Abnormal Behavior Recognition in Infrared Imagery Based on Daubechies Wavelets

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ABSTRACT

Infrared image is primarily used to safeguard a country from intruders and smugglers. A thermal imaging camera is used to see a man at a distance of 20 kilometers away in total darkness. To detect abnormal human behavior, a simple and efficient approach is to build a model that measures the deviation from the constructed normal model. In this paper daubechies wavelet transform based abnormal human behavior has been recognized. D4 wavelet to decompose images into multilevel scale and wavelet coefficients, with which perform image feature extraction and similarity match by means of F-norm theory. The abnormal behavior recognition performance of daubechies wavelet is compared with Haar and wavelet histograms in terms of recall rate and retrieval speed. Experiments on infrared images and the comparison to the Haar and wavelet histograms validate the advantages of proposed daubechies wavelets. The Forward Looking Infrared (FLIR) records the infrared videos. The experimental results show the performance of fast and efficient retrieval.

INTRODUCTION

Intelligent visual surveillance has got more research attention and funding due to increased global security concerns and an ever increasing need for effective monitoring of public places such as airports, railway stations, shopping malls, crowded sports arenas, military installations, etc., or for use in smart healthcare facilities such as daily activity monitoring and fall detection in old people’s homes. Often times, the objective is to detect, recognize, or learn interesting events which contextually may be defined as “suspicious event”, “irregular behavior” (Zhang and Liu, 2007), “uncommon behavior”, “unusual activity/event/behavior”, “abnormal behavior” (Mehran et al., 2009), “anomaly” (Kratz and Nishino, 2009) etc.

Infrared Imaging technology that detects infrared radiation - or heat. Infrared Thermography is the art of transforming an infrared image into a radiometric one, which allows temperature values to be read from the image. In order to do this, complex algorithms are incorporated into the infrared camera. Infrared camera image has the capability to detect and evaluate the presence of any anomalies in image. Wavelet transform proved to be effective in visual feature extraction and representation.

In infrared imagery, abnormal behavior recognition (Li et al., 2013) wavelet approaches mainly include wavelet histogram and wavelet moments. The wavelet transform is a tool that cuts up data or functions or operators into different frequency components and then studies each component with a resolution matched to its scale. In this paper, we used D4 and Haar wavelet transforms to decompose infrared images into multilevel scale and wavelet coefficients, with which we perform image feature extraction and similarity match by means of F-norm theory. We present a abnormal behavior recognition strategy, which contributes to flexible compromise between the retrieval speed and the recall rate. The recognition performances are compared with wavelet histogram technique (Imtiaz and Fattah, 2013). The efficiency in terms recall rate and retrieval speed is tested with infrared images and the results reflect the importance of wavelets in abnormal behavior analysis. F-norm theory improves recognition performance.

The rest of the paper is organized as follows. Chapter II briefs out literature survey. Chapter III presents the proposed system. Chapter IV describes methodology. Chapter V deals the experimental results and Chapter VI concludes the proposed work.

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Literature Survey:

The literature survey on an abnormal human behavior Recognition in video surveillance is abundant.

Maatta et al,(2012) propose a method which can analyse data received from a surveillance system. Their proposed system report abnormal activities, such as malfunctioning or dead sensors, abnormal usage, and abnormal events created by the surveillance system. The experimental evaluation is performed by using six cases describing different types of abnormal activity.

Hu et al,(2013) present a fully unsupervised method for abnormal activity detection in crowded scenes. Neither normal nor abnormal training examples are needed before detection. By observing that in crowded scenes, normal activities are the behaviors performed by the majority of people and abnormalities are behaviors that occur rarely and are different from most others, they proposed to use a scan statistic method to solve the problem. It scans a video with windows of variable shape and size. The abnormality of each window is measured by a likelihood ratio test statistic, which compares two hypotheses about whether or not the characteristics of the observations inside and outside the window are different. A semi parametric density ratio method(Kanamori et al., 2012) is used to model the observations, which is applicable to a wide variety of data. They used a fast sliding two-round scanning algorithm for reduce the search complexity of the sliding window.

Palaniappan et al (2012) focus is on detecting abnormal activities of the individuals by ruling out all possible normal activities. Abnormal activities are unexpected events that occur in random manner. Human activities can be recognized using various approaches. Most widely used approach is multi-class SVM(Xu et al., 2007). They proposed a scheme of representing human activities in form of a state transition table. The transition table helps the classifier in avoiding the states which are unreachable from the current state. By avoiding the unreachable states, computational time for classification is reduced significantly when compared to conventional approaches.

Thida et al.(2013) addresses the problem of detecting and localizing abnormal activities in crowded scenes. A spatiotemporal Laplacian eigenmap method(Hou et al., 2013) is proposed to extract different crowd activities from videos. This is achieved by learning the spatial and temporal variations of local motions in an embedded space. They employ representatives of different activities to construct the model which characterizes the regular behavior of a crowd. This model of regular crowd behavior allows the detection of abnormal crowd activities both in local and global contexts and the localization of regions which show abnormal behavior.

Cho and Kang (2012) presented a method to detect abnormal crowd behavior using integrated multiple behavior models. Traditional abnormal detection methods are based only on personal behavior models. However, a single behavior model cannot accurately reflect complex crowd behavior. They introduce an integrated multiple behavior model for accurate abnormal behavior detection in a complex crowd scene.

Wang and Dong (2012) propose model typical motions associated with normal crowd behaviors with a set of motion subspaces, computed through low-rank matrix approximation. Then, abnormal crowd behaviors are identified by the motion deviations from the representative subspaces. In addition, through the adaptive learning module (Fernandes et al., 2011), their model is built on the observed data, and can be expanded by incorporating new crowd behavior patterns during the detection process.

Hou et al.(2013) paper proposes an abnormal behavior recognition method of trajectory characteristics and regional optical flow based on the characteristics of the two kinds. By adopting a modified hybrid Gauss model for background modeling, the moving foreground in video is extracted using the background subtraction method. The 8-adjacent connection area labeling method is used to label the foreground region so as to obtain the regional center trajectory. The Lucas-Kanade algorithm(Zhao et al.,2012) is used to extract the optical flow information within the movement region, and the regional flow features are described by the histogram with the weighted amplitude direction. The abnormal pedestrian behavior ( Armanfard et al., 2012) is identified through the analysis of the target trajectory and the entropy of histogram in the computational region. The modified mixed Gauss background model can effectively remove the interference factors and environmental disturbance on the foreground extraction so as to improve illumination changes.

So, from the various literature reviews it is observed that it is still a tricky task for abnormal human behavior activity. This work is implemented in infrared videos using wavelet transform.

Proposed Scheme Description:

In this system infrared image is used for abnormal recognition. The proposed system architecture as shown in Figure 1. It is based on decomposition of the database images using Haar and D4 wavelets. With resulting coefficients using F-norm theory, we extract the features and perform highly efficient image matching.

The valid images are stored in to the database which is deviated from query image. Both normal and abnormal behavior images are decomposed using wavelet transform. The feature extracted images are stored in the database which reduces the storage space and increases the retrieval speed. This difference is used as a measure of correlation between the images. If the deviation value is closer to query image then, it can be
identified as normal behavior otherwise abnormal behavior. The query image is compared with Database Image. Then the closely related images are displayed and also deviation is measured.

![Proposed Architecture](image)

**Fig. 1**: Proposed Architecture.

In case of comparison of infrared images the color features can’t be used, since infrared images can be considered as special gray-scale images. In this case the comparison of images is very similar to the comparison of gray-scale images, but the special properties of thermal images must be taken into account.

**Methodology**:
We used daubechies based wavelet approach for infrared image decomposition. These wavelets are used to find the abnormal behavior recognition in the human behavior.

**The Daub4 Wavelet Transform**:
The Daubechies wavelet transforms are defined by computing the running averages and differences via scalar products with scaling signals and wavelets the only difference between them consists in how these scaling signals and wavelets are defined (Walker, 2008).

The D4 transform has four scaling function coefficients,

\[ h_0 = \frac{1 + \sqrt{3}}{4\sqrt{2}}, \quad h_1 = \frac{3 + \sqrt{3}}{4\sqrt{2}}, \quad h_2 = \frac{3 - \sqrt{3}}{4\sqrt{2}}, \quad h_3 = \frac{1 - \sqrt{3}}{4\sqrt{2}}. \]  

Each step of the wavelet transform applies the scaling function to the data input. If the original data set has \( N \) values, the scaling function will be applied in the wavelet transform step to calculate \( N/2 \) smoothed values.

In the ordered wavelet transform the smoothed values are stored in the lower half of the \( N \) element input vector.

The wavelet function coefficient values are: \( g_0 = h_3 \); \( g_1 = -h_2 \); \( g_2 = h_1 \); \( g_3 = -h_0 \).

Each step of the wavelet transform applies the wavelet function to the input data. If the original data set has \( N \) values, the wavelet function will be applied to calculate \( N/2 \) differences (reflecting change in the data). In the ordered wavelet transform the wavelet values are stored in the upper half of the \( N \) element input vector.

The scaling and wavelet functions are calculated by taking the inner product of the coefficients and four data values. The equations are shown below,

**Daubechies D4 scaling function**,

\[ a[i] = h_0 s[2i] + h_1 s[2i+1] + h_2 s[2i+2] + h_3 s[2i+3] \]  

**Daubechies D4 wavelet function**,

\[ c[i] = g_0 s[2i] + g_1 s[2i+1] + g_2 s[2i+2] + g_3 s[2i+3] \]

Each iteration in the wavelet transform step calculates a scaling function value and a wavelet function value. The index \( i \) is incremented by two with each iteration, and new scaling and wavelet function values are calculated.

**Implementation of daubechies wavelets in the proposed work**:
Consider \( A \) is a square matrix and \( A_i \) is its \( i^{th} \) order sub matrix where...
As greatly speeded retrieval as well as ensured enough recall rate comparable with its Haar wavelet schemes with wavelet histograms. It turns out that D4 wavelet has greatly speeded retrieval as well as ensured enough recall rate comparable with its Haar wavelet decomposition of images, followed by feature extraction and similarity match under F-norm theory.

Steps used in the proposed work:
1) The behavior of a normal image is measured and stored into the database.
2) Input the query image.
3) Extract the features of the query image.
4) Perform similarity measure and recognize the abnormal image.

Experimental Results:

FLIR PS32 camera image is used for this Abnormal behavior analysis work. The daubechies based wavelet is implemented in Java Media Framework (JMF) and runs under Intel, Xeon CPU (2.40 GHz) machine with 8 GB of RAM.

The general flow of the experiments starts with the decomposition of data base image using D4 wavelet. With F-norm theory (Hunag et al., 2005) we extracted the image feature vector and performed highly efficient image matching. We used progressive retrieval strategy to balance between computational complexity and retrieval accuracy. We focus on the comparison of two important retrieval indices, namely retrieval accuracy and the speed. The test infrared image database contains 5 images. For simplicity, all images are pre processed to be 960x480 sizes before decomposition.

Sample retrieved images for the given query is shown in the Figure. 2 and 3. The number at the foot of each image indicates its similarity (α) to the example image.a values indicate the similarity between the Query image and the images in the database. For similar images, α value is 1.Fig.2 given query image shows one person holding the plastic bottle. This image compared with all the valid images from database. It displays the α value is 1.00. So it is observed that the normal behavior is identified.

Valid normal behavior images are stored into the database. Query image is compared with all the normal behavior images. Similarity is measured by F-norm theory and also it displays the α value. If the behavior is not matched with any other images in the database, then it should be abnormal behavior. In Figure 3 given query image shows one person is doing suspicious activity. For Normal behavior, the α value should be 1 in any of other images in the database. But the result displays the less than value of 1. So it is observed that the abnormal behavior is identified. Retrieval speed is also measured.

The following Table.1 shows the Recall rate achieved by the two schemes namely D4 ,Haar Wavelet Transform and existing wavelet histogram for infrared images. The Recall rate is defined as the ratio of the number of relevant (same category) retrieved images to the number of relevant items in collection. D4 wavelet transform achieves the best Recall rate and retrieval speed. Table 2 illustrate the retrieval speed.

Conclusion:

In this paper, we discussed abnormal behavior recognition in Infrared Imagery based on daubechies wavelet decomposition of images, followed by feature extraction and similarity match under F-norm theory. We compared the retrieval performance of D4 wavelet, Haar wavelet schemes with wavelet histograms. It turns out that D4 wavelet has greatly speeded retrieval as well as ensured enough recall rate comparable with its Haar wavelet decomposition.
wavelet and wavelet histogram. In addition, the progressive retrieval strategy helps to achieve flexible compromise among retrieval indices. Finally we conclude from the results that wavelets achieve high retrieval performance. This is also the most apparent advantage of the wavelets in real time applications. The progressive retrieval strategy contributes to flexible compromise between the retrieval speed and the accuracy.

**Fig. 2**: Normal Behavior.

**Fig. 3**: Abnormal Behavior.

<p>| Table I: Comparison of recall rate. |</p>
<table>
<thead>
<tr>
<th>Si.No</th>
<th>Techniques</th>
<th>Recall rate (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D4 Wavelet</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>Haar Wavelet</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>Wavelet Histogram</td>
<td>78</td>
</tr>
</tbody>
</table>

<p>| Table II: Comparison of retrieval speed. |</p>
<table>
<thead>
<tr>
<th>Si.No</th>
<th>Techniques</th>
<th>Retrieval speed(seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D4 Wavelet</td>
<td>1.82</td>
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<tr>
<td>2</td>
<td>Haar Wavelet</td>
<td>2.24</td>
</tr>
<tr>
<td>3</td>
<td>Wavelet Histogram</td>
<td>3.25</td>
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**REFERENCES**


Ding, J., 2007. Time-Frequency Analysis and Wavelet Transform. Lecture Notes, National Taiwan University.


