A Novel Clustering-Based Method for Adaptive Background Segmentation

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Video Surveillance Systems

Over the past decade, video security has been deployed by governments and private institutions to combat street crime, by corporations to detect and interdict employee theft and shoplifting and by casinos to uncover cheating or fraud etc.

Forecast

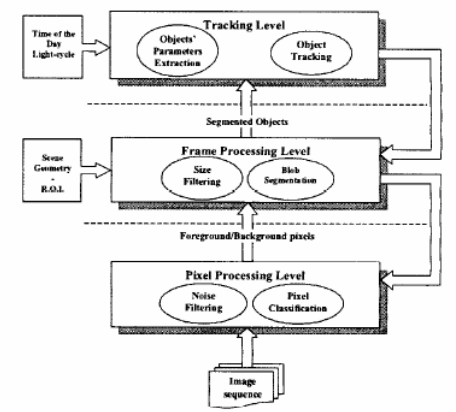
Background Modeling is the heart of background subtraction technique.

- Background modeling in dynamic environments.
- Segmentation of moving objects in the scene region.

Outline

- Background of Video Surveillance Systems
- Motivation and Problem Statement
- Proposed Method
- Experimental Results
- Summary and Future Extensions

Background of VS System



[Stefano'01]

Motivation

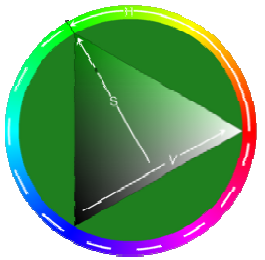
- Segmentation is a key issue in surveillance applications. In previously published works [Haritaoglu'2000], [Kumar'03] and many others used an approximate threshold which is manually set by the user.
- Background modeling has issues to deal with starting from modeling, adoptin and computational complexity.

Problem Statement

- To achieve good tracking rate we have identified the following aspects:
  - A Model which characterizes the pixel stability to develop an approximate background model.
  - A method which calculates an approximate threshold to separate the moving foreground regions.

Operating in HSV Color Space

- HSV Color Space is mentioned in many previous works [Francois'99]. The reason behind using this space due to the following advantages.
  - It can deals better with noise in the scene region.
  - It helps to eliminate most of the shadow regions in the segmentation.



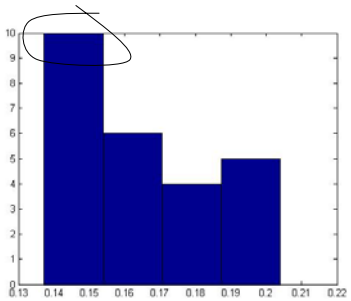
Background Modeling

- Background Models were generated using various statistical information extracted from video frames [Ridder'95],[Hin'03],[Stauffer'99]
- A histogram based method is presented here, which is formed out of the pixel values of different frames over a period of time.

Method I: Dynamic Background Modeling

- We considered 4 bins for estimating each background pixel intensity.
- We are interested of these two bin characteristics
  - It groups the approximate closest values together.
  - It gives the overall value of the entire values inside the bin.
- Take these observed values to model the background image.

Sample Histogram with 4 bins



This is the observation of a pixel over 25 images, the values are in HSV space so they appear between 0 to 1

Method I: Algorithm

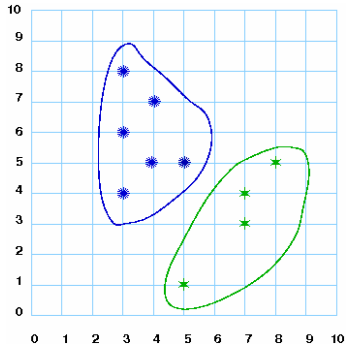
- Extract frames from video file and convert them from RGB space to HSV space.
- **While** (Read all the images)
  - Store all the pictures in an array (I) which is having dimensions 320X240X3 and can hold 100 images.
- **While** (Until end of all Pixels)
  - Model the histogram of $I_{n=1..m}(x_i,y_i)$ where I is the image sequence from *1..m* and (x_i,y_i) is the position of the pixel in each image.
    - Distribute the pixels in to 4 bins.
    - Calculate the median value of the largest bin.
- Back substitute the value obtained from the above step in the Background Model.
- Standardize the Background Model as Background Image for later clustering process.

Segmentation by Clustering

- This is a traditional technique in image processing applications.
- It separates the foreground pixels from background pixels, by using repetitive calculation of median values of both the clusters.
- This repetitive calculation determines the threshold value for segmenting foreground pixels.

Method II: K-means clustering

- This algorithm was implemented on the value component of HSV space.
- The number of clusters in this routine are 2, this number has also been incremented to more clusters but 2 is idle for finding decent results.
- It has two classes one for background pixels and other for foreground pixel intensities.
- The median value of these two classes are repeatedly calculated until they stabilized.



Method II: Algorithm

- The algorithm starts by calculating the difference matrix from the background frame and current frame and assigning Mean1*(for lowest intensity value),* Mean2*(for highest intensity value).*
- Subtract each pixel intensity value from previously estimated Mean1 and Mean2 of the difference matrix, and store the difference of the two values.

  $D_{ij} = || x_i - M_j ||$

  Where i = every pixel in the image and $j=1,2.$
- Check the condition if it is true $(D_{i1} > D_{i2})$, then assign x_i to the background cluster otherwise, assign it to the foreground cluster. Repeat this step until the pixels are classified.
- After clustering the whole difference matrix, recalculate the mean for background and foreground clusters.

  $NewMean j = \Sigma D_{ij} / n;\ j=1, 2.$
- If the $NewMean_j$ is different from the existing means M_j, $j=1, 2$, then reassign the means to these vales and repeat the whole process, i.e., step 1, 2 and 3, until the means standardizes.

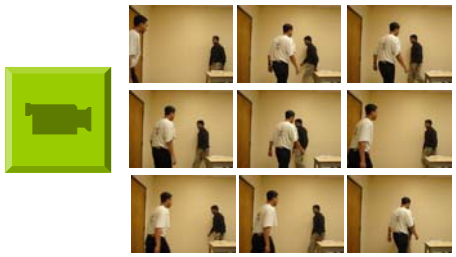
Implementation & Results

Implementation

- These two methods were implemented in MATLAB version 7, using Image Processing tool box, running on a Pentium 4, 2.79GHz workstation.
- We used Sony off the shelf digital camera to take videos and the frames are of size 320X240 extracted from the video for processing.

Dynamic Background Modeling

Extracted frames from the video



Generated background from the video

Segmentation by K-means

- Clustering using brightness quotient (V) of HSV space.
- Use of Chromaticity (H and S), with a measure H&S>0.
- Results obtained from Gaussian Model in [3].

Compared with various method in Wallflower Algorithm[4]

-- Proposed Method

Summary

- A Histogram based background model was presented, which models the background scene with out prior knowledge of the background.
- A k-means clustering technique was presented to segment the foreground objects using the above background.
- The background model will be updated with every incoming frame.

Future Work

- Background Modeling Issues
  - Needs further classification of statistical information to avoid blending.
- Segmentation Issues
  - Identifying methods to deal with holes in the shadow object region. And to remove noise regions.

References

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Modeling Background in a Shopping Mall

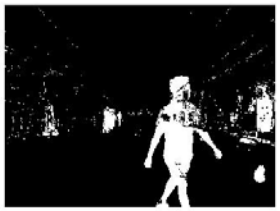
Movie 1

Movie 2

Identified Backgrounds

Segmentation Results



Thank You!

Questions