Article **ECORFAN Journal- Taiwan**
June, 2020 Vol.4 No.7 28-34

Prototype robot rover with Arduino, LabVIEW and mobile devices

Prototipo de robot rover con Arduino, LabVIEW y dispositivos móviles

BELTRAN, Miguel†, SALINAS, Oscar and LUNA-ORTIZ, Martha

Universidad Tecnológica Emiliano Zapata del Estado de Morelos. Universidad Tecnológica No. 1 C.P. 62760 Emiliano Zapata, Morelos

ID 1st Author: *Miguel, Beltran*

ID 1st Coauthor: *Oscar, Salinas*

ID 2nd Coauthor: *Martha, Luna-Ortiz*

DOI: 10.35429/EJT.2020.7.4.28.34 Received March 22, 2020; Accepted June 11, 2020

Abstract

Terrestrial robot prototype all – terrain explorer, for exploration of areas that pose a danger to humans was developed. Mega Arduino microcontroller was used for remote control of the robot's movements as well as shipping and receiving signals in a wireless way. The visual interface is adapted to be used with mobile devices, with which the robot can be controlled, and also signal processing for decision- making. This visual interface was developed in LabVIEW executable mode, so this software not need be installed on the mobile device. A comparison between RF technologies and Wi - Fi point to point, no significant difference was found between them, with respect to the wireless functionality of the robot. The terrestrial prototype designed has four wheels, it is functional is independent and can be moved into different types of surface and places where humans cannot access, either for safety or for the same site. The proof of concept was successful, the prototype is expandable in functionality, appropriate technologies and application-specific functions can be integrated into the overall scheme.

Autonomic Robot, Signal analysis, Arduino, Mobile Devices

Resumen

Se desarrolló un prototipo de robot explorador terrestre tipo todo terreno, para exploración de áreas que representen un peligro para el ser humano. El microcontrolador Arduino Mega se utilizó para el control remoto de los movimientos del robot así como del envío y recepción de señales de manera inalámbrica. La interfaz visual se adapta para el uso con dispositivos móviles, con la cual se puede controlar el robot, así como el procesamiento de señales para la toma de decisiones. Esta interfaz visual fue desarrollada en LabVIEW en modo de archivo ejecutable, por lo que no es necesario tener instalado el software en el dispositivo. Se hizo una comparación en desempeño de tecnologías RF y Wi– Fi punto a punto, no se encontró diferencia significativa entre ellas, con respecto a la funcionalidad inalámbrica del robot. El prototipo diseñado terrestre tiene cuatro llantas, es funcional es autónomo y se puede desplazar en diferentes tipos de superficie, y lugares donde el ser humano no puede acceder, ya sea por seguridad o por la misma accesibilidad. La prueba de concepto se realizó con éxito, el prototipo es expandible en funcionalidad, se pueden integrar al esquema general tecnologías y funciones adecuadas para aplicaciones específicas.

Robot autónomo, Análisis de señales, Arduino, Dispositivos Móviles

Citation: BELTRAN, Miguel, SALINAS, Oscar and LUNA-ORTIZ, Martha. Prototype robot rover with Arduino, LabVIEW and mobile devices, ECORFAN Journal-Taiwan. 2020. 4-7: 28-34

† Researcher contributing as first author.

Introduction

Historically humans have used machines to help with difficult tasks to perform, to make more efficient use of time or simply to provide comfort. These machines can be simple or very complicated, depending on the situation it faces, and the type of solution required. In the case of areas inaccessible to humans, either by the difficulty itself or because it represents a risk to humans, machines are useful to explore these areas. Therefore is possible to explore in a safer way areas that represent a danger to human access, and are to be considered at risk or be simply inaccessible.

There are two complicated situations for a human being can access a specific area: a disaster area and unexplored area. A disaster area most of the times implies a risk for humans to get in it. A disaster area is one where a particular natural phenomenom occured, a tornado, an earthquake for instance. It means an emergency situation needs to be attended, and some times the level of disaster do not let humans explore some small areas by themselves.

A disaster area in addition to the damage already done is an imminent risk to persons accessing this, either out of necessity or to help someone else. If one person is getting caught due to a natural disaster another important thing related with this issue is the rescuing time. Both are important survival factors, getting caugth is only a matter of fortune, the second depends on many factors, and is the difference between surviving or not. In an unexplored area there is also risk because people do not know what it will find in it, and thus it is almost impossible to estimate the risk for a human being to access. For both situations the common solution is to use some kind of tool to solve the problem without jeopardizing the life of someone else in rescuing people, or unforeseen risks in unexplored areas.

For instance, an autonomous robot which can access both areas of risk for human beings can be an adequated solution. The Robot must have autonomy to be able to explore area controlled remotely outside of the area. This must be done by a wireless control system, developed based on any wireless technology (IEEE Standard, 2012).

An image acquisition device is needed to get information about the general conditions of the area, and get an idea about the level of the risk, adquired images, either video or pictures, and data have to be transmitted by wireless connection. Temperature and humidity sensors, gas sensors, light sensors, to have an overview of the conditions of the environmental conditions of the area. Another important factor of auntonomy is that the robot must be able to avoid obstacles. It needs to detect them identify if is fixed or mobile and wait to it disappear or avoid it, respectively.

The researching idea came watching a video about the earthquake in 1985 at México City. Professors and students of Mechatronics Engineering review the documentary and ask themselves: What about if we build an explorer robot? It can do the risky work instead of called―human moles‖. After that the next objective was raise: Design and build a prototype robot type land rover to explore areas of risk, with sending and receiving signals by wireless telecommunication, and it can be controlled from a mobile device.

In literature are reported different types of rover, which have various forms and applications (Arévalo, 2014) (Ortíz, 2007) (Bauer, 2009) (Lidoris, 2009) (Acosta, 2013) (Villafuerte & Guzmán, 2014) (Oliva, 2011) (Rodrigo, 2014) (Bauer, 2009) (Sirish & Suresh, 2014). However the characteristics of this robot are no reported, for example the integration of Arduino and LabVIEW for a similar technological application is no reported so far.

The structure of this report is as following:

– Abstract.
– Introduction.
– Theoretical perspective.
– Hypothesis approach.
– Methodology.
– Results.
– Conclusions.
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Students were involved in the project development, because for authors is important to involve students in the researching process and project managment to get autonomous behavior.

ISSN 2524-2121

Theoretical perspective

Today technology has had an unprecedented development in the history of mankind. After the steam era, followed the age of electricity, which is to say that was founded in 1808 with David Humpry (BBC, 2014). Almost a century after Nikola Tesla gave social life the way we know it today.

Thanks to Tesla have the generation and distribution of electricity current (conventional network) and wireless telecommunications. George Westinghouse commented laconically: without Tesla's contributions today's world would be impossible. (Steathskater, 2014) (Company, 2013) (Wordpress, 2012). These are the foundations of knowledge on which rests the breakthrough of current technology. Perform a technological development that would coordinate different technological areas to develop a work product that has the added value of social impact, is the motivation of the authors and students.

The equation could be as easy as: Technology (Electrical + Wireless telecommunication + mechanical + electronic) + social impact = Robot land rover explorer prototype. Telecommunications technology is used to send the information remotely and electronic technology is basically used to control the robot movements, processing data and convert them to information for making desitions. This taks are performed by a microcontroller. Microcontrollers are very dynamic electronic tools for building automation systems and elaborate and efficient control. The Arduino is a low cost open source microcontroller, which is easyto use and has diverse uses and applications (Arduino, Arduino, 2012), (Salinas, Low cost solarimetric station with solar resource calculation based on Arduino microcontroller and web platform, 2014), (Diana, 2015).

For wireless telecommunication there are two options: RF point to point and Wi – Fi one. Generally RF itself is taken as a synonymous of high-frequency signals and wireless telecommunication, describing anything from AM radio between 535 kHz and 1.605 MHz to computer local area networks (LANs) at 2.4 GHz. However, RF has traditionally defined frequencies from a few kHz to roughly 1 GHz. In some cases it is extended to 300 GHz to consider microwave frequencies as RF ones (Instruments, 2011). Arduino can work for wireless telecommunication either with Xbee (Arduino, Arduino, 2012) or Wi – Fi shield (Arduino, 2013). The first one allows Arduino microcontroller to communicate by Zigbee protocol, which is a standard for low power mesh networks working robustly. A comparison about the main technological characteristics about wireless connection is presented at Table

According to the data wireless telecommunication using Zigbee (XBee shield) should be the best option for land rover robot, Table 1, the only disadvantage is the low data rate, comparing to Wi – Fi, it means communication is going to be slow but cost, power consumption, complexity and coverture ratio must be better. ZigBee (Arduino Xbee shield) has been designed for applications that require safe communications with low data rate and low power consumption to maximize the usefull live of batteries, actually is more oriented to home automation systems (Diana, 2015) (Vázquez, Salinas, & Guillermo, Universidad Tecnológica Emiliano Zapata del Estado de Morelos, 2014) (Vázquez D. U., 2014) (Srinivasan, Raajan, Manonmani, & P, 2014) (Negus, Stephens, & Lansford, 2000). Arduino Xbee looks like the adequated one for the proposed robot, however one important point to keep in mind is about the image processing capability, due to one of the main purposes of the robot is get images from the unknown or disaster area.

Technological parameter	Xbee	Wi - Fi
Coverture ratio (m)	Indoor: 305; Outdoor 914	Indoor: (802.11b) 35 ; (802.11g) 38; Outdoor: 802.11b/g 140
Date rate (Mb/s)	0.020, 0.040 and 0.250	From 2 to 11 aproximately
Power consumption	Low	Medium
Cost	Low	Medium
Complexity	Low	Medium
Frequency (GHz)	2.4	2.4
Security	Medium	WEP / WPA2

Table 1 Comparison betweenZigbee and Wi – Fi, about characteristics for the proposed land rover robot (IEEE Standard, 2012)

Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) is an Integrated Development Environment oriented to virtual instrumentation. According with National Instruments definition: ―LabVIEW is a highly productive development environment for creating custom applications that interact with real-world data or signals in fields such as science and engineering‖ (National Instruments, 2013).

It is a very usefull electronic and programming tool, it is not a simple simulator, to test simple or complex integral electronic elements, such as controls, indicators, actuators, measurement instruments and so on. Engineers, scientists or students can convert their ideas to the reality in a not easy but neither very complex way, since programation is based in objects, not in code lines. Therefore is an adequated tool to develop systems to get and analize data to make decisions. LabVIEW is compatible with mobile devices, the visual interface can be designed and built with LabVIEW and save into device mobile as an exe file.

The exponential rise of mobile devices has caused more and more users prefer them instead of desktop computers. For example, to have the first 1000 million mobile subscribers passed 20 years, and only 15 months to get the other 1 billion. CISCO company predicted that this year 2015 will have the same number of mobile phones that human beings on the planet, and by 2020 there will be around 50 000 million of mobile devices users connected to the network, an average of three for each human being (Deloitte, 2013). Also there is the growth of the so-called App Economy, which is of 1 000 million smartphone users. This is an economy that generated 20 000 million of United States dolars (usd) at year 2011 (Deloitte, 2013). Therefore is very important to keep in mind this data, when every technological development, actually every kind of product, is going to be developed to be innovative and launch to the market.

Hypothesis approach

Currently the technological advancement has allowed the technology is available to almost everyone. The cost of technology is becoming more accessible even for low budget universities.

This allows technologists researchers to design and build computers that have the same performance as those of trade, or the design of new and innovative technological applications brands. Therefore one hypothesis can be written:

Hypothesis: It is possible to build a working prototype rover autonomic, based on Arduino and LabVIEW, which allows sending signals and control remotely.

Methodology

The methodology is simple, Figure 1, and is basically the one suggested by Sampieri (Sampieri, 2010). The researcing idea of technological development emerges as a local need for exploration unsafe for human being areas which may not or areas where disaster strikes explored. In the metropolitan area of the city of Cuernavaca Morelos, Mexico, due to a problem of over population, people have the need to locate their homes in unsafe areas, which are in constant danger of being in a disaster situation. Therefore the need to build an autonomous robot was raised for access to these areas in cases of a disaster, without putting in risk other human beings.

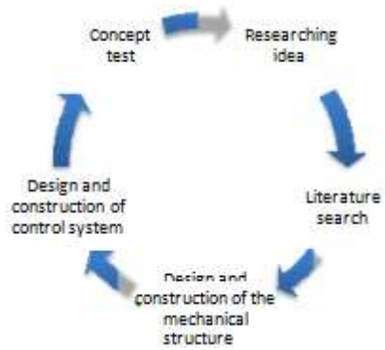

Figure 1 Conceptual map of used methodology

Upon review of the literature no similar technological developments are found, which can occur that are integrating three types of teconlogías: mechanical, wireless communications and mobile devices. In addition to integration of Arduino programming in LabVIEW is recent (Instruments, 2011). The design of the mechanical structure is proper and craft, he drew on the expertise of automotive mechanical technicians.

This design is empirical, and everything is based on the experience of mechanical mechanical technician rather than an educated design and structural calculations. This is because no team member has expertise in mechanical structures.

The wireless electronic control system is developed based on Arduino and LabVIEW. Although elements for Arduino have been added to LabVIEW, programming the signal acquisition and processing them is not so trivial. As an added value presented in this prototype, it has functionality that can be controlled from a mobile device. This is accomplished by having the program in LabVIEW executable, so you should not have installed the software on the mobile device. Following this procedure the prototype was designed and developed.

Results

The initial prototype is built aluminum profiles and acrylic material mechanical structure. The prototype has eight standard type tires, which have their own strength, to have the facility to move in any terrain. The tires at upper are to have a smooth ride and give strength to the robot to climb on land with steep slopes.

The robot has an automated mechanical arm that allows low weight lifting and moving objects. This arm is commercial, it was not built by the authors, just programmed, Figure 2. The utility of the arm is still under study because at this stage, priority is the prototype autonomous mobility. LabVIEW programming environment is graphic, designed for virtual instrumentation. This allows a versatile and dynamic programming, where you can simulate the behavior of components without having physically connected.

Figure 2 Autonomous explorer robot prototype

It also allows physical interaction with measuring instruments and sensors on one card automatic data acquisition. The whole program is not possible to show in a figure, so that in Figure 3 is showed a screenshot of part of it.

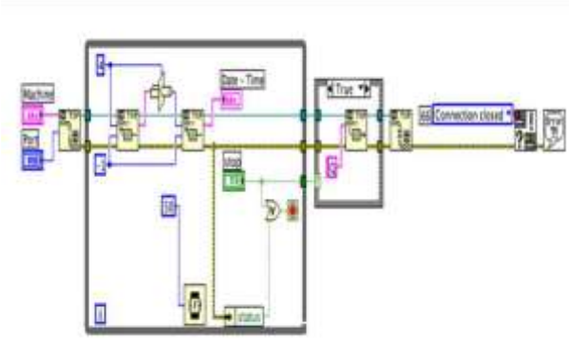

Figure 3 Part of the virtual programation in LabVIEW

LabVIEW allows custom user interfaces, which are suitable for mobile devices, Figure 4. The interface shown in Figure 4 is the one where the user can control the features of land rover explorer robot. With this interface user are able to control: the movement of the robot using touch button; sending signals to the robot; acquiring signals from the robot and processing the basic data for decision-making. You can turn the robot motion control using the accelerometer of electronic tablet, however at this stage is not covered.

Figure 4 Visual interface for mobile devices

Conclusions

It is possible to build a robot explorer combining functional autonomic free hardware (Arduino) and licensed control software (LabVIEW). Using Arduino microcontroller greatly reduces the cost of building the robot and does not impact the performance of the same, as it has the same functionality as other commercial microcontroller.

ISSN 2524-2121

Involving young students in developing technological developments have both academic research and business impact. Young people develop skills for autonomy since they themselves carry out basic research to implement a technological development.

They also recognize the on-going importance of teamwork and integration of multidisciplinary teams, as the skills of each other come together.

The proof of concept has been successful, and is able to keep improving the rover, working on their autonomy and also in the number of signals that can send and receive, to convert them into information to improve the decision making process.

Acknowledgement

The authors wish to thank to the students Martín Omar Vázquez Reyes, Luis David Aviles Wenceslao, Ángel Carlos Giles Jiménez y Gilberto Hernández Tumalán for their commitment in developing the prototype. For their dedication and professional work as well as all the ideas that have contributed to the design and optimal operation of the rover.

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