{i=k}^{k+15}\sum_{j=l}^{l+15}\left(S(i,j,t) - S'(i,j,t-1)\right)^2 \quad (9)$$

The Lagrangian multiplier λ is chosen by using [21] with $\lambda = 0.85Q^2$ where Q is the discrete cosine transform (DCT) quantizer and we have used $Q = 7$. In equation 8, $R(S_{k,l}, m)$ is the number of bits necessary to represent the motion vector; in this work, we take $R(S_{k,l}, m) = 4\,bits$.

1) ESTIMATION OF MOTION PARAMETERS

The initial motion vector estimated is used for the compensation of the current frame (frame at time *n*) with the precedent frame (frame at time *n-1*). This is done by using equation 10:

$$\hat{s}[x, y, t] = s'\left[x - m_x^I, y - m_y^I, t - m_t^I\right] \quad (10)$$

This motion compensation is elaborated for each block of 16x16 pixels using the minimization criterion given by equation 11:

$$a^R = \arg\min \sum_{x,y \in A} u^2[x, y, t, a] \quad (11)$$

Where the vector *u* is given by equation 12:

$$u[x,y,t,a] = s[x,y,t] - \hat{s}\left[x - m_x[a,x,y], y - m_y[a,x,y], t\right] \quad (12)$$

It is necessary to linearize the signal given by equation 13 around the position (*x, y*) considering a small spatial motion defined by the following expression $(m_x[a,x,y], m_y[a,x,y])$:

$$\hat{s}\left[x - m_x[a,x,y], y - m_y[a,x,y], t\right] \quad (13)$$

So, the linearization of equation 13 is given by equation (14):

$$\hat{s}\left[x - m_x[a,x,y], y - m_y[a,x,y], t\right] \approx \hat{s}[x,y,t] - \frac{d\,\hat{s}[x,y,t]}{dx} m_x[a,x,y] - \frac{d\,\hat{s}[x,y,t]}{dy} m_y[a,x,y] \quad (14)$$

By introducing equation 14 in equation 12, this last become equation 15:

$$u[x,y,t,a] \approx s[x,y,t] + \frac{d\,\hat{s}[x,y,t]}{dx} m_x[a,x,y] + \frac{d\,\hat{s}[x,y,t]}{dy} m_y[a,x,y] \quad (15)$$

We use now, for the motion model given by equation 2 and equation 3, the vector elements given by equation 1 to obtain the expression given by equation 11. These vector elements must be minimized. Then, this expression to minimize is now given by equation 16:

$$u[x,y,t,a] \approx s[x,y,t] - \hat{s}[x,y,t] + \left(g_xc_1, g_xc_2x', g_xc_3y', g_yc_1, g_yc_2x', g_yc_3y'\right) \times \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \end{bmatrix} \quad (16)$$

Where g_x, g_y, x', and y' are given respectively by equations 17, 18, 19 and 20:

$$g_x = \left(\frac{w-1}{2}\right)\frac{d\,\hat{s}[x,y,t]}{dx} \quad (17)$$

$$g_y = \left(\frac{h-1}{2}\right)\frac{d\,\hat{s}[x,y,t]}{dy} \quad (18)$$

$$x' = x - \frac{w-1}{2} \quad (19)$$

$$y' = y - \frac{h-1}{2} \quad (20)$$

We define the spatial gradient as $\frac{\partial \hat{s}[x,y,t]}{\partial z}$. The expression of this spatial gradient is given by equation 21:

$$\frac{\partial \hat{s}[x,y,t]}{\partial z} = \frac{1}{4}\sum_{i=0}^{1}\sum_{j=0}^{1}\alpha_{i,j}^{z}\hat{s}[x+i,y+j,t] + \beta_{i,j}^{z}\hat{s}[x+i,y+j,t] \quad (21)$$

Where $\alpha_{i,j}^{z}$ and $\beta_{i,j}^{z}$ represent the elements of the row i and the column j of the following matrix A and B defined by equations 22 and 23:

$$A^x = B^x = \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \quad (22)$$

$$A^y = B^y = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix} \quad (23)$$

For the determination of the motion affine parameters, we have to determine in the first step the elements a_i of vector a by using the least square method. We calculate u^2 and we define equation 24:

$$\frac{\partial u^2}{\partial a_i} = 0 \; \forall i \in \{1,2,\ldots,6\} \quad (24)$$

The computing of equation 24 allows us to linearize it and obtain the matrix defined by equation 25 where the unknown is the vector X:

$$AX = B \quad (25)$$

We use the Gauss method to resolve the equation 25 and we obtain $X = (a_1, a_2, a_3, a_4, a_5, a_6)^T$.

The motion affine parameters relative to the motion compensation between two successive frames are obtained by the concatenation of the initial motion vector m^I and the parameters a^R estimated. The results are presented in equation 26:

$$\begin{aligned} a_1 &= \frac{2m_x^I}{c_1(h-1)} + a_1^R, a_2 = a_2^R, a_3 = a_3^R \\ a_4 &= \frac{2m_y^I}{c_1(h-1)} + a_4^R, a_5 = a_5^R, a_6 = a_6^R \end{aligned} \quad (26)$$

D. ALGORITHM OF THE DETECTION OF CAMERA MOTION

To detect the movement of the camera, we consider two successive frames partitioned in blocks of 16 x16 pixels. We estimate in a first time the initial motion vector by using the least square method. In a second time, we operate the compensation of the affine parameters by the concatenation of the initial motion vector m^I and the parameters a^R. In a third time, we estimate the camera motion. Figure 5 shows this algorithm.

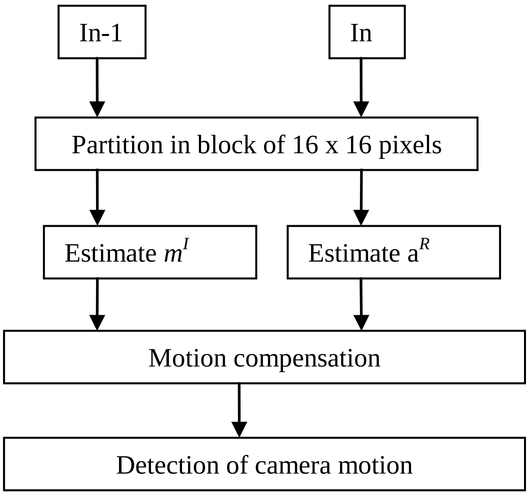
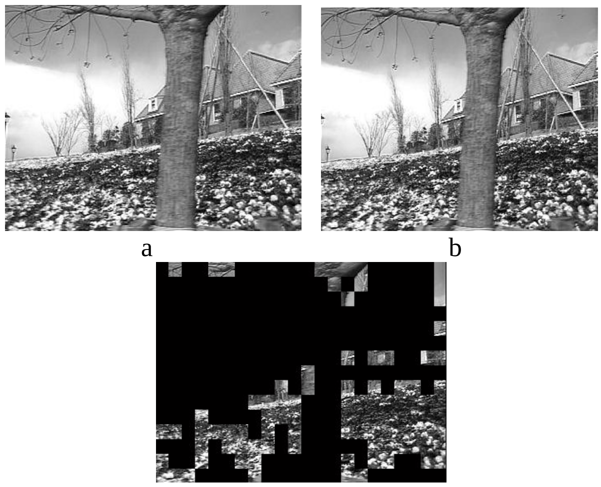


Fig. 5 Camera motion detection algorithm

The figures 6 and 7 show the results obtained for Flowers, and Tennis video sequences.



c

Fig.6 Detection of camera motion of Flowers video sequence: a) frame I_{n-1}, b) frame I_n, c) camera motion

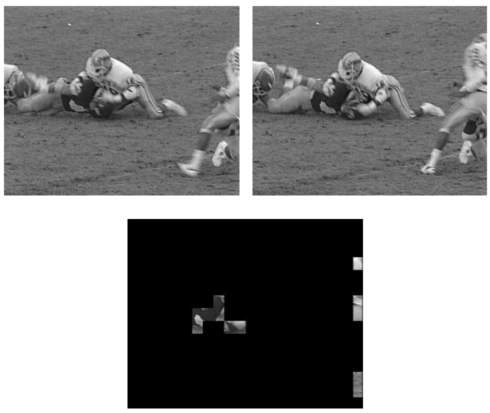
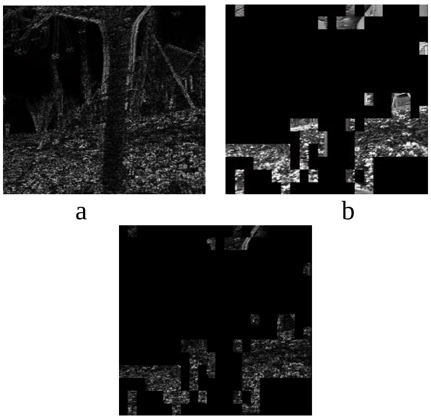


Fig.7 Detection of camera motion of Football video sequence: a) frame I_{n-1}, b) frame I_n, c) camera motion

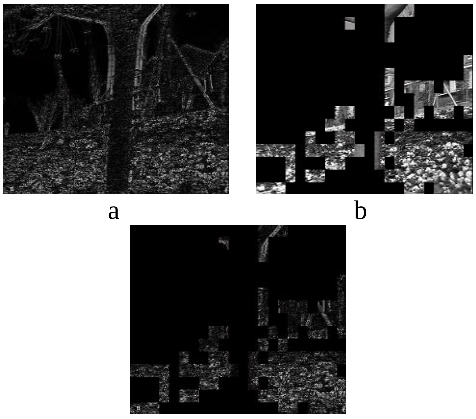
IV. Detection Of Motion Objects And Camera Motion

We apply the algorithm presented if figure 5 for the simultaneous detection of the motion objects and the camera motion. The results are the intersection between the motion objects and the camera motion. The figures 8 to 13 show the obtained results.



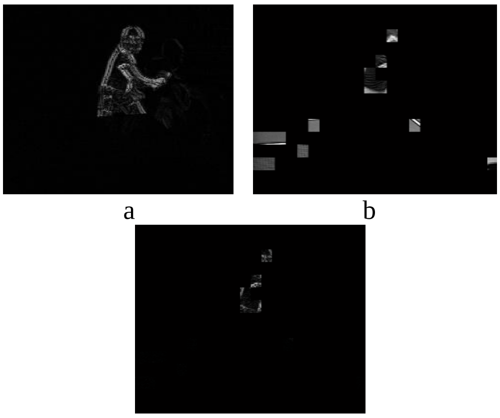
c

Fig.8 Objects and camera motion detection of frame number 6 of Flowers video sequence: a) objects detection, b) camera motion detection, c) simultaneous objects and camera motion detection



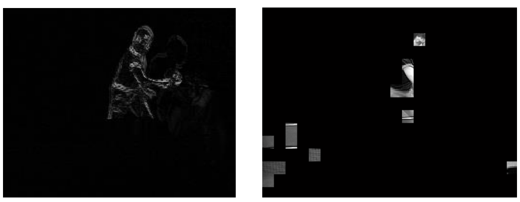
c

Fig.9 Objects and camera motion detection of frame number 8 of Flowers video sequence: a) objects detection, b) camera motion detection, c) simultaneous objects and camera motion detection

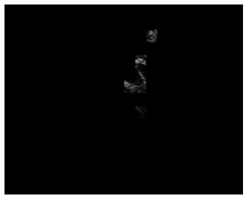


c

Fig.10 Objects and camera motion detection of frame number 139 of Tennis video sequence: a) objects detection, b) camera motion detection, c) simultaneous objects and camera motion detection

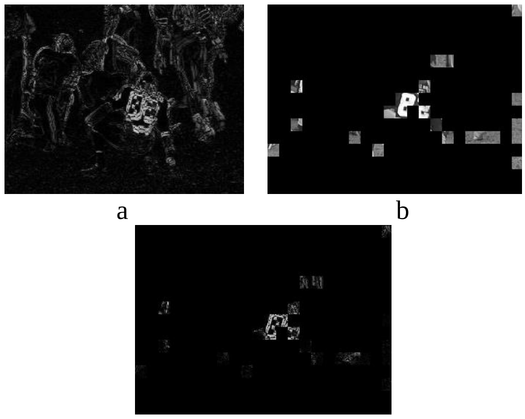


a b



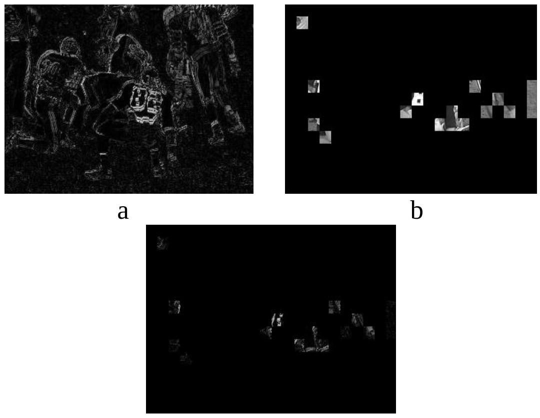
c

Fig.11 Objects and camera motion detection of frame number 143 of Tennis video sequence: a) objects detection, b) camera motion detection, c) simultaneous objects and camera motion detection



c

Fig.12 Objects and camera motion detection of frame number 91 of Football video sequence: a) objects detection, b) camera motion detection, c) simultaneous objects and camera motion detection



c

Fig.13 Objects and camera motion detection of frame number 94 of Football video sequence: a) objects detection, b) camera motion detection, c) simultaneous objects and camera motion detection

V. Objects Extraction

After detecting the camera motion and objects motion, we operate the objects extraction in video sequences. For this task, we have developed two algorithms, the one for object localization and the other for object extraction.

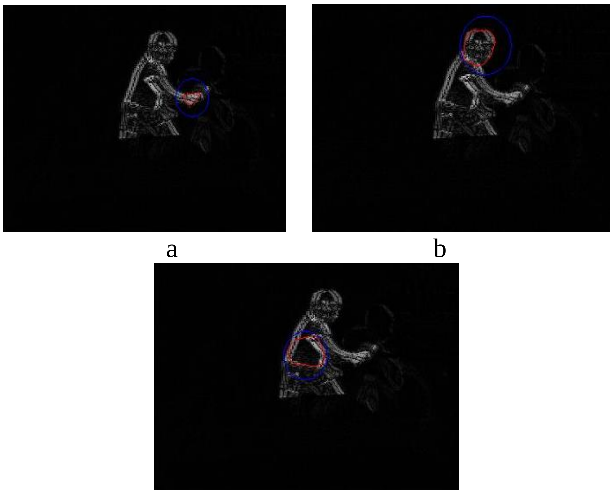
A. ALGORITHM OF OBJECT LOCALIZATION

For the localization of the objects, we use the active edge method. The algorithm of active method is shown below.

1. *Initialize the edge covering the object to extract*
2. *Define the parameters of the elasticity and rigidity of the model*

3. *Define the attraction force*
4. *Treat the iterations until obtaining convergence*
5. *Extract object using object extraction algorithm*

The figure 14 shows the results obtained for Tennis video sequence.



a b c

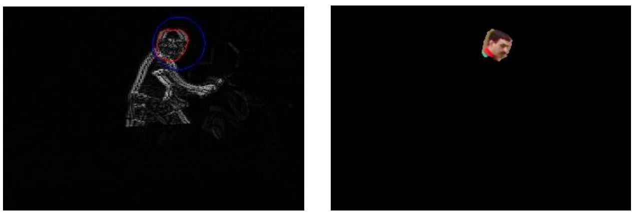
Fig.14 Objects localization in frame number 139 of Tennis video sequence: a) localization of the hand, b) localization of the head, c) localization of the body

B. ALGORITHM OF OBJECT EXTRACTION

The drawback of the method based on the active edge is the fact that it cannot allow obtaining all the points belonging to the edge. This method produces a curve containing some points of the edge but not all its points; so it is difficult to correctly extract an object with its active edge and the object extracted loses the regularity of its edge. So, we have proposed a new interpolation algorithm based on the number of row occurrence which allows us to look for the lost points (points not obtained by the active edge method) in *V* where *V* represents the characteristic vector of the active edge. So, this algorithm is shown below.

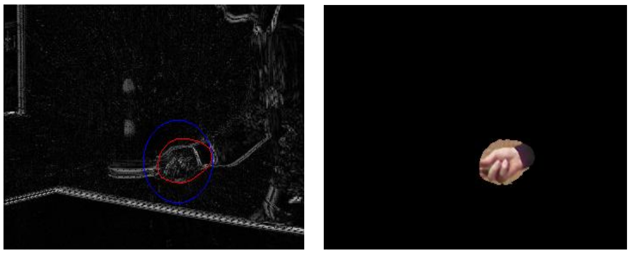
1. *Compare the rows for each couple of successive points* $V(2,i)$ *and* $V(2,i+1)$
2. *Add the lost points* (x,y), $x \in]V(2,i), V(2,i+1)[$, $y = V(1,i)$
3. *Calculate a number of the points of a given row*
4. *Add the lost points*
5. *Extract the object using the updated characteristic vector.*

The figures 15 to 17 present the results of extracted objects for Tennis and Football video sequences.



a b

Fig.15 Objects extraction in frame number 139 of Tennis video sequence: a) localization of the head, b) extraction of the head



a b

Fig.16 Objects extraction in frame number 39 of Tennis video sequence: a) localization of the hand, b) extraction of the hand

a b

Fig.17 Objects extraction in frame number 2 of Football video sequence: a) localization of the head, b) extraction of the head

VI. CONCLUSION AND PERSPECTIVES

We have in this work presented our contribution in object detection and extraction in video sequences.

In the first time, we have used the pixel differences by considering three successive frames. We have defined a threshold allowing the localization of the moving areas. The obtained compensated frame called ΔI is analyzed by a geometric transformation which simulates the optimal vision angle. This analysis allows observing the maximum of moving points.

In the second time, we have operated the detection of the camera motion. We have estimated the initial motion vector of the affine model of the camera motion; this vector is updated by taking in consideration the dynamic of the movement and an algorithm is proposed for this purpose. We have then evaluated the proposed algorithm on some standard video sequences. The results obtained allow observing the movement of the objects in the video sequences and the movement of the camera.

In the third time, we have used the active edge method to extract the objects. In fact, the active edge method produces a curve containing some points of the edge but not all its points and it is difficult to correctly extract an object with its active edge. To resolve this difficulty, we have proposed a new interpolation algorithm based on the number of row occurrence which allows us to look for the lost points. Applied to some standard video sequences, some objects are correctly extracted showing the performance our method.

In perspectives, we think that it is possible to outperform our contribution by using the panoramic model which consists to characterize once all static objects in video sequences captured with a mobile camera. The static objects being already characterized, we can optimally analyze the moving objects in the video sequences.

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Raida Charfi received her Master degree in Automatic and Signal Processing at the National High School of Engineers of Tunis, University of Tunis El Manar, Tunisia in 2008. She is a Teacher in the secondary school in Tunisia. He has begun the PhD thesis at the same university. Her research interest includes Signal Processing and Image analysis.

Dr. Mbainaibeye Jérôme have received the Master degree in Signal Processing and the PhD degree in Electrical engineering at the National High School of Engineers of Tunis, Tunisia, University of Tunis El Manar in October 1997 and July 2002 respectively. He was an Assistant Professor in the department of Computer Science at the Faculty of Sciences of Bizerte, Tunisia from 2002 to 2007. From May 20 to June 20, 2003, he was a scientific visitor at "ÉQUIPE SIGNAL et IMAGE of Ecole Nationale Supérieure d'Electronique, d'Informatique et de Radiocommunication de Bordeaux (E.N.S.E.I.R.B), University of Bordeaux I, France.

In 2008 he has joined the Faculty of Applied and Exact Sciences in the University of N'djamena, Chad, as an Assistant Professor in Electrical Engineering. Since April 2012, he has joined the Polytechnic High Institute of Mongo (Chad) as Director General. In February 14th, 2017, he has joined the University of Doba (Chad) as Rector. Since July 2014, he is an Associate Professor of Electrical Engineer. He is member of Signal, Image and Pattern Recognition Laboratory of the National High School of Engineers, Tunis, Tunisia and an associated researcher in XLM Signal, Images and Communication laboratory department, University of Poitiers, France. He has published several papers in scientific journals and in international conference proceedings and was a supervisor of many Master thesis and Engineer degree projects. Now, he is the co-supervisor of three PhD thesis projects. His research activities include Digital Signal Processing, Image Processing, Image Analysis, Image and Video Compression, Wavelet Transform and its applications.