SmarTRescueR-A Drone for Human Detection in Earthquake Affected Areas

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Abstract- ***Many areas of the world get affected by natural calamity. Disasters are unstoppable and leave behind a great loss of life. Disasters like earthquake, floods, etc. cause mass destruction and often lives get buried or trapped in debris. In such situations detection by rescue workers becomes time consuming and due to the vast area that gets affected it becomes more difficult. In this system, we are proposing a human detection quad-copter which can detect alive humans in debris so that timely help can be made available to the victims. The proposed alive human being detection system contains Passive Infrared sensor (PIR) which gives the information about the presence of alive human body. Radio Frequency Technology is used to control the quad-copter. ATMEGA8A microcontroller will give an alerting message to the rescue operator of the affected sites and they will give proper rescue to the affected victims. In disaster sites, it will be a great help to rescuers in detection of more alive human beings at the proper time. This system is also user friendly, economical, semi-autonomous and efficient for detection.***

Keywords – ***Passive Infrared sensor, Radio Frequency Technology, quad-copter, detection system***

I. INTRODUCTION

At present drones can be used in a wide range of commercial applications. A camera equipped drone is used to map an area, to protect border areas from intruders, to gather intelligence information on the battlefield, to take photos and videos of buildings, construction sites and ground areas. Many companies like Amazon are using drones to deliver their goods. Unmanned Aerial Vehicle (UAV) also known as a drone is a remote-controlled aircraft. It can be operated remotely in real time or pre -programmed to fly autonomously on the pre-defined routes. Quad copter is an Unmanned Aerial Vehicle (UAV) which has a capability of vertical take-off and landing at a point. Drones are available as fixed wing or Rotary wing. The fixed wing craft has high speed and heavy load capability, but it cannot stay at a point in mid -air. Whereas rotary wing craft can take-off vertically and can be held at a point. Rotary wing model, will produce three rotary motions about X, Y and Z axes are known as pitch, yaw, and roll respectively and two forces to provide linear motion. The Quadcopter has four rotors in which the contradictory end rotors must rotate in the same direction and the other end in the same direction. Quadcopter is used for carrying payload and crowd monitoring applications.

The Internet of Drones (IoD) is a layered network control architecture designed mainly for coordinating the access of unmanned aerial vehicles to controlled airspace, and providing navigation services between locations referred to as nodes. The IoD provides generic services for various drone applications, such as package delivery, traffic surveillance, search and rescue, and more. In this paper, we present a conceptual model of how such an architecture can be organized and we specify the features that an IoD system based on our architecture should implement. For doing so, we extract key concepts from three existing large scale networks, namely the air traffic control network, the cellular network, and the Internet, and explore their connections to our novel architecture for drone traffic management. A simulation platform for IoD is being implemented, which can be accessed from www.IoDnet.org in the future.

The use of unmanned aerial vehicles (UAVs) is growing rapidly across many civil application domains, including real-time monitoring, providing wireless coverage, remote sensing, search and rescue, delivery of goods, security and surveillance, precision agriculture, and civil infrastructure inspection. Smart UAVs are the next big revolution in the UAV technology promising to provide new opportunities in different applications, especially in civil infrastructure in terms of reduced risks and lower cost. Civil infrastructure is expected to dominate more than $45 Billion market value of UAV usage. In this paper, we present UAV civil applications and their challenges. We also discuss the current research trends and provide future insights for potential UAV uses. Furthermore, we present the key challenges for UAV civil applications, including charging challenges, collision avoidance and swarming challenges, and networking and security-related challenges. Based on our review of the recent literature, we discuss open research challenges and draw high-level insights on how these challenges might be approached.

2014, a Dutch student created a prototype 'Ambulance drone' which would be capable of rapidly delivering defibrillators and include live stream communication capability allowing paramedics to remotely observe and instruct on-scene individuals in how to use the defibrillators.

July 2015, the FAA granted NASA, the drone delivery company Flirtey and Virginia Tech approval to deliver medicine to a rural Virginia medical clinic.[3] Flirtey also made the first fully autonomous FAA-approved urban delivery in March 2016, when it delivered bottled water, emergency food, and a first aid kit to an uninhabited residential area in Hawthorne, Nevada.

2016, the Rwandan government partnered with the company Zipline International Inc. to build a distribution center near the town of Muhanga, from which the company's drones are used to deliver blood and pharmaceutical products to 21 facilities.

March 2017, the company Matternet partnered with the Swiss Post to launch the first medical drone delivery network in Switzerland.

October 2017, REMSA Health, an ambulance and emergency service provider, partnered with Flirtey, to dispatch portable defibrillators when 911 callers report cardiac arrest symptoms in Northern Nevada.

December 2018, Swoop Aero, an Australian drone logistics company, partnered with UNICEF and the Vanuatu Ministry of Health to deliver vaccines in remote areas of the Pacific island nation. A baby on Erromango island became the first person in the world to receive a vaccine delivered by commercial drone.

August 2019, Swoop Aero partnered with the NGOs Village Reach and GAVI to deliver vaccines in the Equateur province of the Democratic Republic of the Congo.

October 2019, CVS, a nation-wide drug store and pharmacy chain, is partnering with UPS, to make drone deliveries for shuttling medical samples. The packages will be up to five pounds and will be left on a back yard.

Boult et al., 2019, mentioned that video surveillance involves watching an area for significant events. Perimeter security generally requires watching areas that afford trespassers reasonable cover and concealment. By definition, such “interesting” areas have limited visibility. Furthermore, targets of interest generally attempt to conceal themselves within the cover sometimes adding camouflage to further reduce their visibility. Such targets are only visible “while in motion”. The combined result of limited visibility distance and target visibility severely reduces the usefulness of any panning-based approach. As a result, these situations call for a wide field of view, and are a natural application for omni-directional VSAM (video surveillance and monitoring). They described an omnidirectional tracking system. They discussed domain application constraints and background on the para-camera. They used frame-rate Lehigh Omnidirectional Tracking System (LOTS) and described some of its unique features. In particular, the system's combined performance depends on adaptive multi-background modeling and a quasi-connected-components technique. These key components are described in some detail, while other components are summarized.

Weiming et al., 2018, stated that visual surveillance in dynamic scenes, especially for humans and vehicles, is currently one of the most active research topics in computer vision. It has a wide spectrum of promising applications, including access control in special areas, human identification at a distance, crowd flux statistics and congestion analysis, detection of anomalous behaviors, and interactive surveillance using multiple cameras. In general, the processing framework of visual surveillance in dynamic scenes includes the following stages: modeling of environments, detection of motion, classification of moving objects, tracking, understanding and description of behaviors, human identification, and fusion of data from multiple cameras. They review recent developments and general strategies of all these stages. Finally, they analyzed possible research directions like occlusion handling, a combination of two and three-dimensional tracking, a combination of motion analysis and biometrics, anomaly detection and behavior prediction, content-based retrieval of surveillance videos, behavior understanding and natural language description, fusion of information from multiple sensors, and remote surveillance.

Hampapur et al., 2017, stated that situation awareness is the key to security. Awareness requires information that spans multiple scales of space and time. Smart video surveillance systems are capable of enhancing situational awareness across multiple scales of space and time. However, the component technologies are evolving in isolation. To provide comprehensive, nonintrusive situation awareness, it is imperative to address the challenge of multiscale, spatiotemporal tracking. They explore the concepts of multiscale spatiotemporal tracking through the use of realtime video analysis, active cameras, multiple object models, and long-term pattern analysis to provide comprehensive situation awareness. Valera and Velastin, 2016, surveyed the current state-of-the-art in the development of automated visual surveillance systems so as to provide researchers in the field with a summary of progress achieved to date and to identify areas where further research is needed. The ability to recognize objects and humans, to describe their actions and interactions from information acquired by sensors is essential for automated visual surveillance. The increasing need for intelligent visual surveillance in commercial, law enforcement and military applications makes automated visual surveillance systems one of the main current application domains in computer vision. The emphasis of the review is on discussion of the creation of intelligent distributed automated surveillance systems. The survey concludes with a discussion of possible future directions. Hsieh et al., 2016, presented an automatic traffic surveillance system to estimate important traffic parameters from video sequences using only one camera. Different from traditional methods that can classify vehicles to only cars and non-cars, the proposed method has a good ability to categorize vehicles into more specific classes by introducing a new "linearity" feature in vehicle representation. In addition, the proposed system can well tackle the problem of vehicle occlusions caused by shadows, which often lead to the failure of further vehicle counting and classification. This problem is solved by a line-based shadow algorithm that uses a set of lines to eliminate all unwanted shadows. The used lines are devised from the information of lane-dividing lines. Therefore, an automatic scheme to detect lane-dividing lines is also proposed. The found lane dividing lines can also provide important information for feature normalization, which can make the vehicle size more invariant, and thus much enhance the accuracy of vehicle classification. Once all features are extracted, an optimal classifier is then designed to robustly categorize vehicles into different classes. When recognizing a vehicle, the designed classifier can collect different evidences from its trajectories and the database to make an optimal decision for vehicle classification. Since more evidences are used, more robustness of classification can be achieved. Experimental results showed that the proposed method is more robust, accurate, and powerful than other traditional methods, which utilized only the vehicle size and a single frame for vehicle classification.

Mohamed et al., 2016, stated that visual surveillance systems have gained a lot of interest in the last few years. They presented a visual surveillance system that is based on the integration of motion detection and visual tracking to achieve better performance. Motion detection is achieved using an algorithm that combines temporal variance with background modeling methods. The tracking algorithm combines motion and appearance information into an appearance model and uses a particle filter framework for tracking the object in subsequent frames. The systems was tested on a large ground-truthed data set containing hundreds of color and FLIR image sequences. A performance evaluation for the system was performed and the average evaluation results are presented.

Lun et al., 2017, stated that classifying moving objects to semantically meaningful categories is important for automatic visual surveillance. This is a challenging problem due to the factors related to the limited object size, large intra-class variations of objects in a same class owing to different viewing angles and lighting, and real-time performance requirement in real-world applications. They implement an appearance based method to achieve real-time and robust objects classification in diverse camera viewing angles. They proposed the multi-block local binary pattern (MB-LBP) to capture the large-scale structures in object appearances. Based on MB-LBP features, an adaBoost algorithm is introduced to select a subset of discriminative features as well as construct the strong two-class classifier. To deal with the non-metric feature value of MB-LBP features, a multi-branch regression tree is developed as the weak classifiers of the boosting. Finally, the error correcting output code (ECOC) is introduced to achieve robust multi-class classification performance. Experimental results showed that their approach can achieve real-time and robust object classification in diverse scenes.

Fang et al., 2018, stated that in many image analysis and interpretation applications, shadows interfere with fundamental tasks such as object extraction and description. According to illumination, shadows interfere with moving vehicle extraction and location and recognition. For this reason, shadow segmentation is an important step in real-time vehicle recognition system. They proposed a simple and effective method for detection of moving cast shadows on a traffic surveillance scene. The proposed method exploits spectral and geometrical properties of shadows and relationship between the point in shadow region and space position and vehicle shape. Firstly, the cast shadows can be rough detected by spectral properties, and then feature points of occluding function are detected using wave transform, finally, the boundary between self-shadow and cast shadow is detected. The proposed method does not know in advance the light source direction and the color information of vehicle and background texture information. The experimental results demonstrate that the proposed cast shadows segmentation method can detect the shadows regions accurately and completely. This is the foundation for future vehicle recognition and understanding.

Hannah et al., 2018, stated that the problem of automated visual surveillance has spawned a lively research area, with 2015 seeing three conferences or workshops and special issues of two major journals devoted to the topic. These alone are responsible for somewhere in the region of 240 papers and posters on automated visual surveillance before they begin to count those presented in more general fora. Many of these systems and algorithms perform one small sub-part of the surveillance task, such as motion detection. But even with low level image processing tasks it is often difficult to compare systems on the basis of published results alone. They answer the difficult question "How close are we to developing surveillance related systems which are really useful?" It considers the question of surveillance in the real world: installations, systems and practices. The work then considers existing computer vision techniques with an emphasis on higher level processes such as behaviour modelling and event detection. It concludes with a review of the evaluative mechanisms that have grown from within the computer vision community in an attempt to provide some form of robust evaluation and cross-system comparability.

Kiryati et al., 2018, mentioned that video surveillance systems produce huge amounts of data for storage and display. Long-term human monitoring of the acquired video is impractical and ineffective. Automatic abnormal motion detection system which can effectively attract operator attention and trigger recording is therefore the key to successful video surveillance in dynamic scenes, such as airport terminals. It presented a solution for real-time abnormal motion detection. The proposed method is well-suited for modern video-surveillance architectures, where limited computing power is available near the camera for compression and communication. The algorithm uses the macro block motion vectors that are generated in any case as part of the video compression process. Motion features are derived from the motion vectors. The statistical distribution of these features during normal activity is estimated by training. At the operational stage, improbable-motion feature values indicate abnormal motion.

Ľuboš et al., 2010, reviewed of many existing video surveillance systems. With the growing quantity of security video, it becomes vital that video surveillance system be able to support security personnel in monitoring and tracking activities. The aim of the surveillance applications is to detect, track and classify targets.

Patrick et al., 2019, mentioned that the utilization of video surveillance systems is becoming common and is expected to more widespread as societies become more complex and the population continues to grow. The implementation of these video surveillance systems has provided valuable information and assistance in monitoring large areas. These systems typically use human operators to determine human behavior and to manually track people or objects of interest over an array of cameras. With the application of computers with video surveillance, real time surveillance of large public areas, people and their activities has been made possible for monitoring and security. They showed the effect of color space on tracking methods in video surveillance. Results from evaluations on different tracking methods have indicated that YCbCr and HSV color spaces have better tracking ability compared to grayscale and RGB color spaces. In addition, the results from evaluations have also indicated that data from selected layers in some color spaces can be used for the purpose of tracking namely the Cb and Cr layers from the YCbCr color space and the H layer from the HSV color space.

Haowei Liu et al., 2019, mentioned that surveillance videos are often compressed for transmission or storage. It is desirable to be able to perform automatic event detection in the compressed domain directly. They investigated the use of motion trajectories for video activity detection in the compressed domain. They showed that it is possible to extract reliable motion trajectories directly from compressed H.264 video streams. To overcome the problems caused by unreliable motion vectors, they proposed to include the information from the compressed domain prediction residuals to make the tracking more robust. They showed a real world application based on the classification of the motion trajectories to detect vacant or occupied parking spaces.

Brajesh and Neelam, 2018, discussed various algorithms related to frame based motion detection in surveillance system. The action of sensing a physical movement in the video sequence area is called motion detection. It can be achieved by mechanical form or electronics form. In mechanical form of motion detection, a tripwire is used. This is a simple form of motion detection. If a moving object steps into the tripwire's field of view (i.e. trips the wire), then a simple sound device (bells) may alert the user. While in electronic form of motion detection, motion detection have sensors which detect the movement of an object and according to that it sends signals to sound device which produce an alarm or switch on to the image recording device. In this method, three stages for video frame extraction are followed: Tracking step, Detection step and Validation step. In tracking step, the objects which have been previously identified are tracked to find their position and shape within the current video frame. Same time motion of these objects is estimated. In detection step, the new moving objects are detected and their shape as well as motion is estimated. This step also consists creation of new hypotheses regarding new moving objects. In final step i.e. validation step, if any of the hypotheses are valid, then new moving object is identified at this frame and this will now be tracked through subsequent frames.

Juhyun et al., 2015, proposed a mechanism to resolve the object tracking problem on the video security surveillance system. The method of location calculation is based on the Chirp Spread Spectrum (CSS) method which is considered the three-dimensional space to improve degree of accuracy of location information. The suggested mechanism can make intelligent tracking and recording for interesting objects so that make the amount of valid video high and improve video's quality.

Kinjal and Darshak, 2014, presented a survey of various techniques related to video surveillance system improving the security. They reviewed of various moving object detection and object tracking methods. They focused on detection of moving objects in video surveillance system then tracking the detected objects in the scene. Moving object detection is first low level important task for any video surveillance application. Detection of moving object is a challenging task. Tracking is required in higher level applications that require the location and shape of object in every frame. They described Background subtraction with alpha, statistical method, Eigen background Subtraction and Temporal frame differencing to detect moving object.

Mamatha et al., 2015, stated that automating the processing of streaming video systems and fast motion detection is an important scientific and engineering challenge in the extraction of information regarding moving objects and makes use of stabilization in functional areas, such as tracking, classification, recognition. They proposed fast motion detection for the CCTV video surveillance system. This achieves complete detection of moving objects by using three significant proposed modules: a Background subtraction (BS) module, and object detection and tracking (ODT) module. For the proposed BS module they use Memory Gradient (MG) Based Background Subtraction to adapt slowly to the changes occurring to the background and produce optimum background pixels for the background model. (ODT) module gives the foreground object along with all the errors induced to illumination, reflection and all the other factors. The detection results produced by this method were both qualitatively analyzed through visual inspection and for accuracy. The analyses showed that this method has a substantially higher degree of efficiency.

Feng et al., 2016, mentioned that in traffic surveillance, computer vision methods have commonly been utilized to detect vehicles because of the rich information content contained in an image. The detection and tracking of moving vehicle in traffic environment is one of the most important components in intelligent transportation system (ITS). The adaptive background modeling method was used to eliminate the negative effects from moving vehicle and rebuild the background images. The moving vehicles were segmented with difference images between background and current images. To suppress noise caused by segmentation and improve robust performance of vehicle detection, a template with 3- by-3 window was utilized to decrease isolated noise points around vehicle contours. Then, the morphological filtering, including erosion and dilation operation, was also applied, which minimizes the influence of the discontinuous block noise. Finally, to reduce the searching scope of vehicle detected and improve the calculation speed, Kalman filter model was performed to track vehicles. The experimental results verified the effectiveness and real-time of algorithm.

Abhishek and Deep Kumar, 2013, discussed a video surveillance scenario with real-time moving object detection and tracking. The detection of moving object is important in many tasks, such as video surveillance and moving object tracking. The design of a video surveillance system is directed on automatic identification of events of interest, especially on tracking and classification of moving objects. Normally a video surveillance system combines three phases of data processing: moving object extraction, moving object recognition and tracking, and decisions about actions. The extraction of moving objects, followed by object tracking and recognition, can often be defined in very general terms. It reviews briefly research works on object detection and tracking in videos. The definition and tasks of object detection and tracking are first described, and the important applications are mentioned.

II. OVERVIEW OF THE PROJECT

The use of unmanned aerial vehicles (UAVs) is growing rapidly across many civil application domains, including real-time monitoring, providing wireless coverage, remote sensing, search and rescue, delivery of goods, security and surveillance, precision agriculture, and civil infrastructure inspection. Smart UAVs are the next big revolution in the UAV technology promising to provide new opportunities in different applications, especially in civil infrastructure in terms of reduced risks and lower cost. We also discuss the current research trends and provide future insights for potential UAV uses. Furthermore, we present the key challenges for UAV civil applications, including charging challenges, collision avoidance and swarming challenges, and networking and security-related challenges. Drone-based delivery of goods could become a reality in the near future, as witnessed by the increasing successful experiences in both research and commercial fields. In this paper, a prototype system exploiting a do it yourself quad copter drone for delivering products is proposed. On the one hand, the hardware choices made in order to limit risks arising from autonomous delivery are presented. On the other hand, a framework for orders placement and shipment is shown. The advantages of a system like the one described in this paper are mainly related to an increased delivery speed, especially in urban contexts with traffic, to the possibility to make deliveries in areas usually difficult to be reached, and to the drone's ability to autonomously carry out consignments. A practical use case, in which the proposed system is used for delivering drugs (an application in which the need to quickly receive the good might be particularly important) is shown. Nevertheless, the proposed prototype could be employed in other contexts, such as take-away deliveries, product shipments, registered mail consignments, etc.

III. OBJECTIVES OF THE PROJECT

At present drones can be used in a wide range of commercial applications. A camera equipped drone is used to map an area, to protect border areas from intruders, to gather intelligence information on the battlefield, to take photos and videos of buildings, construction sites and ground areas. Many companies like Amazon are using drones to deliver their goods. The main objectives are to carry the payload of 250g m cover from one place to another with 6min flight was tested. By mounting high resolution wireless camera and used for monitoring the crowd in the campus. It can be used for surveillance applications.

IV. PROPOSED SYSTEM

The proposed platform comprises two major parts: Drone Systems and Ground Systems

Figure 1: Platform overview.

V. BLOCK DIAGRAM FOR DRONE

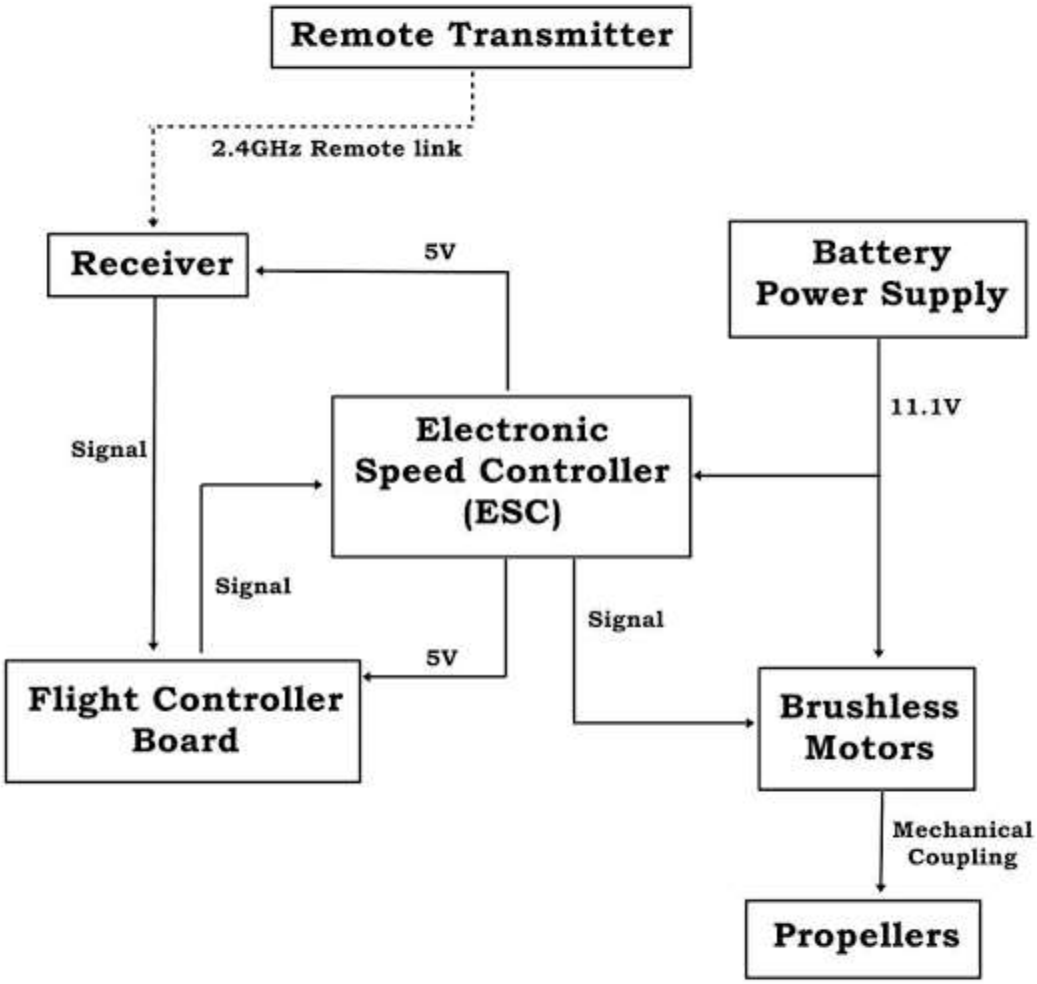

FIGURE 2: DRONE BLOCK DIAGRAM

FIGURE 3 DRONE DESIGN

FIGURE 4 FULL SKETCH OF DRONE

CODING: (ARDINO interfacing)

```
/*
 * PIR sensor tester
 */

int ledPin = 13;                // choose the pin for the LED
int inputPin = 2;               // choose the input pin (for PIR sensor)
int pirState = LOW;             // we start, assuming no motion detected
int val = 0;                    // variable for reading the pin status

void setup() {
  pinMode(ledPin, OUTPUT);      // declare LED as output
  pinMode(inputPin, INPUT);     // declare sensor as input

  Serial.begin(9600);
}

void loop(){
```

```
  val = digitalRead(inputPin);  // read input value
  if (val == HIGH) {            // check if the input is HIGH
    digitalWrite(ledPin, HIGH);  // turn LED ON
    if (pirState == LOW) {
      // we have just turned on
      Serial.println("Motion detected!");
      // We only want to print on the output change, not state
      pirState = HIGH;
    }
  } else {
    digitalWrite(ledPin, LOW); // turn LED OFF
    if (pirState == HIGH){
      // we have just turned of
      Serial.println("Motion ended!");
      // We only want to print on the output change, not state
      pirState = LOW;
    }
  }
}
```

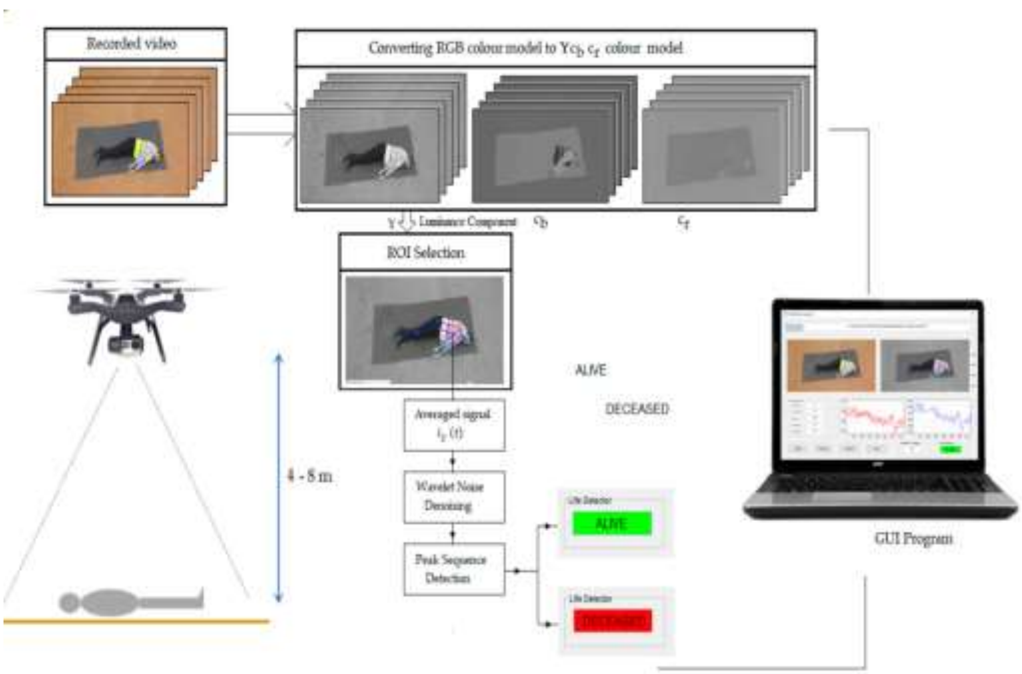

FIGURE 5 OUTPUT OF REMOTE SENSING DETECTION USING DRONE

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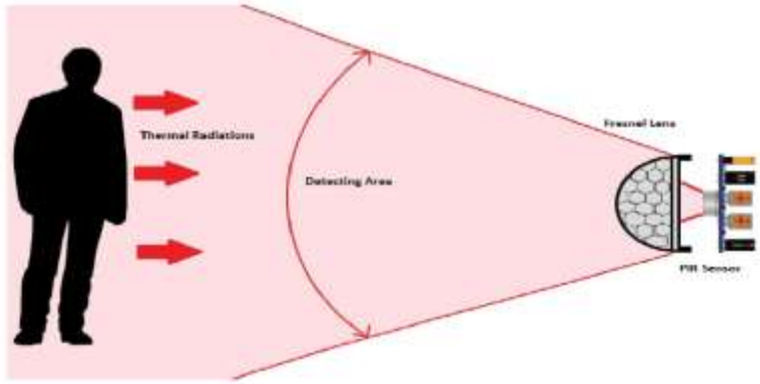

Fig. 3. Passive infared sensor working

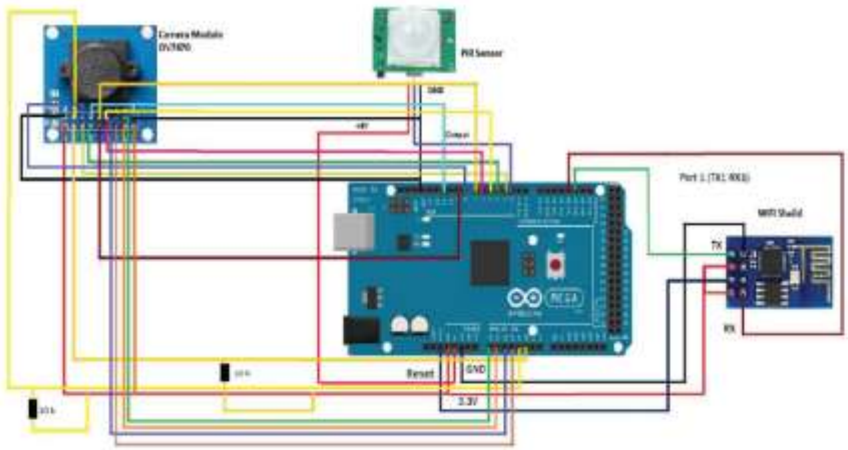

FIGURE 6 OUTPUT OF SMART HUMAN DETECTION DRONE FOR RESCUE

FIGURE 7 OUTPUT OF DETECTOR USING DRONE IN DISASTER EARTHQUAKE

VI. WORKING OF DRONE SYSTEMS

Drones are a complex aggregation of hardware equipments with their own specifications, technicalities and firmware, but all of them are controlled through a microprocessor with auxiliary sensors that can either be built-in or external to the microprocessor board. Since this sort of technical details are out of the scope of this paper, further reference to these technical aspects will be mostly mentioned through the technical term for this piece of hardware, Flight Controller (FC). The Drone Systems are composed by all the required flight components, each of these will play a critical role towards its safe operation

• The Drone Broker supports the main communication bus on board of the drone. The system also has a relay mechanism which is responsible to directly relay back and forth messages with the Ground Systems.

• The Flight Analyzer connect to flight telemetry data to process and analyze the behavior of the drone. Through pattern detection and behaviour profiling, this system can detect anomalies to actively notify the Ground System and try to fix the issue. As a last resort, it can activate Fail-Safe Systems.

• The Fail-Safe System(s) is a mechanism that, when triggered, tries to minimize the consequences of a failure. These can be very basic like preventing takeoff, or forcing a safe landing on the detection of low battery levels.

• The Drone Logger taps in to the required broker channels or topic in order to create a local copy of all the events occurred within the drone for debugging and registry purposes.

• Represented by a code file, the Drone Controller acts as an adapter design pattern, translating broker command messages to messages that are readable by the FC, abstracting the platform from the technical aspects required to properly interact with the FC.

• The Flight Controller (FC) has the task of controlling the flying drone process and correct its behaviour, which properly represents the command end-point and the internal drones' telemetry (altitude, temperatures, barometer, accelerometer, acceleration, voltage and cell voltages, GPS) data source generator.

• The Drone Mapper consists on the further extension of actual geo-fencing functionalities of drones. In direct communication with its other half, Ground Mapper, it supports dynamic map loading based on current GPS data and a given radius. Moreover, it is capable to provide richer information like obstacles and minimum/maximum altitude restrictions, common to urban scenarios.

VIII. WORKING OF GROUND SYSTEMS

The Ground Systems are composed of services, systems and processes that are auxiliary to flight (e.g.: data storage, management, front ends, etc.) or can extend flight functionalities (e.g.: support in-flight drone exchange, automated flight plan for area patrolling or aerial mapping/surveillance) The ground systems' communications are based on brokers which play a key role through their message routing capabilities, development and production instances, which co-exist side by side without the need to build a development oriented deployment of the entire platform. The composition of the ground systems architecture is details of each of the components will be explored as follows:

• The Ground Broker, similar to the Drone Broker, supports the main communication bus to the Ground Systems. Due to the possibility of growing (vertically scalable), it has added responsibility of filtering and routing of each individual drone message. Moreover, because of its clear potential to be a platform bottleneck for architectural purposes, it must be a cluster (horizontally
scalable) capable broker system.

• The Drone Manager has the responsibility of tracking the drones' status and serve as an internal proxy between the drone controlling and the actual controlled drone. Being a proxy, it can reroute commands to a different drone without the need of major reconfigurations either to the controller of the drones involved.

• The Data Storage is the representation of a data storage system for later analysis or auditing purposes of the platform.

• The Ground Logger connect to the required broker channels or topic to create a local copy of all the events occurred within Ground Systems for debugging and registry purposes.

• The Diagnosis Dashboard is a visual front-end that can access performance and sensor data from the entire platform and drones with the lowest latency possible, allowing visual trouble diagnosis. Moreover, it shall be capable of review older datasets for history purposes.

• The Control Dashboard stands for a GCS like front-end dashboard in which users may control their active drones through high-level commands (e.g.: up/down, left/right, etc.). Moreover, they shall allow control for embedded-drone sensors like video cameras, thermal cameras, etc.

• The Systems Monitor is responsible for the monitoring of the Ground Systems for automated detection of service failures, network latency, disk usage and alert emission to the platform administrators.

• The Telemetry Stream Processor connect to telemetry data sent by the drones, and it processes the received data to generate new information to feedback the platform (e.g.: compute number of packets received by drone, compute statistical data for drone behavior analysis, etc.).

• The Telemetry Analyzer connect to the flight telemetry data to analyze the behavior of the drone and detect anomalies. Through this system, the Ground Systems can react to behaviour changes to mitigate the issue (e.g.: parachute deployment, emergency landing). Unlike its similar process on board the drone due to computational capacity available, it can perform complex analysis of flight parameters potentially gaining extra knowledge and awareness about the drone flight conditions.

• The Ground Mapper (depicted as other modules) is the concept to extend the natural geo-fencing supported by most of the drones. It has the responsibility to track each drone location and actively update it for hazards, safe zones, landing zones, no fly zones, etc. Using dynamic map loading techniques, therefore saving memory and storage in the drone also removes the need to reupdate maps and geo-fencing configurations, keeping all the drones constantly up to date.

• The Drone Coordinator (depicted as other modules) has the task of ensuring that drones in a certain area can coexist without interfering with each other. Tapped to flight telemetry, it can detect distances between each drone, up on trespassing a minimum safe distance can notify each of them and even suggest safe actions on how to proceed, like an aerial traffic controller.

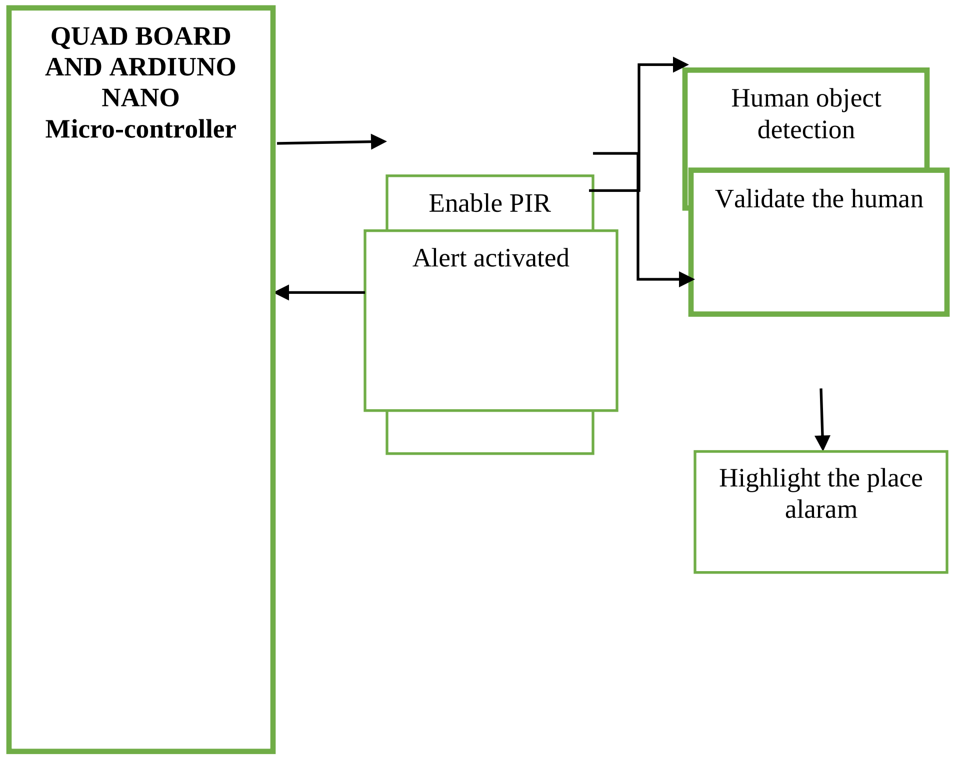

FIGURE 8 ARCHITECTURE DIAGRAM

IX. CONCLUSION

The proposed an automated flying drones platform, building a modular platform to support control abstraction and direct control decoupling, therefore effectively standardizing integration methodologies to allow drones as a service, where high level commands can be issued to the platform, removing the complexities of actually flying the drone itself directly. Moreover, the platform supports user-friendly control of drones, which is an important step towards integrating multiple drones and multiple types of drones within the platform, therefore creating a value added tool to develop and support more complex tasks and use cases with usage of flying drones. The results show that the proposed platform is able to properly abstract and decouple the direct control, handling up to 32 drones with no significant impact to the observed performance. The platform is also capable of displaying and correlating sensor metrics obtained in real-time during the drones' flight. As future work we plan to integrate external sensors and provide mechanisms for data gathering, as well as cameras for tracking objects and people.

REFERENCES

[1] H. Shakhatreh et al., "Unmanned Aerial Vehicles: A Survey on Civil Applications and Key Research Challenges," arXiv preprint arXiv:1805.00881, 2018.

[2] P. Daponte, L. De Vito, G. Mazzilli, F. Picariello, S. Rapuano, and M. Riccio, "Metrology for drone and drone for metrology: Measurement systems on small civilian drones," in Metrology for Aerospace (MetroAeroSpace), 2015 IEEE, 2015, pp. 306-311: IEEE.

[3] A. Shukla and H. Karki, "Application of robotics in onshore oil and gas industry—A review Part I," Robotics and Autonomous Systems, vol. 75, pp. 490-507, 2016.

[4] A. C. Watts, V. G. Ambrosia, and E. A. Hinkley, "Unmanned aircraft systems in remote sensing and scientific research: Classification and considerations of use," Remote Sensing, vol. 4, no. 6, pp. 1671-1692, 2012.

[5] F. A. Al-Wassai and N. Kalyankar, "Major limitations of satellite images," arXiv preprint arXiv:1307.2434, 2013.

[6] K. Máthé and L. Buşoniu, "Vision and control for UAVs: A survey of general methods and of inexpensive platforms for infrastructure inspection," Sensors, vol. 15, no. 7, pp. 14887-14916, 2015.

[7] "Hovering over the drone patent landscape, ifi claims patent services, Nov 2014 [online]. https://www.ificlaims.com/news/view/blogposts/hovering-over-the-drone.htm."

[8] L. Gupta, R. Jain, and G. Vaszkun, "Survey of important issues in UAV communication networks," IEEE Communications Surveys & Tutorials, vol. 18, no. 2, pp. 1123-1152, 2016.

[9] J. Senthilnath, M. Kandukuri, A. Dokania, and K. Ramesh, "Application of UAV imaging platform for vegetation analysis based on spectral spatial methods," Computers and Electronics in Agriculture, vol. 140, pp. 8-24, 2017

[10] Abbasi,E.,And M.Mahjoob " Controlling Of QuadrotorUAV Using A Fuzzy System For Tuning The PID Gains In Hovering Mode." Web.22Mar.2015.