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Moving Object Detection and Tracking

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***Abstract:-*Nowadays video surveillance systems have been developing rapidly. Video surveillance systems detect the target in initial stage and then perform the functions like object classification, its behavioural description & tracking. However there are many problems associated with object detection & tracking, such as illumination changes, fake motion, image noise etc. To overcome such problems, a system based on Particle filter algorithm is proposed in this paper. An attempt has been made to develop effective object detection & tracking system.**

Index terms: Object detection, Tracking, Particle Filter.

I. Introduction

The process of locating the moving object in sequence of frames is known as tracking. This tracking operation can be performed by using the feature extraction of objects and detecting the objects in sequence of frames. Moving object detection & tracking in video sequences is an important aspect of computer vision. However, accurate object detection in a real time environment is a challenging task. There are many problems associated with motion detection. Rapid changes may occur due to illumination changes, fake motion, image noise, and size and shape changes.

There are some old methods which are being used for object detection like background subtraction, optical flow & temporal differencing. Background subtraction approach detects the moving object between current frame & reference frame. It provides almost complete motion detection, but is affected by the dynamic scene changes. Temporal differencing method is suitable for dynamic scene changes, but it provides incomplete motion data. Optical flow method has high computational complexity. All the above mentioned methods are susceptible to illumination changes, fake motions, image noise, and shape and size changes.

Some new approaches were proposed to overcome the problems associated with these typical methods of object detection. Particle filter is one of those approaches. Particle filter provides a fast, effective, multiresolution of images.

In this paper we tried to overcome the problems associated with object detection & tracking. A simple system based on Particle filter algorithm is proposed here. Proposed system consists of a VGA camera mounted on a robotic arm for tracking the moving object. Robotic arm is controlled by the movement of stepper motor. Proposed system helps in accurate object detection & tracking.

Rest of this paper is arranged as follows. Section 2 includes algorithm of the proposed system i.e. Particle filter. Proposed system is described in section 3. Experimental results of proposed algorithm are presented in section 4. Finally conclusions are drawn in section 5.

2. Proposed System

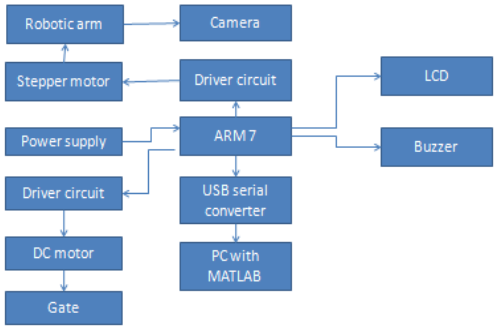

Fig.1. Block diagram

To overcome the problems associated with object detection, a simple method based on Particle filter algorithm is proposed in this paper. Here a VGA camera is mounted on a robotic arm for detecting & tracking the moving object. Here ARM 7 is used for controlling the operations of the various devices which are interfaced with it. 5volt power supply is provided to it. Driver circuits of the motors, USB serial converter, LCD, buzzer are interfaced with the ARM 7. Driver circuits drive the respective motors. Robotic arm is a type of mechanical arm usually programmable. It moves the camera in various directions. 16*2 LCD is interfaced with ARM 7. It is used for displaying the data or command. Buzzer is used as an alarming device.VGA camera is used for capturing the image of the moving object. Buzzer will produce an alarm after target detection. After the detection & tracking of the object there will be an automatic opening & closing of the gate. DC motor will control the opening & closing of the gate. Color images captured by a VGA camera having a size of 640*480 are sent to computer for further processing. ARM7 & PC with MATLAB are interfaced via an USB cable.

3. Software Overview

In this section, algorithms will be introduced. How these algorithms are used in the proposed tracking system is also discussed**.**

3.1 Particle Filter

The particle filter is an efficient technique for tracking the objects in video sequences.

Object Tracking

Tracking means to follow the object in each frame of a video sequence.

The Particle Filter

Particle Filter is concerned with the problem of tracking single & multiple objects. It weights particles based on a likelihood score and then propagates these particles according to a motion model. [11]

Mathematical Background

Particle Filtering estimates the state of the system, x t, time t as the Posterior distribution:

$$P(x_t \mid y_{0\text{-}t})$$

Let, Est (t) = $P(x_t \mid y_{0\text{-}t})$

Est.(1) can be initialized using prior knowledge .Particle filtering assumes a Markov Model for system state estimation. Thus, observations are dependent only on current state**.[**11]

- $Est(t) = P(x_t \mid y_{0-t})$

$$= p(y_t \mid x_t, y_{0-t-1}).P(x_t \mid y_{0-t-1})$$

(Using Baye's Theorem)

$$= p(y_t \mid x_t).\ P(x_t \mid y_{0-t-1})$$

(Using Markov model)

$$= p(y_t \mid x_t).\ P(x_t \mid x_{t-1}).P(x_{t-1} \mid y_{0-t-1})$$

$$= p(y_t \mid x_t).\ P(x_t \mid x_{t-1}).Est\ (t\text{-}1)$$

- Final Result:

$Est(t) = p(y_t \mid x_t).\ P(x_t \mid x_{t-1}).Est(t\text{-}1)$

Where$(y_t \mid x_t)$: Observation Model

$P(x_t \mid x_{t-1}).Est(t\text{-}1)$: Proposal distribution

To implement Particle Filter we need State Motion model: $P(x_t \mid x_{t-1})$, Observation Model: $p(y_t \mid x_t)$, Initial State: Est(1). We sample from the proposal and not the posterior for estimation. To take into account that we will be sampling from wrong distribution, the samples have to be likelihood weighed by ratio of posterior and proposal distribution:

W t = Posterior i.e.Est (t) / proposal Distribution

$= p(y_t \mid x_t)$

Thus, weight of particle should be changed depending on observation for current frame.

Basic Particle Filter Theory

A discrete set of samples or particles represents the object-state and evolves over time driven .Nonlinear motion models can be used to predict object-states. Particle Filter is concerned with the estimation of the distribution of a stochastic process at any time instant, given some partial information up to that time. The basic model usually consists of a Markov chain *X* and a possibly nonlinear observation *Y* with observational noise *V* independent of the signal *X*. [11]

Particle Filter algorithm is composed of 2 steps i.e.:

1) Sequential importance sampling step

2) Selection step

1) Sequential importance sampling

Uses Sequential Monte Carlo simulation. For each particle at time t, we sample from the transition priors. For each particle we then evaluate and normalize the importance weights.

2) Selection Step

Multiply or discard particles with respect to high or low importance weights $w^{(i)}_t$ to obtain N particles.This selection step is what allows us to track moving objects efficiently.

Implementation

We have implemented the Particle Filter algorithm in MATLAB.

Tracking

Tracking task depends on following conditions i.e. whether we attempts to track : [11]

- Objects of some nature e.g. vehicles, faces
- Objects of a given nature with a specific condition e.g. moving vehicles, face of particular person
- Objects of unknown nature e.g. moving objects.

Reference Color Window

The target object to be tracked forms the reference colorwindow. Its histogram is calculated, which is used to compute the histogram distance while performing a deterministic search for a matching window.

State Space

States are assigned as a location of target in each frame of the video.

System Dynamics

A second-order auto-regressive dynamics is chosen on the parameters used to represent our state space i.e. (x, y).The dynamics is given as:$X_{t+1} = Ax_t + Bx_{t-1}$ Matrices A and B could be learned from a set of sequences where correct tracks have been obtained. We have used an ad-hoc model for our implementation.

Observation y_t

The observation y_t is proportional to the histogram distance between the color window of the predicted location in the frame and the reference color window.

$Y_t \alpha Dist\ (q, qx)$,

Where q = reference color histogram.

qx = color histogram of predicted location.

Particle Filter Iteration

Steps:

- Initialize xt for first frame
- Generate a particle set of N particles $\{x^m_t\}_{m=1..N}$
- Prediction for each particle using second order auto-regressive dynamics.
- Compute histogram distance
- Weigh each particle based on histogram distance
- Select the location of target as a particle with minimum histogram distance.
- Sampling the particles for next iteration.

Initialization of state space for the first frame and calculating the reference histogram:

```
reference = imread ('reference.jpg');

[ref_count, ref_bin] = imhist(reference);
```

x1= 45; y1= 45;

Describing the N particles within a specified window:

for i = 1: N

x(1,i,1) = x1 + 50 * rand(1) - 50 *rand(1);

x(2,i,1) = y1 + 50 * rand(1) - 50 *rand(1);

end

For each particle, we apply the second order dynamics equation to predict new states:

if (j==2) x (:,i,j) = A * x(:,i,j-1);

else x(:,i,j)=rand(n_x)*x(:,i,j-1)+rand(n_x)*x(:,i,j-2);

The color window is defined and the histogram is calculated:

rect = [(x(1,i,j)-15),(x(2,i,j)-15),30,30];

[count,binnumber] = imhist(imcrop(I(:,:,:,j),rect));

Calculate the histogram distance:

for k = 1:255

d(I , j) = d(i, j) + (double (count (k)) - double(ref_count(k))) ^ 2;

end

Calculating the normalized weight for each particle:

w(:,j) = w(:,j)./sum(w(:,j));

w(:,j) = one(:,1) - w(:,j);

Re-sampling step, where the new particle set is chosen:

for i = 1:N

x(1,i,j) = state(1,j) + 50 * rand(1) - 50 *rand(1);

x(2,i,j) = state(2,j) + 50 * rand(1) - 50 *rand(1);

end

Functions Used: Track_final1.m : PF tracking codemultinomialR.m : Resampling function.

4. Experimental Results

We have implemented the proposed object detection & tracking system in Windows XP PC with under MATLAB software. Fig.Shows experimental results of tracking in proposed system. When target enters the centre of the scene, system uses its positional information to actuate the stepper motor of the robotic arm to keep the moving object in the centre of the scene.

Frame No: 1 Frame No: 31

Frame No: 47 Frame No: 54

Frame No: 62 Frame No:68

5. Conclusion

In this paper we have proposed a system based on particle filter algorithm, for object detection & tracking. Proposed system is simple to implement. It helps in accurate and efficient object detection & tracking.

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