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Event Identification with Motion Detection

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Abstract:
This explores the various applications of motion detection technology with different systems including Computer web cameras, ultrasonic proximity sensors, laser obstruction and passive infrared radiation detection, and creates a framework for novel applications and embedded systems with unforeseen abilities, with the concept of Event Identification. Various applications of the aforementioned systems will aim at overcoming the use of more sophisticated and costly technologies like computer vision, object identification, wearable sensors or gesture reading, yet, giving accurate and correct detections, thus stimulating response. This will further serve as a base for making various futuristic and seemingly costly technologies reach the general public at affordable prices, and enable other detection and decision making technologies including AI/ML. Besides small appliances, this concept of Event Identification (EI) is going to have applications in various fields of technology in broader terms, in almost all branches dealing with detection and sensing, either as the governing, or a subordinate confirmatory step. This research work summarizes a comprehensive study on how to identify events, using fundamentals, yet unique coordinates and characteristics of the motion, to which the application device tends to respond, and explains its applications that will serve as the base for technologies like spatial typing with finger movements, playing strings and percussion with gestures, detection and surveillance of people staying alone, specified coordinate AI CCTV Surveillance, industrial automation, monitoring and count of the vehicle or humans passing a particular channel, touch less Computer-mouse and many others, with the use of elementary algorithms and firmware assembly. It can effectively and extensively overcome the cost to enable these and dominate over various applications of raw Computer Vision.

IndexTerms: Motion-Detection, Event-Identification, Automation, Infrared, Automation, Computer-Vision, Iot, Arduino, ESP32CAM, Scratch, Algorithm.

INTRODUCTION

Modern research works on the fields of IoT, Automation, holograms, etc. have an extensive reach based on applications of computer vision and comprehensive response. However, there are many drawbacks faced during the extensive large-scale installation of this system, like costliness, parts to be integrated, volume, memory constraints, etc. Keeping these in mind, and after extensive research and experimentation with motion detection technologies and applications, we have developed various algorithms which will use elementary procedures to make the most out of the technology, and it will potentially replace various uses of raw computer vision, keeping thighs small, compact, convenient and affordable. To use the motion erection systems to this extent, we have to train them to identify motion. Animals like bats, though unable to see at night, are expert nocturnal hunters. In the process, they have a step-by-step approach to decision making - An obstruction of waves, can be anything, then they decide its size, the motion of the object, and finally, putting all these together, they decide what actually it is,

or whether it is anything of its interest. In the same way, simple motion detection is the first step which triggers decision-making. The proposed algorithm will do a boolean study on the motion, study its characteristics and narrow it down from a universal set of everything, to whether exactly it is what we desire. The algorithms, after extensive study and experimentation, making devices face exceptions and a comprehensive study, can be utilized by, motion detection technologies not only to detect, but also comprehend via different Booleans, based on the angle and place of installation, fundamental scopes of motion, like a door, or a variety of specific motions as in case of a gesture-controlled keyboard, mouse or musical instruments. Some of these technologies- though existent, require computer vision or wearable only, or support in VRs alone. It can serve as the basic framework for automation systems, surveillance and various futuristic interactive technologies for use in homes, schools, hospitals, traffic sites, museums, industrial automation, and a variety of other places. Ahead in the research, we have developed many raw devices by using technologies like Infrared or ultrasonic sensors integrated with Arduino UNO Microcontroller board, laser interference circuits, and computer programs in even beginner-level language like Scratch (based on JavaScript), which will give various frameworks to applications ranging from day-to-day requirements to futuristic technologies what one had dreamt of; and also, explored the implementation of similar application with different methods of motion detection.

LITERATURE REVIEW

Effective detection of motion can be achieved with various technologies including sensors like PIR (Passive infrared sensor), and HC-SR04 Ultrasonic Distance sensor integrated with Arduino, circuits including laser beam obstruction, or simply using CCTV or web cameras with your computer. These can be selectively used in applications, keeping in mind the feasibility, volume, prices and requirements.
The HC-SR04 uses sound waves to measure distance like sonar. It emits high-frequency ultrasound (40 kHz), listens for the echo, and calculates the distance of the nearest obstacle based on round-trip time. This affordable sensor is popular in robotics, automation, and hobby projects for its ease of use and non-contact measurement, with excellent range, accuracy, and narrow detection angle for close ranges, which is preferred for perfection. On the other hand, a Passive infrared (PIR) sensor detects heat radiation emitted by objects. They don't emit any radiation themselves (passive). Instead, they sense changes in infrared light, commonly used to detect motion, specifically of living organisms. PIR sensors are low-cost, low-power, long-range and widely used in motion-based activation due to their ability to trigger actions based on presence without needing direct contact. To implement either of these, we have to use Arduino and the required sensor together. To develop a high-efficiency system and wireless communications between devices, we can use software and hardware tools to implement this security system.
The board has a serial communication interface, including a Universal Serial Bus (USB) on Arduino models that are also used for loading programs from personal computers.
Cameras can achieve motion detection through software analysis of video footage. This method compares consecutive frames to identify significant changes in pixels, or frames indicating movement within the camera's field of view. It can detect the intensity of motion and the direction of the same. It can be often integrated with hexadecimal colour reading. The laser tripwires system is a setup, where a laser beam is shone across an opening and can be reflected in various directions. If something interrupts the beam, it triggers the motion detection system. This is a simpler system, but it only detects motion

along the path of the laser beam. It hence, has a very perfect angle of detection.
Having detected the situation, the system analyses and sends the appropriate stimuli to the connected responsive gadget. The microcontroller with sensors are programmed using Embedded C programming language, and the computers with languages like Python and Scratch (Visual Languages). The response can be anything from motion, alarms, trigger calls, or SMS, and anything we optimize and program the firmware or PC to.

EVENT IDENTIFICATION (EI)

The considered movement for any particular device, to which it should trigger a response, is what we call an Event. A device may have a couple of events it should respond to, and we call it a set. Event Identification is the process by which an electronic programmed device will identify whether any particular movement belongs to its set of events. Every movement that we aim to react to, has a set of particular motion characteristics. Any particular point in space where a motion can confirm the object's being, will be referred to as the spots of fundamental interception.
Event identification is, basically, the part of the brain of the system, which will asses, what the sense organs read, and comprehend the maximum out of it. EI is going to be the base of all decision-making technologies like advanced AI/ML, IoT, Robotics, Automation and Nature-Computer interaction as a whole. From just replacing computer vision in day-to-day lives, its algorithms, with further research, can contribute to various fields of technology like AI Warfare, and fields of engineering in industry, manufacturing, defence, space and aeronautics.

AIM AND OBJECTIVES

1. **Aim:** The effort will lead to laying the foundation for the creation of a highly economically practical and unique set of robust perception systems which, in all probability, will understand the desired kind of movements in front of it, use fundamental yet unique characteristics of the motion to identify, and stimulate the response expected.
2. **Objectives:** The goal of this project is to provide algorithms and system procedures that will focus on, how exactly, the Motion Detection technology can be used in its various applications, that too, more efficiently than computer vision, or wearables based on the fact that, most motions have a fundamental flow and unique characteristics, which we will try to read and comprehend whether and which type of desired motion it resembles and respond accurately.

1. To develop a set of extremely dependable systems.
2. To explore the framework of the development of various futuristic gadgets.
3. To enable installation of systems in minimum volume and parts.
4. To overcome the requirement of contact and closeness to the gadget for response.
5. To lay down the fundamental base for environmental automation with IoT or Computers.
6. Developing the same in easily accessible and low-end architectural requirements for public use.
7. Creating a low-cost and affordable system of monitoring and response.
8. To create a monitoring system that includes no camera, thus respecting privacy.
9. To use open-sourced environments that can be easily accessed by any supplier or manufacturer.
10. To develop a workflow for beginner-level languages and IDEs to effectively support work on futuristic projects.

EXISTING SYSTEM

The applications and implementations we are talking about here, some of them are enabled by the use of raw Computer vision and its subtopics like gesture reading, face recognition, trajectory tracking, and object identification; and sometimes wearables for motion detection which are still too expensive. Some such applications include gesture keyboards (in VRs, or wearable straps Only), Security systems, traffic monitoring, etc. However, many of these can be replaced with technologies of
motion detection, that will analyze characteristics and in all probability, will work as effectively as expected. Besides, this method will open windows for non-existent systems or practically produce concepts, in a much more effective manner.

EI IN SMALL APPLIANCES

To replace computer vision and its various other sub-parts with motion detection, what we have to first be able to implement, is decision-making; the process, in which the device will be able to classify between any random motion and the motion exactly wanted, through the process of Event-Identification. It does not necessarily require a vision to confirm. Now, it may not always be that it can be overcome, but for regular use, we have to make sure of its installation, and the way it is being used. When both are as per guidelines, it will give a perfect result without any fail. Event-Identification is going to include the most complicated set of steps in the entire procedure of development.
Now, based on the trigger requirement, exceptions and its application, we divide the types of movement into two main types:

1. Conscious Trigger

A conscious trigger is a kind of movement caused within the wave or optical range of the detection device, consciously by a person to obtain a specified response. Such applications require devices which will detect the motion in a particular range, accurate height readings, sharp boundaries and often at different heights and distances in front of the detector. It is, a kind of a particular code language of hand movements the user performs in front of the detector, and the detector stimulates response. However, to make an effectively user-friendly device we have to keep it as aligned as possible with the real-life movement as if the user is handling a hard matter. This replaces the requirements of gesture reading with the camera. Some of its applications with respective event identification procedures are as follows.

1.1 Gesture Keyboard

A gesture control keyboard is a device, when within its range a user moves his hand, not necessarily in contact with any matter, just like typing in any usual keyboard- it will read ur hand movement and finger tapping to show what you are writing. This seems somewhat difficult without vision. However, there are characteristics of this moment. Now, the characteristic of hand finger taping is, that the hand comes in front of the screen, and taps with a finger raised. The tip of the finger, while taping shows the maximum intensity of motion. Through experimentation, the average of the minimum intensity shown in the tapping movement, but likely to not respond to most other movements, studies over a set of at least 50 readings, will be referred to as the threshold intensity. When moved as a whole, the rest of the hand seems to be of less motion. So, in every minor interval, among all the keys on the keyboard facing movement, the set of keys with any intensity more than the threshold intensity will be the ones which will contain the key pressed, for sure. Now, among them, the key, with the highest Y-Coordinate (When the Screen is an X-Y plane), will be the one pressed. Again, if at all there is more than one key with high intensity, for the right-hand half, the key with maximum X value, and for the left-hand side, the key with

minimum X-Coordinate value will surely be the key pressed. Believe me, it has to work!

1.2 Gesture Drums/Percussion (with Arduino Firmware and Ultrasonic sensor)

A gesture drum is again, an Advanced MIDI device for the next generation of Musicians - where one can play the sticks above, in the air, perpendicularly on a board-like device kept below, and the accurate sound is played based on the movements. Here, we have to build the base device with multiple yet minimum numbers of HC-SR04 ultrasonic distance sensors, integrated with the Arduino UNO Microcontroller Module, which can read the obstruction movement, as well as the perfect distance of the same from the device. To classify between any random obstruction and a perfect beat - we have to construct an algorithm studying the fundamentals of a beat - the motion of going down, and coming up, recording the continuous but non-differentiable Modulus graph of function |x+(minima)|, as plotted by measuring the distance in every one-tenth of a second (Fig 1). Also, the minima of the graph will tell about the intensity of the hit. The minima of a soft, medium and hard beat are to be pre decided and corresponding audio files have to be pre-loaded.

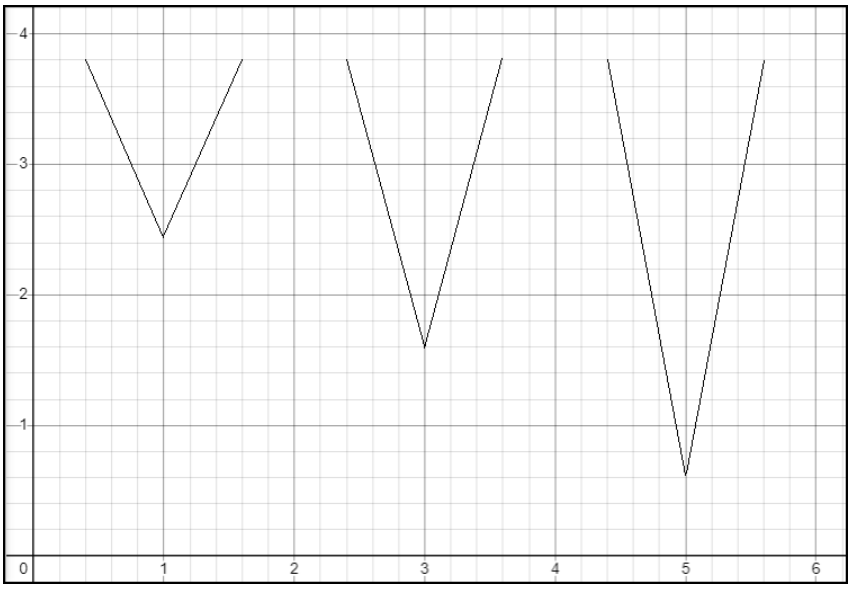

Fig. 1; Graph of Aerial Motion of Beats on Drum

1.3 Invisible Octopad (with Computer Web-Camera)

In the world of music, an Octopad refers to a specific brand of electronic drum pad instrument that features eight rubber pads on a rectangular surface that drummers or percussionists can strike to trigger various sounds. Going one step ahead of this old MIDI System, we can develop a system, where the Musician will play the drumsticks in the air, in front of a computer and as per the beats and movements; the desired sound will be played. When the camera is placed below the drumming area, parallel to the imaginary drumming base (the drumming plane, the camera lens and the floor should be on the same Cartesian plain), it will work the same way as the Gesture Keyboard. As the drumstick is thin, there will be only two governing factors-threshold intensity, and the similar highest Y-Coordinate. As the drummer will lift the stick after each beat, it will also recede in the Y-coordinate from the drumming plane, thus causing no additional disturbance. For consistent threshold and to support speed-drumming, the camera used should be of high frame rate, preferably not less than 60, with high shutter speed, high definition image and resolution.

2. Unconscious Trigger

Unconscious triggers are events caused within the range of the detector, such that, the person causing the motion does not require any voluntary actions to do, or preferably, no point to keep in mind, while the stimulation occurs. In many cases, it should be such that, the subject causes the trigger even when he is unaware of the detector or at times, tries to avoid any trigger by probability. Unlike Conscious triggers, the subject will not align themselves to the detector; rather, the detector needs intricate and tactful installation to receive the subject's motion.

2.1 Solitary Residents Inactivity Monitor

It is one of the best examples to explain the concept of Event- Identification. Sometimes, zero motion is also suspicious. The proposed device can be used for a variety of reasons, for persons of all ages, staying alone in apartments, specifically for senior citizens. A motion monitoring system based on Arduino technology has been built in this project. To monitor one's motion, we have to place the device in a place, across a door which the person will pass through, for sure, in the entire period. A person living alone, without any caretaker, will surely go to use his/her washroom multiple times a day, and hence, it is suggested to install the device beside the washroom door. As the subject goes in and out, his/her movement is detected - By seeing that the distance between the door remarkably reduces from 2.5 ft of the door. When the movement is not detected for a long time, an SMS is sent to the near and dear ones for checking out. This needs perfect monitoring but doesn't require a camera, just an Ultrasonic distance sensor, and an Arduino UNO Module.

2.2 Localized AI Surveillance.

This is a computer web-camera-based system, launched as a FOSS Project, 'CatSight- AI' from Github, coded in Scratch, which serves as the best example of this concept. It can be presented as a pure web application or a lightweight Desktop app, which can even support on low-end PCs as well. This is a CCTV-like monitoring System which does not record but rather serves as a complement to CCTV Systems. It has a very well-organized algorithm which lets the user select a particular area, anywhere on the screen, of any size, which will be seen by the AI, that this particular part is supposed to have no motion. Like, in a museum, there will be a full crowd and motion, but a particular zone is a no-movement zone, where the exhibits are kept. The monitoring person can see the entire room, but that particular point is over-consciously observed, and even when the monitoring is not active, if the computer detects movement, it will hit an alarm, and in a downloadable file, list down all the activities including the selection of zone, the coordinates, the sensitivity (threshold intensity, which can be controlled), and the accurate date and time of the motion. This will serve to be a very productive and helpful application in unmanned security systems. Also, during investigations, the CCTV footage need not be seen for long hours, rather the list can be used to see the assorted times when anything suspicious was seen. This requires a very tactical installation, and preferably a camera with a high frame rate, resolution and shutter speed.

2.3 Security Alarms

The concept of security alarms is well-known and perhaps among the few active applications of raw motion detection. In case any motion is detected, it rings an alarm. This same principle is used for systems like Automatic doors, motion lights, etc. Here, the algorithm is quite simple but requires tactful installation and wise choice of sensors and firmware. Though it can be achieved by almost all detectors, the PIR is suitable, as it can detect the motion of living things, by their infrared variation in the environment, but can be false-triggered by animals as well. The Ultrasonic Sensors or Laser tripwire

systems, if installed, will detect any motion and it is the most preferred for monitoring a particular passage and through perfect lines. The laser and computer-based motion detectors will have a higher range. The detectors need to be chosen as per requirements and installation feasibility.

2.4 Human/Vehicle Counting System

This is a system for a detection device which can count the number of incoming or outgoing people or vehicles through a particular passage, say a door, or a toll. Motion Detection systems can detect the direction of motion as well. In case we use Ultrasonic sensors, it will require two sensors, and the consecutive motion triggers need to be counted, which may not give perfect outcomes at times of large ins and outs. Hence, we would prefer using Computer based detectors, coded in Scratch. It can detect the direction of ay motion, above the threshold intensity, and count accordingly. It requires intricate details to be kept in mind while installing the camera.

The above examples are just a few examples to explain the process of event identification and trigger thoughts about what exactly the fundamental characteristics of motion are, and how to study them. There can be innumerable other applications which can be very beneficial for the public. The Conscious Trigger Devices does not require very sharp installation and the user can easily align to using it, comfortably, whereas, the Unconscious Trigger Devices may often require very conscious installation, keeping in mind intricate details and possibilities, such that it covers the entire range of fundamental motion (all points of fundamental interception) , but no unnecessary zones at all.

SYSTEM ARCHITECTURE

Having made an intelligent choice of sensors and firmware, we should next look into the system set-up for effective results. Here, we will cover the aspects of small applications, for day-to-day or small-scale use. The Systems can be classified into two broad types based on the governing or controlling devices of sensors. The required setups for each technology discussed above are as follows:

1. Arduino/ESP-Controlled Devices:

Arduino refers to a concept of the Internet of Things (IoT), run by an open-sourced hardware – a microcontroller integrated circuit in the form of a circuit board named Arduino-UNO or any other models as per requirement, like NANO, Mega, etc., where the centralized controller is an ATmega328 P Controller. The ESP systems are based on Espressif32 or 8266 Processors, and are much faster and efficient than Arduino boards nowadays. They are programmed in C++ Language in the Genuino IDE, and are compatible with various input and output systems and many other Microcontroller modules. The given Circuit diagram (Fig 2) shows a sample assembly of all the common types of detectors we discussed about here. Besides the sensors, the response system like alarms, motors, GSM, or any other module, needs to be connected to the same board.

1.1 Ultrasonic Sensor Setup:

The HCSR04 Ultrasonic Sensor is placed in front of the device, facing the path of the subject's movement. It should be placed parallel on the front face, or in an extended flexible connectable piece, preferably only the two Ultrasonic emitters and receiver peeping out of the body. The four pins are connected VCC to 5V VCC, GND to GND, and Trig and Echo to two digital pins of the Arduino UNO Board.

1.2 PIR Sensor Setup:

The Passive Infrared Sensor is fixed on a device, from where in a 7m Spherical radius; the subject can cause motion, preferably fixed on the top face of a device, the diffusion dome stuck out. The three pins

are connected as, VCC to 3.3V VCC, GND to

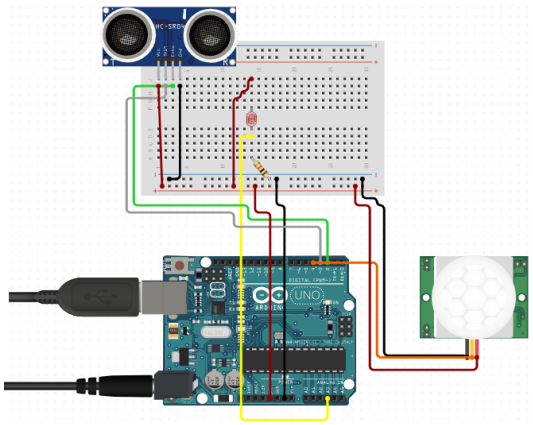

Fig. 2; Arduino Circuit Setup for EI Detection Interface

1.3 Laser Tripwire System:

The laser tripwire system can be developed with a, preferably high-power, laser light, with a good focus and a receiver like a Photo resistor. The laser beam should be reflected into the photo resistor, which is to be connected to the Arduino board.

2. Computer Application:

A computer program does not require any external firmware for programming, rather, the entire system is governed inside the computer itself, and hence, it serves as a standalone computer application. Though there can be many languages to serve the purpose, we would focus on an effective, yet easy-to-code, beginner-level, language where it will be easy to develop algorithms and inbuilt modules has maximum exception handling and a convenient UI/UX setup - Scratch. Scratch has enhanced and effective blocks for efficient motion detection and can serve many of our purposes, and surely each one is discussed here. Projects like the CatSight AI were made in Scratch.

A raw scratch program can be packaged into applications for Mac and Windows (using Electron), as well as can be hosted as a website. The applications are lightweight and easily supported on low-end PCs.

DESGIN AND ALGORITHM

The circuit design for Arduino-based technologies are simple. An integrated circuit with all the three sensors discussed above is given alongside. What matters, is the algorithm which is highly varied and different for each of the applications. After we have set up the device mechanism, we will now head-on for the code it will execute. We simulate the working of the hypothetical code in TinkerCad Circuits, preferably in blocks. Then we go for the final code to be uploaded in the firmware. Arduino is coded in Arduino IDE, offered by Arduino.cc in C++ Language. Keeping efficiency and speed in mind, we have to use the code for our Arduino. The code is then uploaded to the firmware with the help of a USB cable type A/B. We then need to define the PIR, or Ultrasonic sensor's functioning. We then adequately set up the system under the void setup( ) function. We then proceed for the void loop( ) which contains our algorithm, coded in C++, and saved with the extension, '.ino'. We should also not forget about the response. On the other hand, a computer program aims at building an impressive user interface, which will be used to use, efficiently, and securely. The algorithm for both consists mainly of booleans which will be of the type- if 'YES', execute, if 'NO', then, loop; which can also vary in

some projects and often have a delay of a fraction of a second.

The flowchart given alongside (Fig 3) describes the process of Event Identification as a component of Motion Detection. The 'Event Behavior' block is the one which compares the motion with the desired ones, and the conclusion is given. The block can contain in it, plotting programs, Booleans, and distance, etc.

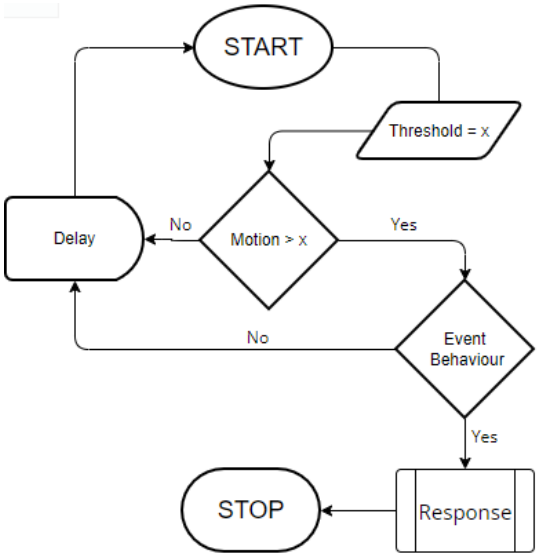

Fig. 3; General Purpose algorithm for EI

ADVANTAGES

The concept of event identification has a broad base, leading to further research and development of various futuristic gadgets. It will enable many hypotheses to be executed, that too, at affordable rates, and make it easily accessible to the general public. Some of the most prominent advantages of this concept, when executed, are as follows:

- It lays down the framework for the development of various futuristic gadgets.
- Supports installation of systems in minimum volume and parts.
- Helps to overcome the requirement of contact and closeness to the gadget for response.
- Makes environmental automation with IoT or Computers easier.
- Developing the same in easily accessible and low-end architectural requirements for public use. Creating an affordable, yet perfect and dependable system of monitoring and response.
- Enables monitoring systems that do not include a camera, thus respecting privacy.
- Even beginners can engage in research in this framework.

EI IN HIBRID SYSTEMS

Besides being a governing factor in making decisions by machines, EI can be a confirmatory test as well. There are ways an object detection system can be bypassed. Hence, to draw a conclusion, only looks are not enough. Where the camera says, "It looks like the Object X", we need EI to say, "It behaves like the Object X" – which, together, can confidently finalize a right outcome.

A perfect example of this, is the new concept of automatic Railway Crossing Gates. Mainly, there are two types of prototypes of the same, in public domain – Ultrasonic Sensor based, which is based on any motion in front of the sensor, and secondly, with Computer vision, which, when sees a train, closes the

gate. However, to be pragmatic, neither of these gives any ultimate solution of the target. Any bare movement in front of the sensor, could not say, it in the train. So, we need to check the perfect behavior of movement using EI - the spots of fundamental interception, and the speed, read using the time span between obstructing range of two consecutive sensors at a gap, along the track. Also, to get a further confirmation, a camera module can be used to check if that approaching thing is a train. Other than the train, the crossing should also be monitored, for zero motion, when the gates are being closed – to avoid trapping or falling on people or vehicles.

CONCLUSION AND FUTURE SCOPE

Event-Identification is going to serve as the backbone of motion detection soon, and will enable the creation, development, and commercial use of highly classified and futuristic gadgets. The system, with input, processing and response/output is going to be the framework for an entire ecosystem of appliances in the near future. It serves as an integral part of automation, AI, IoT and the fifth industrial revolution as a whole. It can be used in a variety of cases, with the right algorithm. The process of EI also lets us understand the ability of just 'algorithms', i.e., with just the same set of snippets- the number of appliances that can be made- just based on algorithm and installation, is enormous. While developing devices based on EI, we should keep in mind that the characteristics and exceptions in the motion need to be studied carefully, the algorithm made should aim at responding to exclusive events of the motion, as compared to other environmental or possible similar events in the vicinity or within range.

It can serve various purposes, of easing day-to-day activities, and necessities, and even be the governing factor in various broader aspects of engineering. It can make seemingly sci-fi gadgets available for commercial use, and make lives easier, that too at affordable prices. It can be used to detect the motion of planes, like modern jets, being stealthy and small, motion detection can study its trajectory and propulsion behavior and give a perfect conclusion of its being. Hence, EI has a huge aspect, a broad base and heights to touch, with extensive research, and development.

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