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Home Security through Digital Image Processing based on IoT

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Abstract: - **This paper gives an outline for an automatic system to control and secure the home, based on digital image processing with the help of Internet of Things (IoT). The system consists of a sensor, digital camera, database in the fog and the mobile phone. Sensors are placed in the frame of the door which alerts camera, to capture an image who intends to enter the house, then sends the image to the database or dataset that is stored in the fog. Image analysis is performed to detect and recognize and match the image with the stored dataset of the authenticated people or pets. If the image captured does not match with the dataset, then an alert message is sent to the owner of the house. The image processing algorithms are considered for the processing spatial and time complexity of the image captured to cross check with the dataset stored in the fog.**

I. INTRODUCTION

The need of security systems for Homes is considered as one of the important aspects of our modern life. These systems could be motion detectors, monitoring cameras, door or window sensors, and Image analysis. The security system consists of two steps:

- Sensor-based systems which are used as movement sensors to trigger the security camera.
- Motion-based systems such as security cameras to capture the image for image analysis.

Image analysis is the mining of the dataset in a sequence of captured images by means of digital image processing techniques . Image analysis tasks can be as complicated as identifying a person from their face. Image Analysis is largely used for pattern recognition, digital geometry, and signal processing. Image Processing is processing of images using any form of signal processing for which the input is an image, or a series of images. The output of image processing may be either an image or a set of parameters related to the input image. Most of the image processing techniques treat the image as a two-dimensional signal and apply signal processing techniques to it. Images which consists of three-dimensional are processed as three-dimensional signals where the third dimension being time or the z-axis. Object recognition is also one of the techniques used for image processing. For, finding and identifying objects in an image or video sequence, despite the fact that the image of the objects may vary somewhat in different view-points, in many different sizes and scales or even when they are translated or rotated. Images can even be recognized when they are partially hindered from view. Appearance-based method like

- Grayscale-based matching
- Edge-based matching
- Divide and Conquer search

Is compared with prior dataset that is stored in the fog database. Algorithms like Template matching and Cooley-Tukey algorithm are used to compare and fetch the result. Due to the spatial and time complexity to reach a speedy solution to match the image captured with the dataset, we need an efficient algorithm.

II. RELATED WORKS

There are few papers related to home security and one among them is by Qusay Idrees Sarhan, discuss about the integrated Real-Time vision based Home Security System which is developed to detect any change of specific place of interest and inform with java technologies. Azegami and Fujiyoshi, described a systematic approach to intelligent building design. Kujuro and Yasuda discussed the systems evolution in intelligent building. Chung and Fu expected to set up the standard of appliances and communication protocols, and proposed a complete system architecture with integrate control kernel to construct an intelligent building. Mobile robots are main roles of the active detection modules in the security system. Yoichi Shimosasa et al. developed autonomous guard robot which integrated the security and service system [7]. Raghavendra Singh proposed a delayed- decision search algorithm for adaptive context-based image processing systems. The algorithm is based on the idea of classifying similar states and then pruning from among a set of states which shows the advantage of applying a delayed- decision processing to these systems [8].

III. PROPOSED SYSTEM

A. Problem Definition

The sensor that are fixed in the door, invokes the digital cameras in the rooms to capture image or motion. The captured image is sent to the fog where the dataset or database is stored. The Digital image processing techniques analyses and interprets the captured data. Information mining, Image enrichment and Feature extraction are the three imperative mechanism of digital image processing.

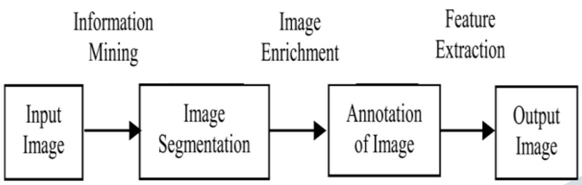

Fig. 1 Mechanism of Digital Image Processing

Image enrichment techniques help in improving the visibility of any feature of the image suppressing the superfluous information. Information mining techniques help in obtaining the statistical information about any meticulous portion of the image. An image processing system consists of a crossing point between the sensor system and the camera. The signal transmitted by the sensors is an either electrical or optical signal which is converted to digital signals. This signal invokes the camera to capture the image or motion and sends the image to the fog where the dataset is stored. The server or the database in the fog starts matching the captured image with the dataset, if it matches, then it takes no action. If the image doesn't match, then it sends an alert message to the owner or the authenticated person of the house. The spatial and time complexity involved in matching the image and the time taken to retrieve the information from the dataset in the fog is a concern. So, we deploy an efficient algorithm for spatial and time complexity to match the image in the database and to take the counter action.

B. Methodology

The contribution of this paper is to compare between the use of Template-based method and Fast Fourier Transform (FFT) with Twiddle Factors method which is used to retrieve and compare the image. The spatial and time complexity is involved while comparing the techniques. The Template-based consist of Grayscale-based matching and Edge-based matching, for templates without strong features. The technique of pyramid matching together with multi-angle search constitutes the Grayscale-based Template matching. The captured image is converted into Grayscale image in which the value of each pixel is a single section, that is, it carries only concentration information. Images are composed of many shades of gray in between, varying from black at the weakest intensity to white at the strongest intensity. Grayscale images are habitually the effect of measuring the intensity of light at each pixel in a single band of the electromagnetic spectrum and in such circumstances they are monochromatic appropriate when only a given frequency is captured. Edge- based matching enhances the Grayscale-based matching, that is, the shape of the object is defined mainly by extracting its edge and matches only the nearby pixels.

Template matching

Template Matching is a technique that identifies the segment on an image that matches a predefined template. Template matching techniques provide a reference image or a predefined image of an object and an image to be inspected or the captured image. This technique can be easily performed on grey-based images or edge-based images. Let us consider the search image as S(x, y), where (x, y) represent the coordinates of each pixel in the search image and the template as T(xt, yt), where (xt, yt) represent the coordinates of each pixel in the template. We move the origin of the template (xt, yt) over each (x, y) point in the search image, it calculates the sum of products between the coefficients S(x, y) and T(xt, yt) over the whole area spanned by the template. As all possible positions of the template are considered with respect to the search image, the position with the highest score is the best position. This method is also known as 'Linear Spatial Filtering'. A translation problem on images is handled, using template matching by comparing the intensities of the pixels, using the Sum of absolute differences (SAD) measure. A pixel in the search image with coordinates (xs, ys) has intensity as Is(xs, ys) and a pixel in the template with coordinates (xt, yt) has intensity It(xt, yt). The absolute difference in the pixel intensities is defined as

$$\text{Diff}\,(x_s, y_s, x_t, y_t) = |\, I_s(x_s, y_s) - I_t(x_t, y_t)\, | \qquad (1)$$

$$\text{SAD}(X,Y) = \sum_{j=0}^{Trows} \sum_{j=0}^{Tcols} diff(x+i.\, y+j, i, j) (2)$$

We loop the pixels in the search image as we translate the origin of the template at every pixel and take the Sum of absolute difference measure as Srows and Scols

$$\sum_{x=0}^{Srows} \sum_{x=0}^{Scols} SAD(X,Y)$$

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Srows and Scols denote the rows and the columns of the search image and Trows and Tcols denote the rows and the columns of the template image, respectively. In this method the lowest SAD score is the best position of template within the search image.

Fast Fourier Transform with Twiddle factor

Fast Fourier transform (FFT) algorithm computes the discrete Fourier transform (DFT). Fourier analysis converts a signal from time or space to a representation in the frequency and vice versa. Direct computation of both convolution and discrete Fourier transform (DFT) requires on the order of N2 operations, where N is the filter length or the transform size. The Cooley-Tukey FFT has the fact that it brings the complexity down to an order of N log2 N operations. As a result, it manages to reduce the complexity of computing the DFT from O (n2) which arises when we applies the definition of DFT, to O (n log n), where n is the data size. An FFT is a way to compute the sequence of values into components of different frequencies in the naive way. The difference in speed can be enormous, especially for long data sets, where N may be enormous in size. In practice, the computation time can be reduced by several orders of magnitude and the improvement is roughly proportional to N / log N. Let us consider, x0,...., xNí1 be the complex numbers. The DFT is defined by the formula

$$X_k = \sum_{i=0}^{N-1} x_n e^{-i2\pi kn/N} \qquad k=0,\dots,N-1 \quad (4)$$

X^k and x^i form a transform pair. Evaluating this definition directly requires O(N2) operations where there are N outputs Xk, and each output requires a sum of N terms. Evaluating the DFT's sums directly involves N^2 complex multiplications and N (Ní1) complex additions, of which O(N) operations can be saved by eliminating trivial operations such as multiplications by 1. The radix-2 Cooley–Tukey algorithm, for N a power of 2, can compute the same result with only (N/2)log2(N) complex multiplications and N log2(N) complex additions.

Cooley–Tukey algorithm

This is a divide and conquer algorithm that recursively breaks down a DFT of any composite size N = N1N2 into many smaller DFTs of sizes N1 and N2 as co prime, along with O(N) multiplications by complex roots of unity traditionally called twiddle factor. The best known use of the Cooley– Tukey algorithm is to divide the transform into two pieces of size N/2 at each step, and is therefore limited to power-of-two sizes, but any factorization can be used in general.

$$xn_2N1 + n_1e^{-i2\pi kn(n2N1+n1)/N}$$

$$A_{n1} = \{n_2N_1+n_1\} \quad (5)$$

Substituting (5) in (4) we get,

$$X_k = \sum_{n1=0}^{N1-1} \sum_{n2=0}^{N2-1} xn_2N_1 + n_1e^{-i2\pi kn(n2N1+n1)/N} \quad (6)$$

$$Y_{n1,k} = \sum_{n2=0}^{N2-1} xn_2N_1 + n_1e^{-i2\pi kn(n2N1+n1)/N_2} \quad (7)$$

Substituting (7) in (6) we get,

$$X_k = \sum_{n1=0}^{N1-1} Y_{n1,k}e^{-i2\pi kn1/N} \quad (8)$$

The result equation (8), expressing the DFT of length N recursively in terms of two DFTs of size N/2, is the core of the radix2 DIT fast Fourier transform. The algorithm gains its speed by reusing the results of intermediate computations to compute multiple DFT outputs. More generally, Cooley–Tukey algorithms recursively re-express a DFT of a composite size N = N1N2 as:

1. Perform N1 DFTs of size N2.
2. Multiply by complex roots of unity called twiddle factors.
3. Perform N2 DFTs of size N1.

Typically, either N1 or N2 is a small factor which not necessarily has to be prime, called the radix, which can differ between stages of the recursion. If N1 is the radix, it is called a decimation in time (DIT) algorithm, whereas if N2 is the radix, it is decimation in frequency (DIF), also called the Sande- Tukey algorithm.

C. Framework

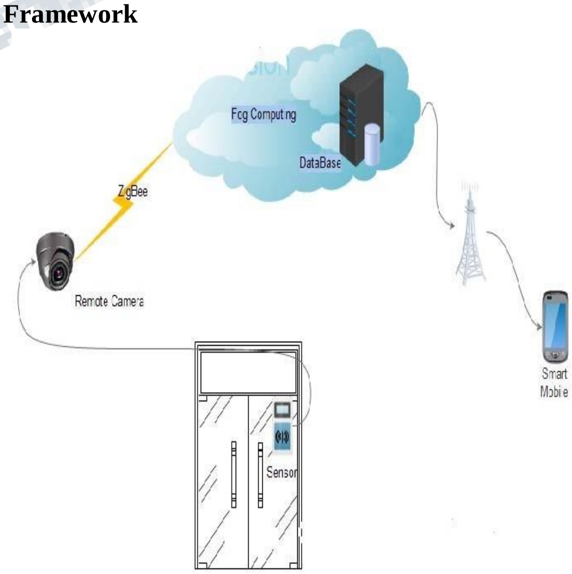

Fig 2. Framework for Home Security

The framework for the home security gives the outline of the components which consists of the Sensor in the frame of the door or window of the house. When the sensor rays that pass through gets cut or disturbed then it invokes the camera to capture the image or motion that occurs inside the house. The captured image is analyzed through the Template matching or Divide and conquer search with that of the dataset which was already stored in the fog database. Here, in fog storage we use these Digital image processing techniques in order to get even the complicated image that has been captured to be easily compare with the stored image. Even though, we retrieve the data from the fog computing in high speed when compared to cloud computing, we use the efficient algorithm for speedy process. If a mismatch occurs then an alert message is sent to the owner of the house to his/her mobile. Internet of Things (IoT) requests mobility support and wide range of Geo- distribution in toting up to location awareness and low latency features. Therefore, we needed a new platform to meet all these requirements. Fog computing as a paradigm that extends Cloud computing and services to the edge of the network. Fog reduces service latency and improves Quality of Service (QoS).

IV. CONCLUSION

To achieve the home security through the digital image processing techniques was followed to match the generated image with dataset in the fog database. Linear filtering and Fourier transforms are the most essential fundamental operations in digital signal processing. This process is done in a considerable time with the help of template matching and Cooley-Turkey algorithm. When, theoretically compare the Template matching and Cooley-Tukey algorithm, both is equally same and effective algorithms. In practical point of view, Cooley-Turkey algorithm is the efficient and best algorithm in terms of processing time and threshold. FFTs are of great significance to a wide range of applications, from digital signal processing and solving partial differential equations to algorithms. For the FFT algorithms there is no known proof that a lower complexity score is impossible. The Cooley-Tukey mapping in equation (5) is generally applicable, and actually the only possible mapping when the factors on N are not co-prime. While we have paid particular attention to the case N = 2n, this huge improvement made the calculation of the DFT practical. These practical algorithms when compared, the best possible ones, leading to an evaluation of their sub-optimality. Attractive features of Cooley-Tukey algorithm are its low arithmetic complexity and its relatively simple structure. In terms of, time and space complexity Cooley-Tukey algorithm is proved to be better than Template matching algorithm. The Home Security also can be done more effectively and speedily through the Cooley-Tukey algorithm which helps us to compare the capture image more appropriately and fetch the result more quickly from the fog database where improved security of encrypted data as it stays closer to the end user reducing exposure to hostile elements and improved scalability arising from virtualized systems.

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