Camouflage Surveillance Robot In Defense Using Artificial Intelligence

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Abstract - *Currently, the military federations are taking assistance of robots within the risk-prone areas which aren't effective when done by army men. In the proposed system the idea is based on the chameleon's Camouflage technique. One of the most aims is to implement an autonomous camouflaged technology-based wireless multifunctional robot that can be controlled through a PC i.e., the camera captures the image and the robot will change its color according to the surrounding ground hue detected at the rear end. Camouflage robot plays a huge role in saving human loses also the robot can serenely enter into the enemy area and send information via camera to the controller. The dark vision camera is used for surveillance purposes. The scope lies within the enemy gun targeting to trace the intruders along with landmine identification. The camouflage robot basically works as a subsidy for the military. Thus, in the proposed model we enforce an AI expert multi-sensor data fusion-based decision-making system to track enemy movement and conduct reconnaissance in unknown areas of a war zone.*

Key Words: **Camouflage, Artificial Intelligence, ZigBee module, LED's, Laser gun, Arduino Microprocessor (ATMega 328).**

1. INTRODUCTION

In the modern combat techniques employed by numerous militant forces across the globe, stealth and the ability to maneuver in inaccessible areas play a key role. Army robot is an autonomous robot comprising of a wireless camera that can be used as a spy.

The idea of the proposed system is to implement a camouflaged technology-based wireless multifunctional army robot capable of disguising itself to infiltrate the enemy campsite embedded with AI features. The word robot means "A machine which is capable of performing complex series of actions automatically that is programmable by a computer." These robots used in defense are usually employed with integrated systems, including cameras, sensors, and video screens. The main motive behind Camouflage Robot is to substitute human losses in terrorist attacks or military operations. Camouflage robot acts as a virtual spy which may faintly enter into the enemy area and send information via camera to the controller. Robots are often made to interact and cooperate more closely with the citizenry by incorporating additional features like robustness and autonomy.

A versatile perception and recording of various parameters during this robot are accomplished employing a multi-sensor platform. In this system, an interfacing module is incorporated to remotely sense the thing parameters using IOT. Since it's exceptionally hard to detect it by an unadorned human eye, the Camouflage robot is often also won't test the varied security systems developed within the market & act as a measure to evaluate its efficiency. Engineering camouflage aims is to form the detection and recognition target difficult within the machine-assisted eye searching target within the massive breadth background around.

The purpose is to implement the system (model) for a particular face and distinguish it from a large number of stored faces with some real-time deviations as well. This model consists of a mobile robot, restrained by the web, which features a camera mounted and a PIR sensor for detecting the living bodies. The user will be able to control the robot through the internet, thus, providing wireless control of the robot.

Face recognition is one of the most promising fields in computer vision plays an important role in conveying identity and emotions. Face detection is a computer coding technology that determines the location and size of human faces in a given image format. It detects only the facial features and ignores the rest.

Human capabilities are very good at recognizing and remembering faces despite the passage of time. Hence, it is essentially beneficial if the current computer technologies become robust as humans in face detections.

Training a machine learning algorithm can take a great deal of data to achieve maximum optimization and reduce error. In this paper, we will try to differentiate between the implementation of different algorithms in OpenCV. OpenCV provides us the freedom to run on any platform that supports the execution of python coding. It can be used on machines with Windows, mac OS or, Linux. Here we discuss three algorithms, Haar cascades and Local Binary Pattern Histogram (LBPH) and, Eigen face. These algorithm performances were evaluated based on some parameters. In our simulations in OpenCV, the examples shown are real-time and images are captured by using a USB camera.

Prem Kumar has proposed a reviewed systems used color detection sensor which requires the object to be close to detect the color of the object using Zigbee Technology[1].

Akshay Ravindran has proposed the camouflaging feature makes it difficult to detect the robot by the unaided human eye. The color sensor detects the color of surrounding surfaces & determines the color of surroundings [2].

M.Jagtap has proposed the various techniques and comparison of Machine Learning algorithms based on certain parameters and the performances of algorithms in face detection for automation[3].

S.Bhargavi has explained an idea for automated border control to represent one area in the digital transformation of border control Additionally, it has been based on artificial intelligence and the safety of the robot[4].

The unique property of face detection is quite robust despite large variations in visual stimulus due to changing conditions such as environment, aging and, other natural factors (beards, mustache, hairstyles and, spectacles). Facial recognition can be practiced to a larger extent on video footage in real-time for more people [5].

2. OBJECTIVE

Our main aim is to enhance the communication between soldiers and military room by using advanced and highly efficient, powerful systems.

- To design a camouflaging robot that uses face recognition to detect entry of trespassers at the borders.
- Our robot should assist soldiers and try to prevent the damage that might arise due to terrorist attacks (intruders), hidden ground bombs.
- Ability to change its color (LED's) while in motion according to the surrounding environment.

A Gun Targeting system is an AI-based detection and targets - the living object or any movement in highly secured areas.

3. PROPOSED MODEL

This paper describes the working of the army robot as shown in Fig.3.1 and Fig.3.2. The principle is based on Artificial Intelligence ,Surveillance, and Reconnaissance i.e. to track enemy movement and conducting reconnaissance in unknown areas of a war zone. The project aims is to design, develop and, implementation of an autonomous smart surveillance system with AI-assisted decision making and camouflage using Haar-classifier and LBPH algorithm to monitor the trespassers. The automatic gun targeting system will enhance border security using automation. Apart from this, the main feature is the camouflage technique; i.e.it can reproduce the color accordingly with the ground surface, based on the hue color hence being camouflaged to the outside world. We've used LEDs that will diffuse uniform colors, coupled to sensors that will precisely identify the color of the bottom. On the opposite hand, AI assisted common operating picture would catalog and display a disposition of friendly and enemy forces, automatically built and updated through an enormous data approach. Here the model is redesigned to compel the machine to perform multitask so that along with checking for several parameters for monitoring, it also carries out other significant tasks on its own using IOT.

Block diagram comprises arduino, an open-source electronics platform based on easy-to-use hardware and software, camera for capturing the images, IR sensor to sense the presence of humans, proximity metal sensor for metal identification, the relay acts as a switch for both LED and laser, DC motor for backward and forward direction with H- Bridge and, Zigbee acts as an information trans-receiver with a power supply.

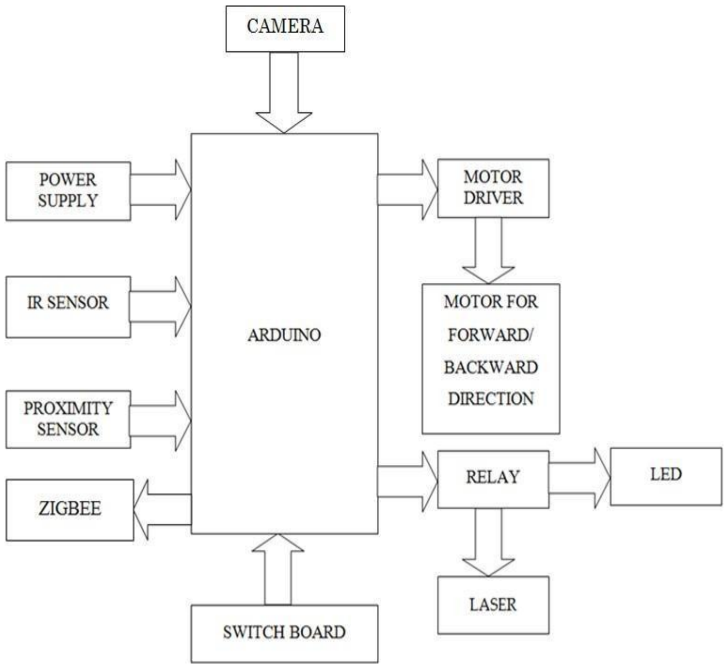

Fig -3.1: Block Diagram of Camouflage Robot

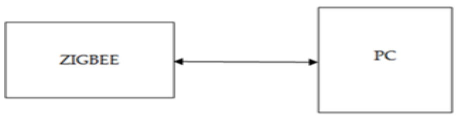

Fig -3.2: Base Station

The camouflage robot uses arduino Microprocessor (ATMega328) board and works on python language. Each of the programming languages used in this robot has its working process like (motor control, camera movement, and display control).

All the input and output actions are performed by the developed robot whereas on the PC side all the image processing is done. The robot is mounted with input devices like a camera, obstacle sensor and, proximity sensor to collect all the required data for processing. The computer then does the processing of the received data using various algorithms for image processing. HAAR Cascade algorithm and Local Binary Pattern Histogram (LBPH) algorithm are primary algorithm techniques used to determine the color of the background and this data is transmitted to the robot. All the transmission is completed serially using a Zigbee transceiver. The robot can output the received color by changing the color of LEDs covering the model. This is done by turning on one of the three relays present on the robot.

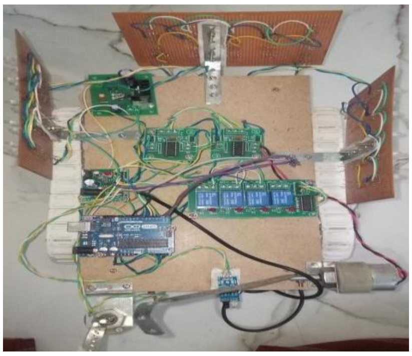

Fig -3.3: Circuit Schematic of Army Robot

4. METHOD

4.1 Haar-Cascade

Cascade classifier is one of the fewest ML object detection algorithms where the speed of computation is high for face detection to train the classifier to run in real-time. The key to its high performance is the use of an integral image, which only performs basic operations in a very low processing time. This can be used in surveillance systems with distributed cameras and a back-end server in which the detection takes place. The speed of computation is high for face detection where a lot of positive and negative images are used to train the classifier. It lies on the principle of computing the difference between the sum of white pixels and the sum of black pixels. The main advantage of this method is the fast sum computation using the integral image. They are adjacent rectangles in a particular position of an image.

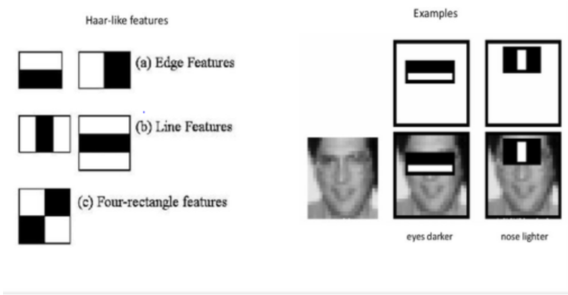

Fig -4.1.1: Haar-like features

This algorithm is achieved by creating the database, then training the database, and finally, recognition is performed. The integral image consists of having a small unit's representation of a given image.

4.2 Local Binary Pattern Histogram

LBPH local binary pattern histogram algorithm is used for front and side face recognition of the dataset. The first computational step of the LBPH is to create an intermediate image that describes the original image highlighting the facial characteristics.

To do so, the algorithm uses a concept of a sliding window, based on the parameters **radius** and **neighbors.**

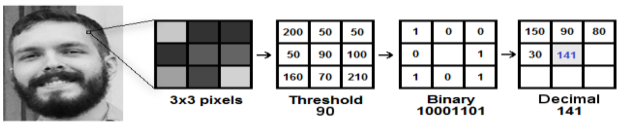

Fig. -4.2.1: The basic LBPH operation

The original LBPH operator labels the pixels of an image by keeping the 3x3 neighborhood or it can be also said as a matrix. Each pixel has a value that can vary depending upon the image and pixel quality. The middle pixel "90" is chosen which has eight neighbors, subtract these neighbor values with 90 if the value is less than zero put it as zero and if the value is more than zero put it as one. Following the arrow direction in figure 1.1, you will get the binary number as 00110101 i.e. 141 in a decimal system. Now, using the image generated in the last step, we can use the **Grid X** and **Grid Y** parameters to divide the image into multiple grids, as can be seen in the following image:

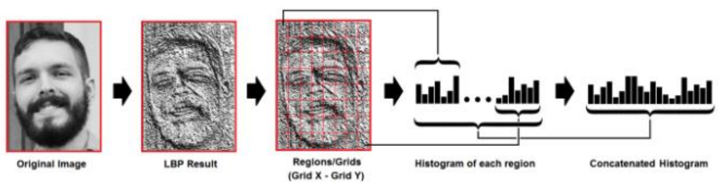

Fig -4.2.2: Extracting the Histograms

We can use various approaches to compare the histograms (calculate the distance between two histograms), for example, Euclidean distance, chi-square, absolute value, etc. In this example, we can use the Euclidean distance (which is quite known) based on the following formula:

$$D = \sqrt{\sum_{i=1}^{n}(hist1_i - hist2_i)^2}$$

So the algorithm output is the ID from the image with the closest histogram. The algorithm should also return the calculated distance, which can be used as a '**confidence**' measurement.

4.3 Eigen Face

A major problem that it faces is that the data is mostly noisy (i.e. pose, angle, lighting condition). Random images are chosen, but in such a manner that they have a face in it, that is not in a truly random way. We define the characteristic feature as eigenface, these characteristics include the presence of objects like the nose, eye, mouth in a face as well as the relative distance between objects. PCA (Principal Component Analysis) which is a mathematical tool is used for the eigenface algorithm. It provides features to recreate and rebuild any original image from the training set by combining eigenfaces. That way only if a face adds in the right proportional manner can we recapture an original face. The images used as input should be of the same size in terms of pixel and grayscale as that of trained images. One of PCA's main advantages is its low sensitivity to noise and its ability to reduce the dimension. The Euclidean distance method is used to calculate the distance between the eigenvector between eigenfaces. If the distance is small, then the subject is identified, whereas too large distance indicates that the model requires more training to identify the subject.

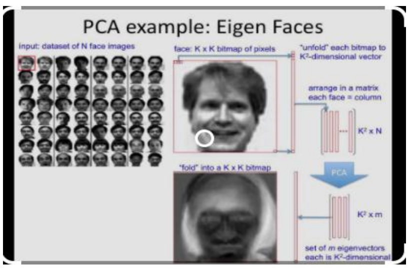

Fig -4.3.1: PCA Calculation on the image

The unique feature is computed by subtracting the average face from each image vector. The Average human face property is shown by the resultant matrix. Now we from the result we find the covariance matrix. PCA is used in eigen analysis. The result is in the form of the covariance matrix.

It has the highest variance as the first eigenvector and the second eigenvector is in direction of the next eigenvector and it is in 90 degrees of first and so on.Each column is considered an image, duplicate face, and this is called eigenface.

4.4 Camouflage Technique

The implementation of the Army Robot is based on camouflage techniques and the flowchart explains the schematic view. To achieve these goals, LED's are used i.e., primarily RGB, which can diffuse uniform colors by using a webcam followed by morphological transform and then detection of the colors in real-time.

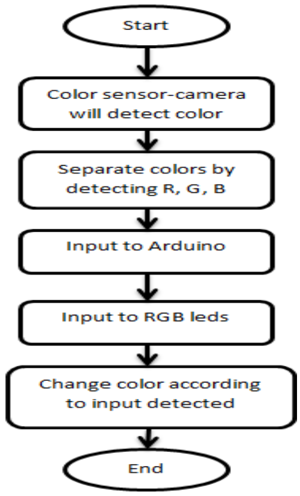

Fig -4.4.1: Camouflage Process Flowchart

Hence, this feature makes it difficult to detect the robot by the naked human eye, can access all the important information from other parties, and also helps in hiding from the enemy's insight

4.5 Land Mine Detection:

One of the most scathing problems faced by soldiers is the identification or removal of landmines that are present on or under the ground during war fields, natural disasters, land development. Therefore, it takes high priority to detect landmines in the ground and remove them carefully with sensors. For safe identification, non-touch-based detection technologies are required. These methods help in the detection of landmines in the signals obtained by non-touch-based

sensors, such as proximity metal detectors. The robot will stop and detects as soon as any metal is identified.

4.6 AI-based Gun Targeting:

In gun targeting, there are two separate operation modes: Interactive and Motion Detection. Interactive play a vital role in controlling the dc motor remotely using computer and motion detection uses OpenCV i.e., computer vision to track living objects that move in front of the camera.

Laser is used for gun targeting up to 360 degrees, if at all the captured image sent for processing by the robot does not match with the faces present in the database folder, robot labels them as an intruder and per- forms gun targeting action.

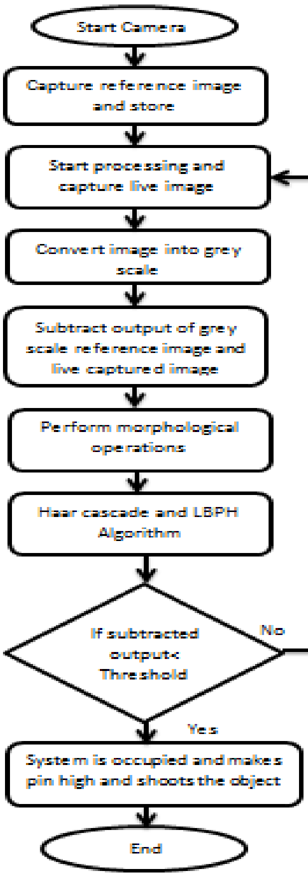

Fig-4.4.2: AI-based Gun Targeting Flowchart

The above flowchart illustrates the algorithm behind the gun targeting using laser, which mimics face detection-based gun action of the camouflage robot.

5. EXPERIMENTAL ANALYSIS AND PERFORMANCE

(1) Evaluating the Performance of Eigenface and Local Binary Pattern Histogram-Based Facial Recognition Methods under Various Weather Conditions.

Environment constraints	Eigen Face	LBPH
Rainy	95%	100%
Foggy	86.6%	96.6%
Cloudy	75%	85%
Sunny	90%	100%

Table -5.1: Algorithm Performance in Percentage

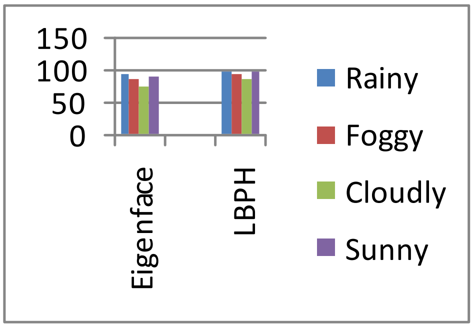

Chart -5.1: Algorithm Performance in an Unconstrained Environment

Resolution	Detected faces	Recognition rate
At 15 pixel	28/101	27.7%
At 20 pixel	54/101	53.4%
At 30 pixel	57/101	56.4%
At 35 pixel	89/101	88.1%

Table -5.2: Accuracy result of Haar-cascade

Resolution	Detected faces	Recognition rate
At 15 pixel	12/101	11.8%
At 20 pixel	38/101	37.5%
At 30 pixel	56/101	55.4%
At 35 pixel	76/101	75.2%

Table -5.3: Accuracy result of LBPH result

The impact of rain on the image causes loss of image contrast and color fidelity. As a result, it is difficult to make the image visible with adequate quality. While there is evidence of removing the effect of rain on video or data with multiple frame images in literature. The overall accuracy of all facial recognition (FR) methods was analyzed in foggy, cloudy, rainy, sunny, and specific conditions (images captured when the weather was not sunny or cloudy) Eigenface had the lowest performance in terms of accuracy (86.60%). Similarly, in cloudy weather, LBPH has the best performance (96.6%), while Eigenface displayed the lowest performance in terms of accuracy the experimental results show that facial recognition(FR) in an unconstrained situation using Eigenface(EF) and Local binary pattern histogram (LBPH) is challenging. LBPH showed the highest accuracy on both LUDB datasets (images captured in different weather) and the dataset (containing unconstrained images).

(2) Comparison of the pixel values of Haar & LBPH vs Eigenface recognition rates

Pixel values	Haar cascade Accuracy	LBPH Accuracy
At 15 pixel	27.7%	11.8%
At 20 pixel	53.4%	37.5%
At 30 pixel	56.4%	55.4%
At 35 pixel	88.1%	75.2%
At 45 pixel	94%	87.1%

Table -5.4: Haar cascade and LBPH

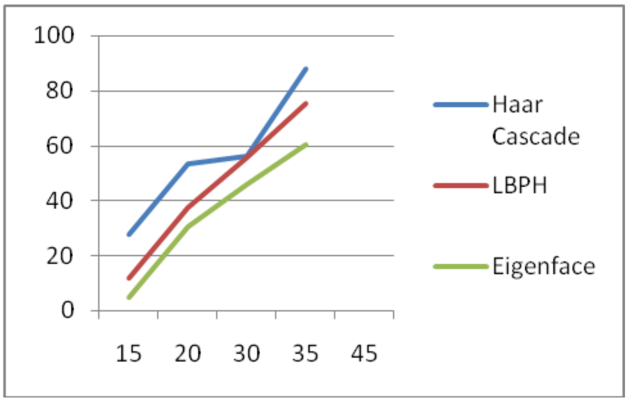

Chart -5.2: Comparison of Haar and LBPH of Pixel values Vs Accuracy

As the detection rate was increasing the rate of recognition for each pixel value increased. After the simulations of the algorithms, Haar and LBPH using Opencv are more accurate than Eigenface, From the above results, it shows that the hit rate of Haar was 94% and LBPH was 87.1% compared to Eigenface 59.4% at optimum lighting condition. If the light intensity is equal to or above 45 pixels, we get the maximum accuracy rate. The result from the table shows that Haar embedded with LBPH is more robust in achieving a high recognition rate compared to eigenface. The percentage of face detection using Haar was almost 8% more than the LBPH algorithm.

6. RESULTS

This paper discusses the camouflaging feature cataracting AI-based algorithms that is been used for surveillance, face and landmine detection, with automatic gun targeting Haar features and Local Binary Patterns Histogram (LBPH). We also observe that when we inculcate AI-based LBPH with Haar cascade we get the best recognition rate compared to eigenface by varying the light intensities accordingly in the scope of our study. A Comparative study has shown that the haar and LBPH algorithms performance rate is high 85-100% in an unconstrained environment compared to the eigenface (75-90%). The mobility of the defense bot with AI-like features covers all aspects of traversing various terrains of the all plane for a given altitude level of a tangible platform meant for movements.

7. CONCLUSION

We have achieved our objective by designing a multifunctional army robot that executes chameleon camouflaging features with locomotion, landmine identification, and performing gun targeting upon intruder detection. We can see an AI expert multi-sensor data fusion-based decision-making system to track enemy movement in the border area. Real-time data processing is done using Zigbee trans-receiver technology, making it low of cost to rebuild. Based on overall results, it can be concluded that Haar cascade and LBPH with the robot exhibit an overall faster Recognition rate and detection speed. The percentage of face detection inculcating Haar and LBPH is significantly higher 27.7% - 34.6% than the eigenface algorithm. From here, we can say that the AI-based Camouflage Robot face is more accurate and reliable when played together compared to other algorithms in the study for face detection. Thus, the proposed autonomous system assists our security forces and soldiers and keeps the nation away from the foe.

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