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# Heuristics of Machine Learning for Home Intrusion Detection Application

**Chatharajupalli Navya Sneha, Illuri Sreenidhi, Penke Satyanarayana**

***Abstract:Security has become a very vital role in present modern world. We need security for various applications and for our data. In particular security in home application is very crucial. So to serve this purpose in an efficient and easy manner we developed an intrusion system where in HOG (Histogram of Oriented Gradients) algorithm is used to detect person and an API to give alerts for intrusion. HOG is the Machine Learning (ML) algorithm used particularly for the person detection. The API used here is TWILIO which is the most suitable API for sending messages within seconds and accurately. Since every system is becoming automated we focused more on implementing the HOG and making the system to learn by itself and perform accurate results. In this paper we explained how HOG algorithm is implemented to detect the person entering the house and send the alerts as the person is detected. The accuracy of the model along with further developments that can be possible is given in detail.***

***Keywords: Machine Learning (ML), Histogram of Oriented Gradients (HOG), Open Source Computer Vision (OpenCV), Scale-Invariant Feature Transform Descriptors (SIFT), Amazon Web Services (AWS), Global System for Mobile Communications (GSM), Support Vector Machine (SVM)***

## I.INTRODUCTION

ML (Machine learning) is effective the study of algorithms and mathematical methods used by intelligent systems to perform a fixed task without using specific instructions, on the basis of patterns and inferences. It is known as artificial intelligence subset. ML algorithms [1] create an example information dependent mathematical method, known as training data, to make assessments or decisions without the functions being specifically designed. Machine learning algorithms are useful in a huge range of applications, such as computer vision and email sorting where designing a basic algorithm is impossible or unfeasible to execute the task effectively. ML is closely related to statistics of machine, which focuses on predictions made by computer. The analysis of mathematical optimization provides the field of machine learning with techniques, theory and application domains. Data mining is an area of study within the ML which focuses on experimental data analysis through unsupervised training. Machine learning is also referred to as predictive analytics in its implementation through business problems.

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***** Correspondence Author
**Chatharajupalli Navya Sneha***, Department of Electronics and Computer Engineering, KLEF, Andhra Pradesh, India.
**Illuri Sreenidhi**, Department of Electronics and Computer Engineering, KLEF, Andhra Pradesh, India.
**Penke Satyanarayana**, Department of Electronics and Computer Engineering, KLEF, Andhra Pradesh, India.



The fundamental idea of descriptor histogram of oriented gradients (HOG) [2] is the shape and position of localobject among the images can be represented by the edge directions or distribution of gradients of intensity. The image is partitioned into small connected areas named cells, and a gradient direction histogram is compiled for the pixels in each cell. Both histograms are concatenated by the descriptor. The contrast-normalization of local histograms can be used to enhance the efficiency by measuring the intensity of calculation across the wider area of frame, known as block, which are used to value and stabilize cells in the block. Such normalization leads to increased invariability in lighting and shadowing shifts. The HOG as a function descriptor was used in object detection purposes in computer vision and image processing. This method calculates the number orientations for gradient in image which have portions that are localized. This approach is a close technique to histograms of shape contexts, SIFT descriptors for edge orientation, but it is varied in the assessment of a heavy grid of spaced cells that are uniform and uses overlap local contrast normalization to increase performance. There are various research papers based on the HOG algorithm implementations. Mostly the techniques include the detection of person on the traffic or at a particular area. The bounding boxes are huge problem in the HOG algorithm [5] in order to avoid this problem a hybrid model based on the HOG and its implementation using SVM is been developing. In the HOG algorithm the main focus should be made on the scale value in order to give an exact detection of persons individually without any overlapping. The other applications of the HOG include the pedestrian detection, people counting and so-on.The descriptor of the HOG has some significant advantages than other relevant descriptors. Because it acts on local cells, with the exception of object orientation, it is uniform to photometric and geometric shifts. This improvement will occur for larger regions of space only. In addition, strong local photometric normalization, coarse spatial sampling and fine orientation sampling allow each pedestrian movement and can be ignored for a period, until they maintain an approximate position. Therefore, the HOG descriptor is specifically suitable for the identification of persons. Intrusion system plays an essential task in home security [6] applications. Previously the intrusion system mostly has GSM [8] or other devices interfaced to it so that the alerts can be sent to the owner of the particular house but due to rapid development of the various cloud API's it has become easy to send alerts without any addition hardware. The API's are very reliable and sends information relatively with high speed and accuracy.

There are various API's available online we can use any one of them. For this particular project we have used the TWILIO [4] API for sending the alerts.

## II. ALGORITHM IMPLEMENTATION

Normally in real time we generally use HOG approach of machine learning for identifying a person. We need different scaling factors to be taken into consideration for the detection of person using the bounding boxes. When we use the appropriate scaling we get the detection accurately for the person present in the frame. The HOG algorithm for person detection follows the following steps to be computed

### 2.1 Gradient computation

In several feature detectors, the first step of image pre-processing calculation is for maintaining the gamma values and normalized colour. Therefore, this method can be skipped for computing of the HOG descriptor, since subsequent standardization of the descriptor efficiently achieved the same output. Pre-processing of images has, therefore, no influence for performance. Rather, the gradient values determination is the foremost step to be calculated. One or both vertical and horizontal directions in the 1D centred, point-discrete derivative masks is the relevant technique. This approach specifically required the filtering of image's colour or intensity information.Researchers have tried other more complicated masks like diagonal masks or sobel mask (3x3), but usually these masks were less effective in detecting people in pictures. Until adding the derivative mask they tried with gaussian smoothing and found that smoothing omission in practice have proven to be better.

### 2.2 Orientation binning

The next method in algorithm is the calculation for evaluating the histograms for single cell. Inside each cell pixel performs a calculated vote and depending on the values found in the calculation of gradient the orientation will be based on histogram flow. The cells can be rectangular, from 0 to 360 degrees and 0 to 180 degrees the histogram channels are spread equally, depending on whether or not the gradient was allocated. Researchers found that unsigned gradients used in their human detection [6] experiments in combination with 9 histogram channels are proved to be best. As for the weight of the vote, the contribution of pixels may be either the gradient magnitude itself, or other magnitude variable. Generally, gradient magnitude itself provides best outcomes in the trials. Certain voting choices may include a clipped variable of magnitude, or gradient of square root or square magnitude,

### 2.3 Descriptor blocks

In general, square grids are representation of HOG blocks, and have main important parameters such as number of channels, pixels per cell and cells per block for each cell histogram are taken. For person detection [7] test, four per frame 8x8 pixel cells and 9 histogram channels are defined to be the optimal parameters. However, the researchers found that some small changes in value may be made by inserting spatial gaussian window before calculating histogram votes to weigh pixels mostly around the edge of the frames in each block. R-HOG blocks tend to be same as SIFT. Therefore, given the same structure the R-HOG blocks can be measured at some single level in dense grids with no orientations alignment, while descriptors that usually determine at low are SIFT, rotated for orientation alignment and scale-invariant key object points. Spatial shape data in combination with SIFT descriptors being individually used are generally represented by R-HOG blocks.

### 2.4 Block normalization

Four separate block normalization approaches are discussed by some researchers. For this we take vas the non-normalized vector that contains the histograms in a given frame, its k-norm can be$\|v\|_k$ , k and e are small constants (hopefully the accurate value is not necessary).

### 2.5 Person detection

HOG descriptors can also be used to identify objects by supplying them with a machine learning algorithm as applications. In SVM (support vector machine), researchers used HOG descriptors as features; on other hand HOG descriptors were not related to any machine learning algorithm.

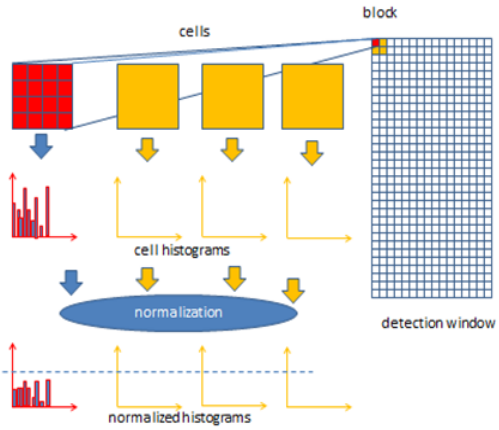


Fig. 1. HOG feature extraction process

From the above figure 1 we can know clearly how the HOG descriptor uses the SVM technique for the human detection. HOG for person detection follows the following steps:

- Scan a picture using detection window.
- For each position and size of detected window, the gradient is computed.
- It is divided into cells and a gradient is compared for each pixel and gradients are used to fill a histogram.
- The histograms of all cells are put together and fed to machine learning discriminator to decide whether cells of current detection window corresponds to a person or not.

## III. IMPLEMENTATION OF INTRUSION SYSTEM

In this system we have used a processor (whether it may be a PC or any embedded hardware), a simply camera connected to it which takes the continuous feed. And for the implementing of HOG algorithm we used the OpenCV and for sending the alerts we used Twilio. The proposed intrusion system is shown in figure 2.

### 3.1 OpenCV (Open Source Computer Vision)

It is a library function primarily focused for programming in computer vision for real time applications. It is developed by Intel and Itseez originally, which is also again acquired by Intel and then sponsored it. The software was used by open-source BSD license which is cross-platform and free to use. OpenCV supports TensorFlow, Torch / PyTorch and Caffe's deep learning frameworks. OpenCV [3] is originally programmed and primary interface are both in C++, but it still maintains an older C interface that is less detailed though extensive. Python, Java, MATLAB have bindings. The interfaces were found in the internet. Wrappers are created for many languages such as Ruby, Haskell, Perl, Ch and C #to enable more audience to embrace them. OpenCV.js has been a JavaScript binding for the web platform's selected subset of OpenCV functions since version 3.4. In the C++/Python interface, all new technologies and algorithms in OpenCV are now being developed.

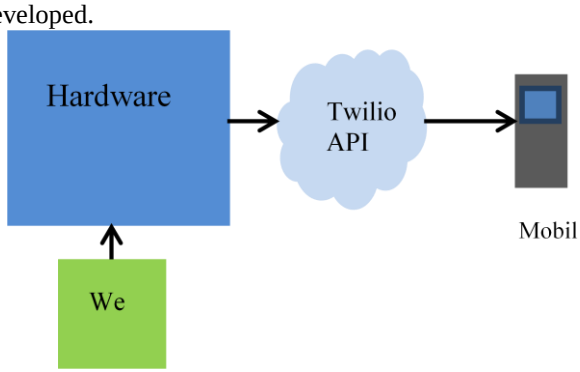


**Fig.2. Proposed Intrusion system**

### 3.2 Twilio API

Amazon Web Services provide the communication network for Twilio [4] and also provide access through its APIs between HTTP and PSTN. Twilio incorporates a collection of design concepts to avoid unintended failures and has got support to stay available during the major AWS (Amazon Web Services) outage in April 2011.Twilio promotes open-source software development and contributes to the open-source community on a regular basis. Twilio released OpenVBX in June 2010, an open-source service which enables corporate users to customize their telephone numbers for receiving and routing calls. Stashboard was released by Twilio developer Kyle Conroy, python programming is used to develop the dashboard for open-source from this process an API or application provider can show how their product is working properly. Twilio provides support for local tunnel, developed by Jeff Lindsay who is a former Twilio employee. It allows developers to reveal their development environment from behind a NAT to the public internet. Twilio lists on their website a variety of many open projects that include:

1. Flask Restful: REST APIs were created by Python Flask.
2. Shadow: Process the requests with real production traffic through a release candidate
3. Banker's Box: Space backend cover

From figure 2 we have an intrusion system with the hardware it may be PC or any embedded system and it is interfaced with the web cam. The process will be whenever a person enters the house or any kind of secured room the HOG algorithm identifies the person using the camera feed and it will immediately give an alert message to the end user using the Twilio API. This system overcomes the previous systems where there are various other devices connected to it to give the alerts. So this system essentially reduces the power consumption due to less hardware and there are no delays or errors during the information transfer.

## IV. RESULTS

The particular message is generated whenever the person enters the room or house. The time took for Twilio is within seconds and there is no problems like networks issues since we are using the cloud based interface for our alerts, wherein previously the GSM has network and power issues for the message transfer. This system overcomes all the above cases. This is possible only if we have the high speed processors (Raspberry pi4 or any PC) which are continuously connected to the internet without any interruption. And also we can use any USB or PiCamera for the video feed to the processor.


**Fig. 3. Alert message send using Twilio**

## V. CONCLUSION AND FUTURE WORK

A suitable system for the intrusion detection has been developed and the implementation of the system was done effectively. The implementation of HOG algorithm is done properly and there was overlapping of detection boxes, so we have to set a suitable scaling factor for bounding boxes so person detection is done accurately. Moreover for this scaling factors there are some in built methods in HOG algorithm which we can make use of. This system is easily understandable and accuracy is more compared to the previous systems which uses GSM. In future this work can be extended by taking the live images of a person and sending them to user to give alert of intrusion. And we can integrate the HOG with SVM algorithm to detect the person more accurately.

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## AUTHORS PROFILE

**Ms.Chatharajupalli Navya Sneha**is currently pursuing Masters of Technology in Embedded Systems, Koneru Lakshmaiah Education Foundation(KLEF), Andhra Pradesh, India. She obtained Bachelor of Technology in Electronics and Communication Engineering in 2017.

**Ms.Illuri Sreenidhi**is currently pursuing Masters of Technology in Embedded Systems, Koneru Lakshmaiah Education Foundation(KLEF), Andhra Pradesh, India.She obtained Bachelor of Technology in Electronics and Communication Engineering in 2016.

**Dr. Penke Satyanarayana** is a Professor & Head in the Dept. of Electronics and Computer Engineering.He obtained his B.Tech (Electronics) from Koneru Lakshmaiah College of Engineering , M.Tech (ECE) with specialization in "Computers and Communications" in Department of Electronics and Communication Engineering, JNTUH, Hyderabad and Ph.D. from JNTUK University, Kakinada. For the last 18 years, he is involved in teaching and research in the areas of Wireless Communication, Signal Processing, Embedded Systems and VLSI. He is supervising 8 Ph.D. students and supervised more than 50 B.Tech and M.Tech Projects. He published several papers in National & International journals.He received a best Teacher award from KLEF in 2012.