International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

# New Wireless Multifunctional Smart Robot for Border Security Surveillance with Real Time Object Recognition

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***Abstract:*** ***Fringe observation is the most significant errand in the field of national protection and security. To keep up the harmony and to guarantee security of the outskirts it needs to hold under all day, every day observing. Particularly, under the present conditions, as Illegal movement, bringing in, embedding hazardous gadget, fear monger exercises are regular difficulties happen in our nation outskirt. To check such happenings on the outskirt regions, the least that should be possible is to give a constant observing.The edge of a country border spreads to several thousand heaps for which human surveillance is more challenge and may lead to loss of human life. To overcome the problem in this paper a new Wireless Multifunctional Smart Robot for Border Security Surveillance with Real Time Object Recognition (OR) system is introduced the proposed robotics system is based on IOT and OR. This method mechanically senses the interruption form the strangers and sends the photos to the admin that categorized which kind of object is to be capture in the image sensor with the help of convolution neural networks (CNN). The multi-sensor Smart robot is proficient for sensing motion using Passive and also Infrared Sensor, poisonous gas using Gas sensor, fire or blast using Flame Sensor, high temperature using Temperature sensor, Camera for capturing the activities in the border, ultrasonic sensor for detecting any obstacles and GPS is used for tracking the location. Any trespasses, bombs, harmful gases, fire and other dangerous situations are sensed and sent to the server. This system detects the dangerous conditions near the border and saves the life immediately without any loss of human life.***

***Key-words:*** ***Object Recognition (OR), Raspberry pi, Robotics, Surveillance Monitoring and wireless sensor.***

## I. INTRODUCTION

BS is a major challenge in the security of a country. Large number of man power are involved in the BS which may lead to loss of human life during attacks [1]. Hence an automated BSsystem has been developed to monitor the security in the borders by using Internet of Things. “Multi sensor Smart Robot for Border Security Surveillance”, an automated surveillance system has been developed to monitor the security at the borders [2]. The system is based on a multifunctional robot using various sensors to detect intrusion using PIR Sensor, poisonous gas using Gas sensor, fire or blast using Flame Sensor, high temperature using Temperature sensor, Camera for capturing the activities in the border, ultrasonic sensor for detecting any obstacles and GPS for tracking the location. This system saves a lot of human life [3]. Fringe security has been a noteworthy worry since quite a while, for India as well as for the world all in all [4]. It ensures the nation's limit against unlawful development of merchandise, medications, weapons and people [5]. It is a key factor to keep up the exchange and voyaging legally just as giving security against fear based oppression, over the globe. This aides in keeping up a nation's economy, wellbeing and opportunity [6]. BS frameworks are the gadget attempting to screen the exercises occurring around the outskirts and recognize if some suspicious exercises are going on.

On the off chance that anything happens execution set of pre-decided errands happens. It might include alarming the concerned specialists or conjuring some different frameworks accordingly, for example, a notice or fight framework [7]. Gatecrasher Detection Systems (IDS) are fundamental piece of the BS [8]. They are intended to work in forceful condition to screen, identify and track the interlopers (moving focuses), around the camera [9]. As it is a truly tiring errand for people to watch and screen 24x7 live so camera can screen live video spilling with complete consideration, and GPS can follow the area that produce programmed cautions [10]. The sign is in charge of the situating of reconnaissance camera toward the path where gatecrasher has been distinguished [11]. In this paper, the plan and execution of outskirt security observation utilizing robot was actualized the proposed framework clarify the capacity of the robot. With the assistance of cloud, it tends to be gotten to anywhere.it is utilized to screen the outskirt regions with the assistance of remote sensor.

The remainder of paper is composed as pursues: Section II overviews a few ongoing papers on Multisensory shrewd robot for outskirt security observation. In Section III, the nitty gritty portrayal of the proposed strategy MSRBSS is exhibited. In Section IV, the presentation of the MSRBSS is assessed by directing arrangement of examinations. At long last, the end is made in the Section V.

Manuscript published on 30 September 2019
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## II. LITERATURE SURVEY

YasaminMostofi, et al., [12]. This framework that comprises of a versatile robot, constrained by Internet, which has camera mounted and a PIR sensor for identifying the living bodies. Client will most likely control the robot through web, in this manner, giving the remote control of robot. Likewise data with respect to the location of living bodies will be given to the client on the site page from the PIR sensor and at the same time client will probably get to the video transmission from the robot.

SarathChandran.c, et al., [13]. An autonomous intelligent robot which identifies trespasser using PIR motion sensor, alerts security personnel by short messaing service using GSM and captures image of the trespasser using camera in Android device and mails this image to specified e-mail id using Android based application.

Anjali, et al., [14]. Displayed the principal mission of the rescuers is to recognize the circumstances by thinking about different parameters. Apply autonomy is bringing innovatory changes on the planet by presenting new advancements. Self-ruling robots are clever machines fit for performing assignments on the planet independent from anyone else, without express human control.

Alireza Ghaffarkhah, et al., [15]. Proposed a working framework in which a video moving item following strategy is proposed. It is a significant technique in information investigation in view of its capacity to discover‟ the characteristic highlights in the information. The principal systems which are gathering to give a lot of articles into subsets as indicated by properties related with each item, so the individuals in every individual subset share some comparative characterized highlights. Consequently, a multi target human following is endeavored.

K. Damodhar, et al., [16]. Structured an ongoing shrewd observation framework has been prepared for distinguishing, following and checking individuals and vehicles in an indoor-open air genuine condition. The test procedure demonstrates the unwavering quality of the created framework as a device for the distinguishing proof of security episodes. In addition, utilizing remote associations and a disseminated engineering together, we have accomplished an extremely adaptable, simple to introduce and bring down upkeep framework that supports a wide range of gadgets. Hence, the proposed engineering can be connected in conveyed areas, for example, savvy urban communities.

## III. PROPOSED METHODOLOGY

“Multi sensor Smart Robot for Border Security Surveillance” is an automated system with multiple sensors for border security surveillance. The system has designed with seven blocks such as Infra-red Block, Ultrasonic Block, Flame Block, Temperature Block, Gas Block, Human Detection Block and Location Detection .The proposed block diagram are shown below figure 1.

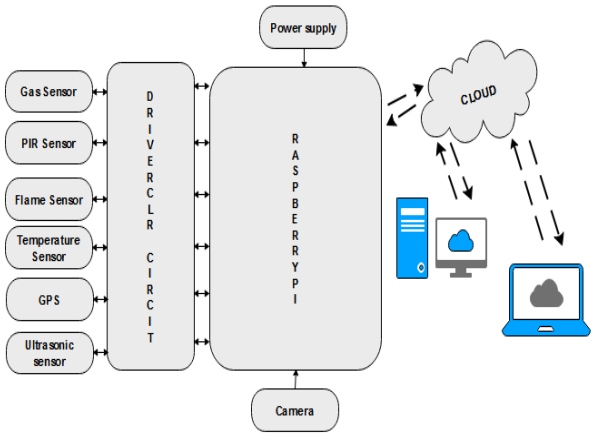


**Fig.1.New Wireless Multifunctional Smart Robot for Border Security Surveillance with Real Time OR.**

The proposed system explains multifunctional robot for border security surveillance. This designed system involves for the border security purpose, here various sensor is used to monitor especially, under the current circumstances, like Illegal immigration, importing, implanting explosive device, terrorist activities. PIR sensor detect the object, the object will recognize the image and alert the user. Ultrasonic sensor detects the obstacles and alert the user, flame sensor detects fire and alerts warring to the user temperature sensor detects the temperature it automatically generates the particular temperature and sends the alert to the admin, gas sensor detects poison gas around the bounders and alert the user, camera is used to detect surveillance around the border through web pages it can be viewed. PS is used to track the location.

### Sensor Acquisition

**PIR Block:** To detect the living objects, in this proposed surveillance systems PIR Sensors is used. PIR sensors are worked based thermal radiations (it’s nothing but heat of the human body). The thermal radiations are converted into a voltage values and which is given to raspberry pi. Generally PIR consist of two different conditions such as high and low. Whenever the PIR sensor detect the object at the time it will provide high condition or otherwise it will lower condition.

**Ultrasonic Block:** In this proposed surveillance system Ultrasonic sensor sensors is used to detect the obstacles based on the trigger pulse. In this obstacles detection system, if it detect any kind of obstacles means at the time it will switch the alarm and also its send the intimation to the reviser system.

**Flame Block:** A fire indicator is a sensor intended to distinguish and react to the nearness of a fire or fire, and permitting fire recognition. In this proposed surveillance system Flame Sensor are used to detect the fire. Flame sensor gets the input from the raspberry pi and that data is transformed to the sensor. If any fire is detected and which alert the user.

**Temperature and GAS sensing block:** In the proposed surveillance system, this block helps to detect the Temperature and GAS. Temperature sensor consists of a physical that performs the operation according to temperature this vary in action. This change of action is sensed by electrical device and it calculates the temperature. When the voltage increases then the temperature also rises, when voltage decreases the temperature decreases. Gas indicator is a gadget that identifies the nearness of gases in a zone, regularly as a feature of a security framework. This sort of hardware is utilized to distinguish a gas spill or different emanations and can interface with a control framework so a procedure can be consequently closed down.

**Location Detection Block:** This GPS is used to track the current location of the robot. This location tracking system help to save the time and save human life.

**Weapon Detection (WD):**In the proposed surveillance system, to reduce the unwanted attacks the new weapon detection system is introduced. It's basically worked based on the image sensors. Initially, the WD system recode the video and which is transferred to the raspberry pi. Raspberry pi contains of below detection system, based on that the proposed system detect the weapon. The proposed Weapon Detection system can detect the two different kind of weapons such as handguns and knives. The recognition of weapons hid underneath an individual's attire is a significant hindrance to the improvement of the security of the overall population just as the wellbeing of open resources like air terminals and structures. It is attractive to have the option to distinguish disguised weapons from a standoff separation, particularly when it is difficult to orchestrate the progression of individuals through a controlled system. The objective is the possible sending of programmed discovery and acknowledgment of disguised weapons. The square outline of the proposed WD module is appeared in the figure.2.

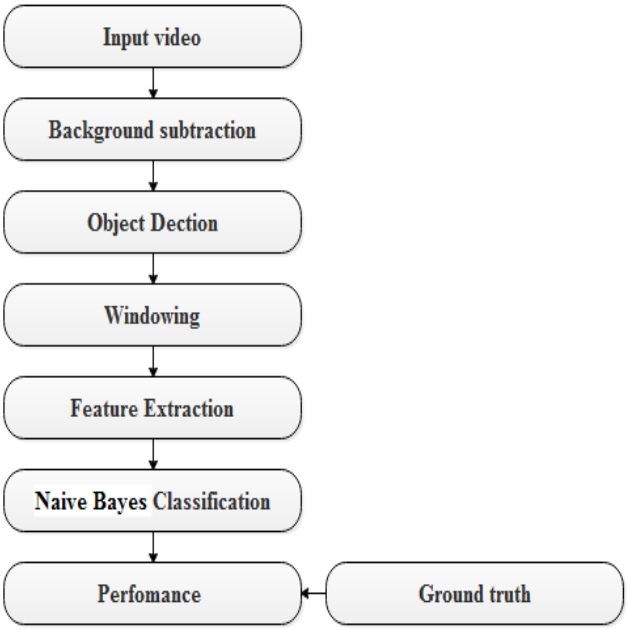


**Fig.2.Weapon Detection block diagram**

The first step of the WD is background subtraction. Background subtraction or background modeling is a computer vision process which estimating an image background from a sequence of video using a statistical model. In that background eliminated frame objects are detected by the help of blob detection algorithm. If the object is present at the time the windowing is applied as well as AOD. After that each and every window features are extracted and classified by using navy Bayes algorithm if the weapon is presented or not which will be defined and continuously that object position has be monitored in the all the continues frames.

**Background subtraction & object detection:** After the acquisition of datasets, foreground detection is carried-out on each frame by using background subtraction. Here, the background of the image frames is determined by subtracting the current frame from the previous frame or from the average image of the number of frames. Background subtraction works well in specific conditions of frame rate and object speed and also it is very sensitive to the threshold. The general formula of background subtraction is given in the Eq. (1).

$$|I_i(x,y) - I_{i-1}(x,y)| > T \qquad (1)$$

Where, $I_{i-1}$ is represented as previous frame, $I_i$ is denoted as current frame and $T$ is represented as selected threshold.After foreground detection, blob detection is carried-out for obtaining a particular region of interest to perform further operations like feature extraction, optimization and classification. In the application of object detection or object tracking, the obtained blob region indicates the parts of objects and the presence of objects. Each blob regions are starched in horizontal and vertical directions until the entire blob is enclosed in a rectangle box. In this paper, the blob detection system is based on bounding box, centre-of-mass and adjacency pixels. Additionally, the statistical features of blobs like volume bounded by the membership function, location of the center gravity, pixel count of the blob, and size of the rectangular enclosure are also determined.

Currently, blob detection have found increasingly popular, because it uses interest points for wide baseline stereo matching and also for signaling the presence of informative image features for appearance based object detection on the basis of local image statistics.

**Feature extraction:** Usually, feature extraction is defined as the action of mapping the image from image space to feature space and it also transforms the large redundant data into a reduced data representation. It helps to decrease the complexity of the system. In this research study, feature extraction is performed on the basis of HOG, GLCM, STIP, DWT and SIFT. The detailed description about the feature descriptors are given below

**Histogram of oriented gradients:** Generally, HOG describes about the distribution of spatial directions in each image region. It exploits the local object appearance, which is well characterized by the distribution of edge directions or local intensity gradients. The general idea of HOG is to divide the image into small spatial regions and for each region it creates one-dimensional gradient orientation histogram with gradient direction and gradient magnitude. A key normal for HOG highlight is equipped for catching the neighborhood appearance of articles, and furthermore to account the invariance in item changes and light condition.

The edge data about angles are controlled by applying HOG highlight vector. From the outset, a slope administrator N is utilized to compute the inclination esteem. The angle purpose of the picture is indicated as $(x, y)$ and the picture edges are communicated in the Eq. (2).

$$G_x = N * I(x, y) \text{ and } G_y = N^T * I(x, y) \quad (2)$$

Picture identification windows are ordered into different minor spatial locales, which is known as cells. Consequently, the size slopes of the pixels are knowledgeable about edge direction. At long last, the size of the inclinations $(x, y)$ is signified in the Eq. (3).

$$G_x(x, y) = \sqrt{G_x(x, y)^2} + \sqrt{G_y(x, y)^2} \quad (3)$$

Edge orientation of the point $(x, y)$is specified in the Eq. (4).

$$\theta(x, y) = tan^{-1} \frac{G_y(x,y)}{G_x(x,y)} \quad (4)$$

Where, $G_x$is mentioned as the horizontal direction of gradients and$G_y$is represented as the vertical direction of gradients.

For superior in-variance in illumination and noise, a normalization procedure is performed, after the calculation of histogram values. Normalization is an essential step in the HOG feature descriptor, it maintains discrimination characteristics and perform consistently even against parameters like background-foreground contrast and local illumination variations in the input image. Normalization is done by using "block" as a fundamental region of operation. Each block region comprises of a square array of four cells. Each new block is defined with a 50% overlap with the previous block. Normalization effectively maintains the cell-based local gradient information, which is invariant to local illumination conditions. In HOG, four unique examples of standardization are accessible, for example, L2-standard, L2-Hys, L1-Sqrt and L1-standard. Among these standardization, L2-standard gives better execution in person on foot identification and characterization, which is numerically given in the Eq. (5).

$$L_{2-norm} : f = \frac{x}{\sqrt{||x||_2^2 + e^2}} \quad (5)$$

Where, $e$is denoted as small positive value,$f$is represented as feature extracted value, $x$ is meant as non-normalized vector in histogram blocks and $||x||_2^2$ represents the 2-norm of HOG normalization.

**Gray level co-occurrence matrix:**The GLCM descriptor is used to decide the recurrence of pixel sets, when the pixel power esteems are equivalent. In this exploration study, GLCM descriptor involves auto-connection, differentiate, relationship, bunch unmistakable quality, group conceal, divergence, vitality, entropy, homogeneity, most extreme likelihood, entirety of squares, fluctuation, aggregate normal, total change, whole entropy, distinction difference, contrast entropy, data proportion of relationship, reverse distinction, opposite distinction standardized and converse distinction minute standardized [17].

**SIFT:** The SIFT change gives the pictures of an article that are unaffected by the item scaling and turn. Filter calculation comprise of 4 phase sifting draws near, that are Scale-Space Extreme Detection (SSED), Key point (KP) Localization (KL), Orientation Assignment (OA) and KP Descriptor [26].

**DWT:**The DWT technique has properties like better compression energy and perfect reconstruction with short support filters, low-computation and no redundancy. The DWT follows the fuzzy de-noising procedure, which provides shift capable sub-bands and better directional selectivity with less redundancy. The real input images $A_{2^{j+1}}f$ at resolution $2^{j+1}$ decompose into 4-subband images in the frequency domain. Three sub-band images such as $D_{2^i}^h f, D_{2^i}^x f, D_{2^i}^d f$ are the brain tumor images at resolution $2^{jaaa}$ in vertical, horizontal and diagonal between the 4-subband images. The fourth image is an approximation image, $A_{2^j}f$ detected coarse resolution. So, the entire input image $A_{2^{j+1}}f$ is presented in the equation (6).

$$A_{2^{j+1}}f = D_{2^i}^h f + D_{2^i}^v f + D_{2^i}^d f + A_{2^j}f \quad (6)$$

The deteriorated mammogram sub-pictures are the 2-dimensional symmetrical wavelet. The consequences of the wavelet decay of a mammogram picture is resultant into 4-symmetrical sub-groups, for example, Low-Low (LL) band, Low-High (LH) band, High-Low (HL) band and High-High (HH) band, which is spoken to as $D_{2^i}^h f, D_{2^i}^v f, D_{2^i}^d f$and $A_{2^j}f$ respectively.

**STIP:** STIP is a most effective approach is to extract local features at space-time interest points and encode the temporal information directly into the local feature. This results into the definition of spatio-temporal local features that embed space and time jointly. Space time interest point detectors are extensions of 2D interest point detectors that incorporate temporal information [17]

**Naive Bayes Classifier:** In this NB predicts conditionally independent class from a given class labels are stated as problem of instances and then modifies the feature vector into feature values. Now, assuming a group of unidentified data tuples, in that every tuple is shown by a $n-$dimensional vector, $X = \{x_1, x_2, ..., x_n\}$ depicting $n$ measurements are made to the tuple of $n$ attributes.

Considering a set of $m$ classes, $C_1, C_2, ....C_m$ .Using Bayes theorem, the NB calculates the posterior probability of class, conditioned on $X$ and then it assigns the class label on each class with maximum posterior probability. Therefore, class label of posterior probability is given by eq (7),

$$P(C_x \mid X) > P(C_y \mid X) \quad for \quad 1 <= y <= m, y \neq x \quad (7)$$

A Maximum posterior hypothesis can be utilized to attain a point estimate of an ignored quantity on the basis of empirical data. Maximize the value of $P(X \mid C_x)P(C_x)$ with constant $P(X)$ over many attributes; it is computationally complex to estimate the probability of predicting $P(X \mid C_x)$. Probability of maximum posterior equation is given by eq.(8),

$$P(C_x \mid X) = \frac{P(X \mid C_x)P(C_x)}{P(X)} \quad (8)$$

Where, $P(C_x)/X$ is mentioned as the class posterior probability, $P(C_x)$ is denoted as the class prior probability, $P(X \mid C_x)$ is represented as the likelihood

probability of predictorclass, $P(X)$ is denoted as the prior probability of predicting.

A given data set with several attributes, it would be computation all expensive to compute $P(X \mid C_x)$. In order to minimize the computation in $P(X \mid C_x)P(C_x)$, the innocent presumption of class conditional independence is made. This assumes, the estimation of the properties is restrictively free of each other, given by a class mark of the example.

NBC assumption of "class conditional independence" is mentioned as eq.(9),

$$P(X_k \mid C_x) \approx \prod_{k=1}^{n} P(X_k \mid C_x) \qquad (9)$$

The probabilities $P(X_1 \mid C_x), P(X_2 \mid C_x)....,P(X_k \mid C_x)$ c an easily estimate from the training set. Recall that here $X_k$ refers to the attribute value $A_k$ for sample $X$. If $A_k$ is categorical, then $P(X_k \mid C_x)$ is the number of samples of class $C_x$ in $T$ having the value $X_k$ for attribute $A_k$ is divided by frequency $(C_x, T)$. The number of sample of class $C_x$ in $T$ is mathematically given by Eq (10),

$$G(x, \mu, \sigma) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (10)$$

If $A_k$ is continuous-valued, then typically assume that the values have a Gaussian distribution with a mean $\mu$ and standard deviation $\sigma$ is given by Eq (11),

$$P(x_k \mid C_x) = g(x_k, \mu_{C_x}, \sigma_{C_x}) \qquad (11)$$

Compute the values of $\mu C_x$ ad $\sigma C_x$, which are considered as the mean and standard deviation values of attribute $A_k$ for training samples of class $C_x$. Applying NB has shown significant accuracy and speed over large database.

## IV. RESULT AND DISCUSSION

The "Multi-sensor Smart Robot for Border Security Surveillance" is an automated system to detect any abnormalities in the border during surveillance. The system provides accurate detection of any intrusion in the border based on the sensors fit on the system. The immediate alert sent to the authorized persons along with the necessary images captured from the intrusion detected area provides immediate action saving human life and providing BSeffectively. In this proposed surveillance system major advantage is weapon detection.In this weapon detection the performance are analyzed using various dataset which has been recorded with the help of CCTV recordings.To the proposed Performance evaluation purpose this proposed system is compered to various existing system [18].Both test sets were made by shooting a progression of CCTV chronicles with an on-screen character. Since unfit to acquire an adequate number of genuine video shots among openly accessible clasp. Some example pictures of Gun Detection Dataset is appear in fig.3. The HSS is tested utilizing Python (adaptation 2018a) with 3.0 GHZ Intel i3 processor, 1TB hard circle and 8 GB RAM. For deciding the viability of the HSS, the exhibition of the proposed framework is contrasted and the current frameworks on the presumed datasets: UT-Interaction dataset, Gun Detection and Abandoned Objects Dataset (ABODA).

**Fig.3. Gun Detection dataset samples.**

**Performance Analysis:** From the HSS, four different parameters such as True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) are calculated. This TP, TN, FP and FN are used for calculating the performance. The performance parameters analyzed in this proposed method are described as follows.

**Recall:** the number of True Positives $(tp)$ divided by the number of $(tp)$ and the number of False Negatives $(fn)$. Recall mathematical equations show as (12):

$$R = \frac{tp}{tp+fn} \qquad (12)$$

**Precision:** is the number of tp divided by the number of (tp) and False Positives. It is also called the Positive Predictive (PP) Value. Precision mathematical equations show as (13):

$$Precision = \frac{tp+tn}{tp+tn+fp+fn} \qquad (13)$$

**Sensitivity:** Sensitivity is a basic property of image processing the. Sensitivity is also called as $tp$ rate. Mathematically, Sensitivity mathematical equations show as (14):

$$Sensitivity = \frac{tp}{tp+fn} \qquad (14)$$

**Specificity:** The specificity provides, how likely the test is to come back negative characteristic. Specificity also called the true negative rate, Mathematically, Specificity mathematical equations show as (15):

$$Specificity = \frac{tn}{tn+fp} \qquad (15)$$

**Accuracy**: By using the Specificity and Sensitivity the Accuracy of the image is calculated. Accurately represent the quantity of the image. Mathematically, mathematical equations show as equation (16):

$$\text{Accuracy} = \frac{tp+tn}{tp+fp+tn+fn} \qquad (16)$$

In this experimental section, the performance evaluation of proposed system is carried out by using Gun detection dataset. The detection of Gun in Gun detection dataset is meant in the Fig.4. In Table.2.

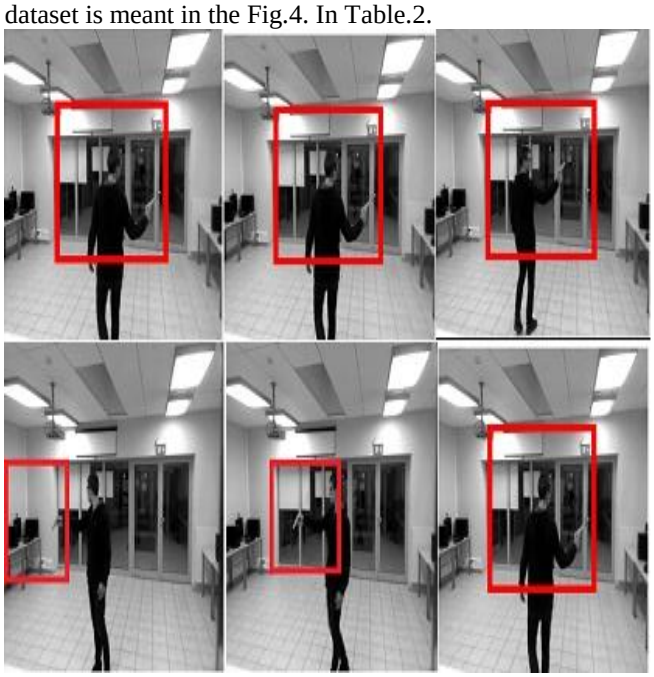

**Fig.4. Detection of Gun in Gun detection dataset**

**Tab.2. Comparative analysis of proposed and existing works in Gun detection dataset**

| Year | Method | Dataset | Sensitivity | Specificity |
|---|---|---|---|---|
| **2016** | Automated Detection of Firearms and Knives in a CCTV Image [25] | Gun Detection | 35.98% | 96.69% |
| **2018** | HSS | Gun Detection | 30.12% | 98.65% |

From the tabulation 2. Analysis shows that sensitivity and Specificity comparison of the proposed and existing systems. In that the Automated Detection of Firearms and Knives in a CCTV Image [25] provides sensitivity as 35.98% and the Specificity is 96.69% compared to that proposed HSS system archive 30.12% of sensitivity and 98.65% of Specificity.

## V. CONCLUSION

A new system is developed in this paper to detect HAR, WD and AOD in the video using crowd motion pattern. The main aim of this research is to obtain the HSS using UT-Interaction dataset, Dataset for Gun Detection and ABODA dataset. In this research paper, hybrid feature extraction is utilized to extract the feature vectors from the blob detected image frames. Then, this optimal feature information is given as the input for SVM classifier or Navy Bayes for classifying the objects. Though, tracking and detection of HAR, WD and AOD are a crucial part in video surveillance. Compared to other existing systems in HAR, WD and AOD, the proposed system delivered an effective performance by means of accuracy, precision, recall, sensitivity and specificity. In future work, a new unsupervised classification approach is implemented with descriptor level features for further improving the classification rate of HAR, WD and AOD. As a future enhancement the system could be enhanced with surveillance at the in-flight.

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