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Vision Based Robotic System for Military Applications – Design And Real Time Validation

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Abstract: This paper presents the design, development and validation of vision based autonomous robotic system for military applications. Sum of Absolute Difference SAD algorithm is used for the implementation of the proposed image processing algorithm. It works on the principle of image subtraction. The developed algorithm is validated in real time by change-based moving object detection method. The novelty of this work is the application of the developed autonomous robot for the detection of mines in the war field. Developed algorithm is validated both in offline using MATLAB simulation and in real time by conducting an experiment. Once the confidence of using the algorithm is increased, developed algorithm is coded into the Microcontroller based hardware and is validated in real time. Real time experimental results match well with those of the offline simulation results. However, there is only a small mismatch in distance and accuracy of the target detection, which is due to the limitations of the hardware used for the implementation.

Keywords: Surveillance, Vision, Target Detection, AVI, Wireless camera.

I. INTRODUCTION

The Embedded Technology is now in its prime and the wealth of Knowledge available is mind-blowing. Embedded System is a combination of hardware and software. Embedded technology plays a major role in integrating the various functions associated with it. This needs to tie up the various sources of the Department in a closed loop system. This proposal greatly reduces the manpower, saves time and operates efficiently without human interference. This project puts forth the first step in achieving the desired target. With the advent in technology, the existing systems are developed to have in built intelligence. It is well known fact that, most of the tasks in military applications are more dangerous than others. For example walking through minefields, deactivating unexploded bombs or clearing out hostile buildings, are some of the most dangerous tasks a person is asked to perform in the line of duty. These tasks can be solved by an autonomous robot. But, complete autonomous robot which can perform varieties of tasks is still under development. Therefore researchers all over the world work towards the design and development of such robots, so as to simplify our works in various fields. The initial step towards the complete autonomy of a robot is the design and development of obstacle avoidance and path planning. The vision based target detection using surveillance camera can be employed in the region of deployment. Some areas like Kargil for human beings it is difficult for surveillance. So Robot is used in such a surveillance area. The traditional tanker is limited intelligence and mainly operated by human operator. Also the mechanism design is modeling as a 2 (degree of freedom) robot arm, which is rather restricted in operating orientation angles.

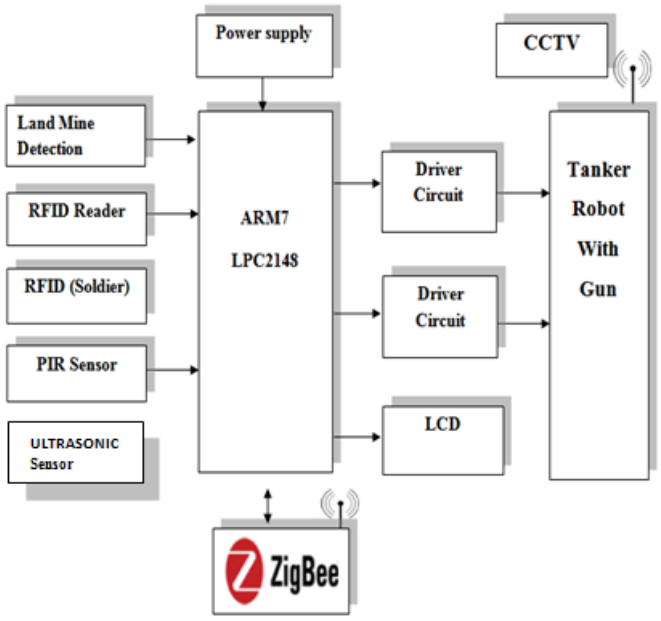


Fig.1. Block diagram.

This paper presents the design, development and validation of vision based autonomous robotic system for military applications. We propose a new tanker robot to detect and attack the intruder in the battle area. We can control the tanker from remote area using Zigbee wireless technology.

Wireless CCTV camera is placed on the tanker. The CCTV camera receiver is connected in remote section. We watching the intruder through the CCTV it is continuously monitored in remote section. RFID tags are given to our own soldiers to detect opposite soldier. RFID reader is used to detect our own soldier as shown in Fig.1. Land mine sensor is used to detect the land mine. The shooting commands given by the control section as per the Corresponding commands received from control section, the robot will shoot the human being. In order to control the robot we use relays to run the motor in that PIR Sensor is used to check and detect the human.

II. PROJECT DESCRIPTION

A. Remote Section

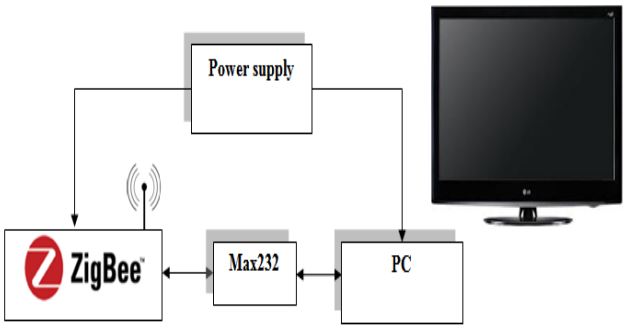


Fig.2. Remote Section.

Wireless Camera: A wireless camera is placed on the top of the robot .It is an effective camera having operating range of 100 feet generally whatever the target image/videos captured by the camera is sent to control station as shown in Fig.2. The received signal can be seen in PC directly.

RFID Tag: RFID tag is useful to identifying the unauthorized persons. These tags given to our soldiers.

RFID Readers: This is used to identify own soldiers. It is helpful to avoid mistakes while attacking.

Land Mines Sensors: This sensor is used to detect the land mine.

B. Control Section

Whatever the image/video captured by camera is sent to control section .It connect of PC/TV and hardware like stepper motor ,As per positive rotation of stepper motor and software in PC, an approximate commands given back to the robots to do further actions.

C. PIR Sensor

All objects with a temperature above absolute zero emit heat energy in the form of radiation. Usually this radiation is invisible to the human eye because it radiates at infrared wavelengths, but it can be detected by electronic devices designed for such a purpose. The term passive in this instance refers to the fact that PIR devices do not generate or radiate any energy for detection purposes. They work entirely by detecting the energy given off by other objects. PIR sensors don't detect or measure "heat"; instead they detect the infrared radiation emitted or reflected from an object.

D. Micro Controller Unit

LPC2148 microcontroller board based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontrollers with embedded high-speed flash memory ranging from 32 KB to 512 KB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate as shown in Fig.3. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. The meaning of LPC is Low Power Low Cost microcontroller. This is 32 bit microcontroller manufactured by Philips semiconductors (NXP). Due to their tiny size and low power consumption, LPC2148 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale.

LPC2148 Chip Features:

- 16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 8 kB to 40 kB of on-chip static RAM and 32 kB to 512 kB of on-chip flash memory.
- 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software. Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1 ms.
- Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high-speed tracing of instruction execution.
- USB 2.0 Full-speed compliant device controller with 2 kB of endpoint RAM.
- Single 10-bit DAC provides variable analog output (LPC2142/44/46/48 only).
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input.
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C-bus (400 Kbit/s),
- SPI and SSP with buffering and variable data length capabilities.

Pin Description: In order to add more functionality into ever smaller physical package sizes, chip manufacturers have had to resort to 'multiplexing' their chips. All that multiplexing means is that you have more than one 'function' attached to a single 'pin' (in the case of ARM7 chips, there are as many as 4 'functions' per pin). The obvious advantage to this approach is that you can offer more functionality and peripherals, while keeping the package size reasonably small. The disadvantage, of course, is that you can only use one 'function' of a pin at a time, so you need to carefully choose which pins you use in order to avoid losing some required functionality, simply because the particular pin you need is also being used for something else. Looking at the image below, you can see a diagram of all 64 pins available on the

LPC2148, along with the various functions that are physically connected to or associated with each pin as shown in Fig.4.

LPC2148 Microcontroller Architecture:

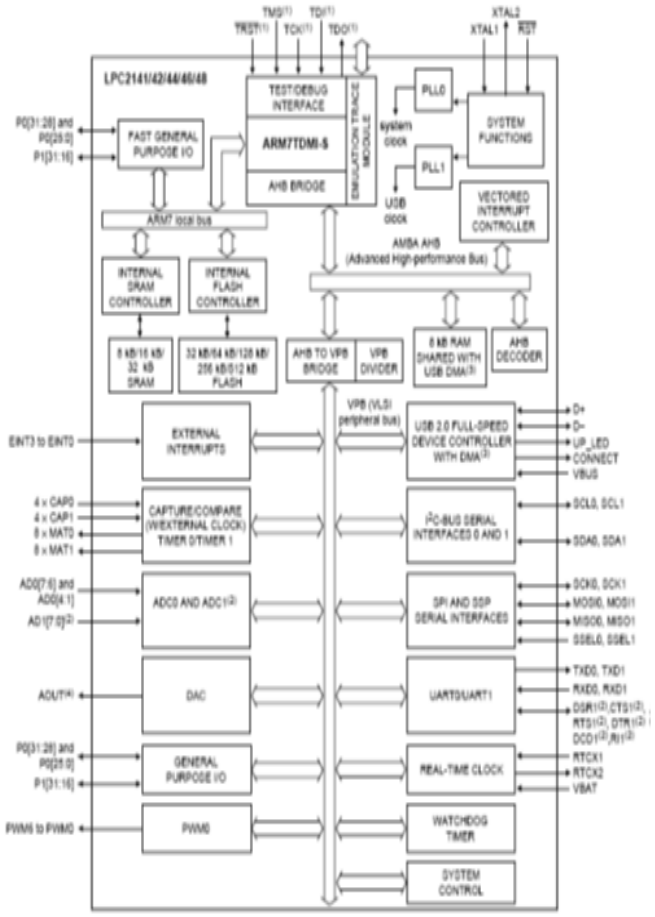


Fig.3. LPC2148 Microcontroller Architecture.

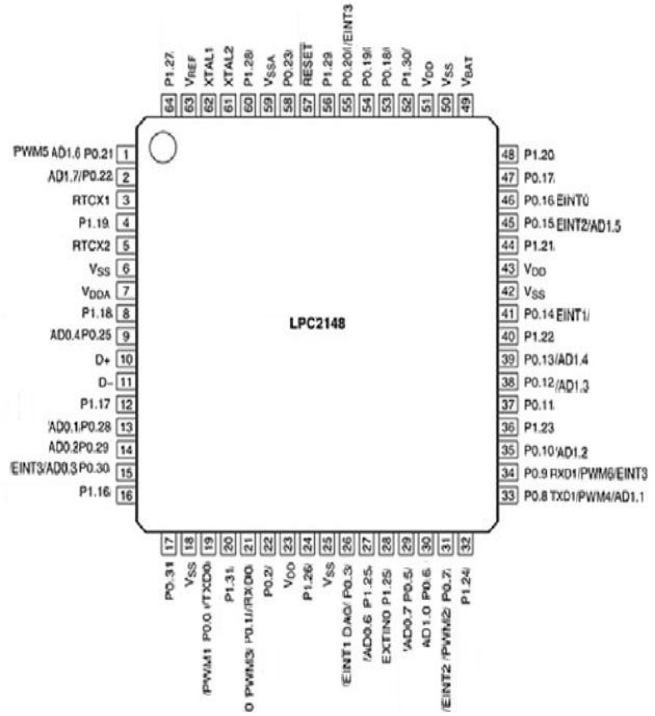


Fig.4. Pin Diagram of LPC2148.

E. LCD Unit

(LCD) has material which combines the properties of both liquid and crystals. They have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an order form similar to a crystal.

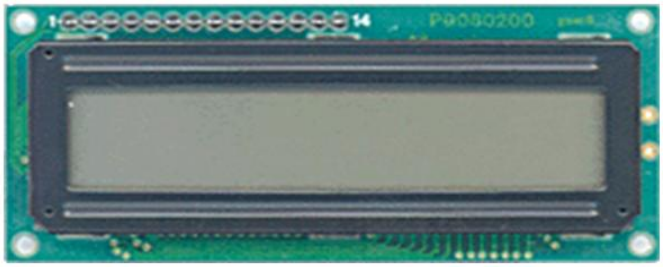


Fig.5. LCD Display.

More microcontroller devices are using 'smart LCD' displays to output visual information. The following discussion covers the connection of a Hitachi LCD display to a LPC2148 microcontroller as shown in Fig.5. LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8 x 80 pixels of the display. Hitachi LCD displays have a standard ASCII set of characters plus Japanese, Greek and mathematical symbols. For an 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus seven extra lines. When the LCD display is not enabled, data lines are tri-state which means they are in a state of impedance (as though they are disconnected. The LCD also requires 3 "control" lines from the microcontroller.

F. Zigbee

Zigbee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low-power digital radios. Zigbee is based on an IEEE 802.15 standard. Though low-powered, Zigbee devices often transmit data over longer distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices as shown in Fig.6. The decentralized nature of such wireless ad hoc networks makes them suitable for applications where a central node can't be relied upon.

Fig.6. Zigbee Modules.

F. MAX232

The MAX232 is an IC, first created by Maxim Integrated Products, that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5V) from a single + 5V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0V to + 5V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case. The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 VTTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V.

G. DC Motors

A DC motor in simple words is a device that converts direct current (electrical energy) into mechanical energy. It's of vital importance for the industry today. A DC motor designed to run on DC electric power. Two examples of pure DC designers are Michael Faraday's homo-polar motor (which is uncommon), and the ball bearing motor, which is (so far) a novelty. By far the most common DC motor types are the brushed and brushless types, which use internal and external communication respectively to create an oscillation AC current from the DC source so they are not purely DC machines in a strict sense. We in our project are using brushed DC Motor, which will operate in the ratings of 12V DC 0.6A as shown in Fig.7. The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems called DC drives.

Fig.7. Motor.

Usage: The DC motor or Direct Current Motor to give it its full title, is the most commonly used actuator for producing continuous movement and whose speed of rotation can easily be controlled, making them ideal for use in applications were speed control, servo type control, and/or positioning is required. A DC motor consists of two parts, a "Stator" which is the stationary part and a "Rotor" which is the rotating part. The result is that there are basically three types of DC Motor available.

H. RFID Reader

RFID technology is a simple method of exchanging data between two entities namely a reader/ writer and a tag as shown in Fig.8. This communication allows information about the tag or the element carrying the tag to be determined and in this way it enables processes to be managed more easily. An RFID system comprises a number of elements:

Fig.8. RFID Reader.

RFID Reader/Writer: The reader write is used to communicate with tags that may pass within range. The RFID reader writer will normally be located in a fixed position and will be used to interrogate an RFID tag. Dependent upon the application and the format of the system and the RFID reader / writer, data may also be written to the RFID tag

RFID Tag: RFID tags may also be called RFID transponders and are typically located on items that are mobile as shown in Fig.9. They are small and generally cheap so that they can be attached to low cost (or high cost) items that need to have information associated with them. They are also generally considered as being disposable. The RFID tag contains data that is relayed to the reader, and in some systems it may also be possible to update the data within the tag to indicate that the tag and hence the item has undergone a specific stage in a process, etc.

Fig.9. RFID Tag.

RFID application software: Like all systems these days, RFID systems need application software to run the overall system. With many systems there will be a number of different reader / writers and the data to and from these needs to be coordinated and analyzed. Application software will be required for these. Although each RFID system will vary according to its requirements, these are the main elements

which can be found. RFID technology has become widespread in its use. It offers May advantages and RFID is a particularly versatile system, being able to be used in many areas from shops, to manufacturing plants and also for general asset tracking as well as a host of other innovative applications. The use of RFID, Radio Frequency Identification technology has become widespread within many areas of industry. RFID, Radio Frequency Identification provides an ideal technology for tracking assets and identifying them by using a simple low cost antenna attached to the item in question. Alongside RFID provides automatic data collection for which there are now several standards, and this enables RFID technology to be deployed in an effective and known manner. With RFID technology standardized, users are able to rely on the technology to provide the results they need.

RFID benefits: RFID technology provides many benefits for organizations ho use the system. RFID provide an easy way in which data can be collected and assets tracked:

- RFID technology provides a low cost form of data collection and asset management.
- RFID technology is widely used and therefore the economies of scale can be utilized to advantage.
- RFID technology enables data collection in environments that are unsuitable for workers as RFID tags can provide data in harsh environments.
- RFID is able to provide many reads and write functions per second, although it is not a very high data rate system, it is sufficient for most data monitoring applications.
- Data on an RFID tag can be altered repeatedly.
- RFID technology can be used with existing systems including bar codes and Wi-Fi.

As a result, RFID technology is being used increasingly as organizations need automatic methods of tracking assets and collecting data.

RFID Applications: RFID systems can be used in a variety of ways. There are many RFID applications which have gained popularity over the past years:

- Store product identification - RFID technology can be used within shops and stores as a form of alert for goods that have / have not been paid for.
- Asset tracking - RFID systems can monitor when RFID tags pass given points and in this way track the assets.
- Airline baggage identification - airlines need to monitor where baggage is and route it to the required destination. RFID tags can be attached to the bags to automate baggage routing
- Parts identification - Data can be written to an RFID tags defining the identity of a part. This can then be used within a manufacturing, stock holding or other process to identify and locate parts.
- Production control - when items are manufactured they pass through many stages. RFID tags can be attached to items. These can be updated each time the item passes through a stage in production. This will enable the manufacturing system to track all items and know what stage they are at, and any other information such as test failures, etc.
- Employee access control - many companies today require intelligent access control systems. RFID technology is able to provide control as well as tracking, noting when cards pass particular access points, etc.
- Supply chain control - with manufacturing working to much tighter timescales with items such as Just-In-Time techniques being involved tracking of the items in a supply chain becomes more critical. RFID tags can be added to items to enable this to be undertaken accurately and more quickly.
- Vehicle tracking - RFID technology can be used to determine when vehicles have passed particular points and in this way their location can be approximately determined.
- Livestock identification - RFID tags can be injected into animals, under the skin and this enables accurate determination of which animal is which so that injections, etc can be given to the correct animal.

These represent some of the more standard applications for RFID technology. Many more specialized applications are also in use.

Working: In this project we are designing a system to monitor physical parameters of a location like temperature, smoke, rain fall and also the presence of a person say tourist. For this we are using different sensors integrated to an ARM7 micro controller. The data acquired continuously and sent to the remote server using Zigbee module. Presence of a tourist is detected by using the contactless RFID cards allotted to the tourist. Whenever tourist enters in to the location he should show the card at entrance. This can be used as a ticket at the same time the details of the candidate will be sent to the server through Zigbee while the low frequencies of 125 kHz were initially used, systems around the 13.56 license free frequency were also developed. The use of the higher frequency allowed for higher data rates and longer ranges to be achieved. The history of RFID has shown a steady development in RFID technology. Having its routes in the earliest days of electrical science and then radio, RFID history has come out of developments such as radar and IFF. Now RFID is a technology in its own right which is widely used and showing massive benefits to industry and society as a whole.

III. WORKING AND RESULT

We propose a new tanker robot to detect and attack the intruder in the battle area. We can control the tanker from remote area using Zigbee wireless technology. Wireless CCTV camera is placed on the tanker. The CCTV camera receiver is connected in remote section. We watching the intruder through the CCTV it is continuously monitored in remote section. RFID tags are given to our own soldiers to detect opposite soldier. RFID reader is used to detect our own soldier. Land mine sensor is used to detect the land mine. The shooting commands given by control section. As per the Corresponding commands received from control section, the robot will shoot the human being. In order to control the

robot we use relays to run the motor in that. The current frame and the previous frame are compared, if change is detected the indicates that the area is a new object is captured by the camera. Hence motion is detected as shown in Fig. 11.The offline simulation results for motion detection obtained using the tracking algorithm as shown in the Fig.12. With this algorithm the object is detected properly and hence proved efficacy of said algorithm for the obstacle avoidance and path planning for any unmanned vehicles. Fig.9 shows the comparison of two images by pixel by pixel. The SAD algorithm works as shown in the Fig9. Finally it displays the percentage similarities between two images and robot tracks the object in which region change of pixel values detected.

Once the confidence of using the proposed algorithm is increased, the actual hardware is built based on Microcontroller AT89C51 as shown in Fig.10.

Fig.10. Microcontroller based Surveillance.

In this system, the main unit is AT89C51 microcontroller, RF ID reader and two stepper motors-one for horizontal direction and another one for vertical direction. Laser light is used as target and bullets are used to hit the target (laser). Again Vision based Surveillance system i s developed as shown in Fig 11. It consists of wireless camera, robot, metal detector and laser light (to track the object). It works on the principle of SAD algorithm for motion detection and tracking algorithm for tracking the object.

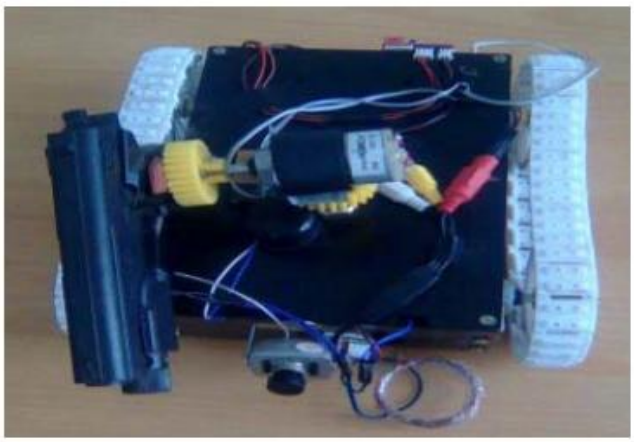
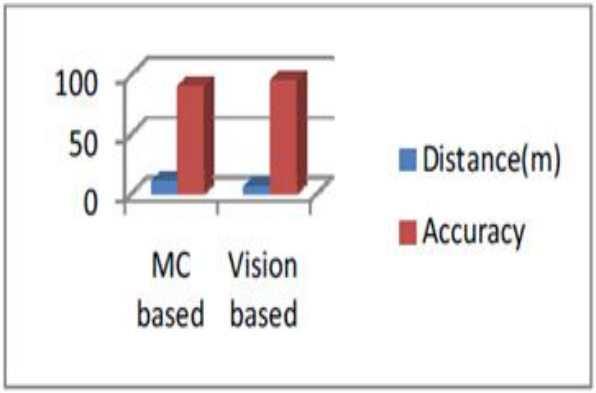


Fig.11.I.P. based Surveillance.

The real time experiments are conducted in both systems given in Fig9 and 10. The Fig12 shows the comparison of the results obtained from Microcontroller and Vision based Surveillance in terms of distance and accuracy. The accuracy in Vision based system is 95% and in Microcontroller based accuracy is 92 %(because we have used target as laser light and it would be hit by plastic bullet). And the distance in Vision based system in our system is 7.6m (depends on camera resolution) and in Microcontroller based accuracy is 10m. The effect of ADC resolution decreases the efficiency o f the both the systems.



*Calculated manually

Fig.12. Comparison of two type's of target detection system.

IV. CONCLUSION

The military has recognized that automatic devices are far more efficient than the use of human soldiers as there is a reduced risk of mistakes and the devices can also be equipped with powerful weapons. The military has recognized advantages such as more and more robots can do dangerous work that was previously undertaken by humans. The use of robots for such tasks makes a soldier's work much more secure, it even saves lives. They all have a common goal: to minimize human losses on their side and increase efficiency.

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