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Bionics-Based Approach for Object Tracking to Implement in Robot Applications

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Abstract

In this paper, an approach for object tracking that is inspired from human oculomotor system is proposed and verified experimentally. The developed approach divided into two phases, fast tracking or saccadic phase and smooth pursuit phase. In the first phase, the field of the view is segmented into four regions that are analogue to retinal periphery in the oculomotor system. When the object of interest is entering these regions, the developed vision system responds by changing the values of the pan and tilt angles to allow the object lies in the fovea area and then the second phase will activate. A fuzzy logic method is implemented in the saccadic phase as an intelligent decision maker to select the values of the pan and tilt angle based on suggested logical rules. In smooth pursuit phase, the object is kept in the center area of the field of the view by smooth adjusting the values of the pan and tilt angles where this stage is analogue to putting the observing object in the fovea centralis of the oculomotor system. The proposed approach was implemented by using (Camera-Pan / Tilt) configuration and showed good results to improve the vision capability of the humanoid robots.

Keywords: *Tracking, bionics, and fuzzy decision maker.*

1. Introduction

Human vision systems have an appropriate ability to interpret nature scenes in real time, despite the limited speed of the biological architecture available for such tasks. The cerebral control system that directs the eye toward an object for viewing is as significant as the system that interprets the visual signals received from the eye. In the same way as the cerebral control system, the most important role of the active vision system is to direct an artificial visual receptor, such as a CCD camera toward an interesting target object in the visual field as in a human vision system [1]. This redirection is usually referred to as object tracking, where it is the problem of following image elements moving across a video sequence automatically. Object tracking is an essential building block for vision systems addressing robotic tasks like visual servoing, pipe and cable inspection, and metrology [2].

Many studies considered the object tracking problems. Some of the most recent and related papers to the present paper are reviewed. In [3], [4], [5], and [6] object tracking algorithms for mobile robot are developed, where [3] suggested a control technique that end-effecter of manipulator can chase an object using an image gained from a stereo camera installed in a robot platform. The adaptive color matching and Kalman filter were used in the proposed algorithm in [4]. In [5], the developed algorithm is based on sensor network, where the occlusion problem is assumed and solved. 3D-object tracker using a new Kalman-filter based framework that carries out fast and accurate rigid object tracking was introduced in [6].

The authors of [7] presented a grasp tracking method to be used in eye-in-hand robot configuration, where it consists of three stages, grasp synthesis, grasp transfer, and grasp analysis. An object tracking method based on image segmentation and rough set minimal rule set was presented in [8], where the rough set theory is used to control the camera pose. In [9], the problems of tracking human face using active camera that installed on 2-DOF (pan-tilt) platform was discussed, and the kinematics model between object in motion and image of the camera is achieved.

In [10],[11],and [12], fuzzy technique is adopted in the developed tracking algorithms, where the author of [10] applied fuzzy method in the CIElabcolor space to model target color in a target recentering task using an active camera. Fuzzy control system and adaptive Rao-Black partial filter to track object in 3D space were used in [11]. In [12], texture segmentation approach using both wavelet transform and fuzzy grammar as classifier was introduced.

The references [13] and [14] demonstrated multi-sensor fusion in object tracking algorithms, where in [13], the cooperation method of cameras for object tracking was introduced, while [14], presented the localization and object tracking problems using audiovisual measurements, where two microphones are used beside CCD camera to achieve target localization.

Bionics studies simulating the principles of biologic system principles to build advanced technology systems or enable the artificial technology systems have some characteristics or functions of biologic system [15]. In the following, some of the recent studies that simulating the biological oculomotor system to use in visual tracking applications will be presented.

Fortunato Flores Ando and Alfredo Weitzenfeld Ridel [16] introduced a model of the oculomotor system involved in the generation of saccadic and its implementation in a real robot used to keep track of visual input lost due to reorientation. Reference [17] presented a new method for visual scanning and target tracking by means of independent pan-tilt cameras, which mimic chameleon visual system. In [18], a discussion of how human eyes track an object by moving the optical axis is presented. Reference [15] introduced a visual tracking system for unmanned aerial vehicle (UAV) where the principle of biomimetic eye is used.

In this paper, an approach for object tracking based on bionics of human eye movements has been introduced and verified experimentally. The proposed tracking method is divided into two stages, saccade and pursuit stages. In the saccade stage, fast searching and tracking algorithm for the observing object is developed, where fuzzy technique is used as decision maker to predicate the proper pan and tilt angles that are needed to direct the camera platform to allow the tracked object to be within the field of camera view. In the second stage, pursuit-tracking algorithm is proposed where a smooth object tracking will occur.

The present paper layout is as follows: a description of the human oculomotor system is presented in section two. The proposed tracking approach is illustrated in section three. Experimental setup and results with their discussions are shown in sections four and five. Finally, conclusions are drawn in section six.

2. Human Oculomotor System

The ocular motor control system is an effective device for capturing an object in the central pits (fovea) of the retinas. Human eyes always move their optical axes to keep the image from leaving the central pit, i.e. eyeballs never let an image move freely over the retina. When the fovea of the retina catches a moving target, the oculomotor control system performs different kinds of eye movements according to the position and velocity of the target and head. These movements are produced by contractions of the extrinsic eye muscles, innervated by neurons originating in the brain [18],[19],[20]. Figure (1) shows the fovea centralis and the internal anatomy of the eyeball.

There are three types of eye movements coordinated by the brain [20]:

Saccade eye movements are very high velocity movements, 400 to 800 degree per second, of both eyes that target an image on the fovea centralis.

Smooth pursuit movements are slower (up to 30 degree per second), and match the speed of the moving objects to keep their images at or near the fovea.

Vergence movements (30 to 150 degree per second) cause the eyes to converge so that an image of an object is brought to the fovea of both eyes, allowing the object to be seen more clearly three-dimensionally.

The saccadic movements occurred when an object enters the filed of view, where the projected image of the object will be lied on the periphery area of the retina. This area contains a type of photoreceptors, which allowed the visual cortex to diagnose a non-accurate shape and position of the observing object. The brain will send impulse signals to the eye muscles to actuate the eyeball position to a new position allowing the projected image of the object laying on the fovea, which is a pit in the retina containing a rich amount of cones photoreceptors that can give a clear view and accurate location of the seen objects.

When the image of object is projected on fovea, a smooth pursuit movement will take place. This movement is coordinated by the brain when the eyes track a moving target smoothly.

The developed tracking approach used both saccadic and smooth pursuit principles to achieve object-tracking process. The vergence movements will not considered in this research because a monocular vision system is assumed.

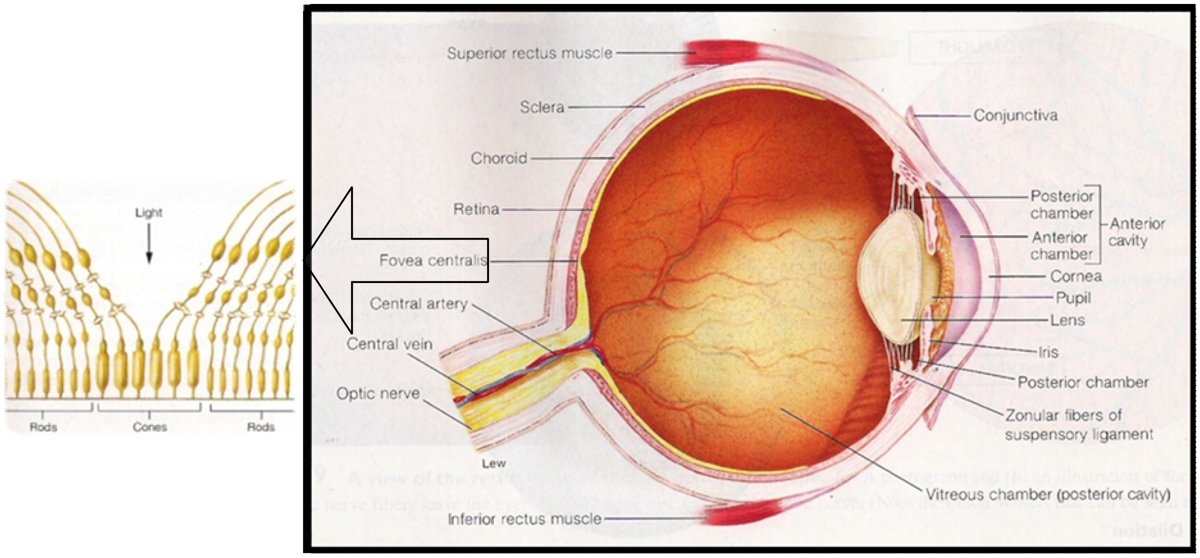


Fig.1. The internal Anatomy of the Eyeball [20].

3. Tracking Approach

In this section, an overview of the developed approach will be presented.

The tracking approach assumed a monocular active camera, which is installed on pan/tilt platform. This structure refers to artificial eyeball, where the acquired images from the active camera will process through artificial central processing unit it gives the proper decisions to pan/tilt platform form of angle values and then the platform motors will be actuated based on these values. The process of acquiring and manipulation of the images and giving the instructions to the platform is referred to as visual feedback and it is used widely in the applications of robot tracking.

Two stages of the tracking method is assumed, fast or saccadic and smooth pursuit. Since the human oculomotor system reflects the object image in tracking task on the retina into two regions, periphery and fovea, image plane will be divided into two regions also, periphery and fovea regions, where fast tracking will occur in the periphery region and the smooth tracking will take place at the fovea region. In the saccadic stage, a developed searching algorithm will be applied on the saccadic region to check if the object entered the field of the view. If so, a developed fuzzy decision maker will select the pan and tilt angle values to redirect the artificial eye system in order to put the object within the fovea region. If the object enters the fovea region, the second stage of the tracking approach will be activated. In this stage, the tracked object will be kept in the fovea region by adjusting the pan and tilt angle values of the platform, where a search algorithm based on object centroid is used. Figure (2) presents a block diagram of the developed approach. In the following subsections, complete descriptions of saccadic phase, the used fuzzy technique, and smooth pursuit phase will be illustrated.

3.1. Saccadic Phase

In human oculomotor system, saccadic is small jerking movements that rapidly bring eye from one fixation point to another and allow search of the visual field [21]. During a saccade, the oculomotor system operates in an open-loop mode because the information from the retina and muscle proprioceptors is not transmitted quickly enough during the eye movement for use in altering the control signal [22]. For that, open-loop mode will be considered in the saccadic phase of the tracking approach.

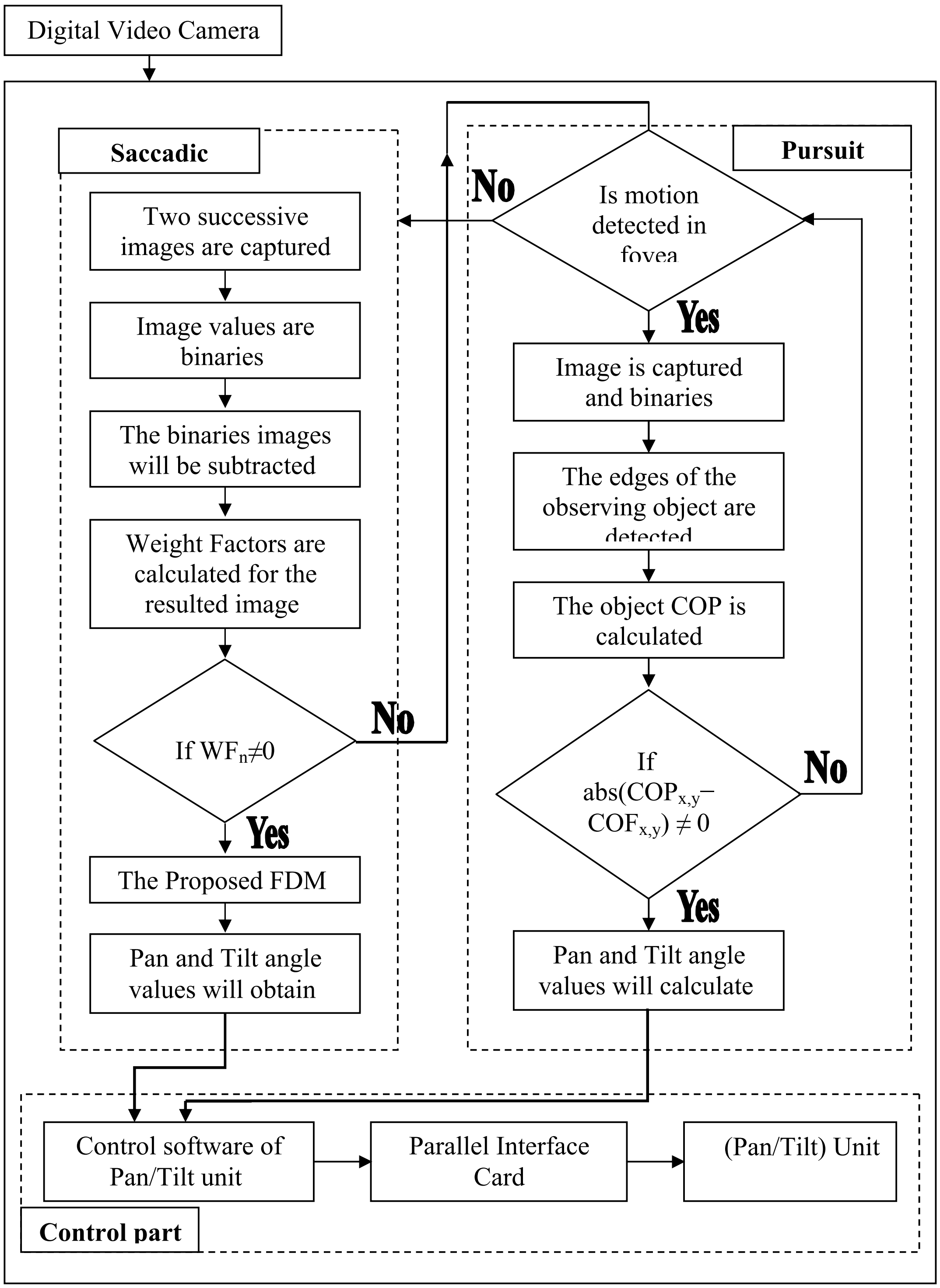


Fig.2. The Proposed Approach for Object Tracking.

The image plane, artificial retina, is divided into two regions, saccadic and fovea, where at saccadic region the saccadic tracking phase will be applied, while the smooth pursuit-tracking phase will occur in the fovea region. Figure (3) presents the proposed divisions of the image plane, where the saccadic region is divided into four zones. These zones are analogue to the periphery area of retina. Weight factor will be introduced at each zone to give an indication about the amount of the object that is entered in each zone. This weight factor can mathematically be presented as the ratio of the summation of the white pixels, object pixels, in each zone to the total number of pixels in the zone. Equation (1) presents this relation:

$$WF_n = \frac{\sum I(x_z, y_z)}{Z_n} \qquad \ldots(1)$$

where: $I(x_z, y_z)$ is the pixel value at each zone and the subscript (n) refer to zone number.
Z is the total number of pixels at each zone.

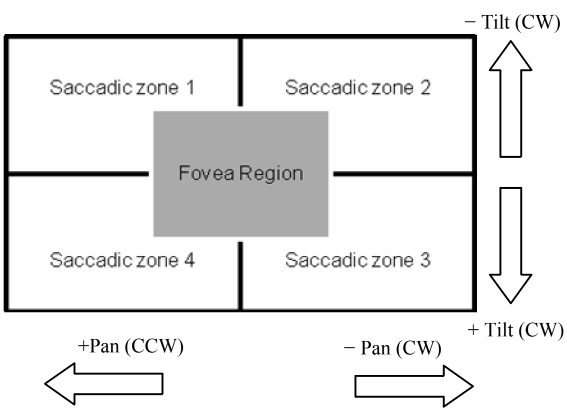


Fig.3. The Proposed Divisions of Image Plane.

The weight factor may have any value between 0 to 1, where zero value means no object entered the zone, while one value points to the object that entered the whole zone.

Interference between object and background pixels may occur. To minimize the effect of the interference, a subtraction process between successive frames will be adopted and the gained image will be used to calculate the weight factors. This process can be expressed as follow:

$$I(x,y) = I^{'}(x,y) - I^{''}(x,y) \qquad \ldots(2)$$

where the super scribe presents the image function after a certain period.

The weight factors for the saccadic zones will be used to give the proper pan and tilt angle values that are used to drive the camera platform to a new location. The selection of the pan and tilt angle is based on logical statements, where table (1) shows the required logical values of pan and tilt when the object enters saccadic zones individually. To clarify this, assume the weight factor of the first zone indicates a value, so, to redirect the camera platform to allow the object to be in the fovea region, positive pan and negative tilt angle values are needed. The amounts of these values depend on the weight factor value, where a large weight factor means a large increase in angles value.

Table 1,
The Required Logical Values of Pan and Tilt when the observing Object Enters the Saccadic Zones Individually.

Weight Factor	Weight factor value	Pan value	Tilt value
WF_1	Nil	Nil	Nil
	0.25	Positive small	Negative small
	0.5	Positive middle	Negative middle
	0.75	Positive large	Negative large
WF_2	Nil	Nil	Nil
	0.25	Negative small	Negative small
	0.5	Negative middle	Negative middle
	0.75	Negative large	Negative large
WF_3	Nil	Nil	Nil
	0.25	Negative small	Positive small
	0.5	Negative middle	Positive middle
	0.75	Negative large	Positive large
WF_4	Nil	Nil	Nil
	0.25	Positive small	Positive small
	0.5	Positive middle	Positive middle
	0.75	Positive large	Positive large

When two weight factors have values; i.e. the object enters two zones; new logical statements are needed to be added. If three weight factors indicate certain values, zoom out is required because the object is large. However, this case is limited because the large object will lie on the fovea region; therefore, there is no need to the saccadic phase.

Since, the selection of the pan and tilt angle values needs a combination between two or more of the logical statements when the object enters more than one zone, fuzzy logic will be used as a decision maker to select the proper pan and tilt values.

3.2. Fuzzy-based Decision Making (FDM)

The FDM was used to choose the pan and tilt angle values based on the weight factors of the saccadic zones. Figure (4) shows a block diagram of the FDM, where four linguistic variables (LVs) were used as input to the FDM and two (LVs) were used as output. The input (LVs) are the weight factors and the output (LVs) are Pan and Tilt angles. Both input and output (LVs) used five different fuzzy sets for each input and output. These sets are Out, In Small, In Middle, In Large, and In for the input (LVs) and Negative Large (NegL), Negative Small (NegS), Zero, Positive Small (PosS), and Positive Large (PosL) for the output (LVs). In figure (5), the membership functions of the input and output (LVs) are illustrated, where triangular shape was adopted to present the membership function. The developed rule base consists of 81 rules, where table (2) shows sparse rules of the developed rules. The singleton technique was used for fuzzification and the adopted fuzzy inference method is Mamdain's, while the defuzzification is the center of gravity method.

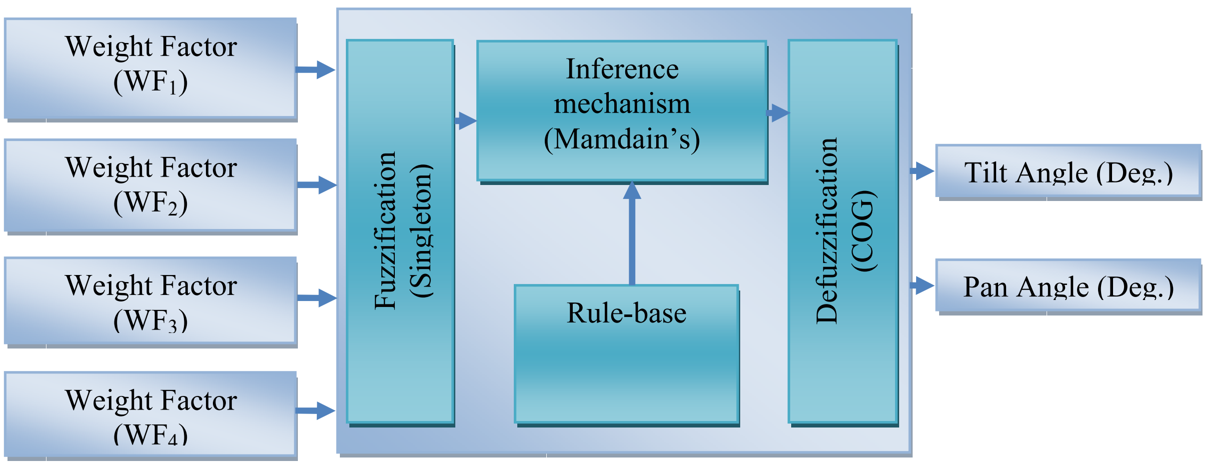


Fig.4. Block Diagram of the FDM.

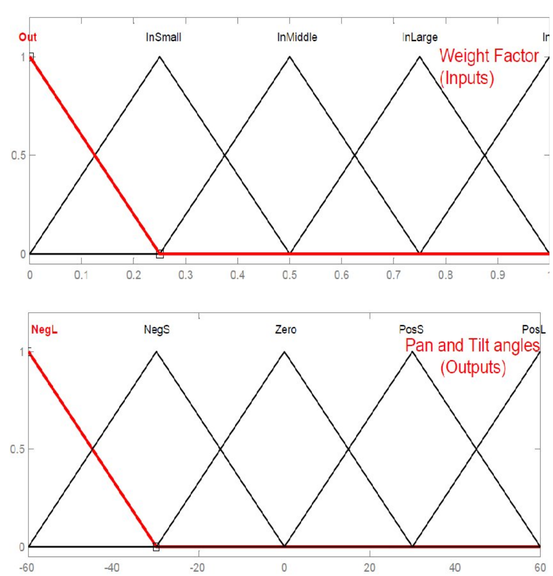


Fig.5. The Proposed Membership Functions of the Input and Output Linguistic Variables.

Table 2,
Sparse Rules of the Developed FDM.

Input of FDM				Output of FDM	
WF_1	**WF_2**	**WF_3**	**WF_4**	**Pan**	**Tilt**
In Middle	Nil	Nil	Nil	PosS	NegS
In Small	In Middle	Nil	Nil	NegS	NegS
Nil	In Small	In Large	Nil	NegS	PosS
Nil	In Middle	In Middle	Nil	NegS	Nil
Nil	Nil	In	In Small	NegL	PosL
Nil	Nil	In Large	In Middle	NegS	PosS
In Large	Nil	Nil	In Large	PosL	Nil
In	Nil	Nil	In	PosL	Nil

3.3. Smooth Pursuit Phase

This phase will be activated when the object enters the fovea region, where fovea in human eyeball is a pit in retina that contains a dense amount of photoreceptors. The important task here is to keep the object in the fovea region otherwise saccadic phase will be reactivated. The developed algorithm for this phase is based on detecting the object edges and then locating the center of the perimeter (COP) of it. This process will be repeated for the next frame. The path between COP and the center of fovea region (COF) will give the orientation of the pan and tilt angles, where figure (6) presents the logical orientation of them based on determining the direction of the path between COP and COF. Since the orientations of the angles are obtained, the values of pan and tilt are needed to be determined, where these values depend on different parameters. The most significant parameters are the velocity and the acceleration of the object. In addition, the extrinsic parameters of camera, such as resolution and focal length, can play an important role in this phase. In terms of mathematics, the angles value can be expressed as follow:

$$angle = f(V_o, f_{cam}) \qquad \ldots(3)$$

where: V_o is the object velocity

f_{cam} is the camera extrinsic parameters.

Equation (3) is an empirical function and depends on the selection of camera specifications, boundary conditions of the fovea region, lighting conditions, image digitization, and environmental noise. However, in this paper fixed and controlled conditions will be assumed in this phase.

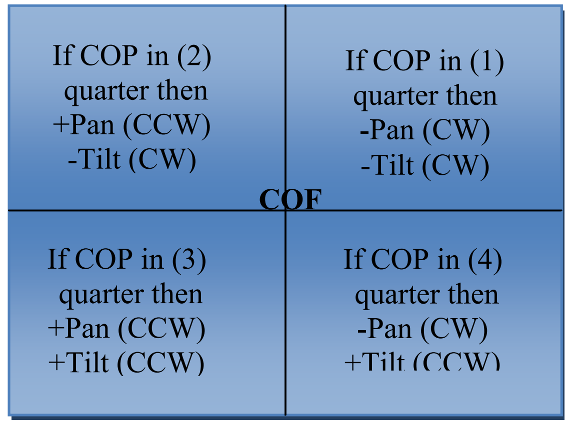


Fig.6. The Logical Orientation of the Pan and Tilt Angles in Fovea Region.

4. Experimental Setup

An experimental setup was developed to verify the proposed approach. It consists of Pan / Tilt unit type (Luntai - PTS 302), where it has two rotational joints, one perpendicular to the other in order to simulate the pan and tilt motions of a real eye. Digital video camera type (Panasonic NV-GS25) is used as an image acquiring device, where it is held on the pan/tilt unit and linked with PC computer using hi speed USB link. The images are digitized at 720×576 and the fovea region is selected as 240×192. Interface card between the pan/tilt unit and PC is built in order to control the pan/tilt unit via MATLAB environment. Figure (7) presents a photograph of the developed experimental setup.

5. Results and Discussions

In this section, the proposed method for object tracking is verified using the developed experimental setup. The algorithm of the tracking approach was written using (MATLAB-Ver. 7.3) environment. Each phase of the approach is verified separately. In the following subsections, the results and their discussions will be presented.

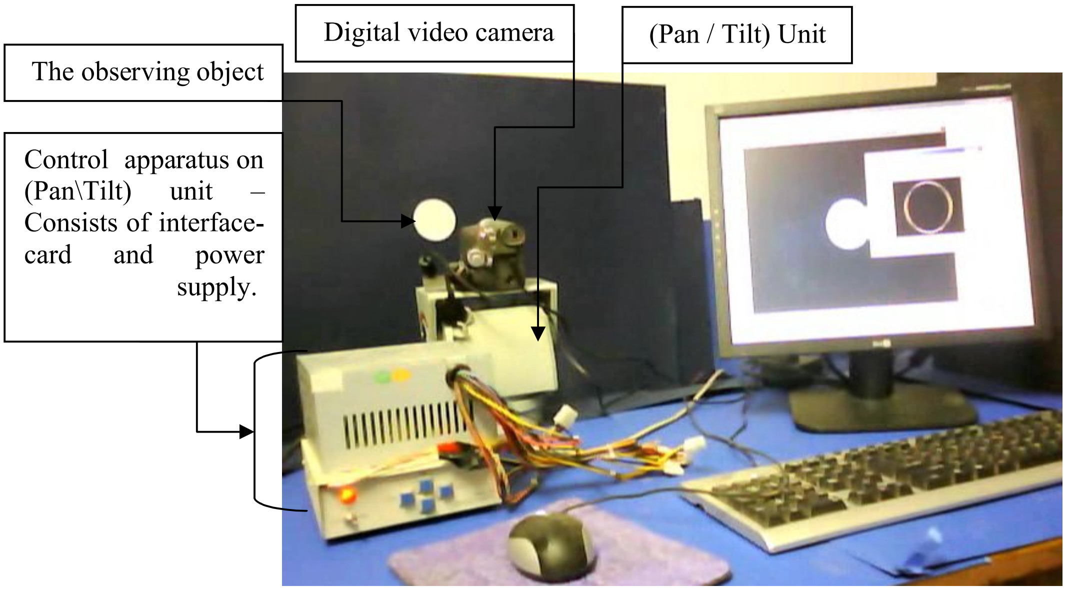


Fig.7. Photograph of the Developed Experimental Setup.

5.1. Saccadic Phase

Eight different cases are adopted to investigate this phase. In each case, part of the observing object is appeared in the image plane. Figure (8) shows the adopted cases. A circular plane object is used as the observing object where its diameter is 8 cm. To scrutinize the effect of object enlargement on the proposed approach, three different locations are used for the (Camera/(Pan-Tilt unit)) (CPT) configuration, where the distance between each location is 10 cm.

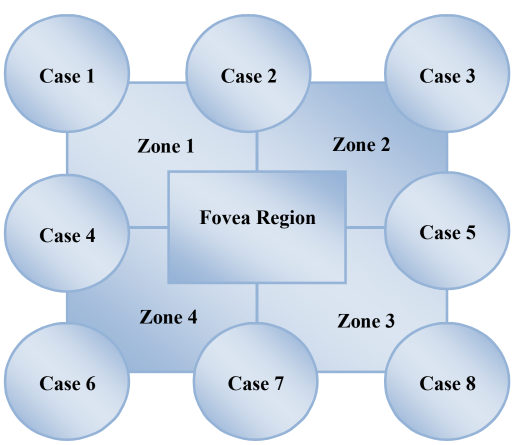
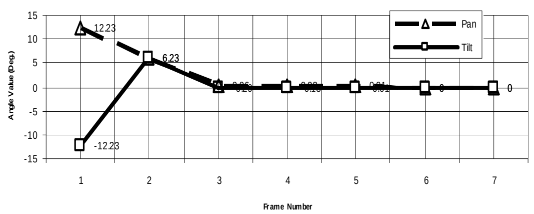


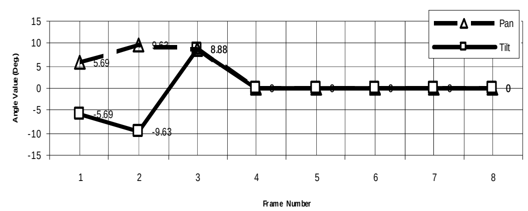
Fig.8. The selected Cases to Investigate Saccadic Phase.

Case1: In this case, a part of the observed object is laid in the upper left corner of the image plane. This area belongs to the first saccadic zone and the proposed approach will respond by giving the proper pan and tilt angle values to put the object in fovea region. Figure (9) shows the output results of the saccadic phase for the three different locations of the CPT configuration, where it presents the relation between the pan and tilt values with frame number. From figure (9), the absolute values of pan and tilt angles of the first frame are matched, while the sign of tilt angle is negative and it shows that the object is laid in the first zone of the saccadic region. This result conforms the operation of developed FDM. Figures (9 - b and c) show different behavior form figure (9-a), where this is related to different reasons. The first one is object enlargement that results from decreasing the distance between the object and the CPT configuration, which may cause the weight factors of the saccadic zones to increase. This increasing will have an effect on the outputs, pan and tilt angles, of the FDM. The second reason is the initial values of the pan and tilt angles, where these values may cause transferring the object form a certain zone to another or may cause the object to lie between two zones that make the FDM give diverse outputs for each case. In addition, noise that comes from light condition and object projection on the image plane may increase or decrease the weight factors of the saccadic zones and this will change the outputs of the FDM. However, the total net values of the pan and tilt angles has nearly similar values for the cases (a), (b), and (c) of figure (9) and that indicates the robustness of the developed approach to object enlargement problem.

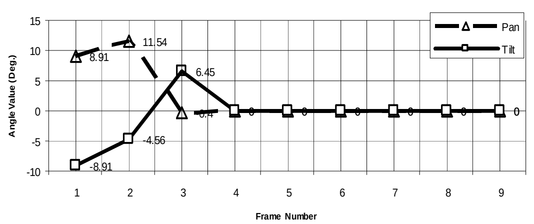
It can be seen from figure (9) that the number of frames that are required to put the object in fovea region does not exceed four frames for all location cases. This result indicates the acceptable response of the developed approach.



(a) 50 cm far from



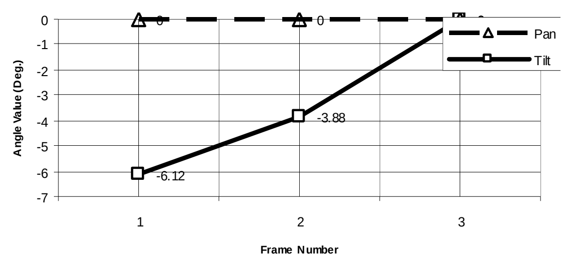
(b) 40 cm far from



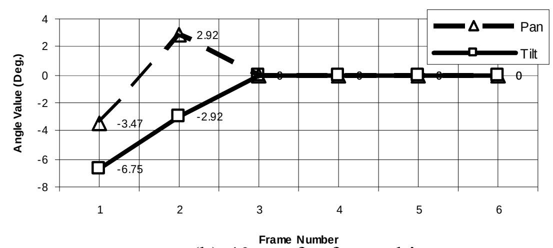
(c) 30 cm far from

Fig.9. Results of Case 1-Saccadic Phase.

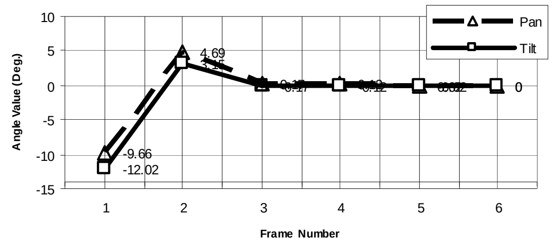
Case2: In this case, part of the observed object is laid in two zones (1 and 2) of the saccadic region. Figure (10) shows the obtained results of this case, where the optimal response of this case can be considered as changing in tilt values and that is presented in figure (10-a). In other figures (10-b and c), varying in pan values can be recognized. The enlargement of the object causes this varying where the weight factors of the zones (1 and 2) are increased and the rules of the FDM will add an additional amount of the pan angle value. However, the total net values of the pan angle for each location case of case 2 is close to zero or can be neglected.



(a) 50 cm far from object



(b) 40 cm far from object



(c) 30 cm far from object

Fig.10. Results of Case2 –Saccadic Phase.

Case 3: The object in this case is laid in the upper-right side of the image plane. Figure (11) shows the experimental results of this case, where it can be observed that in the first frame the values of the pan and tilt angles are identical. This is caused by laying the object in the second zone of the saccadic region. The FDM responded ideally in this case. In figure (11-c), fluctuation in the angle values could be recognized and the number of frames that are required to put the object in fovea region is increased from that which is stated in figures (11-a and b). This behavior can be explained as follows: the first angle values are large because the influence of the object enlargement. These large values will put the object in the third zone of the saccadic region. Then the object will lie in the first saccadic zone because of the pan and tilt angle values, as shown in figure (11-c). This object fluctuation between the first and third zones will continue until the object is laid completely in fovea region.

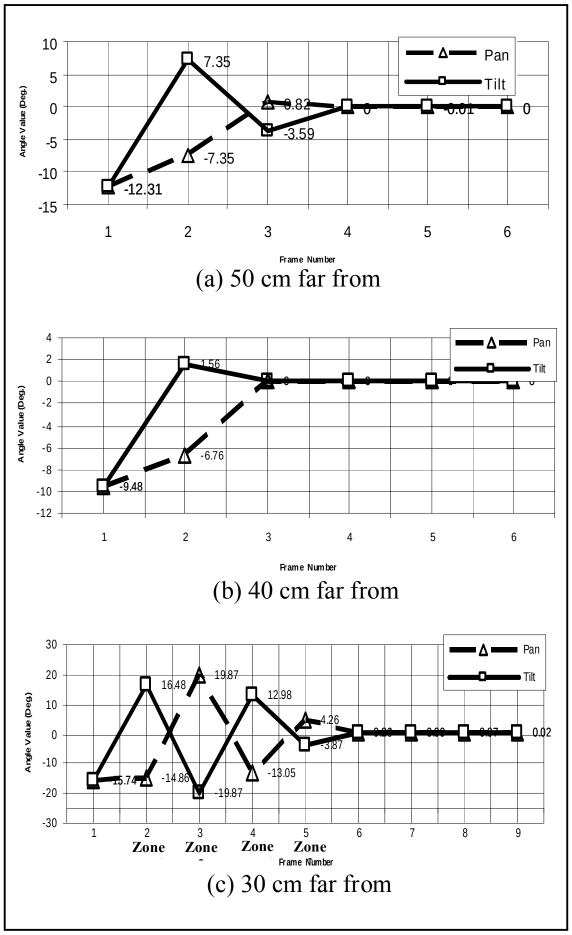


Fig.11. Results of Case3 –Saccadic Phase.

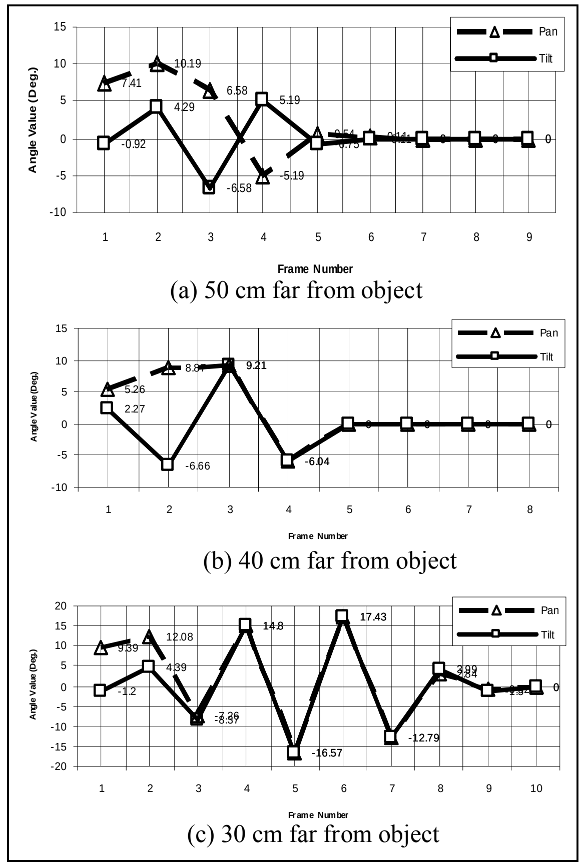


Fig.12. Results of Case 4 –Saccadic Phase.

Case4: In this case, part of the object is placed in the middle-left side of the image plane. The ideal response of the FDM to this case is by giving a value to the tilt angle only. From figure (12), it can be seen that in the first case the tilt angle is less than 1 degree. However, the FDM gives a value to the tilt angle for other location cases that are presented in figures (12- b and c) and in the next frames in figure (12-a). This manner of acting is caused due to unavailable knowledge of the object size that is similar to human response in the saccadic movement. The overall tilt values for all cases presented in figure (12) are less than 1.5 degree and that shows the adaptability of the developed approach to the object size.

Case 5: This case is the mirror to case 4, where the object is laid in the second and third zones of the saccadic region. From figure (13), the response of the FDM is ideal, where the maximum tilt value does not exceed 2.2 degree and the overall tilt values for each location case of figure (13) is less than 0.4 degree.

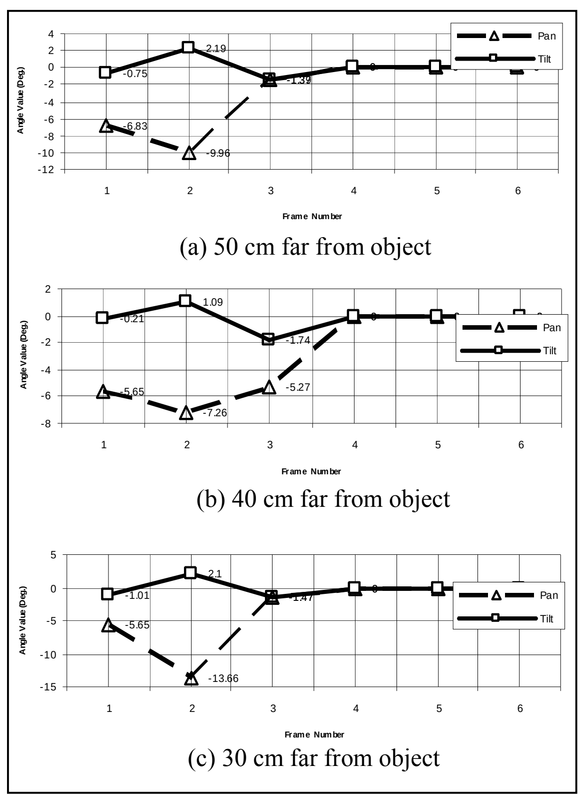
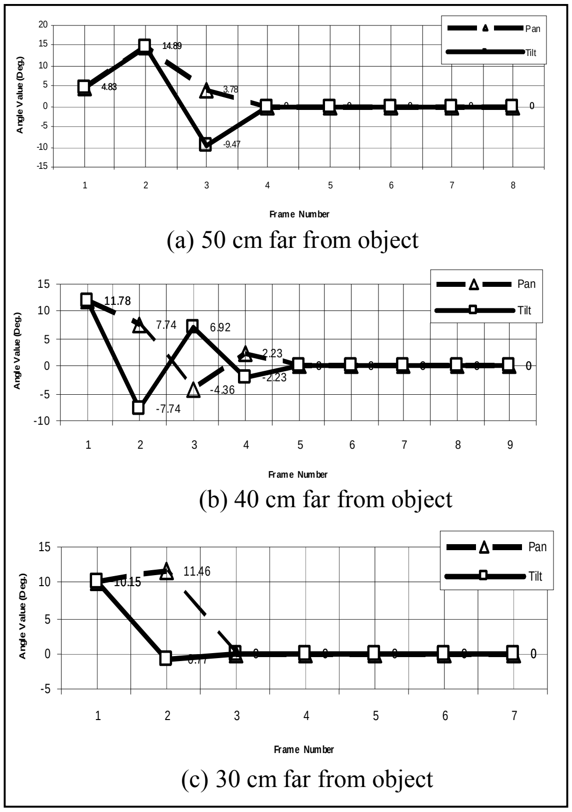
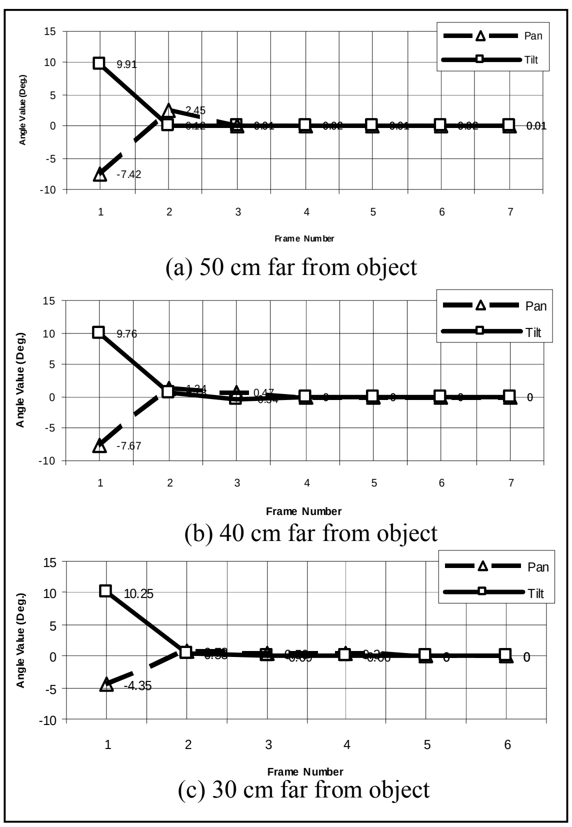


Fig.13. Results of Case5 –Saccadic Phase.



(a) 50 cm far from object
(b) 40 cm far from object
(c) 30 cm far from object

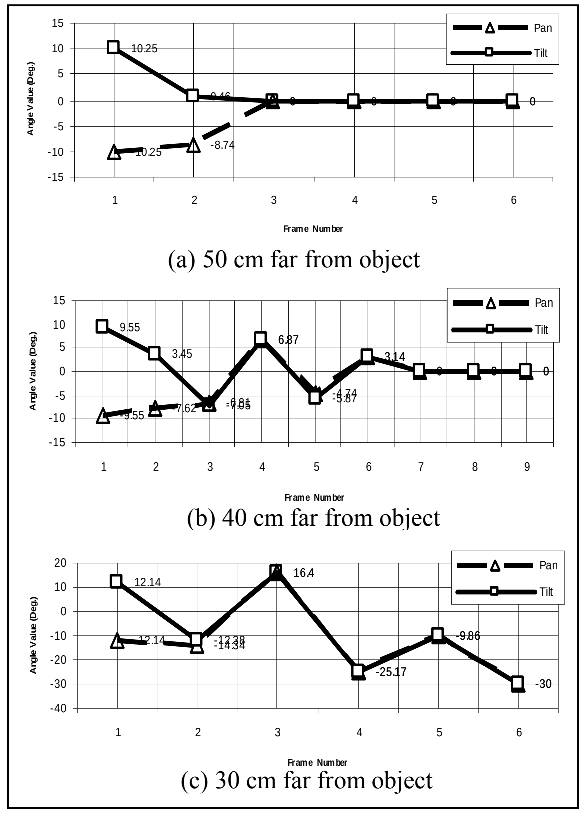
Fig.14. Results of Case6 –Saccadic Phase.



(a) 50 cm far from object
(b) 40 cm far from object
(c) 30 cm far from object

Fig.15. Results of Case7 –Saccadic Phase.

Cases 5, 6, and 7: These cases are similar to cases (1,2, and 3), where the same behavior in general can be noticed as shown in figures (14,15, and 16) respectively. However, figure (16-c) presents the outputs of the third location case of case 7; the FDM failed to put the object in the fovea region. This miss tracking can relate to the effect of object enlargement. However, the tracking of large objects in human oculomotor system will be in fovea and no saccadic movements are necessary.



(a) 50 cm far from object
(b) 40 cm far from object
(c) 30 cm far from object

Fig.16. Results of Case8 –Saccadic Phase.

5.2. Smooth Pursuit Phase

This phase is verified using the developed experimental setup. The proposed algorithm is based on minimizing the difference between the center of object perimeter (COP) and the center of fovea region (COF). In mathematic expression:

$$\left|\mathrm{COP}_{x,y} - \mathrm{COF}_{x,y}\right| \approx 0 \qquad \ldots(4)$$

The acceptable error value of equation 4 will be selected to 10 pixels. In the adopted tests, 10 pixels are less than 4 mm in real environment; i. e., if the object moves more than 4 mm, the CPT configuration needs to change its pan and tilt angles in order to keep equation (4) within 10 pixels error.

The same circular object that is used in saccadic phase is adopted in this phase. The directions of the pan and tilt angles are selected depending on figure (6). The absolute values of the pan and tilt angles are calculated based on calibration process between visual domain and real world domain. The same locations of the CPT configuration used in saccadic phase are used in this phase.

To verify the robustness of the developed algorithm, the CPT configuration will be moved manually in two directions. The first direction is from left to right and from right to left, while the second one is from down to upward and from up to downward. The total distance that the CPT configuration will move is about 30 cm for each case. The COF_x and COF_y are 120 and 96 pixels respectively.

Left – Right case: Figure (17) shows the relation between pan and tilt angles with frame number for different locations of the CPT configuration. In addition, it presents the relation between the object COP and frame number. It can be seen from figure (17-a), the initial values of the pan and tilt are small and can be neglected because the object is laid in the fovea region and the difference value between the COP of the object and the COF is less than 10 pixels. However, in figures (17-b and c), the location of the object needs an adjustment because the difference value is larger then 10 pixels.

The CPT configuration is moved to the right and the proposed algorithm will respond by changing the values of pan angle to prevent the object from leaving the fovea region, where the net variation of the pan angle is positive. After that, the CPT configuration moves backward to the initial location, where the average change in the pan values is negative. The observed object is always in fovea region during this verification, where the influence of location of the CPT configuration is limited on the approach as shown in figure (17). However, ripples in the angles values can be recognized, where the manual movement of the CPT configuration causes these ripples.

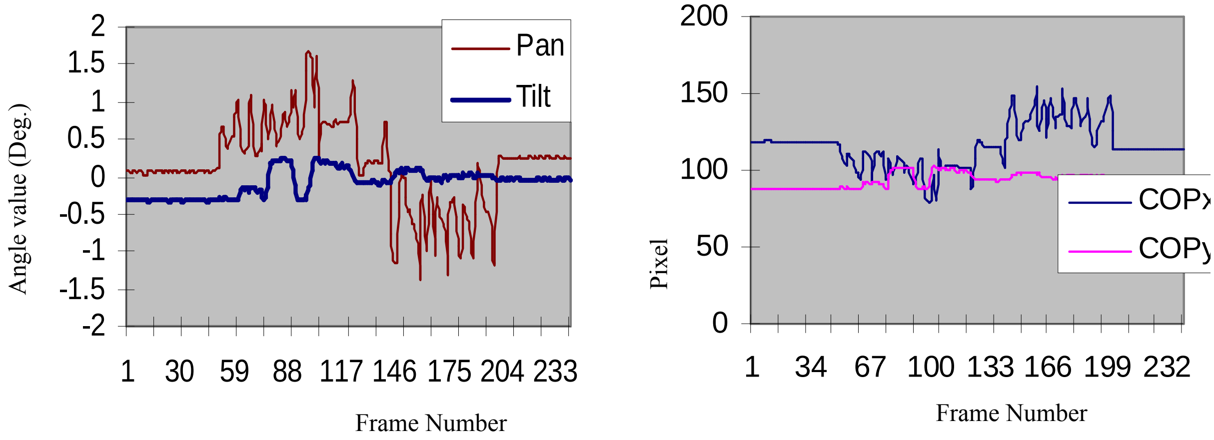
Up – Down case: In this case, the CPT configuration will be moved in an upward direction until it reaches 15 cm from the initial position and then back to its initial location. Figure (18) shows the verification results of this case, where tilt values are changed in the same behavior that pan angle was changed in the previous case. From figure (18), it can be noticed that the pan values are changed while the ideal situation assumed no change. This is because of the manual movement of the CPT configuration that makes the moving track not straight, where the pan angle is needed to correct such movements.

6. Conclusions

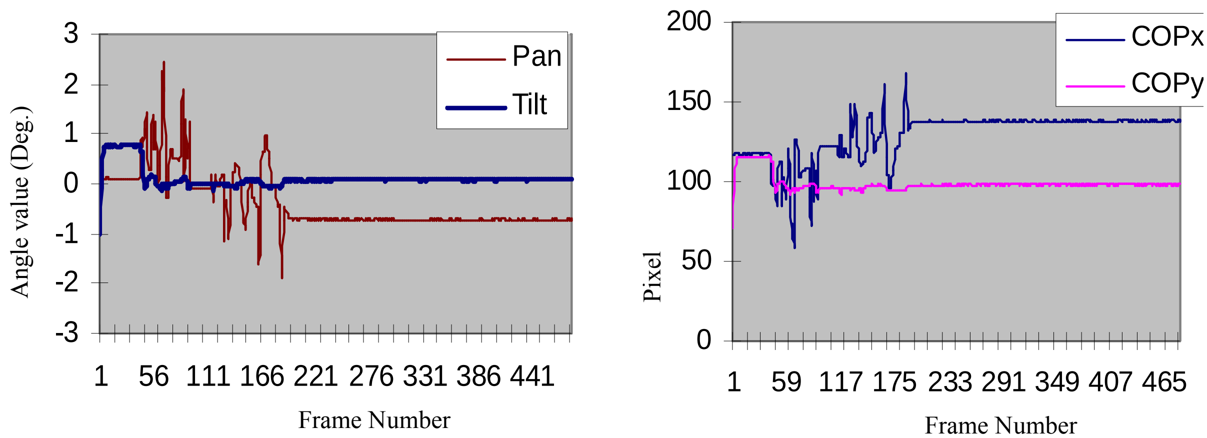
In this paper, an approach for object tracking was proposed and verified experimentally. The main conclusions of this research are:

1. Both tracking phases showed beneficial results and robust response to the object enlargement and digital noise.
2. The use of FDM in the saccadic phase is beneficially and it accelerates the response of the approach to meet its goal in few frames. However, the adjustment of the output membership functions may reduce the effect of the object enlargement.
3. The smooth pursuit phase showed efficient smooth tracking of the observing object, however, calibration process between the real and visual domains is necessary.

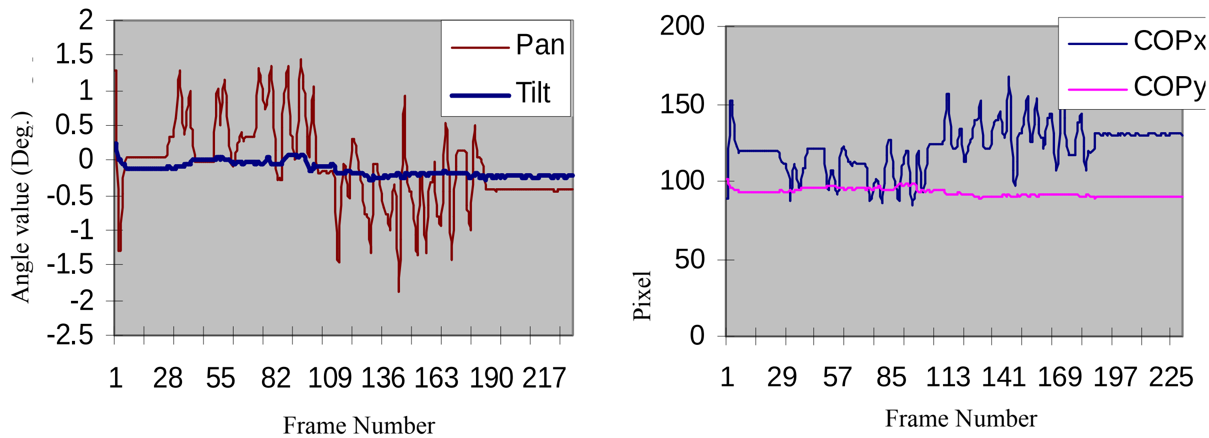
In general, the proposed approach can be used with confidence in robot applications.



(a) 50 cm far from object

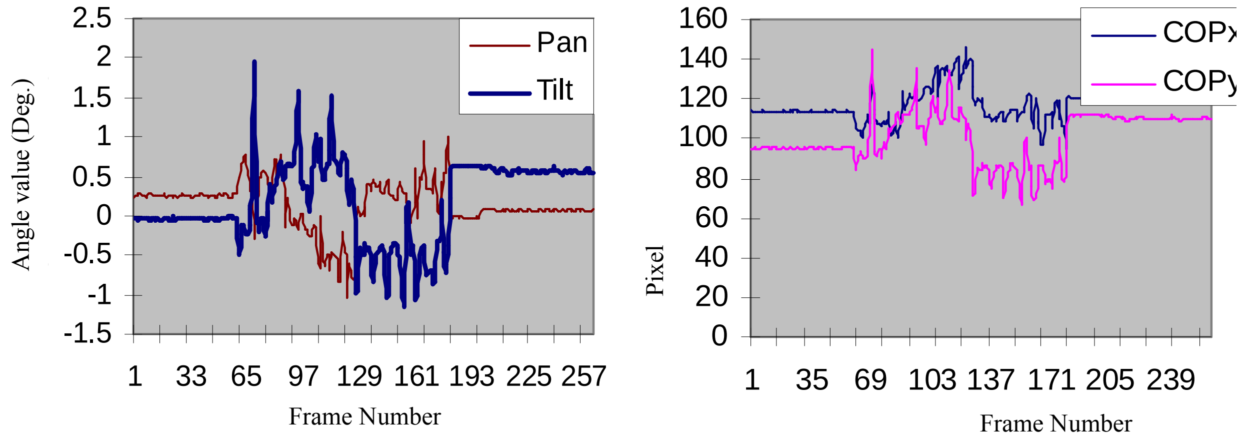


(b) 40 cm far from object

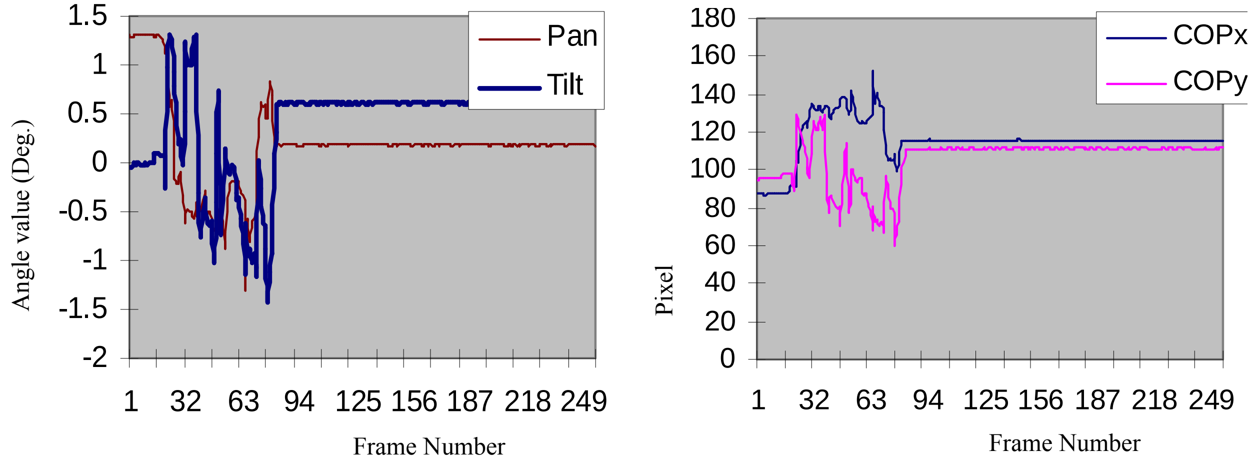


(c) 30 cm far from object

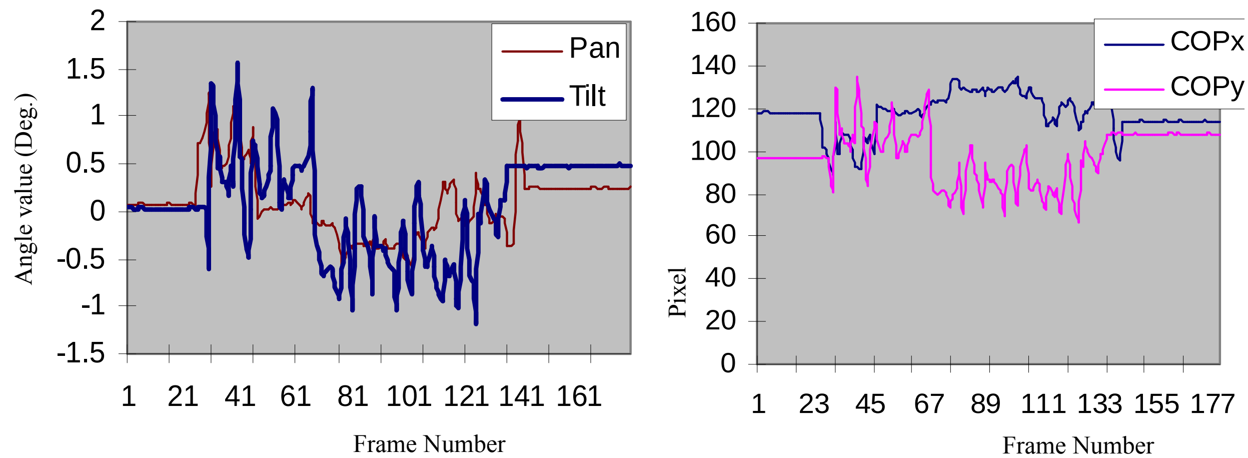
Fig.17. Results of *Right-Left* case-Pursuit Phase.



(a) 50 cm far from object



(b) 40 cm far from object



(c) 30 cm far from object

Fig.18. Results of *Up-Down* case-Pursuit Phase.

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طريقة مقترحة باعتماد (Bionics) لتتبع الأجسام للاستخدام في تطبيقات الإنسان الآلي

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الخلاصة

تناول البحث اقتراح طريقة لتتبع الأجسام مستوحاة من نظام الرؤيا البشري و التحقق منها عملياً, حيث قسمت الطريقة المقترحة إلى جزئيين,الأول هو التتبع السريع (Saccadic phase) و الثاني الملاحقة الهادئة (Smooth pursuit).

قسم مستوى الصورة و الذي يماثل شبكية العين البشرية إلى جزئيين, الأول (Saccadic region) والذي بدوره قسم إلى أربعة مناطق وهذه المناطق تقابل منطقة (Periphery) في شبكية العين و الثاني (Fovea region) حيث يتم فيه الجزء الثاني من عملية التتبع. عندما يدخل الجسم منطقة (Saccadic) يبدأ النظام المعد بتتبع الجسم و إدخاله إلى منطقة (Fovea) من خلال تغيير قيم زوايا (Pan) و(Tilt) ويتم هذا التغيير من خلال استخدام المنطق المضبب كأسلوب اتخاذ قرار ذكي حيث اعد مجموعة شروط منطقية لذلك. الجزء الثاني من الطريقة المقترحة ينشط عند دخول الجسم منطقة (Fovea) و خروجه من منطقة (Saccadic) حيث يتم الحفاظ على الجسم داخل تلك المنطقة من خلال تغيير قيم زوايا (Pan) و(Tilt) وفق طريقة الفروق بين مركز محيط الجسم و مركز منطقة (Fovea). طبقت الطريقة المقترحة عمليا على نظام (Camera-Pan/Tilt) لهذا الغرض و أظهرت نتائج جيدة لتحسين قابلية الرؤيا الاصطناعية للإنسان الآلي المماثل للإنسان .
