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Research Article

Single Camera System for Surveillance, Identification and Reporting

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Abstract

Modern camera surveillance systems incorporates motion tracking facility which will reduce the system cost ,power consumption and improves the performance by sensing the movements of a suspected person. More over the system is capable to identify the person (thief)and able to report the same to the authority concerned ,it will definitely benefit the user to safe guard his valuables from theft and robbery. This system has to perform basically four operations such as sensing ,tracking, identifying and reporting .A PIR sensor array is used for sensing, an arduino based servo mechanism for tracking, A Gabor Volume based identification method for face detection and a GSM based system for reporting the location and details of the identified person. If the image of the person does not matches with the stored database, then information regarding the location with a remark "THE PERSON NOT IDENTIFIED "will be sent otherwise the matching information of the identified person will be sent. Our system performs very well with an accuracy of more than 71% with inputting the images from stored database and with an accuracy of 63% with real time captured images. The performance of this system is better with less complexity and low cost. ..

Keywords: *Camera surveillance system, PIR sensor, Gabor volume based local binary pattern*

1. Introduction

Automation of security systems has been an active area of research for several reasons. Over the past few years, a lot of surveillance and tracking systems are used in the locations that need to be monitored and controlled remotely by means of detecting devices and sensors. Automated systems are smart enough to manage the situations without any external support from humans. Nowadays a number of sensors are available, which can identify the presence, movement and even the nature of the objects within the sensing limit .More accurate and sensitive components are evolving day by day . This will simplify the sensing purpose and in turn simplifies evaluations and manipulations. A camera surveillance system has utmost importance in protecting ourselves from theft, robbery, attack etc. In usual practice we may be using some dedicated cameras for some dedicated purposes or directions. A single camera operated in a wide angle in different steps, always reduces the job of many cameras .To utilise a single camera to cover a large area is really challenging ,but all these are possible by utilising valuable inputs from different sensors from different locations. The role of sensors are very important, the efficient sensing of the motion from different location can manage the rest of the system efficiently .

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Face detection, face recognition and facial expression recognition has turned out to be the key areas of research in face analysis research. This is because of the immense potential of these in application fields such as machine vision, visual surveillance, automation systems, security Face recognition comes in the broad area of biometric systems. The International Biometric group (IBG), the biometric industry's leading independent integration and consulting firm providing broad range of biometric services and solutions since 1996, have evaluated the various biometric schemas and their effectiveness. This includes ease-of-use, cost, distinctiveness (accuracy), and perceived intrusiveness on the user. The need to extract unique discriminating features from a face and to increase the margin between the features of faces of different persons has made this area a critical and challenging one. The design of face recognition algorithms that are effective over a wide range of viewpoints is still a major area of research. The reliability of such systems has to be validated by precise testing and verification on real-world datasets

In this work, a PIR sensor array is utilised to gather the basic information regarding the movement in the considered area, it can sense the movements of a hot blooded animal or a human. The outputs from the sensor array is given as the input to the arduino uno board. Depending upon the sensed inputs from respective PIR sensor the arduino uno will run certain

sequence of the programme and based on that the servo mechanism will be activated. The movement of servo mechanism will be in the direction of the sensed input, the mounted camera on to the servo mechanism now will be ready to capture the video from that direction. If the person is moving from one sensor location to another, the arduino uno will drive the servo to that direction. So the activity of the person is continuously monitored. The camera can initially be operated in two modes –power saving mode and continuous tracking mode. In continuous tracking mode ,the camera will be rotated in steps, continuously and will capture the information. If any one of the sensors senses some movement ,the arduino will manage to rotate the camera in that direction .In power saving mode the camera and servo will be kept idle and whenever the sensor senses the motion ,the programme will drive the servo in that direction of the particular sensor and thus the camera will be made active and captures the motion, and can track the movement.

The captured information is given to the computer and the it will try to identify the person by using some MATLAB programme. For this we are using some stored data base. The programme will compare using Gabor volume based algorithms. If the captured image matches, with the stored one, the system will send a suitable message, with some id number of the person identified, with the help of GSM modem to the mobile no of the authority. If the image does not matches with that in the data base, a message " person not identified" will be sent with location details.

The remaining sections are organised as follows , section two is for the literature survey of sensors , face representation, analysis, and face detection . Section three deals with the proposed system, which includes the block diagram and the description of other components used. Section four deals with the implementation. Section five deals the result analysis

2. Literature survey

A literature survey has been done for the discussion of the recent technologies in the field of the surveillance systems. There are a number of designs and approaches being implemented to improve the systems.

2.1 PIR based systems

Byunghun Song (IEEE, 2008), made an performance analysis of a system with PIR Motion sensors and achieved a better results in real environments . Azghandi, M. V., Nikolaidis, I., & Stroulia. (IEEE 2015), demonstrated a simulator to embed the PIR motion sensors in a room with RFID tags to identify the person entered . Minh Pham (IEEE 2015) by deploying PIR motion sensors picked the body activity of the person. Particle filter-based sensor fusion algorithm proposed to increase the accuracy of detection. Authors Jeremy Schiff and Ken Goldberg (CASE'06 2006), used inexpensive PIR motion sensors for determining the position of an intruder by using the wireless network technique. They presented a model to determine the velocity and the probability of determining the location for any intruders. Upadrashta, R., Choubisa, T., Aswath, V. S)((ISSNIP, 2015). An animation-and-chirplet based approach to intruder classification using PIR sensors.

2.2 face analysis, representation and detection

Literature already points out the extensive research that has resulted in the development of several approaches based on various models and features. Image-based face recognition techniques can be mainly categorized into two groups based on the face representation which they use: appearance-based which uses holistic texture features; model-based which employ shape and texture of the face, along with 3D depth information

2.2.1 LBP based face description

The LBP operator [W. Zhao,2003] is one of the best performing texture descriptors and it has been widely used in various applications. It has proven to be highly discriminative and its key advantages, namely, its invariance to monotonic gray-level changes and computational efficiency, make it suitable for demanding image analysis tasks. The idea of using LBP for face description is motivated by the fact that faces can be seen as a composition of micro patterns which are well described by such operator**.**

2.2.2 G V-LBP Scheme

It is propose to explore discriminative information by modelling the neighbouring relationship not only in spatial domain, but also among different frequency and orientation properties. Particularly, for a face image, the derived Gabor faces are assembled by the order of different scales and orientations to form a third-order volume where the three axes X, Y, T denote the different rows, columns of face image and different types of Gabor filters, respectively[C. Liu and H. Wechsler2002].

2.2.3 GV-LBP-TOP

It can be seen that the existing methods can be applied on XT and YT planes to explore more sufficient and discriminative information for face representation. This techniques is christened GV-LBP-TOP. It first applies LBP analysis on the three orthogonal planes (XY, XT, and YT) of Gabor face volume and then combines the description codes together to represent faces. The codes from three planes are different and, hence, may supply complementary information helpful for face recognition. After that, three histograms corresponding to GV-LBP-XY, GV-LBP-XT, and GV-LBP-YT codes are computed. The GV-LBP-TOP histogram is

finally derived by concatenating these three histograms to represent the face that incorporates the spatial information and the co-occurrence statistics in Gabor frequency and orientation domains and, thus, is more effective for face representation and recognition.

2.2.4 Algorithm of GV-LBP-TOP

1. Compute Gabor face volume by convolving a face image with 40 Gabor filters.
2. Compute GV-LBP-XY, GV-LBP-XT, GV-LBP-YT codes based on XY, XT and YT planes of Gabor volume respectively.
3. Divide the face into several blocks and for each block, compute the local histogram HXY , HXT , HY T respectively and concatenate them into one H = [HXY ,HXT,HY T].
4. Concatenate the local histograms into a single histogram sequence and use the weighted histogram intersection defined in equation given below to derive the dissimilarity score.

$$D(H^1, H^2) = \sum_{i=1}^{n} w_i D(H_i^1, H_i^2)$$

where H^1,H^2denote the two histogram sequences and we is the weight for the it local histogram pair H_i^1 ,H_i^2 .

In this project, we take the similar measure in to set the weights for different blocks. For each block, we first compute the dissimilarity means mime and variations σ2i , σ2 e based on the block, for intra (the same person) and extra (different persons) sample pairs respectively and then the weight for the block can be computed following the fisher criterion as

$$w = \frac{(m_i - m_e)^2}{(\sigma_i^2 + \sigma_e^2)}$$

where mi, σ2i denote the mean and variation of intra sample pairs and me, σ2e are those of extra sample ones.

2.2.5 LGBPHS Based recognition

Local Gabor Binary Pattern Histogram Sequence (LGBPHS) is actually a representation approach based on multi-resolution spatial histogram[W. C. Zhang,2005]. It combines local intensity distribution with the spatial information, Therefore, it is robust to noise and local image transformations due to variations of lighting, occlusion and pose. Additionally, instead of directly using the intensity to compute the spatial histogram, multi-scale and multi-orientation Gabor filters are used for the decomposition of a face image, followed by the local binary patterns (LBP) operator. The combination of Gabor and LBP further enhances the representation power of the spatial histogram greatly. To construct the LGBPHS model, one does not need a training stage necessarily, which has naturally avoided the generalizability problem. For recognition, histogram intersection is used to measure the similarity of different LGBPHS and the nearest neighbourhood is exploited for final classification. Additionally, considering the fact that different local regions in face image are with different contribution to classification.

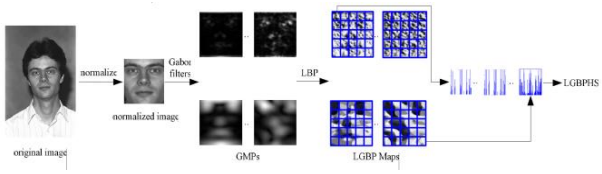

Fig 1: The framework of the proposed LGBPHS face representation approach

This technique is found to be impressively insensitive to appearance variations due to lighting, expression, and aging. Moreover, the modelling procedure of LGBPHS does not involve in any learning process, that is, it is non-statistical learning based. Therefore, the inherited generalizability problem is naturally avoided in this representation approach. The effectiveness of the LGBPHS comes from several aspects including the multi-resolution and multi-orientation Gabor decomposition, the Local Binary Pattern, and the local spatial histogram modelling. LGBPHS actually consists of many pieces of histogram corresponding to different face components at different scale and orientation. Basics of Proposed Scheme

The scheme that is proposed in this project uses LBP operator and Gabor wavelets.

22.6 LBP Operator

The operator assigns a label to every pixel of an image by thresholding the 3X 3-neighborhood of each pixel with the centre pixel value and considering the result as a binary number, as shown in the figure.

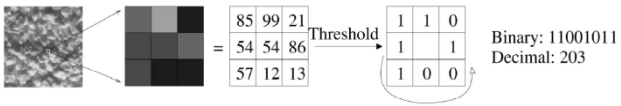

Fig 2: LBP operation

Then, the histogram of the labels can be used as a texture descriptor.

The LBP operator was can be extended to use neighbourhoods of different sizes. Defining the local neighbourhood as a set of sampling points evenly spaced on a circle cantered at the pixel to be labelled allows any radius and number of sampling points. Bilinear interpolation is used when a sampling point does not fall in the centre of a pixel. In the following, the notation (P,R) will be used for pixel neighbourhoods which means P sampling points on a circle of radius of R.

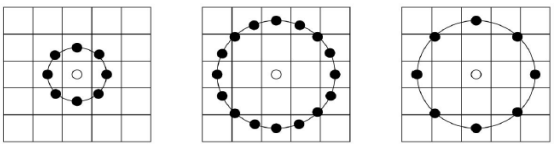

Fig 3: The circular (8,1), (16,2), and (8,2) neighbourhoods

Another extension to the original operator is the definition of so-called uniform patterns. A local binary pattern is called uniform if the binary pattern contains at most two bitwise transitions from 0 to 1 or vice versa when the bit pattern is considered circular. For example, the patterns 00000000 (0 transitions), 01110000 (2 transitions) and 11001111 (2 transitions) are uniform whereas the patterns 11001001 (4 transitions) and 01010011 (6 transitions) are not uniform. In the computation of the LBP histogram, uniform patterns are used so that the histogram has a separate bin for every uniform pattern and all non uniform patterns are assigned to a single bin

3. Proposed System

3.1Block diagram

The block diagram of A single camera system for surveillance is shown in Fig. 5

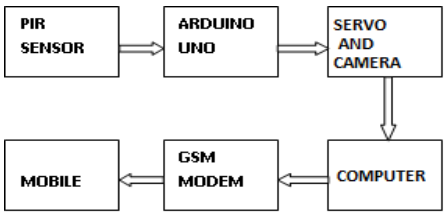

Fig 5: Block diagram

The system can be implemented using these blocks . the function of sensing is carried out by an array of PIR sensors. The output of the sensor array is given to the micro controller and it will control the servomotor and camera assembly. The output from the camera is given to a computer with matLab. The program will compare and identify the image from the camera. The computer will transfer a message to the mobile hand set through the GSM modem.

3.2 System requirement

- Arduino uno, resistors , capacitors ,PIR sensors servo mechanism, camera, computer with matLab , GSM modem etc.

- 3.2.1 Micro Controller

It plays an important role in this system. The required program is dumped in the Micro controller. It always takes the input from various devices present the circuit and performs operations in controlling motor. Here we use Arduino uno R3.

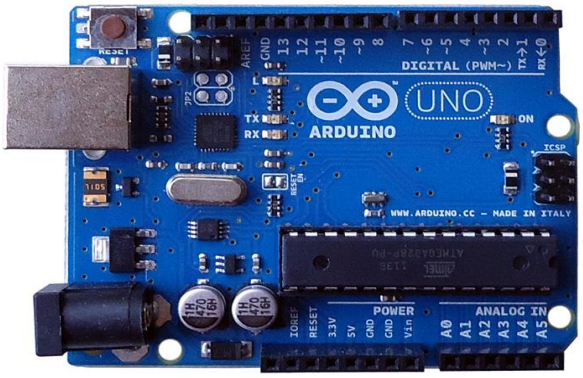

Fig.6: Arduino board

The Arduino Uno is a microcontroller board based on the AtMega328.It has 14 digital input/output pins(of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller. Simply connect it to a computer with a USB cable or power it with an AC to DC adapter or battery to get started. The UNO differs from all preceding boards in that it does not use the FTDI USB to serial driver chip. Instead, it features the AtMega8U2 programmed as a USB to serial converter.

3.2.2 PIR Sensor

- We used the HC-SR501 model PIR sensors for this project. Each PIR sensor needs to be connected to a digital input (2-6) on the Arduino, 5V power, and ground. We connect each PIR sensor to the corresponding LED light in the code.

Fig. 7: PIR sensor

3.2.3 Servo motor

- The servo motor is attached to the stand where the camera sits, and rotates the camera to align with the active PIR sensor.
- Using the pinout for our motor, connect one pin to power source, another pin to the Arduino digital input 7, and the last pin to ground.

Fig. 8: Servomotor

3.3 Proposed Scheme for Face detection

3.3.1 Gabor Wavelets

The Gabor wavelet representation captures salient visual properties such as spatial localization, orientation selectivity, spatial frequency characteristic. Gabor wavelets were introduced to image analysis due to their biological relevance and computational properties. The Gabor wavelets, whose kernels are similar to the 2-D receptive field profiles of the mammalian cortical simple cells, exhibit desirable characteristics of spatial locality and orientation selectivity, and are optimally localized in the space and frequency domains.

The Gabor kernels we used are defined as follows:

$$\psi_{\mu,\nu}=\frac{k_{\mu,\nu}^2}{\sigma^2}\exp\left(-\frac{k_{\mu,\nu}^2 z^2}{2\sigma^2}\right)\times\left[\exp(ik_{\mu,\nu}z)-\exp\left(-\frac{\sigma^2}{2}\right)\right]$$

where μ and ν define the orientation and scale of the Gabor kernels, respectively, z=(x,y) and the wave vector $k_{\mu,\nu}$ is defined as $k_{\mu,\nu}=k_{\nu}e^{i\varphi_{\mu}}$ where $k_{\nu}=k_{\max}/f^{\nu}$, $k_{\max}=\pi/2$, $f=\sqrt{2}$, $\phi_{\mu}=\pi\mu/8$.

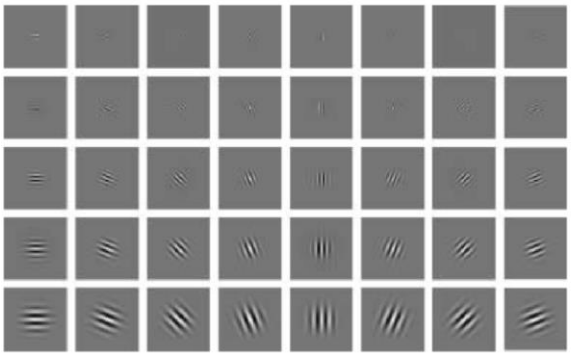

Fig 11: The real part of the Gabor kernels at five scales and eight orientations with the following parameters

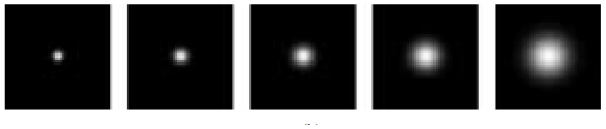

Fig 4: The magnitude of the Gabor kernels at five different scales

Here we use Gabor kernels at five scales $\nu \in \{0,1,2,3,4\}$and eight orientations $\mu \in \{0,1,2,3,4,5,6,7\}$with the parameter $\sigma = 2\pi$ to derive the Gabor representation by convolving face images with corresponding Gabor kernels. For every image pixel we have totally 40 Gabor magnitude and phase coefficients, respectively, that is to say, we can obtain 40 Gabor magnitude and 40 Gabor phase faces from a single input face image. For the centred point I, I0 and I4 are the orientation neighbouring points; I2 and I6 are the scale neighbouring ones; I1, I3, I5 and I7 are the neighbouring points in spatial domains. Like LBP, all the values of these points surrounded are compared to the value of the centred point, threshold into 0 or 1 and transformed into a value between 0 and 255 to form the E-GV-LBP value[W. C. Zhang,2006]

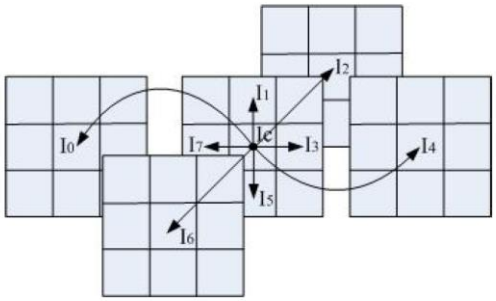

Fig 9: Formulation of E-GV-LBP

The E-GV-LBP value can be found using the given equation

$$E-GV-LBP=\sum_{p=0}^{7}2^{p}S(I_p-I_c)$$

where S(IP-IC) is a threshold function defined as

$$S(I_p-I_c)=\begin{cases}1 & \text{if } I_p-I_c\geq 0\\ 0 & \text{if } I_p-I_c<0\end{cases}$$

4.Implementation

4.1 Deploying of PIR sensors

Here we used five PIR sensors in the array. One sensor can trace 30 degrees so movements within this will be identified by the particular sensor. All the five sensors are arranged to manage 30 degrees each so as a total of 180 Degrees can be controlled by these sensors.

4.2 Servo and Camera

The camera is mounted to the same structure of the servo, so whenever servo rotates the camera also can rotate in that direction.

4.3 Arduino uno programming

This is programmed in such a way that a mode selection is possible as two modes are set. Continuous tracking mode and power saving mode. In continuous tracking mode the camera will be capturing images continuously in steps of 30 degrees. If any one of the PIR sensor is active, then the programme will manage to rotate the camera in that particular direction. In power saving mode the camera will be inactive and if a sensor senses some motion the system will activate the camera and turns in .that direction, then it can continuously track the movements.

4.4 Face detection and reporting

The camera output is given to a computer, By using face detection algorithms ,compares the image with the stored database, then identifies .

4.4.1 Algorithm

1. Compute Gabor faces by convolving a face image with different scales and orientations Gabor filters.
2. Compute effective GV-LBP code introduced on Gabor faces.
3. Divide the face into several blocks and for each block, compute the local histogram H of E-GV-LBP code.
4. Concatenate the local histograms into a single histogram sequence and use the weighted histogram intersection to derive the dissimilarity score.

4.4.2 Software Requirement

Using MATLAB 7.6.0.324 (R 2008a) version, this project can be implemented. Database Requirement

For testing of face detection we utilised standard databases

Several standard databases are available for implementing and testing face recognition problems. The AR database contains occlusions due to eye glasses and scarf. The CMU PIE database is collected with well-constrained pose, illumination and expression. FERET and XM2VTS databases are the two most comprehensive databases, which can be used as a benchmark for detailed testing or comparison. It is proposed to use The FERET database which is one of the largest publicly available databases ,or any Indian data base

Face detection was done using a database of human face images called Indian Face Database. The database can b e viewed and downloaded at the following web address http://vis-www.cs.umass.edu/~vidit/AI/dbase.html. This database has been created by Vidit Jain and Dr. Amitabha Mukherjee in cooperation with Neeraj Kayal, Pooja Nath and Utkarsh Hriday Shrivastav.

The database of faces contains a set of face images taken in February, 2002 in the IIT Kanpur campus. The database was prepared in the context of a face recognition project carried out in the course Artificial Intelligence in the Computer Science and Engineering Department.

There are eleven different images of each of 61 distinct subjects. For some subjects some additional photographs have been included. All the images were taken against a bright homogeneous background with the subjects in an upright, frontal position. A preview image of the database is shown below.

Fig .10: preview image

The files are in JPEG format. The size of each image is 640x480 pixels, with 256 grey levels per pixel. The images are organized in two main directories - males and females. In each of these directories, there are directories with name as a serial numbers, each corresponding to a single individual. In each of these directories, there are eleven different images of that subject, which have names of the form abc.jpg, where abc is the image number for that subject. The following orientations of the face : looking front, looking left, looking right, looking up, looking up towards left, looking up towards right, looking down- are present in the database. Various emotions like neutral, smile, laughter, sad/disgust are present in the database.

The information regarding identified person will be sent to the authorized person through GSM modem with suitable captions . If the person is not identified, the information regarding the location will be sent to the police department.

5.Results

The system is capable to cover a moderate area such as a hall , museum ,park etc with 180 degrees of rotation in Five steps, each can trace 30 degrees. A smooth movement of servo mechanism is observed. The camera captured real time videos .The images from these videos are used to analyse the face detection. For better face detection rates we used standard data base.

Two common parameters used to measure the performance of the Face Recognition system are Recognition Rate and Recognition Accuracy.

Recognition Rate is defined as the percentage of number of faces correctly recognized. It is the ratio of number of faces correctly identified to total number of faces given for identification.

$$\text{Recognition Rate} = \frac{\text{Number of faces correctly identified}}{\text{Total number of faces}} \text{X } 100$$

Recognition accuracy is the number of occurrence of face of a single person identified correctly. It is the

ratio of number of occurrence correctly identified to total number of test faces of a single person given for identification multiplied by 100.

$$\text{Recognition Accuracy} = \frac{\text{Number of occurence correctly identified}}{\text{Total number of test faces of a single person}} \text{ X } 100$$

Table.1 Recognition rate

	Front Faces	Side Faces
Recognition Rate	77.94%	72.68 %

There are around 61 subjects in the database. Various poses of the subjects under various conditions were used as the test images. It has been found that the average recognition accuracy is 71.72% in the simulations.

The information regarding the identified image is successfully sent to the authority using GSM modem.

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