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Implementation of Automatic Kalashnikov with Sound and Human Detectors

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Abstract: The requirement of identifying the ally personnel at the border and during night, shooting them depending on the sound made by the rival personnel motivated us to take up this project. Conventional techniques uses IR rays to detect the movement of identifying human at the border but after confirming the image is human the soldiers have to take the action, it was not automatic. We in our research wish to execute the idea of making the whole process automatic without human interventions. The project is executed in three steps, can be done through important modules namely, Sound Detection System, Image Processing Module and Gun Shot Module. At the initial stage sound will be detected through Sound detection system, and is verified, whether the sound is from impulse sound sources especially a gun-shoot sound or bullet firing sound and then we detect the presence of human by using Image Processing Module. If it is found that the sound is generated from a gun-shoot system or bullet system then and presence of human is confirmed, gun trigger is pressed in that direction.

Keywords: Sound Detectors, Gun Shot Module, Arduino Mega, Stepper Motor, SVM (Support Vector Machine), HoG (Histogram of Orieted Gradients).

I. INTRODUCTION

The requirement of identifying the allay personnel at the border and during night, shooting them depending on the sound made by the rival personnel motivated us to take up this project. Conventional techniques uses IR rays to detect the movement of identifying human at the border but after confirming the image is human the soldiers have to take the action, it was not automatic. We in our paper wish to execute the idea of making the whole process automatic without human interventions. The process is executed in three steps, can be done through important modules namely, Sound Detection System, Image Processing module and Gun Shot Module. At the initial stage sound will be detected through Sound detection system, and is verified, whether the sound is from impulse sound sources especially a gun-shoot sound or bullet firing sound and then we check the presence of human through the image processing system. If it is found that the sound is generated from a gun-shoot system or bullet system then, gun trigger is pressed in that direction.

This concept is taken from military application where to help our soldiers to fight against enemy. It makes automation control of gunshot with the help of sound detection and gun-shoot system. It helps to destroy enemy from a longer distance to the border during war in a war field.

In the current system that we know is have only sound detection and shooting at that point where even if any animals makes some sound the bullet will shot at that direction.

Conventionally, existing system has the following drawbacks,

- Unnecessary shoot against sound made by any birds, animals.
- Lots of requirement of man power to destroy the enemy in a war field, since they are not so accurate to human voice alone.
- Wastage of resources, like lot of bullets wastage etc.

This is also a system that uses sound detection and gun-shot system including an extra module in between to it called image processing module. In this system after detecting a sound it was checked for whether it was caused by human or not .If the sound was due to human then it guides the gun-shot system to shoot at that direction and position where exactly sound has been produced, if not the output of the processing unit will be discarded and gun- shot system remains idle (provided the time interval between each module will be in the range of micro or nano seconds). This project is very useful for military application to help our soldiers to fight against their enemies.

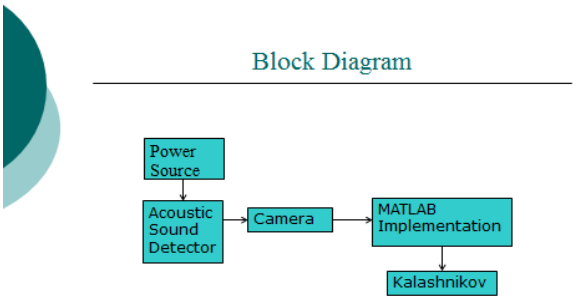

Figure 1: The Block Diagram of the proposed system.

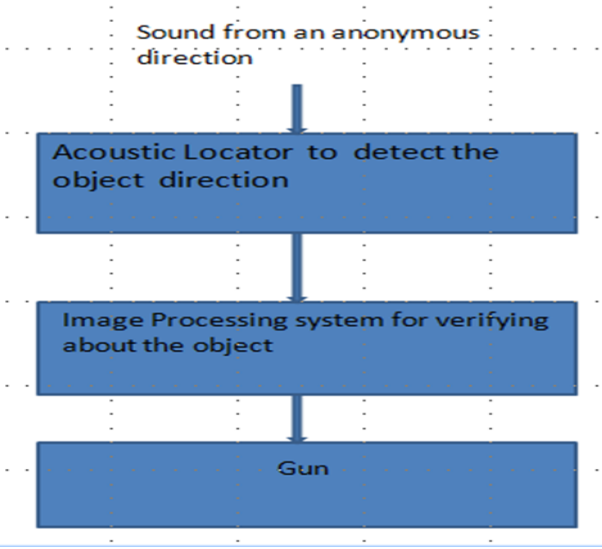

Figure 2: The Flow diagram of the proposed system.

In this project, the control of gunshot is automated, with the help of sound detection. This helps to destroy the enemies easily at the borders and war fields. The main objective of this project is to accomplish automated gunshot based on sound and human detection.In [1] the automatic gun shooting system is discussed and a design approach for auto target detection method is proposed. In [2] the algorithm for the implementation of sound detectors was proposed and an automatic visual tracking and firing system was proposed. In [3] a method for face detection using Support Vector Machine was proposed. In [4] real time object detection using Histogram of Oriented Gradients was proposed. In [5] the proper positioning of stepper motor was discussed. In this paper we first discuss about sound detectors, then image processing system and gun-shot module.

II. SOUND DETECTION SYSTEM

In physics, sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a transmission medium such as air or water. In physiology and psychology, sound is the reception of such waves and their perception by the brain. Humans can hear sound waves with frequencies between about 20 Hz and 20 kHz. Sound above 20 kHz is ultrasound and below 20 Hz is infrasound. Other animals have different hearing ranges.

The speed of sound depends on the medium that the waves pass through, and is a fundamental property of the material. The first significant effort towards the measure of the speed of sound was made by Newton. He believed that the speed of sound in a particular substance was equal to the square root of the pressure acting on it divided by its density.

Acoustics is the interdisciplinary science that deals with the study of mechanical waves in gases, liquids, and solids including vibration, sound, ultrasound, and infrasound. A scientist who works in the field of acoustics is an acoustician, while someone working in the field of acoustical engineering may be called an

acoustical engineer. An audio engineer, on the other hand, is concerned with the recording, manipulation, mixing, and reproduction of sound.

Applications of acoustics are found in almost all aspects of modern society, sub-disciplines include aero-acoustics, audio signal processing, architectural acoustics, bioacoustics, electro-acoustics, environmental noise, musical acoustics, noise control, psychoacoustics, speech, ultrasound, underwater acoustics, and vibration.

The following figure shows the specifications of the sound sensor used and the an image of the sound sensor. We in our research have used eight sound sensors which were placed in all eight directions. A threshold value of 1000 was set for the identification of gun shot sounds. The output values of each sensor is sent to the microcontroller and there we check whether the output value is greater or lesser than the set threshold value. If the sensor's output is equal to or greater than the threshold value, then we identify that the origin of sound is in that direction.

Sound sensor

Parameter	Value
IC	LM393
VCC	5 Vdc from your Arduino
GND	GND from your Arduino
out	Connect to Digital Input Pin
Power LED	Illuminates when power is applied
Sound Detection LED	Illuminates when sound is detected

Figure 3: The specification of sound sensor and image of sound sensor used

III. IMAGE PROCESSING SYSTEM

In the image processing system we use two of the very important image processing techniques to identify the human presence. We have implemented the image processing system using OpenCV software and we have used Python Programming language.

The first important image processing technique that we have used is HoG (Histogram of Oriented Gradients). The histogram of oriented gradients (HoG) is a feature descriptor used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in localized portions of an image. This method is similar to that of edge orientation histograms, scale-invariant feature transform descriptors, and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy.

The essential thought behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The image is divided into small connected regions called cells, and for pixels within each cell, a histogram of gradient directions is compiled. The descriptor is the concatenation of these histograms. For improved accuracy, the local histograms can be contrast-normalized by calculating a measure of the intensity across a larger region of the image, called a block, and the using this value to normalize all cells within the block. This normalization results in better invariance to changes in illumination and shadowing.

The HoG descriptor has a few key advantages over other descriptors. Since it operates on local cells, it is invariant to geometric and photometric transformations, except for object orientation. Such changes would only appear in larger spatial regions. Moreover, as Dalal and Triggs discovered, coarse spatial sampling, fine orientation sampling and strong local photometric normalization permits the individual body movement of pedestrians to be ignored so long as they maintain a roughly upright position. The HoG descriptor is thus particularly suited for human detection in images.

In their original human detection environment, Dalal and Triggs compared their R-HoG and C-HoG descriptor blocks against generalized Haar wavelets, PCA-SIFT descriptors and shape context descriptors. Generalized Haar wavelets are oriented Haar wavelets, and were used in 2001 by Mohan, Papegeorgiou and Poggio in their own object detection experiments. As part of the Pascal Visual Object Classes 2006 Workshop,

they presented results on applying histogram of oriented gradients descriptors to image objects other than humans, such as cars, buses and bicycles as well as common animals such as dogs, cats, and cows. They included with their results the optimal parameters for block formation and normalization in each case.

The second important image processing technique used here is SVM (Support Vector Machine), In machine learning, support vector machines are supervised learning models with associated learning algorithms that analyse data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall.

In addition to performing linear classifications, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces. When data are not labelled, supervised learning is not possible, and an unsupervised learning approach is required, which attempts to find natural clustering of the data to groups, and then map new data to these formed groups. The clustering algorithm which provides an improvement to the support vector machines is called support vector clustering and is often used in industrial applications either when data are not labelled or when only some data are labelled as a pre processing for a classification pass.

More formally, a support vector machine constructs a hyperplane or set of hyperplanes in a high or infinite-dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyperplane that has the largest distance to the nearest training data point of any class (so called functional margin), since in general the larger the margin the lower the generalization error of the classifier.

SVM can be used to solve various real world problems:

- SVMs are helpful in text and hypertext categorization as their application can significantly reduce the need for labelled training instances in both the standard inductive and transductive settings.
- Classification of images can also be performed using SVM. Experimental results show that SVM achieve significantly higher search accuracy than traditional query refinement schemes after just three to four rounds of relevance feedback.
- Hand written characters can be recognized using SVM.

As already mentioned we have used OpenCV software, OpenCV (Open Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel's research centre in Nizhny Novgorod (Russia), it was later supported by Willow Garage and is now maintained by Itseez. The library is cross-platform and free for use under the open-source BSD licence.

Python is widely used high-level programming language for general purpose programming, created by Guido van Rossum and first released in 1991. Python has a design philosophy which emphasizes code readability and a syntax which allows programmers to express concepts in fewer lines of code than possible in languages such as C++ or Java. The language provides constructs intended to enable writing clear programs on both a small and large sale. Python features a dynamic type system and automatic memory management and supports multiple programming paradigms, including object-oriented, imperative, functional programming and procedural analysis. It has a large and comprehensive standard library.

Python interpreters are available for many operating systems, allowing Python code to run on a wide variety of systems. CPython, the reference implementation of Python, is open source software and has a community based development model, as do nearly all of its variant implementations. CPython is managed by the non-profit Python software Foundation. The core philosophy of the language is summarized by the document The Zen of Python (PEP 20), which includes aphorisms such as:

- Beautiful is better than ugly
- Explicit is better than implicit
- Simple is better than complex
- Complex is better than complicated
- Readability counts

Python is intended to be a highly readable language. It is designed to have an uncluttered visual layout, often using English keywords where other languages use punctuation. Further, Python has fewer syntactic exceptions and special cases than C or Pascal. Python uses whitespace indentation to delimit blocks rather than curly braces or keywords. An increase in indentation comes after certain statements; a decrease in indentation signifies the end of the current block. This feature is also sometimes termed the off-side rule.

In Python we have used three in-built main functions:

- cv2.HOGDescriptor( )
- hog.setSVMDetector( )
- non_max_suppression( ) .

IV. GUN SHOT MODULE

Here in this research we have used Aurduino Due microcontroller to control the whole system and we have used Raspberry pi 3 model for implementation of image processing system. The following diagram will show the specifications of Arduino Due microcontroller used.

Arduino_due

Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-16V
Digital I/O Pins	54 (of which 12 provide PWM output)
Analog Input Pins	12
Analog Output Pins	2 (DAC)
Total DC Output Current on all I/O lines	130 mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
Clock Speed	84 MHz
Length	101.52 mm
Width	53.3 mm
Weight	36 g

Figure 4: The specifications of Arduino Due

The specifications of Raspberry pi are as follows:

- Broadcom BCM2837 64bit ARMv7 Quad Core Processor powered Single Board Computer running at 1.2Ghz
- 1GB RAM
- BCM43143 WiFi on board
- Bluetooth Low Energy (BLE)on board
- 40pin extended GPIO
- 4 x USB 2 ports
- 4 pole Stereo output and Composite video port
- Full size HDMI
- CSI camera port for connecting the Raspberry Pi camera
- DSI display port for connecting the Raspberry Pi touch screen display
- Micro SD port for loading your operating system and storing data
- Upgraded switched Micro USB power source(now supports up to 2.4Amps)
- Expected to have the same form factor has the Pi 2 Model B, however the LEDs will change position.

The Gun Shot Module consists of Stepper Motor to rotate the gun to the required position, we in our research have made use of a laser diode, which is used as a gun, as getting original gun is difficult.

A stepper motor or step motor or stepping motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

Switched reluctance motors are very large stepping motors with a reduced pole count, and generally are closed-loop commutated. Brushed DC motors rotate continuously when DC voltage is applied to their terminals. The stepper motor is known by its property to convert a train of input pulses (typically square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle.

Stepper motors effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a micro controller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle. The following image shows us the specifications of stepper motor used.

Figure 5: The specifications of stepper motor

As already mentioned we have made use of laser diode instead of real gun in our system. A laser diode, or LD also known as injection laser diode or ILD, is an electrically pumped semiconductor laser in which the active laser medium is formed by a p-n junction of a semiconductor diode similar to that found in a light-emitting diode.

The laser diode is the most common type of laser produced with a wide range of uses that include fiber optic communications, barcode readers, laser pointers, CD/DVD/Blue-ray Disc reading and recording, laser printing, laser scanning and increasingly directional lighting sources.

A laser diode is electrically a PIN diode. The active region of the laser diode is in the intrinsic (I) region, and the carriers (electrons and holes) are pumped into that region from the N and P regions respectively. While initial diode laser research was conducted on simple P-N diodes, all modern lasers use the double- hetero structure implementation, where the carriers and the photons are confined in order to maximize their chances for recombination and light generation. Unlike a regular diode, the goal for a laser diode is to recombine all carriers in the I region, and produce light. Thus, laser diodes are fabricated using direct bandgap semiconductors. The laser diode epitaxial structure is grown using one of the crystal growth techniques, usually starting from an N doped substrate, and growing the I doped active layer, followed by the P doped cladding, and a contact layer. The active layer most often consists of quantum wells, which provide lower threshold current and higher efficiency.Laser diodes form a subset of the larger classification of semiconductor p-n junction diodes. Forward electrical bias across the laser diode causes the two species of charge carrier – holes and electrons – to be "injected" from opposite sides of the p-n junction into the depletion region. Holes are injected from the p-doped, and electrons from the n-doped, semiconductor. (A depletion region, devoid of any charge carriers, forms as a result of the difference in electrical potential between n- and p-type semiconductors wherever they are in physical contact.) Due to the use of charge injection in powering most diode lasers, this class of lasers is sometimes termed "injection lasers,"or "injection laser diode" (ILD). As diode lasers are semiconductor devices, they may also be classified as semiconductor lasers. Either designation distinguishes diode lasers from solid-state lasers.

V. SIMULATION RESULTS

In the process of simulation, we show the outputs of image processing system and gun-shot system. The following figures are the outputs of image processing system.

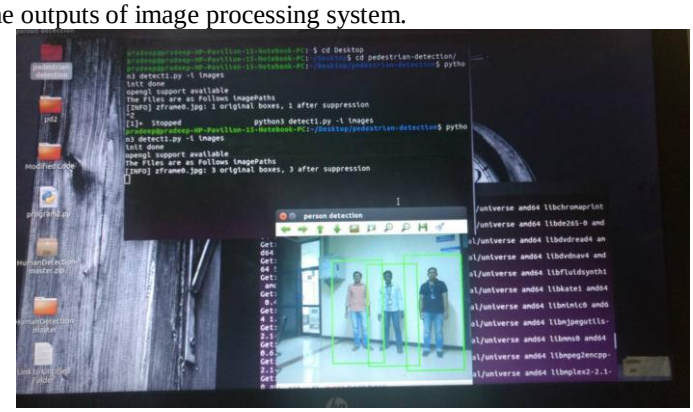

Figure 6: Outputs of image processing system where in three human are detected.

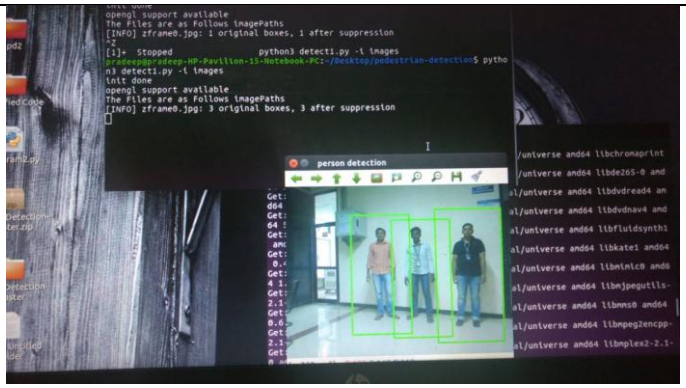

Figure 7: Outputs of image processing system where in three humans are detected.

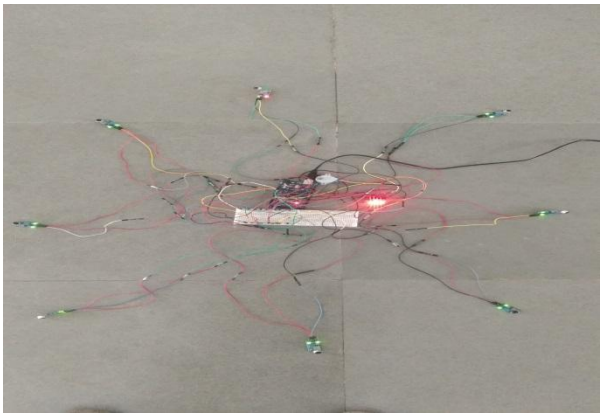

Figure 8: The whole system

The last figure is regarding the whole system, i.e., it contains the sound detection system, image processing system and gunshot system.

VI. CONLUSION

The system i.e., implementation of Automatic Kalashnikov using sound and human detectors was successfully implemented and we have also being able to successfully find the direction of sound origin, and rotating the gun shot module in that direction, which also includes human detection using image processing system.

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