

Wireless Robot with AV camera to Dispose Explosives

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Abstract : *Disposing of any explosive materials is an extremely dangerous and risky job. Bomb disposal teams prefer to stay as far away from their work site as humanly possible, preferably only interacting via remote-controlled, expendable robots. Unfortunately, bomb disposal is also an extremely delicate job, and most robots lack the finesse to properly disarm a bomb. To address this problem, we have replaced the normal arms of the earlier model with a pair of sophisticated less weight gripped arms to a new bomb disposal wireless robot. This paper, presents the design and development of a robot for disposal of explosive ordnance (EOD). With the growing role of Remotely Operated Vehicles (ROV) in bomb defusing scenarios aiding experts to locate, handle and destroy hazardous objects, new intuitive gesture based systems can be modelled on human hand movements to make the control of a complex gripper arm instinctive. Integration of such an arm for more precise control in accurately manipulating explosive devices would allow the ROV to actively assist in defusing the bombs as well. In this model, wireless communication techniques are used to transfer the audio-video data captured by the camera fixed on the top of robot. Strength and stiffness have been kept as design criteria while optimizing the weight of the moving arms. The results have shown corresponding reduction in power requirement for arms movement, demonstrates the ease of operation and effectiveness of gesture control as a technique. This paper provides information about the mobile robot for hazardous job applications.*

Keywords: *Expendable robots, Explosive ordnance disposal (EOD), Gesture control, Gripper arm, Remote Operated vehicles (ROV).*

I. Introduction

In today's modern world, various robots have been designed and used for various types of works which varies from light and dull to heavy and dangerous. The advantages often cited in favor of the introduction of robots are decreased labor costs, increased precision and productivity, increased flexibility compared with specialized machines, and more humane working conditions as dull, repetitive, or hazardous jobs are performed by robots [1]. The idea of using robot in doing dangerous jobs can be found back in the days of World War II. As any new idea would progress, the idea would have to be considered by the military as useful and from that new technology will begin to jumpstart. Some successful examples of robot doing dangerous jobs in the World War II were the German's Goliath [2] and the Russian's teletank [3]. Electrically powered and remotely controlled bomb defusing systems are now growing to play pivotal roles. One of the most widely used bomb-disposal robots today is the Cobham tEODor. The standard tEODor is a bomb-disposal specialist along with a twin-track vehicle with a host of military applications. iRobot's PackBot was massively popular with US and international coalition forces in Iraq and Afghanistan. Northrop Grumman rolled out CUTLASS for the British Armed Forces in 2012 as a next generation Unmanned Ground Vehicle. Even the Defense Research & Development Organization, India broke new ground in 2011 when it handed over the first batch of Daksh Remotely Operated Vehicle (ROV) to the Indian Army[4]. In 2015, Daksh ROV was improved with IED (Improvised Explosives Devices) handling equipment scans, handles and removes hazardous objects. Now, we can find mobile robots that gives museum tours, play soccer (RoboCup), map abandoned coal mines, drive autonomously through the desert (in the DARPA Grand Challenge), assist the elderly, and gather invaluable data from the surface of Mars [5]. So the idea of using radio-controlled robot for the purpose of disposal of bomb is rather similar to those robots with lethal jobs, as even the bomb specialist won't even know the blasting power of the bomb without visually or physically examine the bomb itself, but this action would put the life of the bomb specialist at risk as they need to get close to the bomb. So it is reasonable that to send in a robot with a wireless camcorder sending live video of the robot surrounding which is controlled by the bomb specialist so that the bomb can be classified and disposed off with the bomb specialist in a safe zone, away from the blast of the bomb.

II. Objective And Scope

To design and prototype a radio frequency controlled robot that is complete with a wireless video camcorder capable of sending real life video of the surroundings of the robot, and a robotic arm capable of simulating the actions needed for picking up bomb suspected object to be dispose off.

Despite the great advancements in the field of robotics and continuous efforts to make robots more and more sophisticated to match the capabilities of human beings and even surpass them, still, from a very scientific and logical point of view, robots developed up till these days are no way closer to human beings.

In basic robotics we design machines to do the specified tasks and in the advanced version of it robots are designed to be adaptive, that is, respond according to the changing environment and even autonomous, that is, capable to make decisions on their own. While designing a robot the most important thing to be taken in consideration is, obviously, the function to be performed. Robots have basic levels of complexity and each level has its scope for performing the requisite function.

The levels of complexity of robots is defined by the members used in its limbs, number of limbs, number of actuators and sensors used and for advanced robots the type and number of microprocessors and microcontrollers used. Each increasing component adds to the scope of functionality of a robot. With every joint added, the degrees of freedom in which a robot can work increases and with the quality of the microprocessors and microcontrollers the accuracy and effectiveness with which a robot can work is enhanced.

III. Literature Review

Oates (2005) stated that the field of mobile robotics is currently enjoying tremendous scientific, practical, and popular success. Mobile robots gives museum tours, play soccer (RoboCup), map abandoned coal mines, defuse bombs, drive autonomously through the desert (in the DARPA Grand Challenge), assist the elderly, and gather invaluable data from the surface of Mars [5]. This means that having robot to do hazardous job is not a weird thing to see now in this modern time of life style. This idea can be dated back to 1986, where Thunborg presented a remote maintenance robot system for use in hazardous environment, to perform coordinated and programmed maintenance operations on a pulsed nuclear reactor [6].

According to Thunborg (1986), Sandia Pulse Radiator III (SPR III) produces bursts of neutrons and associated gamma radiation that reach power levels of 118,000MWatt and last only fractions of a second. If the radiator and its room are allowed to cool down for several days after a burst, the residual radiation becomes low enough to allow hands-on maintenance on the reactor by operating personnel. However, such maintenance does result in occupational radiation exposure (ORE) for some operating personnel. Allowing the reactor to cool down also results in a loss of operating time and increase in test costs. Guidelines recently established for ORE specify that exposure should be "As Low As Reasonably Allowable" (ALARA). In conformance with these guidelines, Sandia has developed a Remote Maintenance Robot (RMR) System for the use in the SPR III facility. The RMR should reduce the occupational radiation exposure by a factor of four and decrease reactor downtime due to maintenance [6].

Further examples can be seen from the works of Potemkin et al. (1992) which stated the need of designing a mobile robot-based systems capable for a long time to carryout reconstruction operations in the zones of high level radiation, example like the Chernobyl nuclear accident of 1986 [7]. Qi et al. (2009) stated that key point for a bomb-disposal robot to perform the duty of bomb disposal is target positioning, which implies to control the manipulator fixed on the robot to reach the position of the perilous target. However the manipulator of current bomb-disposal robots are all designed to be manually operated by an operator remotely, which bring in some disadvantages: the operator need to be well trained, high accuracy of target positioning cannot be achieve [8]. According to Qi et al. (2009), the structure of the bomb-disposal robot consists of a remotely operated vehicle and a manipulator fixed on it with five DOF (Degree of Freedom). This kind of structure has been adopted in several commercial bomb-disposal robots and is consider as an effectual design, as shown in Figure 1[8].

The five DOF of the manipulator, which come from the rotation of waist, the joint of shoulder, the joint of elbow, the joint of wrist, the rotate joint of claw, can provide a satisfying agility and manageability for the operation in various surroundings [8].

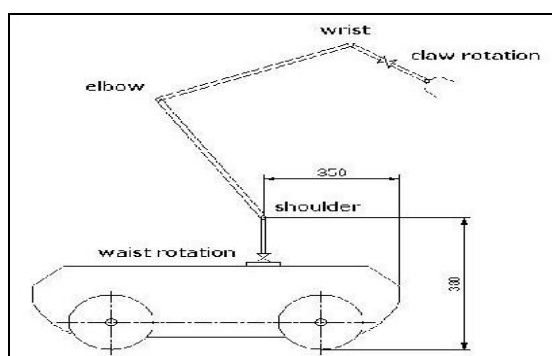


Fig.1: Five degree of freedom manipulator on a vehicle

But to attain high accuracy of target positioning of the manipulator, automatic operation or intelligent techniques are necessary for such robot. Three dimensional coordinates of the perilous target is obtained with high accuracy in the robot-based coordinate system through the binocular stereo vision technique. While after acquired the coordinates, the manipulator will reach for the target position automatically, instead of the manual controlling of the joints by the operator [8].

But due to the cost of the project only one camera will be used and the idea of a manipulator with five degree of freedom will be taken as basic design.

IV. Proposed Model

The whole assembly consists of 4 parts, a remote controlled car, a prosthetic robotic arm, a camera tower and a wireless radio frequency data transmission system. Both the robotic arm and camera tower are mounted on the remote controlled car so it is capable to move around and not fixed to one area. The wireless radio frequency data transmission system is the one providing the control signal to the controller board from a computer wirelessly. An operator can control the servo motors of the robotic arm and the camera tower from the computer with the aid of specific computer software (lynx) provided only for the servo controller board. By using lynx software, the operator is able to control each of the servo motors that were connected to the servo controller board. The robotic arm design consist of 6 different parts which were one waist platform, one shoulder platform, one arm section, one forearm section, one wrist section and one end-effector section. This means that this robotic arm have 6 degree of freedom which was one waist joint, one shoulder joint, one elbow joint, 2 wrists joint and one gripper finger joint. Every joint is capable of moving within the range of an angle of 180 degree. As for the camera tower, it is designed that the wireless video and audio camera is able to tilt up and down of an angle of 180 degree, and turning right and left of an angle of 180 degree or any combinations of turning and tilting. The remote controlled car is capable of turning left or right and moving forward or reverse or any combinations of turning and moving [14, 15].

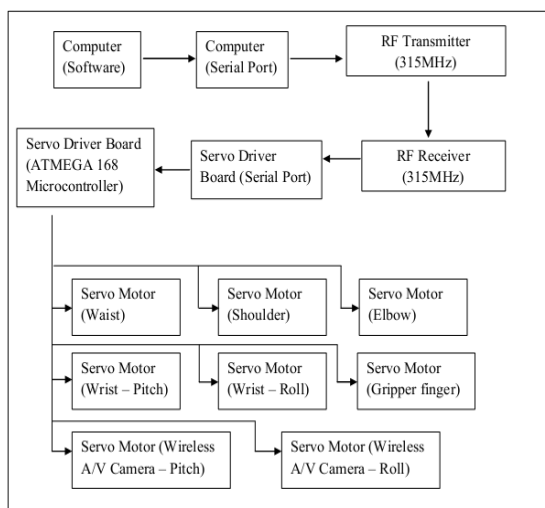


Fig.2 Control tree for servo motors

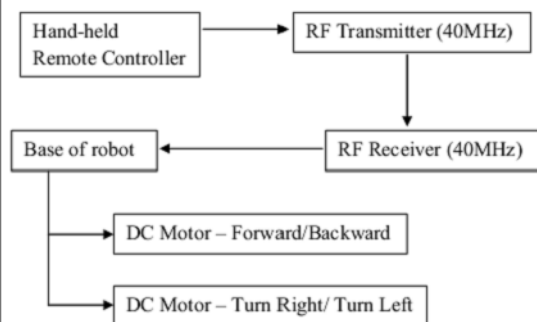


Fig.3 Control tree of the robot base

V. Design

For the mechanical part, the 5 axes robotic arm with gripper will need to be design so that the only 1 axis is being controlled at a time to prevent any unwanted movements that can cause danger during the bomb operation. The material used for the making of this prosthetic robotic arm [12] with gripper would be carbon fiber and acrylic sheet. The reason for choosing such a material is that it is durable and light weight, it is also easily shaped into the dimensions needed by the use of simple tool like the glass cutter.

The actuators for the robotic arm with gripper will be the servo motors as it is easily available and it costs lower if compared to stepper motors. But the weakness of using servo motors would be the controls, as it is the characteristics of servo motor to feedback its' position to avoid any error, there might be some glitch if the positioning feedback systems are very sensitive. While for stepper motor, the movement of its shaft is very stable and it has a higher torque output on the shaft compared to servo motor. All the actuators will be controlled from a servo driver board which is onboard of the robot itself, receiving wireless signal from the serial port of the computer that the user is operating by the use of software provided along with the servo driver board.

The wireless audio/video camera will act as the eye of the user and there will be option to rotate and tilt the camera by attaching the camera to 2 servo motors so that the user can get a better view at the surrounding or at a particular object.

Another matter to be stressed on this model would be the RF control, which in this project consisted of 3 different standalone systems. The first system is the controller with the motor of the robot arm with gripper which is controlled wirelessly from a computer with the use of software provided by the servo controller board (315Mhz), while the second system would controller of the movement of the robot which the base was modified from a remote controlled car which is controlled from the PC based remote controller (40MHz) and the last system would be the wireless video camcorder sending live images and audio back to a television or monitor during the whole operation of the robot (2.4GHz)[13].

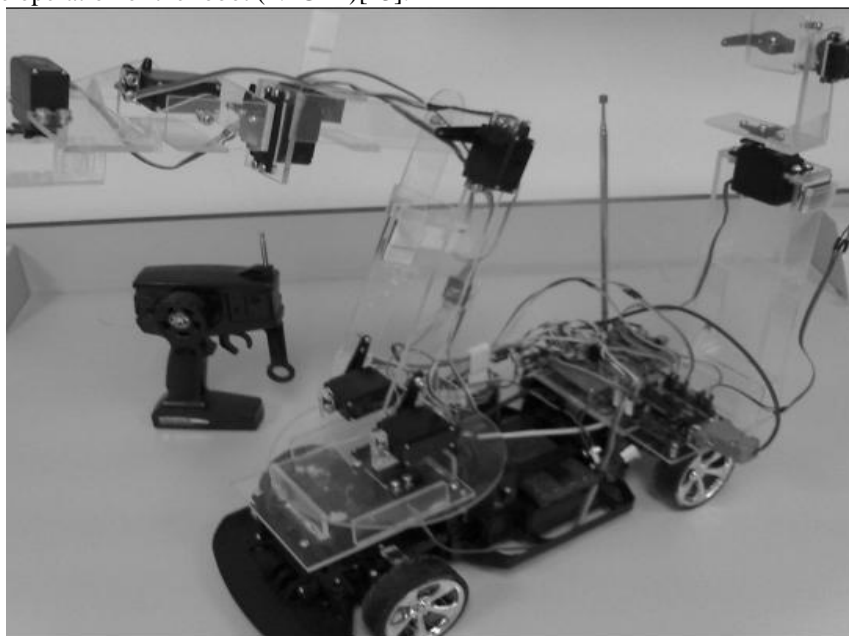


Fig.4 Robot for disposal of explosive ordnance

VI. Results And Discussion

All components of the final system performed as expected allowing the robotic arm to move, open and close according to the user input. Rotation of the bottom most DC motor of the OWI arm was programmed to follow the x-axis while the other 4 motors were programed to work on the z-axis (forward and backward) and y-axis (up and down). Images of the actual arm are provided in Figure 4, showing the movement of the gripper arm. The number of degrees of freedom gives us a fair idea of the measure of abilities of a robotic arm, and essentially refers to the number of separately controlled joints in the gripper arm[11]. Grippers most commonly have two components that move independently allowing for either one or two degrees of freedom. For comparison, the human hand comprises 27 degrees of freedom [9]. More degrees of freedom allow a gripper to grab and manipulate objects more easily and in a greater number of ways. When there are only a few degrees of freedom, the operator must first position the gripper arm accurately with respect to the device. The gripper in turn must be equipped to place large forces on the object to have a sturdy grip [10]. Thus the stability and sensitive of both the arm and explosive are important factors to consider. Greater degrees of freedom allow a greater number of points of contact which make the grasp sturdier while also reducing the force applied on the object. The effect of optimization, ie the current drawn by the motors for raising the explosive material is verified with the previous structure. Due to lighter weight design (robotic arms), power consumption is optimized and their performance characteristics also appreciable.

VII. Conclusion

A robot for disposal of explosive ordnance with wireless video/audio camera is successfully designed, fabricated, tested and proven to be capable of simulating the actions of what an explosive disposal robot is needed to perform. Future extension could focus on limitation of materials and programming to improve more gestures.

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