Remote control and monitoring of landmines detection robotic system

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Abstract - Remote control of processes and equipment is a promising research area. Remote labs are a solution which has big potential to benefit different education purposes, research fields and industrial applications. Working remotely in dangerous environments enhances the security of persons. One of these applications where people’s lives are at risk is the mine detection process. This study investigates reasonable solutions for enhancing the performance of landmine detection in the direction of monitoring and visualization as one of the essential aspects among the topics of research of the landmine detection techniques.

Keywords - Remote Labs, Remote Experimentation, Landmines Detection, GPS, LabVIEW and Remote Panels

1. INTRODUCTION

One of the most important applications of remote labs, (Fig. 1.) is the remote monitoring and control of hazardous applications and experiments, such as existing radiative or explosive materials that present danger to humans. In this research, a case study is conducted representing a remote monitoring of a land mine detection robotic system that serves in both fields. First it is considered as an example of remote experimentation to enhance E-learning[1]. From a practical side and secondly and our aim purpose is to introduce solutions for the landmines detection systems aiming to improve the performance of the detection process (Fig. 2. and Fig. 3.). According to united nations reports, 2000; there are about 100 million of landmines around the world distributed in 77 of affected countries, most of these mines still cause harmful consequences to human lives and hence badly affect agriculture, land usage, resources extraction…etc. In the land of the affected countries; land mines detection systems, mine sensors and aspects relating to this field have been discussed in another paper of the same authors titled “Detection of landmines and explosives systems, performance and field experience”. Demining processes is a very helpful way to save human lives from this hidden danger. There is a growing demand by these countries for reliable landmine inspection systems because of the consequences discussed in [2]; absence of maps or information about the landmine areas and the high cost of locating and removing landmines. In a simple way, detection techniques consist of three main units; a sensor to capture a signature of the landmine, a signal or image processing unit to arrange the acquired data in a format suitable for detection, and a decision making unit to decide whether a landmine exists or not. However the research for landmines and explosives detection can be classified into the following directions:

1. Landmines, info, types, facts, consequences;
2. Detection system and carrying vehicles;
3. Detectors (sensors to detect mines);
4. Detected mines’ location identification;
5. Data (signal/image) processing techniques and algorithms;
6. Data Transmission Techniques;
7. Demining techniques;

This paper focuses on proposed solution of the carrying vehicle and data transmission for visualization and monitoring of data in order to improve detection process.
The manual landmine detection and removal with human hand held detectors, mechanical methods and/or biological (using trained dogs and rodents) methods are still carried out for reasons of the reliability, however it is a very slow method including risk and time consumption[2]; so the need of artificial systems using automated/robotic systems in that field is an essential and pave the way for researchers to work aiming to improve the performance of automated methods for landmines detection.

The research area include many challenges and gaps to work on such as:
- Automated control of gap and attitude of the sensor heads and the ground surface,
- Location process of detected mines,
- Monitoring of speed during the detection process to avoid missing of mines.

Few mine detection robots that have the capability to recognize ground surface and can control the gap and attitude of the sensor heads are reported in (Armada, M.A. et al. 2005), (Chesney, R. et al. 2002), (Nonami, K. et al. 2003). Through the reviewed literature it is obvious that using one of the mines detectors techniques (which is a growing area of research) combined with unmanned vehicles or robots considered as the most suitable technique to minimize the human interaction near to the dangerous area and increase the speed of detection.

II. PROPOSED SYSTEM

2.1. System Description

The reliability on a landmine searching robot is highly dependent upon the performance of the detector with respect to the landmines, whereas, the purpose of the carrying vehicle is to provide the require pattern of movement in such a way that the detector can do its job. A data processing unit is needed on board, to process the input data from the operator and to send out output data to the specific mechanism to perform the necessary function.

The proposed system is basically as any artificial /robotic system comprise of three basic features, namely; the mine detector, a carrying vehicle, a data processing unit and a data processing unit.

The goal of the proposed system is to prepare an outdoor mobile robot platform for humanitarian demining application in addition to introducing solutions for the localization process of detected mines and monitoring of swiped area, in addition to introduce a remote monitoring of the process via Internet. The system consists of atmega microcontroller with Arduino board platform to control the robot motion and steering of motors. The robot is configured as a bomb detecting robot that uses the metal detection technique. The global positioning system (GPS) is attached to the robot in order to trace the position of the robot. GPS signals acquired with the use of NiMyRIO (data acquisition unit from National Instrument) and Labview program where data are transferred and monitored via LabVIEW remote panels. The client and the robot communicate through Internet to monitor the root of the robot in order to get clear information about detection speed and to avoid missing of mines and also to monitor the area inspected and locations of mines detected as depicted in Fig. 3.

![Fig.3. Automated Guided Vehicle robot.](image)

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2.2. Remote Panels in LabVIEW for GPS Data Monitoring

The mines detecting Robot is combined with a GPS receiver which is connected to the server computer using the NiMyRIO board and its IP address is noted. The specified direction of the robot by means of LAB VIEW is transmitted from client system to the robot through Internet. The Arduino board (Uno type) is programmed through the IDE Version 1.6.3 and is used to control the motors drivers system which consists of 4 motors and h bridge converter is used to supply voltage to DC motors according to the intended direction. Differential drive is used to control the steering angle and the direction of the robot. Differential drive is a method of controlling a robot with the 4 motorized wheels. An ultra-sonic sensor is connected to the robot to provide an obstacle avoidance solution for the robot during its navigation. In client end, remote panels of LabVIEW serve as the communication tool for internet; front panel of robot location and detection speed are being monitored through the constructed remote panel of

![Fig.4. Remote monitoring and control system setup](image)
the LabVIEW platform. Once connected to the remote panel server from client user location using the URL required to connect to the front panel published by LabVIEW wizard through the server computer, URL http://virtuallab-Pc:8000/Main.html system can be monitored.

2.3. GPS
GPS is used for positioning, localization and determining time. The civil signal SPS (Standard Positioning Service) can be used freely by the general public, while the Military signal PPS (Precise Positioning Service) can be used only by authorized government agencies. The GPS data can be retrieved from the GPS receiver in various formats. GPRMC data format is used in the proposed system. The GPS data set (Recommended Minimum Specific GNSS) contains information on time, latitude, longitude and height, system status, speed, course and date [3].

Wiring of the GPS used with the NI myRIO is shown in Fig. 5.; GPS receiver requires five connections to NI myRIO, as follows; MXP Connector A:
1. +3.3-volt supply (VCC3V3)/+3.3V (pin 33)
2. Ground (GND)/GND (pin 30)
3. UART transmit data (TXD)/UART.RX (pin10)
4. UART receive data (RXD)/UART.TX (pin 14)
5. One-pulse-per-second (1PPS)/DIO0 (pin 11)

2.4. H-Bridge
DC Motors rotate in two directions depending on how applied voltages are connected to the motor terminals. In order to run the motor in the forward direction, the positive terminal of the motor is connected to the positive terminal of the battery and negative to negative. However, to run the motor in reverse direction, simply switch the connections; connect the positive terminal of the battery to the negative terminal of the motor and the negative terminal of the battery to the positive terminal of the motor. An H-Bridge circuit allows a large DC motor to be run in both directions with a low level input logic signal. The H-Bridge electronic structure is explicit in the name of the circuit - H-Bridge. Input signals to the H-Bridge are being provided from the Arduino board according to the control program, see Fig.6 and Fig.7.

2.5. Mine detector
The metal detector in the robot serves as the landmines detection. Through our literary research regarding landmine detection techniques metal detectors are the basic, simple and cheap technique of mines detection, based on detecting the metal casing of landmines, hence give signals of detection of mines, however there are some kinds of mines with low metal content, so it has limitations for these kinds of mines in addition to metal detectors give false signals of any metal pieces or scrap instead of landmines. But it is the suitable solution for completing the proposed system of this project as other effective methods like thermal camera and GPR detectors are very expensive techniques (10,000 to 40,000 USD) [4], [5]. In case of metal detector it cost only (8-12 USD) and it still able to complete our system and help for the main goals for the proposed system. The used metal detector is shown in Fig.8.

The status of IR sensor helps for path planning and changing the direction of the robot. When a mine is detected by the metal detector the robot is stopped and the location of bomb is identified with the help of the GPS sensor. Figure4 shows the block diagram of...
control setup of the proposed system. Among the landmine detection techniques, metal detectors is considered as the simplest and cheapest technique for detecting landmines, however it has limitations for detection of low metal content mines, and it might have false alarms of non-mines such as scrap and non-explosive metal parts existing in the area of inspection[6].

To implement the system, a metal detector is used to complete the system where we focused more on improving the performance of detection process, localization of detected mines, visualization of robot/detector motion and speed during the inspection process, aiming to reduce errors and save human lives; Fig.9. shows the sweeping and detection problems.

Fig.9. Importance of monitoring speed and trace of sweeping

IV. RESULTS AND DISCUSSION

The test is carried out with the prototype assures us of the success of the robot, except for some minor problems. Detectors are made of cheap components and thus the reliability is uncertain with low range of detection. Sometimes, false alarms are generated due to the detection of robot’s own metal component. However, this problem is solved by separating the detection coil from the circuit with the use of plastic plates. The second problem occurs in the DC motors. These motors don’t generate precise displacements. They are made to provide speed and torque closest to their specifications, but not the exact amount. However, these minor problems won’t occur in the actual robot since they are caused by the poor quality of the equipment not due to the proposed concept.

3.1 Hardware
- ATMega-328P with the Arduino Board controller; Robot chassis and four 9v Dc , (the structure mainly of a commercial off-the-shelf parts, which are available at low costs;
- H-Bridge is implemented by L293d driver IC, to drive the motors;
- NImyRIO and GPS are attached to the NImyRIO data acquisition;
- Metal detector; Ultrasonic Sensor, IR sensor, batteries and connectors;

3.2 Software
- Arduino IDE 1.6.3, LabVIEW software 2013
- NImyRIO software and drivers

Data and interface of the implemented system are shown in Fig.10. to Fig.14, the process is very simple and the procedure can be summarized as follows.

Fig.10. GPS Data Details Explanation

Fig.11. GPS Data Monitoring Via LabVIEW

Fig.12. Arduino program controlling the robot motion
CONCLUSION

The need of artificial solutions for the landmines detection process to face the problems of long time required, false signals, low performance and dangerous of using biological methods of mine detection like using of trained dogs and rodents or using hand held detectors that still represent danger to humans participate in the demining process. So visualization and monitoring of automated guided vehicle as a system for the detection process is a potential research direction in the field of landmines detection. Also the use of graphical visualization by GPS and Labview is a general can be applied with other techniques not only with the robots as it can be attached to a hand held detectors Fig.15.; to improve the performance of hand held detector from the side of data transmission.


The more important for researchers in this field is not about the robotic mechanical systems structure only but efforts must be done for the locating processes of detected mines, visualization of sweeping trace and velocity, new detectors with higher performance, increasing the range of detections, new detectors that detect the explosive material itself….etc. as proposed as a future work for this research by which the detection system can be used to assess the efficiency of operators in information process, feeding back the information in real time to enhance the accuracy of sweeping and giving an accurate decision of existing mines or proving that the swiped land is free from mines.

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REFERENCES


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