Tracking of Video Objects Based on Kalman Filter

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Abstract

Object tracking is an important task within the field of computer vision. Where, it is the process of segmenting an object of interest from a video scene and keeping track of its motion, orientation occlusion to extract useful information. This paper is intended to the improve the measurement accuracy of the closing moving object by using the median filter for denoising and Kalman filter for tracking. At the denoising stage, 70-80% of the noise is reduced by using a median filter. The median filter has been used instead of the Wiener filter because the noise which is assumed is salt and pepper, and it is less complexity than the Wiener filter. While in the tracking stage, the KF has been used as estimated filter. However, the measurements have been improved by 11.27%. The simulation has been done by using Matlab 2014, while the proposal is applied to the real video.

Keywords: De-noising filter, median filter, Kalman filter, Object tracking

الخلاصة

تتبع الاجسام مطلب مهم مجال رؤية الكمبيوتر. حيث، هو عملية تجزئة الجسم من مشهد فيديو وابقاء التتبع لحركته، لاستخراج المعلومات المفيدة. وتهدف هذه الورقة إلى تحسين دقة القياس من للاجسام المتحركة المتقاربة باستخدام المرشح الوسيط للتصفية ومرشح كالمان للتتبع. في مرحلة إزالة الضوضاء، تم تقليل 70–80٪ من الضوضاء باستخدام مرشح وسيط. وقد استخدم المرشح الوسيط بدلا من مرشح وينر لأن الضوضاء المفترضة هي الملح والفلفل، وهو أقل تعقيدا من مرشح وينر. بينما في مرحلة التتبع، تم استخدام مرشح كالمان كمقدر (مخمن). ومع ذلك، تم تحسين القياسات بنسبة 11.27٪. وقد تم إجراء المحاكاة باستخدام ماتلاب 2014، في حين يتم تطبيق الاقتراح على الفيديو الحقيقي.

الكلمات المفتاحية: مرشح إزالة الضوضاء، مرشح الوسيط، مرشح كالمان، تتبع الاجسام.

1. Introduction

Object tracking is an important task within the field of computer vision (Abhijeet, 2014). It is the process of segmenting an object of interest from a video scene and keeping track of its motion, orientation occlusion to extract useful information (Shanmugapriya, 2013). The use of object tracking is pertinent in the tasks of motion-based recognition, human identification, automatic object detection, and traffic monitoring (Alper, 2006 ; Tang, 2009).

Object tracking is facing some difficulties due to; loss of information caused by projection of the 3D world on a 2D image, noise in images, complex object motion, non-rigid or articulated nature of objects, partial and full object occlusions, complex object shapes, scene illumination changes, and real - time processing requirements (Rupesh, 2008).

There are many object tracking algorithms; *point Tracking*, *kernel-based tracking* and *silhouette based tracking*, the *point tracking* is a tracking which can be formulated as the correspondence of detected objects represented by points across frames(Meha, 2015). In this context, this algorithm can be applied by using; *Kalman Filter*(Himani, 2014 ; Priyanka, 2015), *particle filtering*(Divyani, 2015), *and multiple hypothesis tracking (MHT*) (Joshan, 2012). While the *Kernel tracking* is based on object motion. Many methods can be used to satisfy this algorithm; these are; *simple template matching* (Himani, 2014;Joshan, 2012), *mean shift method* (Joshan, 2013), *support vector machine (SVM)*and *layering based tracking* (Divyani, 2015). While, *the Silhouette tracking* (Meha, 2015) is used when the entire region of an object is required. There are mainly two categories of *silhouette tracking* namely contour tracking (Joshan, 2013) and shape matching (Himani, 2014).

Many surveys on video tracking have been performed, some of these are; (Robert, 2003)develops a smart video system to track pedestrians and detect situations where people might be in peril.(Priyanka, 2015)Proposed a technique to detect the motion vector of an object in a video scene at the run time or real time.(Hemangi, 2015) used an image processing technology for detection and tracking of moving the object.(Habibu, 2013)presented a vehicle classification method which based on both the vehicle’s geometric and the appearance features. Background subtraction and Kalman filter algorithm are used to detect and track individual vehicles throughout the detection zone.(Siddhartha,2015)presented a vehicle detection, tracking, classification with the appearance of shadow and partial occlusion. (Sagar, 2016)proposed a static webcam to capture the live scene to store the database of segmented videos. The object detection and tracking are jointly employed by using mean shift, and particle filters have been presented.(Cai, 1996) presented a framework for tracking human motion in an indoor environment from sequences of monocular grayscale images obtained from multiple fixed cameras.(Andres, 2013) presented an algorithm for automatic video object tracking based on a process of subtraction of successive frames. (Tang, 2009) proposed a method to track the objects consistently in a real-time application.(Ahmed, 2012) discussed the problem of the multi-target tracking in a camera network.(Abdul-Lateef, 2014)presented a real-time multiple human target tracker based on combined features; histogram of oriented gradient and Haar features for the human detection and utilized the Kalman Filtering applied on the parallel Architecture, GPU to perform multiple target tracking.(Pravin, 2015), presented the moving object tracking using the Kalman filter and the reference of Background elimination. (Ankita, 2015) proposed a methodology that combines Kalman filter & TCM to find a threshold value of the background subtraction. (Sadu, 2015)proposed a system for tracking a target in video streams. This system has varied Stauffer‟ s adaptive algorithm along with Spacio-tempor learning parameters and a feedback path comprising of Kalman tracker.(Amir, 2011)described a method, for tracking multiple objects. When the number of the object is unknown and varies. The Kalman filter, color feature, and distance have been used for tracking algorithm.

2. Noise and Filters

The Noise is represented as an unwanted information within digital images. The source of that noise is unrealistic edges, corners, invisible lines and blurred objects. Its effect on the digital image has appeared on the pixel values, and will show rather various intensity values. The noise occurs in the image during image transmission or image acquisition (Ajay, 2015). Many types of noise have been present in the region of interest; these are; *Salt and Pepper Noise, Black and white dots* and *Gaussian noise*. Figure (1-b) represents the effect of appending *Salt and Pepper* noise, to the original image in Figure (1-a), with noise variance 0.008. While Figure (1-c) represents the effect of using a median filter for the reduction of that noise effect.

a) Original Image b) Image with Noise c) Output Image of Median Filter

Figure 1: Treatment of the *Salt and Pepper* noise by using a median filter.

The noise represents the challenge in the image processing in addition to the required processing. Therefore, in the present work, the treatments of this noise is made by using Median Filter. The treatment is done according to the equation (1) (Khalil, 2013);

$$Y(t) = median\ (x\left(t-\frac{t}{2}\right), x(t-T+1), \ldots, x\left(t+\frac{t}{2}\right)) \qquad (1)$$

where; t- the size of the window of the median filter. The output of this treatment is shown in Figure (1-c).

Therefore, the segmentation process has been made to make the scene contains the only moving objects. The segmentation has been made by background subtraction, which represents one of the active or efficient methods of segmentation. Then, the foreground blobs are the segmentation results, and the blobs are a collection of connected pixels (Divyani, 2015).

After that, the segmentation has been made, and then, the size and center are extracted for the moving object. In this context, an object becomes ready to be tracked by using Kalman filter. In effect, the Kalman filter is essentially a set of mathematical equations that implement a predictor-corrector type estimator which is optimal in the sense that it minimizes the estimated error covariance-when some presumed conditions are met(Nikita and Rohit, 2016). The time update equations are given as(Hitesh, 2013**);**

$$\hat{X}_k^- = A\hat{X}_{k-1} + BU_k \qquad (2)$$

$$P_k^- = AP_{k-1}A^T + Q \qquad (3)$$

Where; A - state matrix,

B - coverts control input

Q - process noise covariance.

The measurement update equations are given as

$$K_k = P_k^- H^T (HP_k^- H^T + R)^{-1} \qquad (4)$$

$$\hat{X}_k = \hat{X}_k^- + K_k (Z_k - H\hat{X}_k^-) \qquad (5)$$

$$P_k = (1 - K_k H)P_k^- \qquad (6)$$

where; K_k - Kalman gain

P - prediction error covariance.

R - measurement error covariance and

H - model matrices.

3. Proposed Work

Matching and motion estimation, represent the significant problems in the tracking system. The matching estimation will be our future work. The motion estimation problem involves the prediction of the required object in the next video frame. Kalman filter represents the optimal recursive estimator, which is used in this paper to resolve the motion estimation problem. Therefore, the proposed work improves to the (Zaki, 2015)work as it is shown in Figure 2. The present work has been treatment the noise and the closing between the moving objects by adding the median and Kalman filters as it is shown in Figure (3).

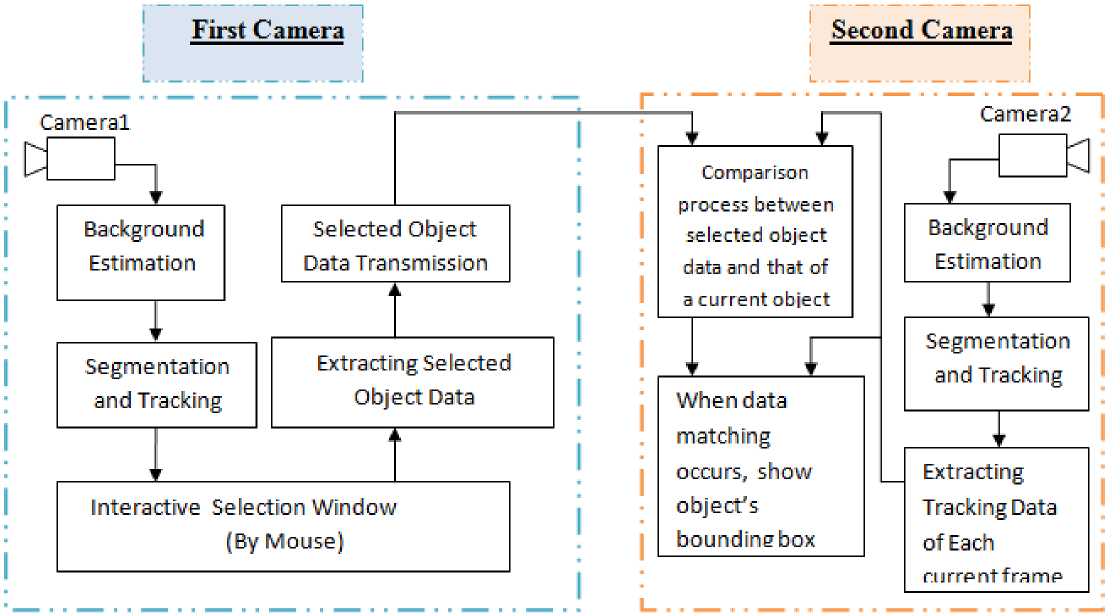


Figure (2) Block Diagram of the (Zaki, 2015)Work

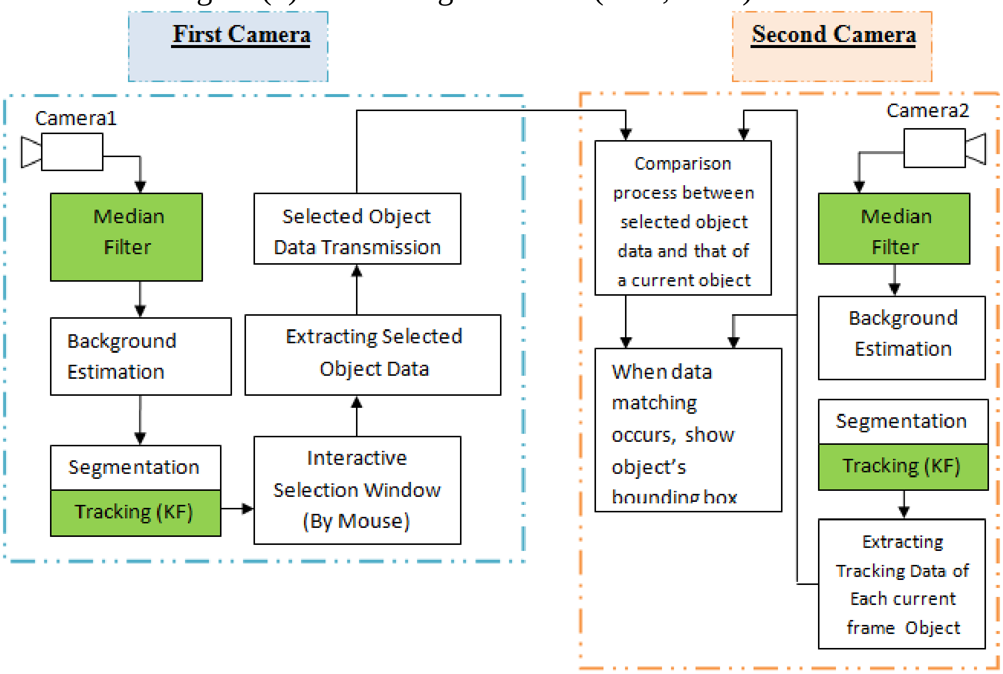


Figure: 3 Proposed Work Block Diagram(Additional Green Blocks)

4. Results and Discussions.

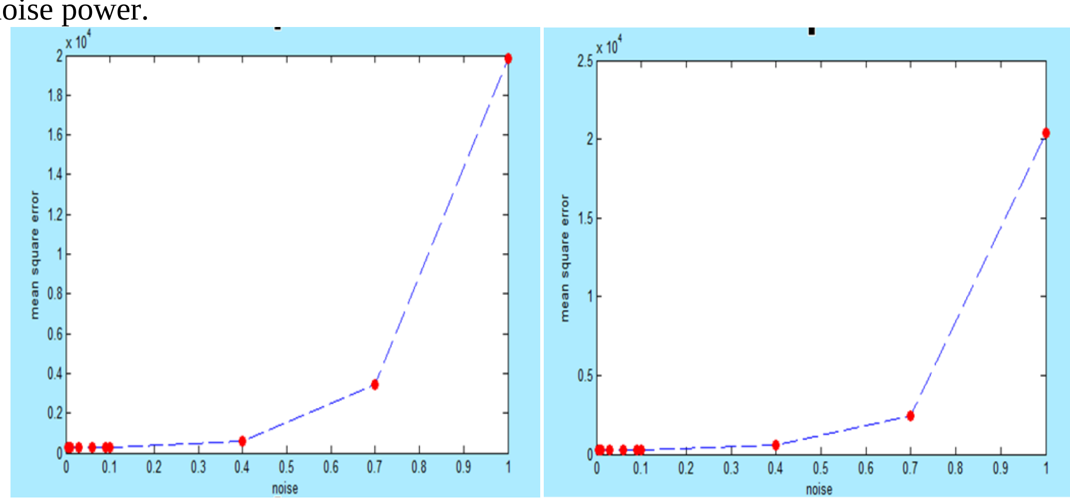
Median Filter Stage:

The work in the real environment has been associated with real environmental effects (noise). The noise reduction is beneficial to enhance the image processing. Therefore, for reducing the effect of noise, many types of filter can be used. In this work, a Wiener, median, average and Gaussian filters have been tested. As it can be seen, the Wiener and Median filters show overperformance as compared to the other types of the filter as it shown in the Table (1).

Table (1) Test of Different Types of Filters

Noise/image	**0, 0.004, 0.008, 0.01, 0.03, 0.06, 0.09, 0.1, 0.4, 0.7, 1.0**	
Types of Filters	**Average of MSE**	**Average of PSNR**
One of Average	1174.943	19.434
Two of Average	1200.992	18.845
One of Gaussian	5035.778	16.714
Two of Gaussian	1168.796	19.127
One of Median	2592.456	20.352
Two of Median	2532.765	20.525
One of Wiener	1092.312	21.348
Two of Wiener	1021.033	21.451
Gaussian and Wiener	1107.273	19.688
Median and Wiener	1509.019	20.719
Average and Wiener	1124.813	19.414
Median and Gaussian	1515.783	20

In brief, the Wiener is slightly better than median, when the noise type is Gaussian. While, the performance of the median filter after de- noising for salt & pepper noise is better than that of the Wiener filter, and it is less complex in implementation than the Wiener filter. Therefore, the median filter is used as the first stage in the image de-noising processing in single and cascaded form to satisfy the noise reduction requirement. Figure (4) shows the median filter behavior against the noise power.



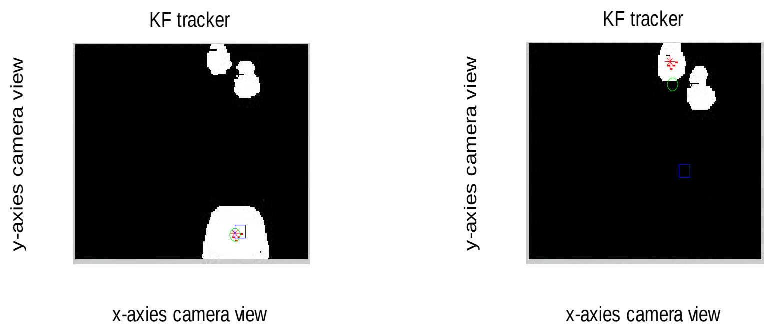
(a) **(b)**

Figure: 4 Effect of Noise with Median Filter, a)Single Filter b) Two Cascaded Filter.

Figure(4) above shows the improvement in the noise environment by 70% for single filter and 80% for cascaded filters with respect to the(Zaki, 2015), where the comparison is made by calculating the reduction of noise at the same noise to signal power ratio. This reduction in noise is caused by using a median filter.This type of filter eliminates the noise in the edge of the image by taking the median of the pixels which surround it.

Kalman Filter Stage:

Object tracking algorithm based on tracking the selected parameters, center location and circular size of the object because these parameters are related to the object motion. Two cases appeared in the scene single object and multi-object. In these two cases many problems appeared in the tracking operation; these are: closer and cross-over object problems as it is shown in Figure (5).



Figure(5) Closer Object Problem

Figure (7) represents the status of the single object tracking. Where the red star represents the object center location in the image, while blue box represents the measurement of that center, and the green circle represents the estimation of the center location by using Kalman filter(KF). The image center location of the object, measurement and estimation of that center location has been shown in figure (6). This figure clarifies the over-performance of the KF. The measurements of the location have been estimated by using KF. In this context, the accuracy of this estimation process depends on the motion object modeling. This modeling is represented by the variance in KF operation.

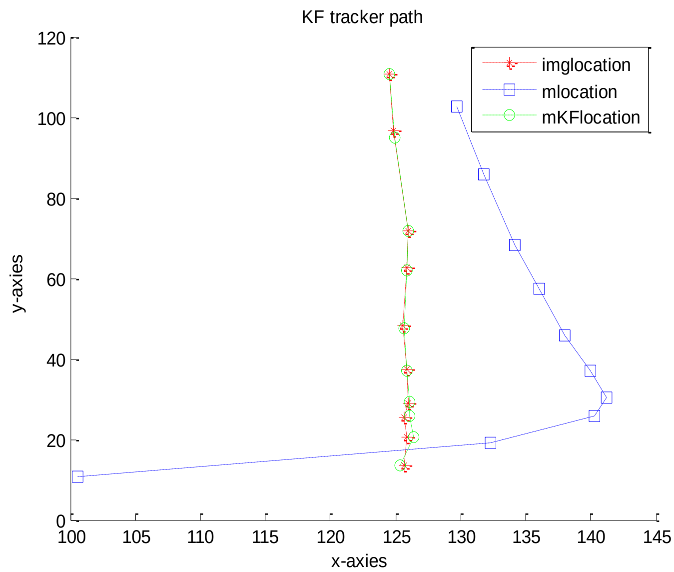
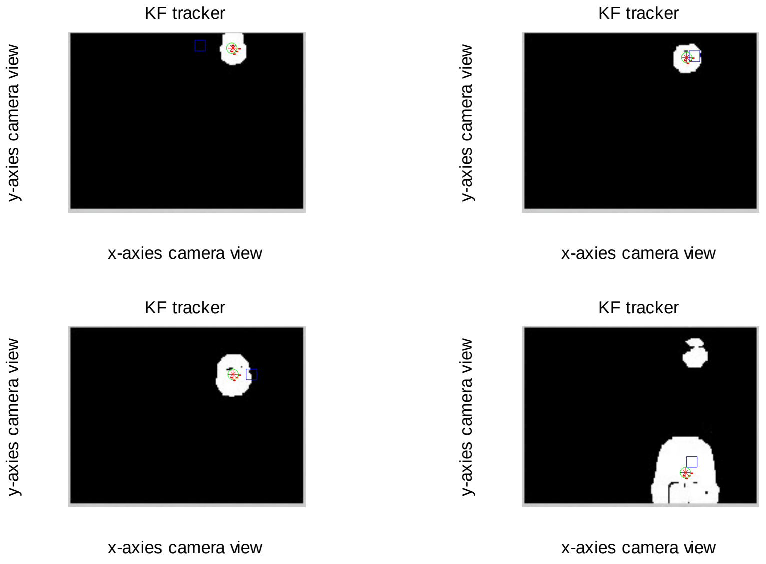


Figure (6) Single Object Path Tracking

Figure (7) represents the tracking operation of single object in the scene, with long distance and with another object.



Figure(7) Single Object Tracking

The more complicated cases occur when other object appeared on the scene before the first one exit from the scene. This case contains two scenarios: the first one happens when two object have been appeared closely in the scene. The second scenario happens when the first object becomes near the end of the scene, while, the second object enters to the scene. In the first scenario, the measurements are confused, while the tracker tracked the nearest object until the latter exit from the scene. In this context, for the second scenario, the tracker tracked the second object at the time when the first object exit from the scene. The transition will cause an error in measurement and estimation, while the usage of the KF reduces this error to the noteworthy percent. Figure (8) shows this case, while figure (9) represent their trajectories.

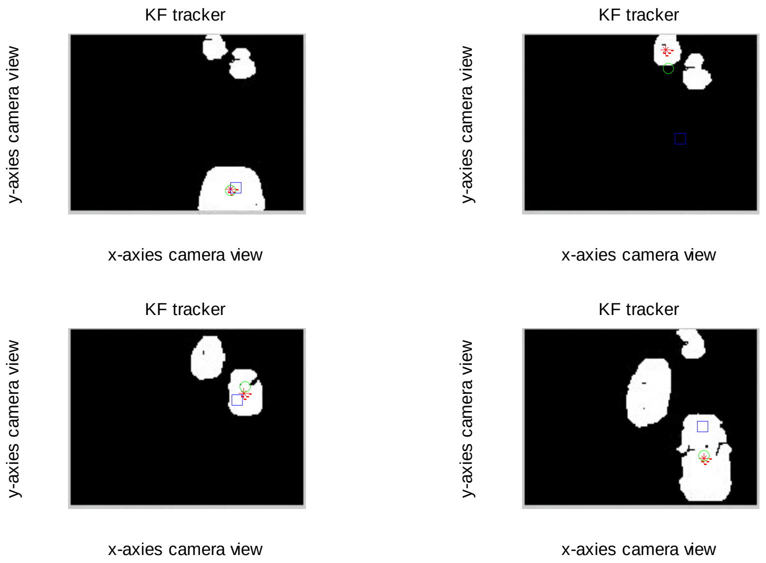


Figure (8) Multi-Object Tracking

This figure clarifies the reduction of the measurements error. Where the red line is the truth path, while the blue and green lines represent the measurements and the tracker estmation respectively.

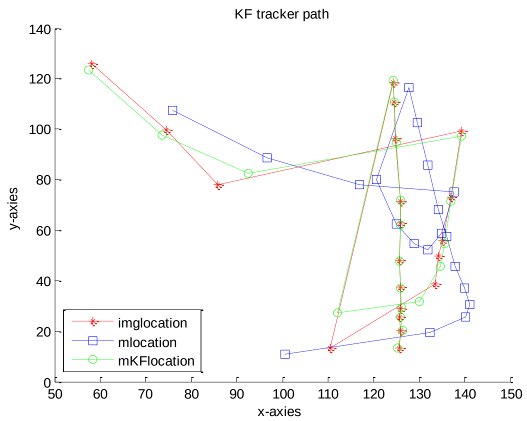
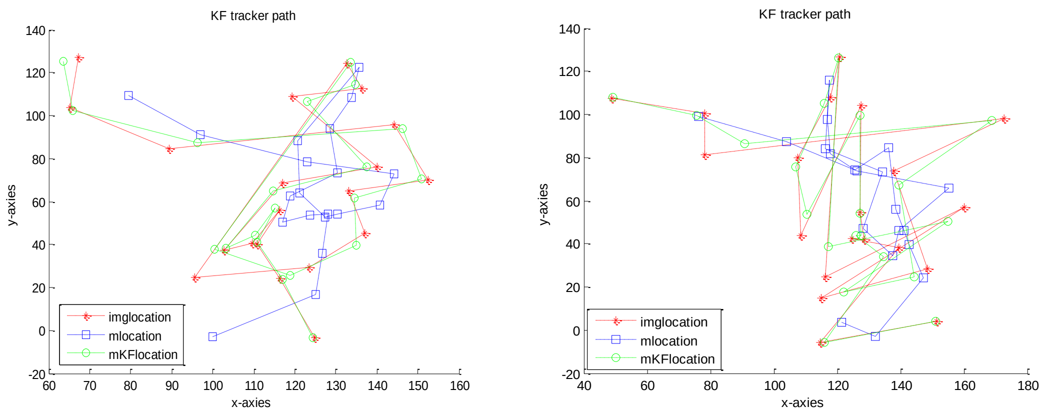


Figure (9) Multi-Object Path Tracking

Figure (10) represents this case with different noise density. Where, the effect of the noise on measurement is clear in figure (10a,b) and, furthermore, the improvement of the center measurement when using KF filter is also clear.



(a) (b)

Figure (10) Multi-Object Path Tracking with Noise

To assist the accuracy of tracking another parameter, the circular size of the moving object, has been tracked. This parameter is important to identify the object in the next camera because the size is related to the motion and the change of the size is related to the object speed. Figure (11) shows the behavior of the tracker filter with the mobile moveale object and with the muti-object appering at the same time in the scene. The tracker will track the fast object and then the next and so on until the required object appears.

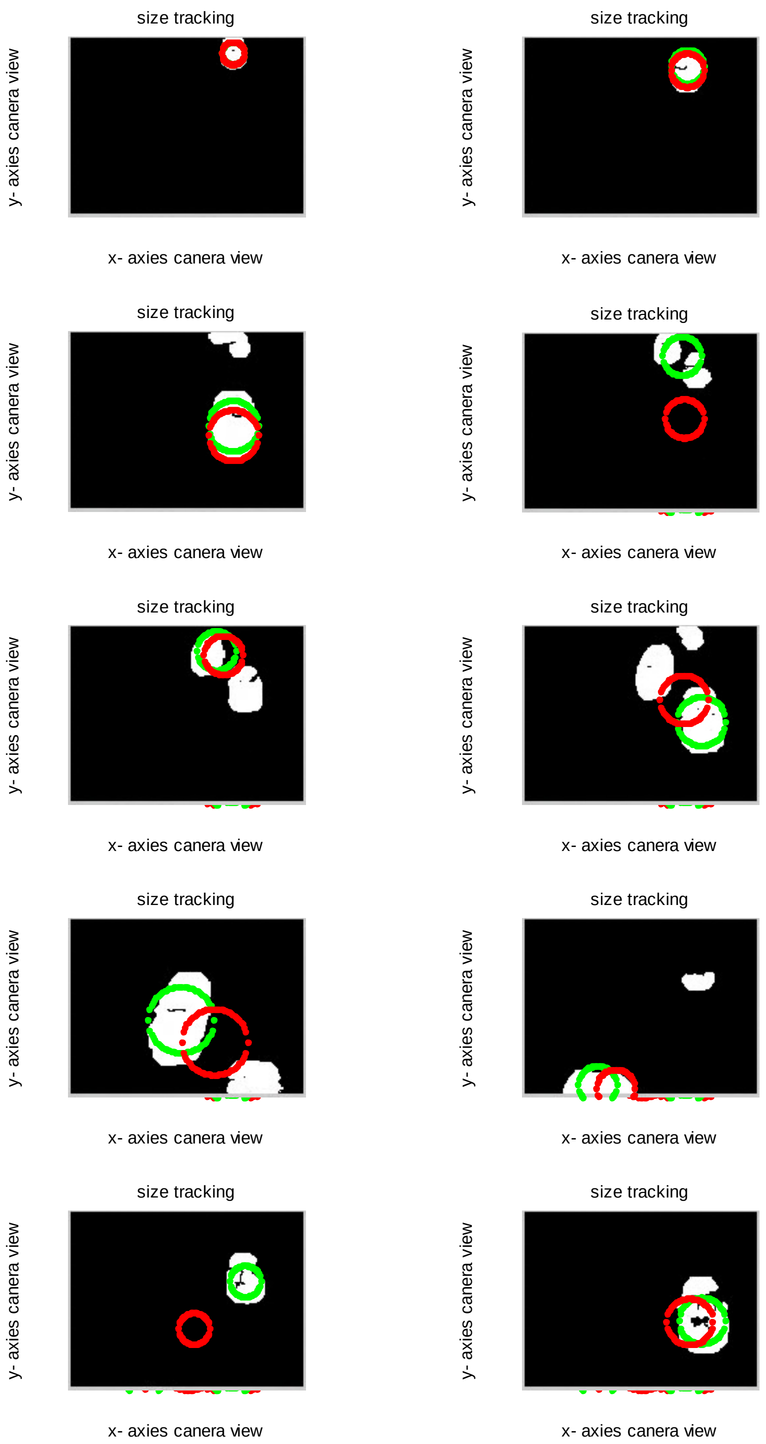


Figure (11) Size Object Tracking

The Kalman filter gain and the covariance error matrix are shown in figure (12), where, at these matrices the KF gives the improvement by 11,27%. This result has been obtained by comparing the measured and estimated values on the truth values by calculating the average error.

```
K =                      P =

    0.4750   -0.0035     0.1351    0.0020    0.0386    0.0005
   -0.0035    0.6624     0.0020    0.0301    0.0005    0.0124
    0.1359   -0.0026     0.0386    0.0005    0.0350    0.0002
   -0.0026    0.2726     0.0005    0.0124    0.0002    0.0243
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Figure (12) Gain and the Covariance error matrix of KF

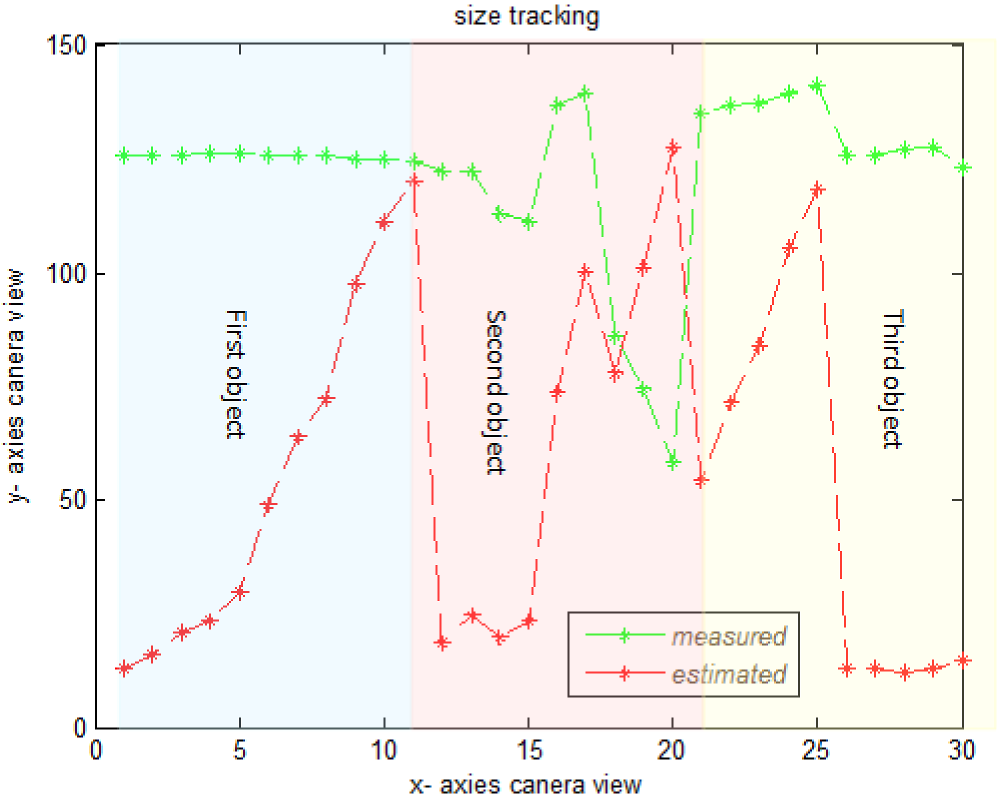

Figure (13) Size Tracker Response with X-Y Location of Successive Objects

Figure(13) represented the tracker estimation of the object size with its location (x,y) for three objects. From this figure, it is clear that each objet take nearly 10 frame, and the manifest error is caused by the transition from the end of the scene to beginning of it.

5. Conclusion

This work is represented as an extended and an improve of the [Zaki, 2015] work in denoising and tracking filters. At the denoising stage, 70-80% of the noise is reduced by using a median filter. The median filter has been used instead of the Wiener filter because the noise which is assumed is salt and pepper, and it is less complex than the Wiener filter. While in the tracking stage, the KF has been used as an estimated filter. However, the measurements have been improved by 11,27%.

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