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Deterministic Fuzzy Approach for Tracking Motion Detection in Video Surveillance Using Image Processing Techniques

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Abstract: The process of object identification in images are generally observable content in image processing due to the immense popularity in image component analytics domain but each existence rely on its foundation theoretical objectives through its unique success rates. The object tracking in video surveillance CCTV or any video source system is a tedious process due to its random motion characteristics and frequent continuous parameter analysis for efficient tracking. The existing surveillance video object motion tracking approach methods fails in the areas of learning and pattern matching strategies along with proper computations and logical reasoning towards the next movement in the successive frames. The primary objective of this research is to incorporate 5 fundamental parameters for object tracking such as relative distance, direction change, speed approximation calculated time to reach the target and prediction of movement using fuzzy approach in the field of image processing. This research article proposes a deterministic fuzzy approach for tracking motion detection in video surveillance using image processing techniques for achieving those 5 fundamental parameters. In near future this research article focuses on the implementation of artificial intelligence based motion detection in video surveillance with augmented reality system.

Keywords: *Image processing, CCTV, motion tracking, motion detection, video surveillance*

I. INTRODUCTION

Deterministic Fuzzy Approach:

Fuzzy approach attempts to solve problems with an open, imprecise spectrum of data and heuristics that makes it possible to obtain an array of accurate conclusions. Determinism is the belief that all actions and events result from other actions, events, or situations, so people cannot in fact choose what to do.

Image Processing:

Image processing is the process of transforming an image into a digital form and performing certain operations to get some useful information from it [1]. The image processing system usually treats all images as 2D signals when applying certain predetermined signal processing methods [2].

Video Surveillance:

Video surveillance involves the act of observing a scene or scenes and looking for specific behaviors that are improper or that may indicate the emergence or existence of improper behavior [3].

CCTV:

Closed-circuit television, also known as video surveillance, is the use of closed-circuit television cameras to transmit a signal to a specific place, on a limited set of monitors [4].

Motion Detection:

Motion detection is the process of detecting a change in the position of an object relative to its surroundings or a change in the surroundings relative to an object [5].

II. METHODOLOGY

The proposed methodology contains 5 stages of implementation. They are

Basic requirements:

- ✓ Object identification using optimal criteria approach for tracking motion detection in video surveillance using image processing techniques.
- ✓ Monitor video sequence of legible quality of viewable content is taken into consideration for motion detection using image processing techniques.
- ✓ Each individual image frame is extracted with utmost care for its clarity [6].

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✓ Unstructured video sequences are not taken into consideration.

Stage-1: Tracking the relative distance in real platform using fuzzy determinism

The video sequence is converted in to image frames. The object identification in images is tested for motion activity. If an object starts moving then the first frame is taken into consideration. The final frame where the object stops moving is taken as the target frame. The co-ordinate difference computation provides the relative object moving distance.

The role of fuzzy in relative distance tracking concentrates on the selection of initial and target frames and check for co-ordinates differences with its computation. Fuzzy membership value is used here.

Stage-2: Tracking approximated speed of objects using fuzzy determinism.

The number of pixels the object moved within the specific interval of time is used to compute the speed of the object. The pixel values are mapped with the real field environment units towards actual computation.

The role of fuzzy in approximated speed tracking focuses on gradual, monotonic increasing, monotonic decreasing, abnormal or halt state of object motion tracking. Fuzzification and defuzzification approaches are used here.

Stage-3: Tracking the Object direction change linguistics using fuzzy determinism.

The object movements with changes on X-axis-axis or both play the vital role in direction tracking of objects.

The role of fuzzy logic determines the object movements with co-ordinates monitoring computation structure. Fuzzy knowledge base is used here.

Stage-4: Tracking and computing the target reaching time using fuzzy determinism.

The object movements along with the approximated speed identify the target reaching time whenever a final frame position is initially taken into consideration.

The role of fuzzy logic computes the speed to reach the distance with variation or without variation including the dynamics in movements are taken into consideration. Fuzzy decision trees are used here.

Stage-5: Perform Object movement prediction using fuzzy determinism.

The combination of object approximated speed and computation of the object target distance along with the direction helps to predict the next movement of the object.

The role of fuzzy logic concentrates on the current position and utilizes the object speed and direction to predict the next move .Fuzzy inference rules are used here.

The proposed methodology of deterministic fuzzy approach for tracking motion detection in video surveillance using image processing techniques is as follows in Fig-1.

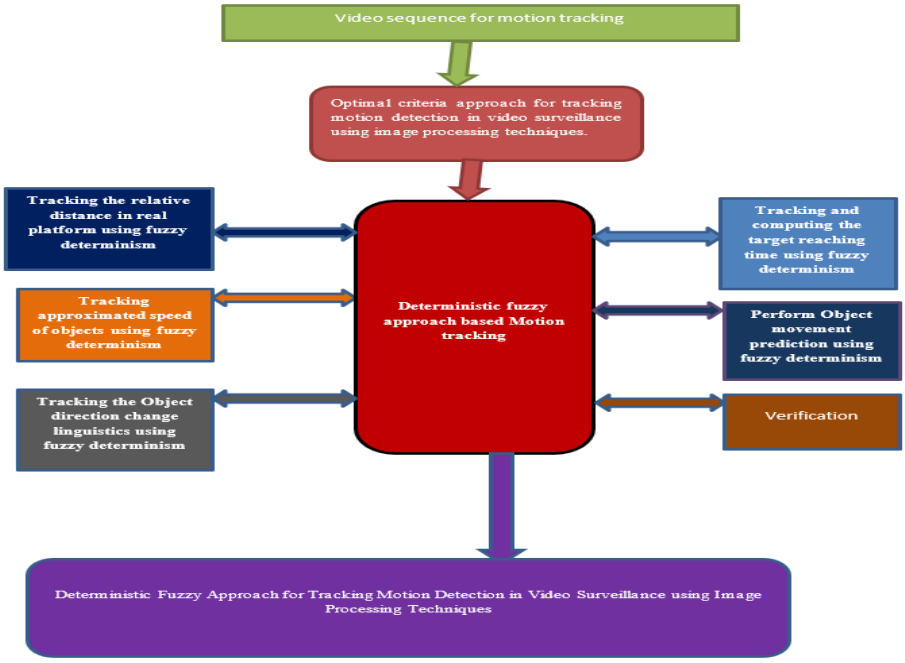

Fig-1: Proposed fuzzy deterministic approach for motion tracking

The flow chart for deterministic fuzzy approach for tracking motion detection in video surveillance using image processing techniques is as follows,

Start

Input: *Video sequence for motion tracking*

Step-0: *Apply optimal criteria approach for tracking motion detection in video surveillance using image processing techniques.*

Step-1: *Tracking the relative distance in real platform using fuzzy determinism*

- ❖ Convert video sequence to image frames.
- ❖ Identify the first frame with motion start state of objects.
- ❖ Recognize the target frame with motion halt.
- ❖ Compute relative object moving distance.
- ❖ Apply Fuzzy membership value for decision making.

Step-2: *Tracking approximated speed of objects using fuzzy determinism.*

- ❖ Compute the number of pixels transition within the specific interval of time
- ❖ Map the pixel values with the real field environment units towards actual computation.
- ❖ Apply fuzzification and defuzzification approaches for curve tracing as increasing or decreasing or constant.

Step-3: *Tracking the Object direction change linguistics using fuzzy determinism.*

- ❖ Track the object movements with changes on X-axis-axis or both.
- ❖ Monitor the co-ordinates computation structure.
- ❖ Apply Fuzzy knowledge base for decision making.

Step-4: *Tracking and computing the target reaching time using fuzzy determinism.*

- ❖ Identify the target reaching time by the object's approximated speed
- ❖ Apply Fuzzy decision trees for decision making.

Step-5: *Perform Object movement prediction using fuzzy determinism.*

- ❖ Link the object approximated speed and object target distance
- ❖ Use the direction to predict the next movement of the object.
- ❖ Apply Fuzzy inference rules for decision making.

Step-6: *Perform verification*

Show the motion detection results.

End

III. IMPLEMENTATION

Step-1: *Tracking the relative distance in real platform using fuzzy determinism*

The initial frame of object started moving and final frame for object movement halt are taken into consideration with object starting position (x1,y1) and ending position (x2,y2).

i. For straight line traverse, the Euclidean distance formula is used

The total distance is computed by the Euclidean distance formula $\sqrt{(x2-x1)^2 + (y2-y1)^2}$

ii. For non-straight line or curve based, such that (a, g (a)) and (b, g (b)) for any smooth function g, then the non-straight line distance = $\int_a^b \sqrt{(1+ [f'(x)]^2}\, dx$

iii. The fuzzy membership value assignment table is as follows in table-1.

Table-1: Fuzzy membership value assignment

Sl.No	Pixel change	Fuzzy membership value
1	Same node	0.0
2	Shadow effect	0.0
3	Light effect	0.0
4	Mirror effect	0.0
5	Straight line	1.0
6	Start point=end point=>Loop	1.0
7	Non-straight line	1.0

iv. Consider the object motion tracking simulation as in Fig-2 and Fig-3.

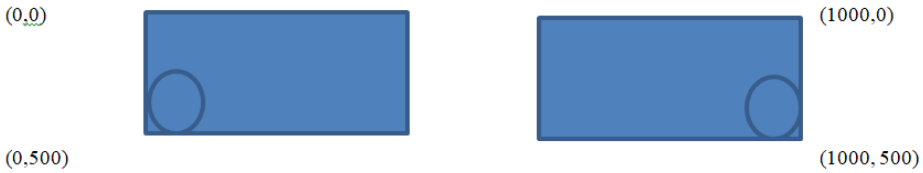

Fig-2: Object motion tracking simulation drawing-1

If the frame length =1000 pixels width=500, object box width = 100 pixels and height =100 pixels then the motion tracking is the distance is bottom right point travel distance (100,500) to (1000, 500). Even the linear apply Euclidean distance for practice.

Then the distance travel= $\sqrt{}$ $(1000\text{-}100)^2$+ $(500\text{-}500)^2$=900 pixels

The actual relative distance for the real field scale value is 1:10 cm

Then 900*10 cm travel

=9000 cm

=300 foot travel in real field.

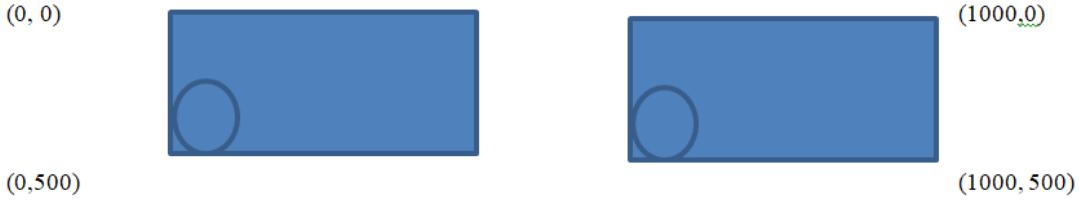

Fig-3: Object motion tracking simulation with no motion drawing-2

v. Consider the real-time image processing for video sequence from st.xaviers college function [10] as in fig-4 and fig-5.

Fig-4: Real-time object motion tracking-1

Fig-5: Real-time object motion tracking-2

The distance travel by the persona is (398,182) to (425,182); the Euclidean distance provides the result as

Distance = 27 pixels

The scale ratio is 1:1 pixel: foot represent that the persona moved or travelled relative distance of 1 foot.

Step-2: *Tracking approximated speed of objects using fuzzy determinism.*

i. The fuzzification process focusing on to the arc distance and defuzzification process computes the time taken to cover the Euclidean distance.

ii. Consider the object movement as follows as in fig-6

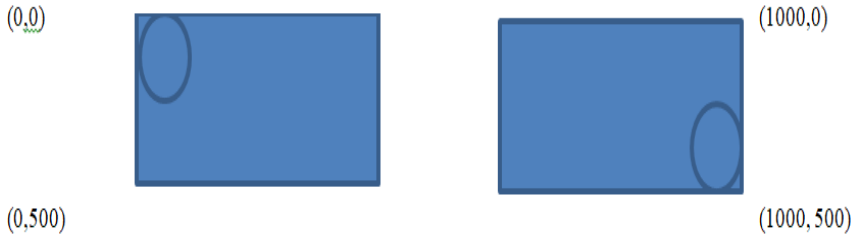

Fig-6: Object motion tracking simulation drawing-3

The time taken to travel the distance is 5000 Milli seconds

The distance travelled by the object's bottom right point from (100,100) to (1000, 500) then the distance travel as per Euclidean distance is=9, 84,886 pixels

Approximated Speed=Euclidean distance /time

=984886/5000

=197 pixels/Milli second

iii. Consider the real-time image processing for video sequence from st.xaviers college function [10] as in fig-7 and fig-8.

Fig-7: Real-time object motion tracking-3

Fig-8: Real-time object motion tracking-4

The distance travel by the persona is (1,576) to (1221, 576), the Euclidean distance provides the result as

Distance = 1220 pixels and the time taken is 1 second or 1000 Milli seconds.

The approximated speed=1220/1000=1.22 pixels/Millisecond.

Step-3: *Tracking the Object direction change linguistics using fuzzy determinism.*

i. The facts from the fuzzy knowledge base collects the linguistic information's for object direction tracking.

The following table-2 illustrates the scenario

Table-2: Fuzzy knowledgebase computation

Sl.No	**X-axis**	**Y-axis**	**Fuzzy Knowledge base**
1	Positive	Zero	Move Right
2	Negative	Zero	Move Left
3	Zero	Positive	Move Bottom
4	Zero	Negative	Move Top
5	Positive	Positive	Forward Bottom
6	Positive	Negative	Forward Top
7	Negative	Positive	Reverse Bottom
8	Negative	Negative	Reverse Top

ii. Consider the object movement scenario for defining the 8 directional movements as in Fig-9

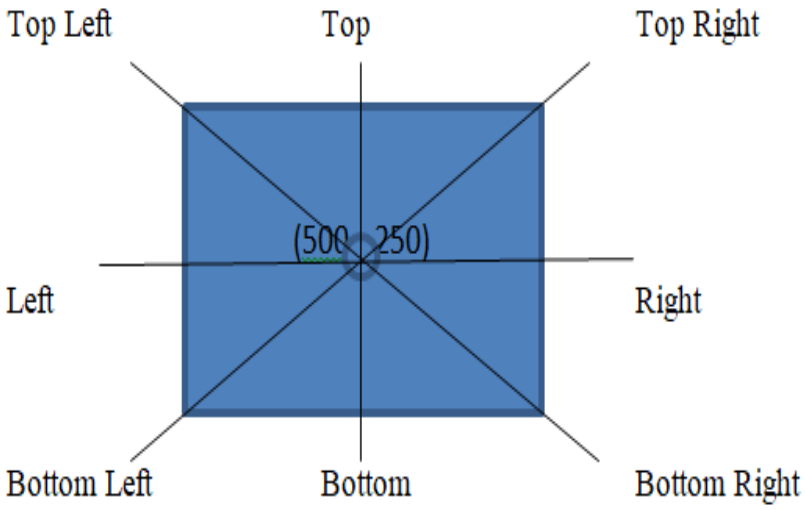

Fig-9: Object motion tracking simulation drawing-4

iii. The combinational implementation of fuzzy knowledge with the direction tracking of object at a single point of reference is as represented in the following table-3

Table-3: Object motion direction tracking sector

Sl.No	**X-Axis**	**Y-axis**	**Object motion direction tracking sector**
1	>500	250	Moving right
2	<500	250	Moving left
3	500	>250	Moving Bottom
4	500	<250	Moving Top
5	>500	>250	Moving Bottom Right

6	>500	<250	Moving Top Right
7	<250	>500	Moving Bottom Left
8	<250	<250	Moving Top Left

Update new position and compare the coordinates using the table, provides the results for object motion direction tracking.

iv. Consider the real-time image processing for video sequence from st.xaviers college function [10] as in fig-10 and fig-11

Fig-10: Real-time object motion tracking-5

Fig-11: Real-time object motion tracking-6

In the real-time image Fig- 11,

X-axis initial state=407

Y –axis initial state=123

X-axis final state=590

Y –axis final state=231

X-axis change=Positive

Y-axis change=Positive

Therefore as per Table the direction of the object is moving towards Bottom Right.

Step-4: *Tracking and computing the target reaching time using fuzzy determinism.*

i. Using the fuzzy decision trees the object reaching the target time is computed.

Let us consider X1=(x1, y1) and X2=(x2, y2) then the object from X1 reaches X2 based on the following condition sets.

If Speed increases then

Target time decreases by s1.

Else if speed decreases then

Target time increases by s2.

End if

If Motion Direction = straight line Then

Target time decreases by d1.

Else if Motion Direction = Arc bends then

Target time increases d2.

End if

If speed increases and motion direction=straight line then

Target time decreases by s1+d1

Else If speed increases and motion direction=Arc bends then

T=s1+d2

If (T>0)

Target time decreases by T

Else if (T<0)

Target time increases by T

Else

Target time=No change

End if

Else If speed decreases and motion direction=straight line then

T=s2+d1

If (T>0)

Target time decreases by T

Else if (T<0)

Target time increases by T

Else

Target time=No change

End if

Else If speed decreases and motion direction=Arc bends then

Target time increases by s2+d2

End if

Step-5: *Perform Object movement prediction using fuzzy determinism.*

The object movement prediction is based on the speed, direction, and target time through verifying the achievable distance or not.

Consider the real-time image processing for video sequence from st.xaviers college function [10] as in fig-

The scenery is to predict the particular person checked shirt with masked face will raise his hand or not through the sample image sets as fig-12, fig-13, fig-14, and fig-15.

Scene-1:

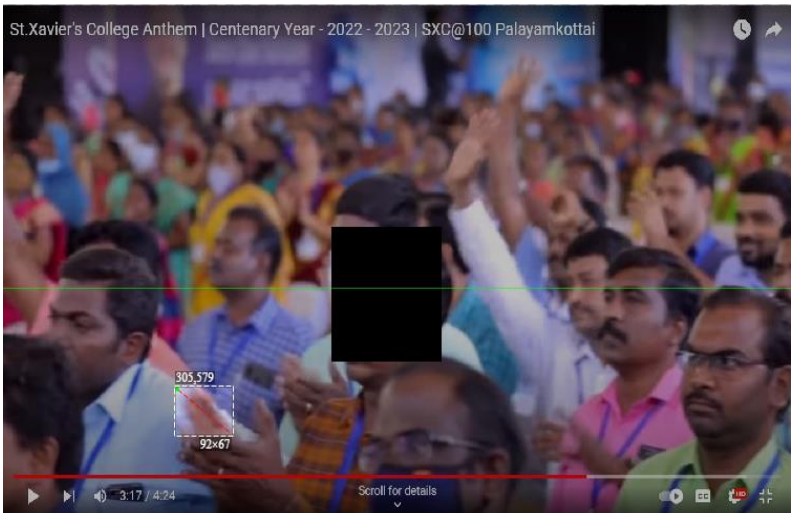

Fig-12: Real-time object motion tracking-7

Now the hands are at the position 305,579 with no resemblance of future movement.

Prediction to raise the hand= 0%

Scene-2:

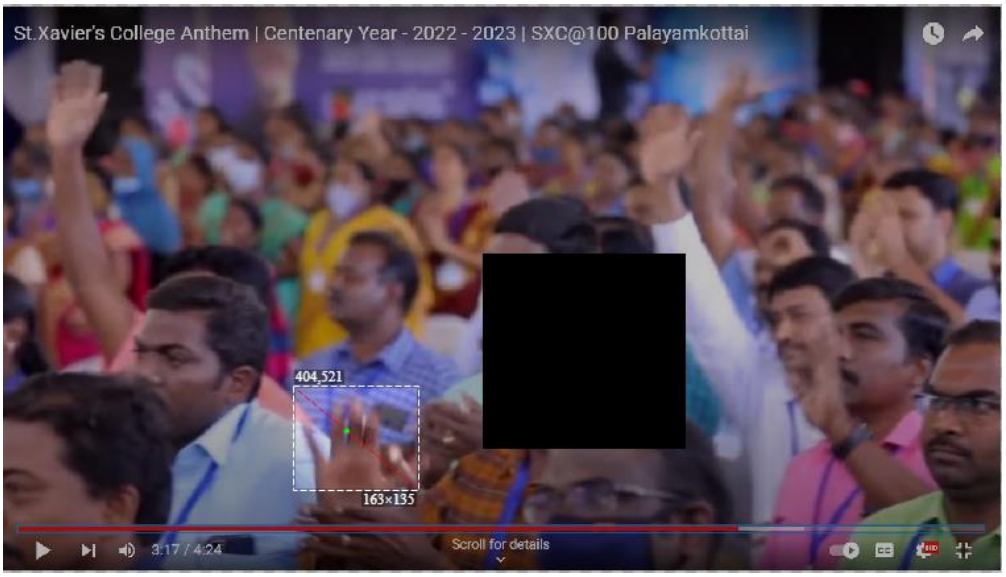

Fig-13: Real-time object motion tracking-8

Now the right hand motion tracking provides the following information's,

a. Right hand moved certain distance from (305,579) to (404,521), this distance is not a normal clapping distance because only right hand starts performing the motion. (20% positive)

b. The speed is little bit faster because the event happens in the same second. (20% positive)

Prediction to raise the hand= 40% positive

Scene-3:

Fig-14: Real-time object motion tracking-9

Now the right hand motion tracking provides the following information's,

a. Right hand moved certain distance from (404,521) to (413,298), this distance is certainly not for the clapping but height reduces. (25% positive)

b. The speed is faster because the event happens in the same second with 3 frames. (25% positive)

c. The direction of the object (Right hand) movement is towards Top. (25% positive)

Prediction to raise the hand= 75% positive. So definitely the person will raise his hand.

Scene-4:

Fig-15: Real-time object motion tracking-10

Now all the speed, time, direction and distance provides the prediction level=100% success.

Step-6: *Perform verification*

The verification process is done through the collection of 25 video sequences in the selected video material produces 22 out of 25 sequences with correct motion detection tracking in a successful way. The proposed deterministic fuzzy approach for tracking motion detection in video surveillance using image processing techniques produces 88% success rate in the process of motion detection tracking.

IV. RESULTS AND DISCUSSION

Consider the video collections from Kaggle standard data set [7] and Papercode [8] with a collection of 54 videos.

The proposed methodology gives better results in computing distance, speed, time, direction, and prediction with a lot of surprising events and actions.

This research article produces 90% (180 out of 200 video sequence sets) of success rate for the deterministic fuzzy approach for tracking motion detection in video surveillance using image processing techniques.

The parametric comparison between existing and proposed methods with recall, precision and accuracy etc. are represented in the below Table-4 format,

Table-4: Proposed methodology parametric comparisons

No	Approach	Accuracy	Precision	Recall	F1 score value
1	Contour mapping based motion tracking approach.	62%	0.61	0.63	0.62
2	Deterministic fuzzy approach for tracking motion detection in video surveillance using image processing techniques.	90%	0.92	0.91	0.9

The following fig-16 shows the performance comparison between the proposed and existing methodologies.

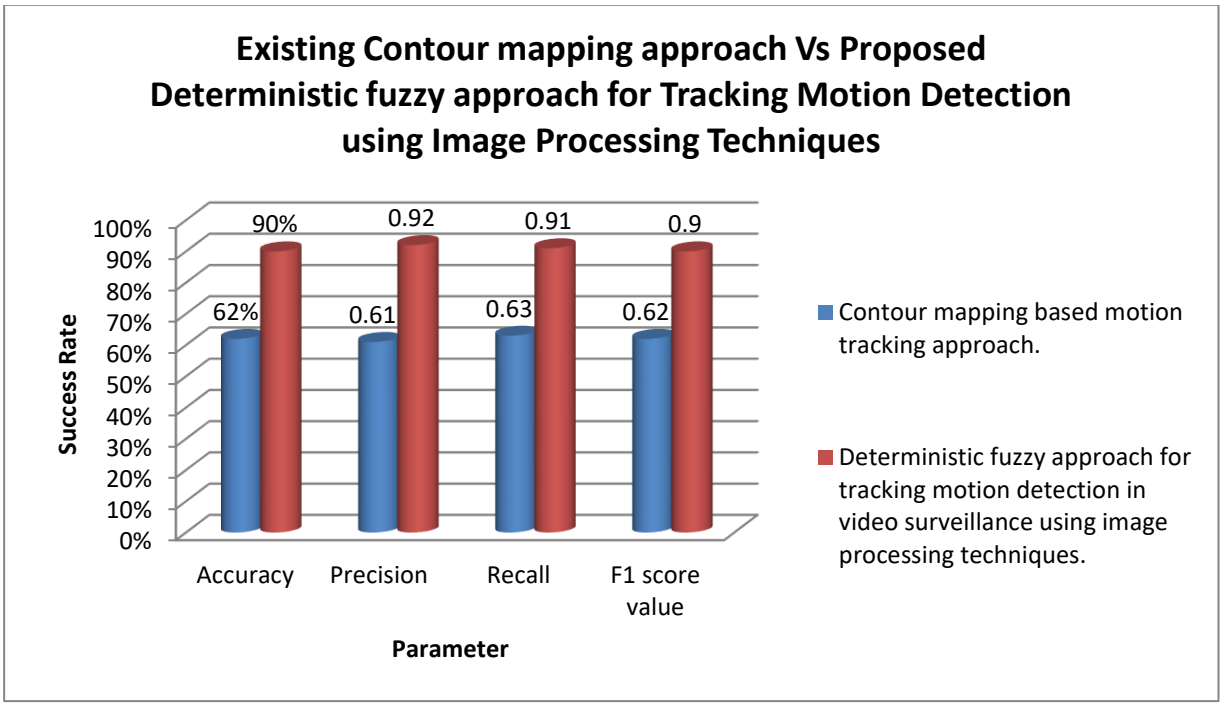

Fig-16: Proposed vs. existing methodology performance comparisons

V. CONCLUSION

The process of tracking the object motion is an important part in the defense systems, business analytics, and Entertainment industry. The methodologies for handling the motion tracking of objects are complex one if it is not implemented with proper care. The combinational approach of fuzzy logic and image processing produces the better results when concentrated on standalone applications.

The existing methodologies for contour mapping approach never handle with the possibilities of permutation and combination structure and unknown movement handling structures. The proper image handling tool implementation produces user friendly access of video sequences and image outputs.

This research article concentrates on 5 stages of tracking in motion detection procedures, initially with fuzzy based relative distance computation, followed by the fuzzy based approximated speed and then with the fuzzy based projected direction followed by the target reaching time assumption and finally with the fuzzy based prediction of movement towards future reference.

This research article produced 90% success for the motion tracking in video surveillance system.

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