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An Innovative Image Processing Method Using Sum of Absolute Difference Algorithm For Real-time Military Applications

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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.

Index Terms:

surveillance, vision, target detection, AVI, Wireless camera.

I. INTRODUCTION:

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 video is converted into frames. Each image frame is compared with its previous image frame; if any difference is observed in the surveillance area target is detected [1, 2].

Autonomous robots are robots that can perform desired tasks in unstructured environments without continuous human guidance [3]. Many kinds of robots have some degree of autonomy. Different robots can be autonomous in different ways. A high degree of autonomy is particularly desirable in fields such as space exploration, cleaning floors, mowing lawns, waste water treatment and military.The structural layer, for many micro-scale platforms, has commonly been implemented using a silicon die, thus leading to robotic platforms referred to as "walking chips" [4].

Security is the first priority in today's unsecured life. The vision system assembles a tree of image processing components to fulfill the request, using, if necessary, shared computational resources [5]. This interface can be moved to any planar surface in the camera's field of view. In an operational computer vision system for real-time detection and tracking of human motion, the system captures monocular video of a scene and identifies those moving objects/human beings [6,7].

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Autonomous video surveillance systems typically consist of several functional modules working in concert. These modules perform specialized tasks including motion detection, separation of the foreground and background, depth estimation, object tracking, feature estimation, and behavioral analysis [8].Object-tracking is one of the most popular areas of video processing; most of the Methods so far are object-dependent and concentrates only on one constraint of the object [9]. Image differencing is used for many applications involving change detection. Although it is usually followed by a threshold operation to isolate regions of change there are few methods available in the literature specific to change detection [10]. For real-time motion detection using an active camera mounted on a pad tilt platform. Image mapping is used to align images of different viewpoints so that static camera motion detection can be applied [11].

Application Robotics and Autonomous Systems include industrial, outdoor and outer space where advanced robotic techniques are required for autonomous systems to accomplish goals without human intervention; this includes robotics for hazardous and hostile environments [12].To overcome the drawbacks mentioned above, this paper presents a novel vision based technique for obstacle identification and path planning for autonomous robot by using image processing algorithms. Captured image is processed using SAD algorithms and the obstacles are identified. The developed algorithm is validated in real time by Change-based moving object detection method. To identify the obstacles and determine the path for an autonomous robot, this paper aims at developing vision based algorithms using image processing techniques. For this Change-based moving object detection Techniques are used.

The organization of this paper is as follows. Section II gives the system description in detail. Next the concept of wireless military robot is given in section III. Object tracking and motion planning is given in section IV followed by results and analysis in section V. Finally conclusions are drawn in section.

II. SYSTEM DESCRIPTION:

Fig.1 represents the block diagram of the military robot system. The image acquisition device (camera) is mounted on Robot.

Camera captures the image of the area under surveillance and sends the information data to a processing PC for the records.

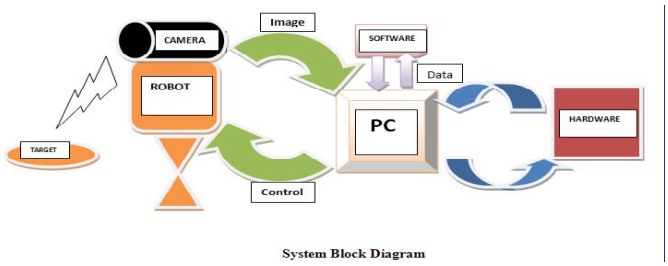

Fig. 1. Block diagram of the Military Robot

The processing of the acquired images is done in MATLAB. The position of the person (intruder) is sent to the stepper motor system in the form of the number of rotations and also the direction of rotation, whether clockwise or anticlockwise. The tracking of the person/object can be observed by the motion of the stepper motor.

III. WIRELESS MILITARY ROBOT:

The main function of wireless military robotic system is to collect the information in difficult places, where human beings can work continuously. To meet the said objective vision based robot is very essential The propose of this research work is to design a wireless robot that would be capable of reaching close to the objects of threat and the real scenario can be observed through an onboard video camera which can send back video feedback to the observatory. By looking into this video the observer can control the robot to perform according to different real time situations like border security, tracking remote places etc.

Powerful motors are employed to make the unit move in different directions. A dc motor in the front end is utilized for the direction controlling mechanism and a main DC motor is used for driving the unit in forward/reverse direction. The camera is mounted in the front which shows clearly where the unit is moving and also detects the target location. The power supply unit is mounted on board and is used to power the entire unit. In the prototype the power from the wall socket is used and the power supply unit comprises AC to DC conversion and also generating the respective voltages as required by the on-board circuit. In addition, events recorded by a robot's camera can provide evidence for future forensic purposes.

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A. Wireless Camera :

Wireless Small size spy camera set for Surveillance and robotics is shown in figure 2. The real scenario can be observed through an onboard video camera which can send back video feedback to the observatory. The very small size and low power operation makes it useful for mounting on wireless robots to transmit the video to receiver.

The received signal can then be directly seen in to TV or in PC through TV Tuner or Video Capture Card. For Laptops USB TV Tuners can be used. Camera unit powered by AC adapter or 9V battery (short life as expected) sends audio & video to receiver unit. Tiny and wireless, this inconspicuous camera offers effective surveillance protection.

It has an operative range of 100 feet (we have used 25 feet range), providing full motion, real-time, color video with no delay. With a fresh battery, camera unit transmitted ~200' of open parking lot and ~75' of industrial building etc. with minimal interference. However, signal strength fell off with battery power.

Fig. 2. Wireless Camera

Features of the Wireless Camera are it is Very Small Size, Low Power consumption, With Microphone, also transmits audio along with video, RF Receiver included in package, Range up to 25 feet in open space, Camera working voltage from 5V to 12V, All cables and connectors required are included, Video can be taken to PC through Video capture/TV tuner for image processing.

B.AVI to USB Converter:

Fig. 3.AVI to USB Converter

In order to monitor the videos from the wireless camera by the computer, a AVI to USB converter is required that tunes the videos into AVI format as shown in figure 3. By looking into the video the observer can control the robot to perform according to different real time situations.

IV. PRINCIPLES OF OBJECT TRACKING AND MOTION DETECTION:

Assuming that the scene illumination does not change, the image changes are due to relative motion between the scene objects and the camera (observer).It works on the principle of image subtraction. That is present frame is compared with previous frame captured by the wireless camera if the difference is nonzero value there is a new object is found, hence it concludes that motion is detected.

There are three possibilities:
i) Stationary camera, moving objects.
ii) Moving camera, stationary objects and
iii) Moving camera, moving objects.

A. Object Tracking:

Object tracking is the problem of determining (estimating) the positions and other relevant information of moving objects in image sequences. Two-frame tracking can be accomplished using Correlation-based matching methods, Feature-based methods and Change based moving object detection methods. We have used Change-based moving object detection method, the principles of which are explained in the block diagram shown in figure 4.

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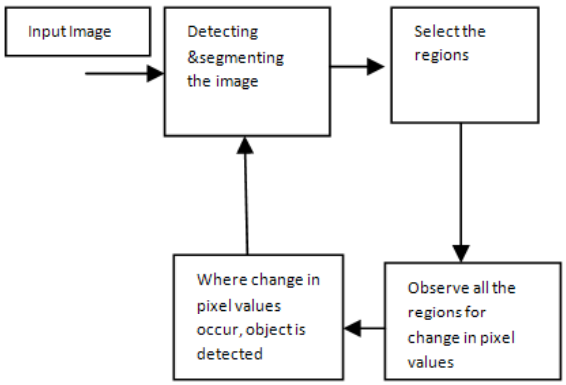

Fig. 4. Image processing block diagram

For the detection of motion first segment the image from the surveillance area into four sub regions. All the four regions are observed, if change in pixel values occurred from current and previous frames indicates that new object is detected in the surveillance area.

V. WORKING AND RESULT:

The working principle of the system is explained in Figs. 5 and 6. Set the camera for image acquisition. Divide the capturing image into 4 regions, observe in which region change in pixel values occur, in that region a motion (object) is detected. After finding the region where motion is detected, set the robot to move in that direction by activating the two stepper motors, one is for horizontal and another one is for vertical direction. Thus object can be tracked. In the Image Acquisition process the first frame will be read and convert it to gray scale image for further operation. Similar process will be applying for subsequent frames.

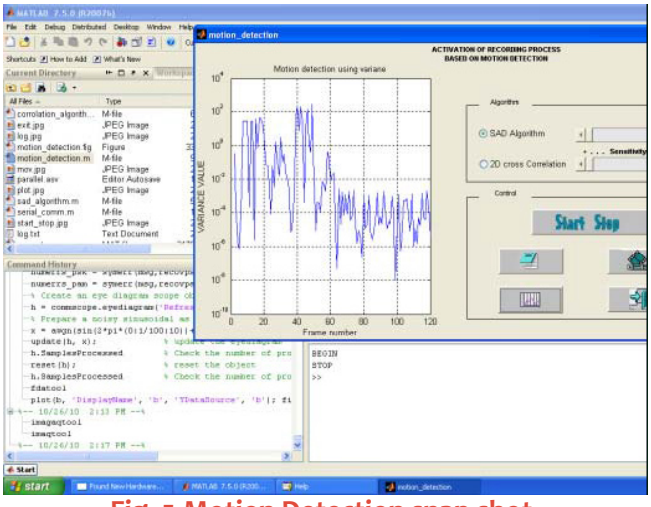

Fig. 5.Motion Detection snap shot

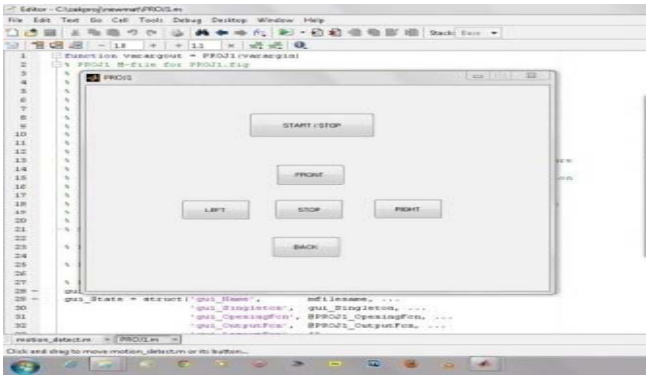

Fig .6.Object Tracking & Motion Detection Result

As shown in figure 7, the area under surveillance is shown with object tracked, here it is a car as indicated. The object is tracked using SAD algorithm. The current frame and the previous frame are compared, if change is detected that indicates that there is a new object is captured by the camera. Hence motion is detected as shown in fig. 5.

The fig.5 shows the offline simulation results for motion detection obtained using the tracking algorithm as shown in the fig.6. with this algorithm the object is detected properly and hence proved efficacy of said algorithm for the obstacle avoidance and path planning for ay unmanned vehicles. Fig.8 shows the fig.8 shows the comparison of two images by pixel by pixel.

The SAD algorithm works as shown in the fig.8. Finally it displays the percentage similarities between two images and robot tracks the object in which region change of pixel values detected.

Fig. 8. Image Comparison results

Once the confidence of using proposed algorithm is increased, the actual hardware is built based on micro controller AT89C51 as shown is Fig. 9.

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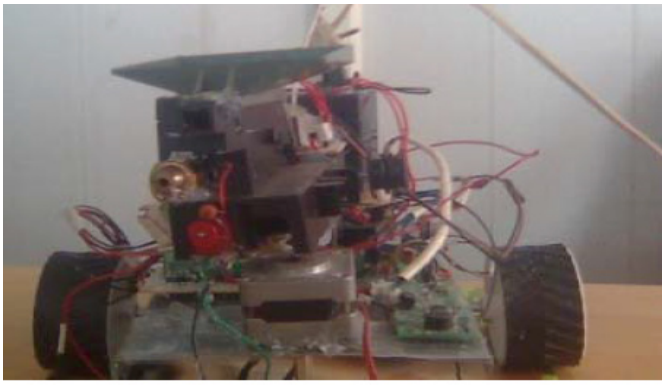


Fig. 9. Microcontroller based Surveillance

In this system, the main unit is AT89C51 RF ID reader and two stepper motors-one direction and another one for vertical direct. Laser light is used as target and bullets are used the target(laser).Again Vision based Surveillance system is shown in fig 10. It consists of wireless metal detector and laser light (to track works on the principle of SAD algorithm detection and tracking algorithm for tracking the object.

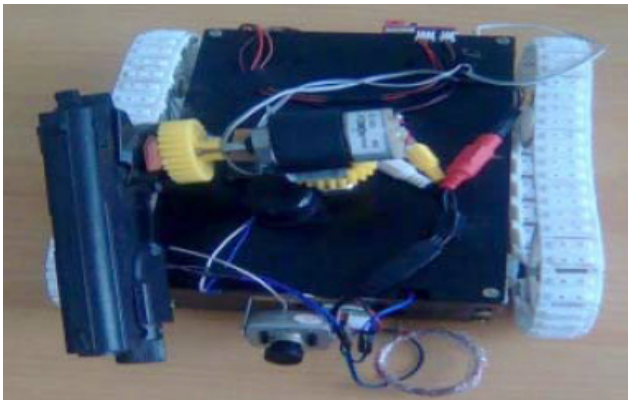
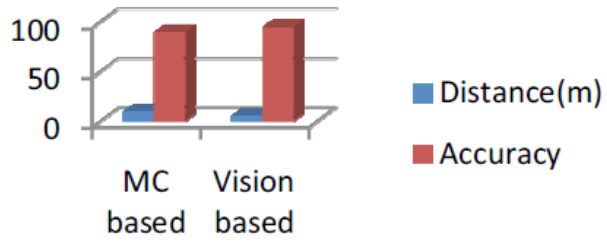


Fig. 10.I.P. based Surveillance

The real time experiments are conducted in both systems given in Fig 9 and 10. The figure 11 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 micro controller based accuracy is 10m. the effect of ADC resolutions decrease the efficiency of the both the systems.



*Calculated manually

Fig. 11. Comparison of two types of target detection system

VI. 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 another advantage such as more and more robots can do dangerous work that weapon previously undertaken by humans. The use of robots for such tasks makes a soldier's work much mire secure, it can even saves lives. They all have a common goal: to minimize human losses on their side and increase efficiency.

The design and real time validation of vision based obstacle avoidance and path planning for military robots is presented. SAD algorithm and image processing techniques are used to develop the proposed system. The results are validated both in offline and in real time using MATLAB simulation techniques and using experimental setups. Both micro controller based and vision based systems are built and results are validated in real time. Real time results are matches well with those of offline simulation results.

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