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# A Wavelet Based Feature Extraction and Detection of Abandoned Objects

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***Abstract*— The goal in image analysis is to extract useful information for solving application-based problems. Image segmentation, feature extraction and image components classification form a fundamental problem in many applications of multi-dimensional signal processing. The main objective of the project is to extract features using wavelets and classify abandoned objects using machine learning algorithm. Abandoned object detection is one of the important tasks in video surveillance system. The proposed method automatically recognizes activities around restricted area to improve safety and security of the servicing area. The computational complexity is reduced thereby increasing the performance. The coding is done in VHDL and synthesis is done in Xilinx ISE series.**

***Keywords*— Feature extraction, Wavelets, Machine learning algorithm, Abandoned object .**

## I. Introduction

As the amount of information grows rapidly and widely, feature extraction becomes an indispensable technique to extract the relatively most significant information from the given data. One benefit of this is that it allows people have better and faster understanding about the main property of a set of data which may contain noises. As long as the feature of the information is found, it can also be used to compress, to compare or to identify some related information. One major application of feature extraction is in image analysis. With the increasing amount of images and videos in our life, it is significant to use some intelligent machines to identify the object shown in a picture, or to detect the occurrence of a specific object in the video. The extraction of image feature has been an active area in the object recognition research for decades. Feature extraction is based on the local property of an image. The objective of the feature extraction is to characterize the object, and further, to reduce the dimensionality of the measurement space to a space suitable for the application of pattern classification techniques. Feature extraction can be viewed as a mapping, which maps a pattern space into a feature space, and the dimensionality of the feature space has to be smaller than pattern space. In this project, wavelet based feature extraction is employed.

Pattern classification is performed taking features extracted from the image and using them to classify image objects automatically. Hence we need to develop a classification algorithm or machine learning algorithm that use feature information. Machine learning, is a branch of artificial intelligence, concerns the construction and study of systems that can learn from data. Machine learning algorithms include support vector machine, quadratic classifiers, K-nearest neighbor, decision tree, Bayesian network etc. Bayesian network is used in this work. It is based on the assumption that the quantities of interest are governed by probability distributions. Abandoned objects are classified using this method.

We define an abandoned object to be a stationary object that has not been in the scene before. In general an abandoned object is an object which is left at a particular place under surveillance and unattended over a period of time. Second, it should remain static in recent frames or for some time t. Detecting abandoned object is a very important in places like airports, railway stations, big shopping malls etc. where there is potentially high security threat.

## II. Wavelets

The wavelet transform has emerged as a cutting edge technology, within the field of signal & image

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analysis. Wavelets are a mathematical tool for hierarchically decomposing functions. Though routed in approximation theory, signal processing, and physics, wavelets have also recently been applied to many problems in computer graphics including image editing and compression, signal processing, communication systems, time frequency analysis.

Wavelet theory was developed as a consequence in the field of study the multi-resolution analysis. Wavelet theory can determine the nature and relationship of the frequency and time by analysis at various scales with good resolutions. Time-Frequency approaches were obtained with the help of Short Time Fourier Transform (STFT). For the better time (or) frequency resolution (but not both) can be determined by individual preference (or) convenience rather than by necessity of the intrinsic nature of the signal, the wavelet analysis gives the better resolution. Generally, the 2- D DWT is frequently applied in image and video processing. The discrete wavelet transform (DWT) has been widely used in audio and image processing, digital communications and other application fields. This computation transform has been widely implemented in very-large-scale integration (VLSI) because of the real-time requirement. Wavelets are functions defined over a finite interval. The basic idea of the wavelet transform is to represent an arbitrary function as a linear combination of a set of such wavelets or basis functions. These basis functions are obtained from a single prototype wavelet called the mother wavelet by dilations (scaling) and translations (shifts). The purpose of wavelet transform is to change the data from time-space domain to time-frequency domain which makes better compression results. The fundamental idea behind wavelets is to analyze the signal at different scales or resolutions, which is called multiresolution.

A Haar wavelet is the simplest type of wavelet. In discrete form, Haar wavelets are related to a mathematical operation called the Haar transform. The Haar transform serves as a prototype for all other wavelet transforms. There are two functions that play a primary role in wavelet analysis, the scaling function (father wavelet) and the wavelet (mother wavelet). The simplest wavelet analysis is based on Haar scaling function.

$$wH(x) = \begin{cases} 1 & 0 < x < 1/2 \\ -1 & ½ < x < 1 \\ 0 & \text{otherwise} \end{cases}$$

The mother wavelet obviously satisfies the two wavelet requirements, as it is both local and oscillatory. The picture below shows the shapes of Haar wavelets for various scales and translations.

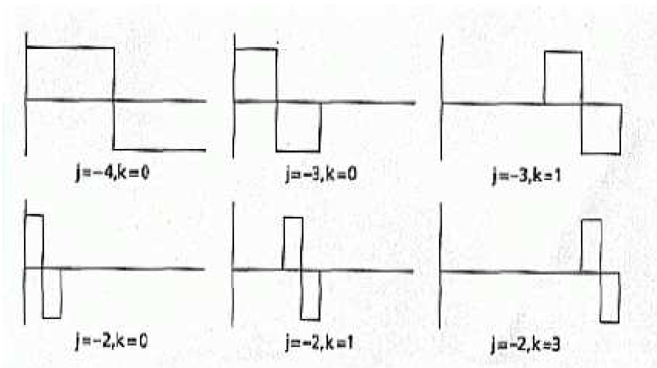


Fig.1 Shape of haar wavelts

## III. PROPOSED ARCHITECTURE

The detection of abandoned objects is more or less the detection of idle/inactive (stationary or non-moving) objects that remain stationary over a certain period of time. The period of time may be adjustable. In several types of images or frames idle objects should be detected. For example in complex near elevator bag is left by some person. An unknown object is any object that is not a person or a vehicle. In general, unknown objects cannot move they are considered as stationary. This paper presents an algorithm for determining the coordinates of abandoned objects appearing in a sequence of scene images based on sum and difference processing of the detailing wavelet coefficients of the current and reference images. Then the two images are compared using difference algorithm and the abandoned object is detected. The block diagram is shown below

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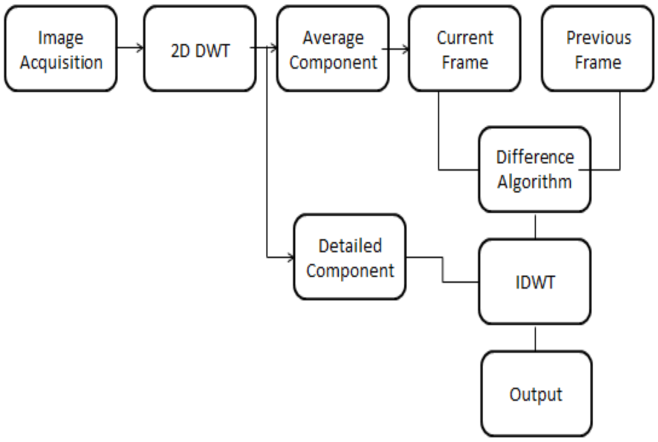


Fig.2 Block diagram of proposed architecture

*A. Feature extraction*

In this work Haar wavelets are used for feature extraction.

**Procedure for Haar Wavelet Transform:**

To calculate the Haar transform of an array of n samples:

1. Find the average of each pair of samples. (n/2 averages)
2. Find the difference between each average and the samples it was calculated from. (n/2 differences)
3. Fill the first half of the array with averages.
4. Fill the second half of the array with differences.
5. Repeat the process on the first half of the array.

(The array length should be a power of two)

Each image is presented mathematically by a matrix numbers. Haar wavelet uses a method for manipulating the matrices called averaging and differencing. Entire row of a image matrix is taken, then do the averaging and differencing process. After we treated entire each row of an image matrix, then do the averaging and differencing process for the entire each column of the image matrix. Then consider this matrix is known an semifinal matrix (T) w hose rows and columns have treated. This procedure is called wavelet transform. Then compare the original matrix and last matrix that is semifinal matrix (T), the data has become smaller. Since the data has become smaller, it is easy to transform and store the information.

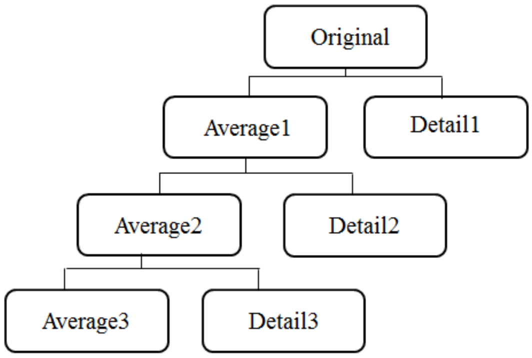


Fig.3 Haar Decomposition

*B. Classification*

Image classification is one important branch of artificial intelligence. Classification is the process of using a model to predict unknown values (output variables), using a number of known values (input variables). In order to perform classification, first we need to model the relationship between the input variables and the output variables we are predicting. This process involves learning a model using data in which both the input variables and the output variables are present. Expert opinion can also be used to build/enhance a model. This model can subsequently be used on unseen data in which only the input data is present, in order to predict the output variables. There are lots of different machine learning algorithms used for image classification nowadays.

Machine learning takes a known set of input data and known responses to the data, and seeks to build a predictor model that generates reasonable predictions for the response to new data.

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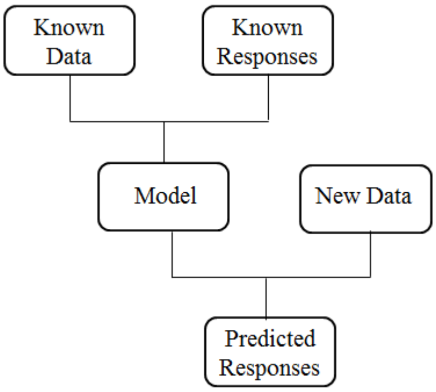


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Fig.4 Machine Learning Algorithm

Bayesian network is the machine learning language used in this work. It is based on the assumption that the quantities of interest are governed by probability distributions. Bayesian networks represent a set of variables in the form of nodes on a directed acyclic graph (DAG). It maps the conditional independencies of these variables. Bayesian networks bring us four advantages as a data modeling tool. Firstly, Bayesian networks are able to handle incomplete or noisy data which is very frequently in image analysis. Secondly, Bayesian networks are able to ascertain causal relationships through conditional independencies, allowing the modeling of relationships between variables. The last advantage is that Bayesian networks are able to incorporate existing knowledge, or pre-known data into its learning, allowing more accurate

results by using what we already know.

Bayesian filtering or Bayes filter is used for classification. Bayes filters2 probabilistically estimate a dynamic system's state from noisy observations. Bayes filters represent the state at time t by random variables $x_t$. At each point in time, a probability distribution over $x_t$, called belief, $Bel(x_t)$, represents the uncertainty. Bayes filters aim to sequentially estimate such beliefs over the state space conditioned on all information contained in the sensor data.

Kalman filters are the most widely used variant of Bayes filters. The algorithm works in a two-step process. In the prediction step, the Kalman filter produces estimates of the current state variables, along with their uncertainties. Once the outcome of the next measurement (necessarily corrupted with some amount of error, including random noise) is observed, these estimates are updated using a weighted average, with more weight being given to estimates with higher certainty. They approximate beliefs by their first and second moment, which is virtually identical to a unimodal Gaussian representation:

$$Bel(x_t) = \mathrm{N}(x_t; \mu_t, \Sigma_t)$$

$$= \frac{1}{(2\pi)^{d/2}|\Sigma_t|^{1/2}}$$

$$\exp\left[-\frac{1}{2}(x_t - \mu_t)^T \Sigma_t^{-1}(x_t - \mu_t)\right]$$

Here, $\mu_t$ is the distribution's mean (first moment) and $\Sigma_t$ is the d × d covariance matrix (second moment), where d is the state's dimension. $N(x_t; \mu_t, \Sigma_t)$ denotes the probability of $x_t$ given a Gaussian with mean $\mu_t$ and covariance $\Sigma_t$,. $\Sigma_t$ represents the uncertainty in the estimate—the larger the covariance, the wider the distribution's spread. Kalman filters are optimal estimators, assuming the initial uncertainty is Gaussian and the observation model and system dynamics are linear functions of the state. Kalman filters' main advantage is their computational efficiency. We can implement both the prediction and correction using efficient matrix operations on the mean and covariance. This efficiency, however, comes at the cost of restricted representational power because Kalman filters can represent only unimodal distributions. So, Kalman filters are best if the uncertainty in the state is not too high, which limits them to location tracking using either accurate sensors or sensors with high update rates.

## IV. CONCLUSION

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This paper gives the details of implementation of abandoned object detection with modified architecture. It is computationally efficient to use the wavelet coefficients for the analysis. Besides, unlike DCT based schemes, wavelet transformed data preserves the spatial content of the image frames. This spatial information made it possible to develop a robust tracking mechanism. Also the performance is increased by using machine learning algorithm for classification and hence the computational complexity is reduced.

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