VISIÓN
ELECTRÓNICA

Robot used in measuring areas using gps
Robot aplicado a la medición de áreas usando gps

César Augusto Díaz Celis[1]
César Augusto Romero Molano[2]

Fecha de envío: 02 de mayo de 2015
Fecha de recepción: 11 de julio de 2015
Fecha de aceptación: 10 de octubre de 2015

Abstract: The geo-referencing and measurement of land areas is the first obstacle to overcome for the farmer, as having no certainty of the place and the extent to which a particular crop began its current state and generates high costs of equipment and personnel movement specialized for this task identification, referencing, and field calculations. One solution to this problem is investigated and described in this article, which comprises software and hardware. In the case of software, this article covers two parts: the first on mobile devices, consisting of 9 classes (GeograficasPlanas, GamePad, Archives, SerieLinux, AreaPoligono, StringMejorado, DatosGPS, VisionArtificial, Xbee) and the second is embedded in the Arduino UNO using 5 classes (SoftwareSerial, PololuQik, Servo, TinyGPS, SD). In the case of hardware worked with the Dagu Wild Thumper 6WD vehicle, stayed in this battery, Arduino, 2s12v10 Pololu Qik, the Xbee, GPS A2100A, sensor pan / tilt and optical sensor.

Keywords: Geo-referencing, free hardware, robotics, free software, GPS.

Resumen: la georreferenciación y medición de áreas de terreno es el primer obstáculo a vencer para el agricultor colombiano quien por no tener certeza del lugar y la extensión en el cual se iniciará un determinado cultivo y su estado genera altos costos en desplazamiento de equipos y personal especializado para realizar labores de identificación, referenciación y cálculos del terreno. El presente artículo describe la investigación que desarrolló una solución a este problema, integrada por software y hardware; el software en dos partes: la primera en el dispositivo móvil, conformada por 9 clases (GeograficasPlanas, GamePad,

1 BSc. In Systems and MSc (c) in IGS –Information Geographic Systems-, Universidad de Los Llanos, Colombia. Current position: research group GITECX, Universidad de Los Llanos, Colombia. E-mail: cesar.diaz@unillanos.edu.co

2 BSc. In Electronics and Sp. In Data Networks, Universidad de los Llanos, Colombia. Current position: research group GITECX, Universidad de los Llanos, Colombia. E-mail: cesar.romero@unillanos.edu.co

Citar este artículo como: C. A. Diaz, C. A. Romero, "Robot used in measuring areas using gps". Visión Electrónica, algo más que un estado sólido. Vol. 9, No. 2, julio-diciembre 2015, pp. 206-214.

Archivos, SerieLinux, AreaPoligono, StringMejorado, DatosGPS, VisionArtificial, Xbee), y la segunda embebida en el Arduino UNO usando 5 clases (SoftwareSerial, PololuQik, Servo, TinyGPS, SD). En el caso del hardware se trabajó con el vehículo Dagu Wild Thumper 6WD, en este se alojaron las baterías, Arduino, Pololu Qik 2s12v10, el Xbee, GPS A2100A, sensor pan/tilt y sensor óptico.

Palabras clave: Georreferenciación, hardware libre, robótica, software libre, GPS.

1. Introduction

Mobile robots can be classified by their autonomy: Manual (teleoperated or remote control) or autonomous (humans are not involved in the development of the task to be performed by the robot). In the case of teleoperated robots' greater application are those who develop dangerous tasks for man (mine detection, handling of radioactive substances, etc.) [1].

There are also applications such as: characterization of soils using autonomous robots [2]; unmanned vehicles guided by GPS [3]; control mobile robots with vision for rectification of images for use in precision agriculture [4]; autonomous and teleoperated mobile robots from a PDA [5]; robot navigation in rough terrain [6]; robots for obstacle detection and navigation via GPS [7]; 4x4 robot navigation in rough terrain [8]; autonomous robots for weeding [9], among other applications.

Therefore, "While still traditional work in the study of nature can be much more efficient in some cases, the use of mobile robots can be more quickly and efficiently in the case of taking action massively " [2].

This article and its structure try to integrate disciplines of the Research Group on Open Technologies, GITECX –Universidad de Los Llanos, Colombia- such as: agriculture, electronics, systems, and geography in finding a solution which consists of geo-referencing and measurement of land areas using a robot and a mobile device which receives the data transmitted by the robot in real time to be observed and analyzed, the robot can be at the distance of a few hundred meters from a computer or internet access.

2. Mobile Robot Implementation

The platform selected for the mobile robot was the Dagu Wild Thumper 6WD Pololu All-Terrain, weighing 2.7 kg and 6 160 rpm motors, [10]. For controlling the engine module Pololu 2s12v10 Qik, weighing 14 g, two channels, the channel current by 13 A and 30 A per channel peak [11] was used, this control card is via a serial port control speed and direction.

Arduino used an Atmega328 with a serial port, although more ports can be emulated by software with a library [12-13] for the processing part and hosting the embedded application, was also used one Shield Wireless for communication between Arduino and Xbee One 2sB, [14].

3. Data GPS Capture Module

To capture spatial coordinates worked on with the GPS A2100A USB card, based on w / SiRF Star IV integrated which supports SBAS for increased accuracy in the position calculation, 48 channels, communication UART-NMEA default rate 4800 bps, nearest 2.5 meters in horizontal and frame rate of 115.2K, [15]. The NMEA 0183 protocol is a medium that enables communication between maritime instruments and most GPS receivers—this protocol is defined and controlled by the US National Marine Electronics Association Organization [16].

The judgment or plot that works is the GPGGA that references data sets of a global positioning system (GPS), an example and frame format can be seen in Table 1.

As shown, the latitude and longitude displayed in decimal degrees to be transmitted from the browser to the mobile robot in this conversion geographic coordinates (WGS84) is performed at Universal Transverse Mercator (UTM).

Based on the geographical coordinates where the length and latitude is, knowing the value of semi-major axis (a) = 6,378,137, minor axis (b) = 6356752.31424518 with these data we can begin operations for converting geographic to UTM [18], first, calculate the geometry of the ellipsoid: eccentricity (1), second eccentricity (2), polar radius of curvature (3) and flattening (4).

$$e = \sqrt{\frac{a^2 - b^2}{a}} \quad (1)$$

$$e' = \sqrt{\frac{a^2 - b^2}{b}} \quad (2)$$

$$c = \frac{a^2}{b} \quad (3)$$

$$\alpha = \frac{a - b}{a} \quad (4)$$

The longitude and latitude must be expressed in decimal degrees (5), then you go from decimal degrees to radians (6).

$$DecimalDegrees = \mathrm{degrees} + \frac{\min utes}{60} + \frac{\mathrm{sec}onds}{3{,}600} \quad (5)$$

$$Radians = \frac{DecimalDegrees * \pi}{180} \quad (6)$$

To calculate the length of the sign if it is west of Greenwich longitude is negative, if the east of the Greenwich meridian, longitude is positive. Now, we proceed to calculate the UTM zone or zone (7), the integer part is taken.

$$Zone = \frac{DecimalDegrees}{6} + 31 \quad (7)$$

Now to obtain the geographical coordinates of the central meridian of the zone (8), the angular distance between the point and the length of the central meridian of the spindle (9) is calculated.

$$\lambda_0 = Zone * 6 - 183 \quad (8)$$

$$\Delta\lambda = \lambda - \frac{\lambda_0 * \Pi}{180} \quad (9)$$

To convert from geographical coordinates UTM Coticchia-Surace equations are used, first, the number of parameters required for using the equations is calculated (10 - 23).

$$A = \cos\varphi * sen\Delta\lambda \quad (10)$$

$$\xi = \frac{1}{2} * \ln\left[\frac{1 + A}{1 - A}\right] \quad (11)$$

$$\eta = \arctan\left(\frac{\tan\varphi}{\cos\Delta\lambda}\right) \quad (12)$$

$GPGGA,161229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M, , , ,0000*18			
Name	Example	Unity	Description
Message ID	$GPGGA		GGA protocol header
UTC Time	161229.487		hhmmss.sss
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=North or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=East or W=West
Position Fix Indicator	1		0=Fix not available or invalid; 1=GPS SPS Mode, fix valid; 2=Differential GPS, SPS Mode, fix valid; 3-5=Not supported; 6=Dead Reckoning Mode, fix valid
Satellites Used	07		Range 0 to 12
HDOP	1.0		Horizontal Dilution of Precision
MSL Altitude	9.0	Meters	
Units	M	Meters	
Geoid Separation		Meters	
Units	M	Meters	
Age of Diff. Corr.		Second	Null fields when DGPS is not used
Diff. Ref. Station ID	0000		
Checksum	*18		
<CR> <LF>			End of message termination

Table 1. Frame format GPGGA. Source: [17].

$$\nu = \frac{c}{(1+e'^2 * \cos^2\varphi)^{1/2}} * 0.9996 \quad (13)$$

$$\zeta = \frac{e'^2}{2} * \xi^2 * \cos^2\varphi \quad (14)$$

$$A_1 = sen(2\varphi) \quad (15)$$

$$A_2 = A_1 * \cos^2\varphi \quad (16)$$

$$J_2 = \varphi + \frac{A_1}{2} \quad (17)$$

$$J_4 = \frac{3 * J_2 + A_2}{4} \quad (18)$$

$$J_6 = \frac{5 * J_4 + A_2 * \cos^2\varphi}{3} \quad (19)$$

$$\alpha = \frac{3}{4} * e'^2 \quad (20)$$

$$\beta = \frac{5}{3} * \alpha^2 \quad (21)$$

$$\gamma = \frac{35}{27} * \alpha^3 \quad (22)$$

$$B_\phi = 0.9996 * c * (\varphi - \alpha J_2 + \beta J_4 - \gamma J_6) \quad (23)$$

After calculating the above parameters, we proceed to solve the equations of Coticchia - Surace (24-25) for the final coordinates in UTM.

$$X = \xi * \nu * \left(1 + \frac{\zeta}{3}\right) + 500{,}000 \quad (24)$$

$$Y = \eta * \nu * (1 + \zeta) + B_\phi \quad (25)$$

In the case of solution Y, if the latitude of geodetic coordinates belongs to the southern hemisphere, must be added to the result obtained 10,000,000.

4. Image Capture Module

For this module, an infrared camera was used with a radio module reception and EasyCap capture, this video goes mobile device and is processed with the library of computer vision OpenCV 2.4 originally developed by Intel, which is a library (Linux platform, Mac and Windows), programmed in C and C ++ using the capacities that provide multi-core processors. [19-20].

Visión Electrónica year. 9 number. 2, july-december 2015, p.p. 206-214,
ISSN 1909-9746, ISSN-E 2248-4728-Bogotá (Colombia)

5 Transmission and Reception Module

By sending GPS coordinates to the mobile device and the robot control modules, we used S2b Xbee Pro 2.4 Ghz, 250 Kbps, with a range of 90 meters indoor and outdoor 3,200 meters line of sight [21].

6 Developed Software

6.1 Mobile Device Software

Smarth a Tablet PC and Ultrabook Samsung Series 5 was used with Debian 6 Operational Testing, computer vision library OpenCV 2.4, GCC 4.7 compiler and Eclipse Juno system. The application consists of nine classes, as shown in Table 2.

6.2 Embededd Software on Arduino Uno

We used an Arduino Uno, the IDE AVR-GCC 1.0.1, in this application five additional classes as shown in Table 3 were used.

7. Results

As a result of the research, the design of a mobile robot is presented all over teleoperated ground, which uses software and hardware designed for geo-referencing areas of land and area calculation thereof. The prototype of the proposed solution is shown in Figure 1 and 2.

Figure 3 shows a block diagram on the left, at the software and hardware designed and used by the mobile device; and right software and hardware designed and used for the mobile robot. The way in which an end user interacts with the prototype design is very simple because this used a GamePad, and this through a USB port communicates with the mobile device and other USB port with a Xbee wireless communication module performs Zigbee protocol which uses the serial port on the Atmega328 (Arduino Uno), which runs the embedded GPS

Class	Description
GeograficasPlanas	Class developed for converting geographic coordinates (WGS84) to plane coordinates (UTM).
GamePad	Class adapted to control the GamePad to control the mobile robot.
Archivos	Class developed for storing data on hard disk
SerieLinux	Class adapted for communication via RS232 port.
AreaPoligono	Class developed for calculating the polygon through determinants.
StringMejorado	Class developed for handling strings.
DatosGPS	Class developed for receiving a frame GPGGA in NMEA protocol and interpret it.
VisionArtificial	Class developed to capture and display video stream.
Xbee	Class that inherits from Series developed Linux for using XBee modules.

Table 2. Developed or adapted Classes on mobile implementing. Source: Own.

Class	Description
SoftwareSerial	This class allows emulation software serial ports using Arduino digital pins, in this application a total of 3 serial ports (Xbee, GPS, PololuQik 2s12v10) was required.
PololuQik	This class allows motor control communication performing a serial port (emulated with SoftwareSerial class) with PololuQik 2s12v10 card.
Servo	This class allows you to control servomotors via Arduino digital pins.
TinyGPS.h	This class enables communication with GPS Arduino for serial communication this case was conducted emulated (SoftwareSerial class).
SD.h	This class allows reading and writing to an SD memory, which is in the Wireless SD Shield, this GPS data transmitted, anticipating possible failures in the transmission of wireless data is stored.

Table 3. Developed or adapted Classes on mobile implementing. Source: Own.

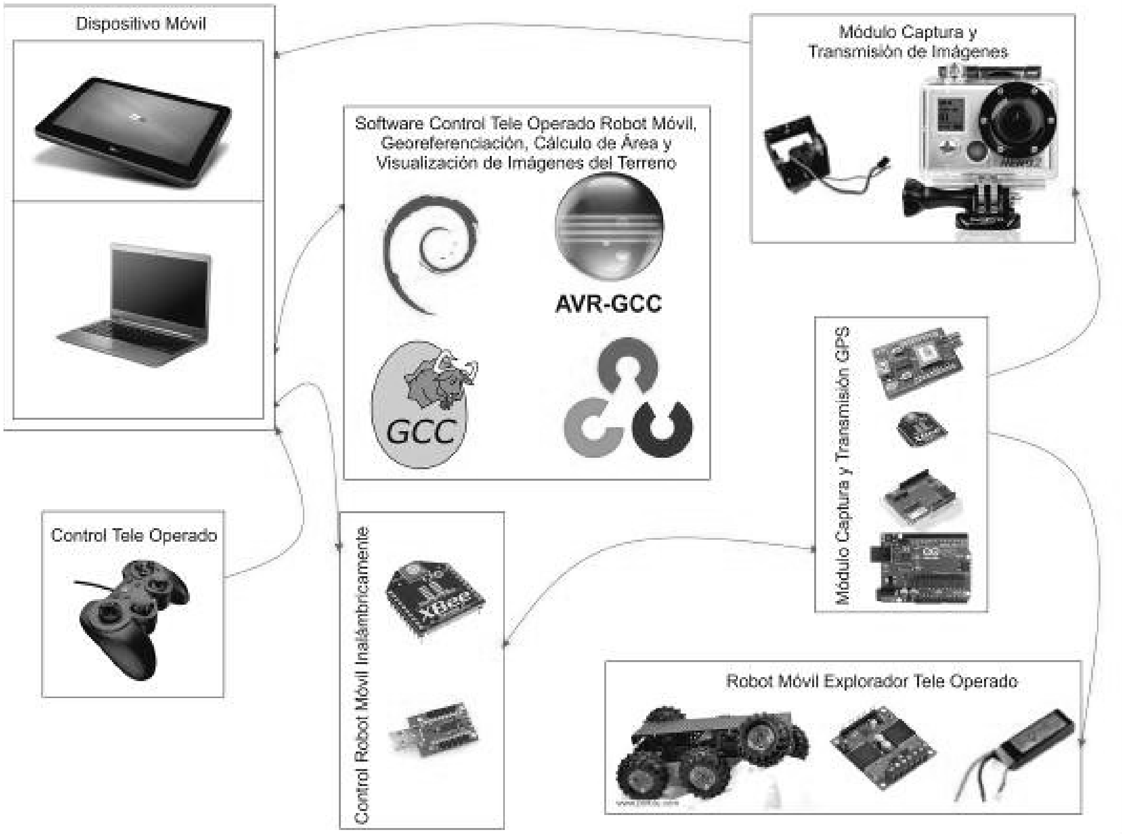

Figure 1. Robot explorer application applied to the measurement of areas - Reama. Source: Own.

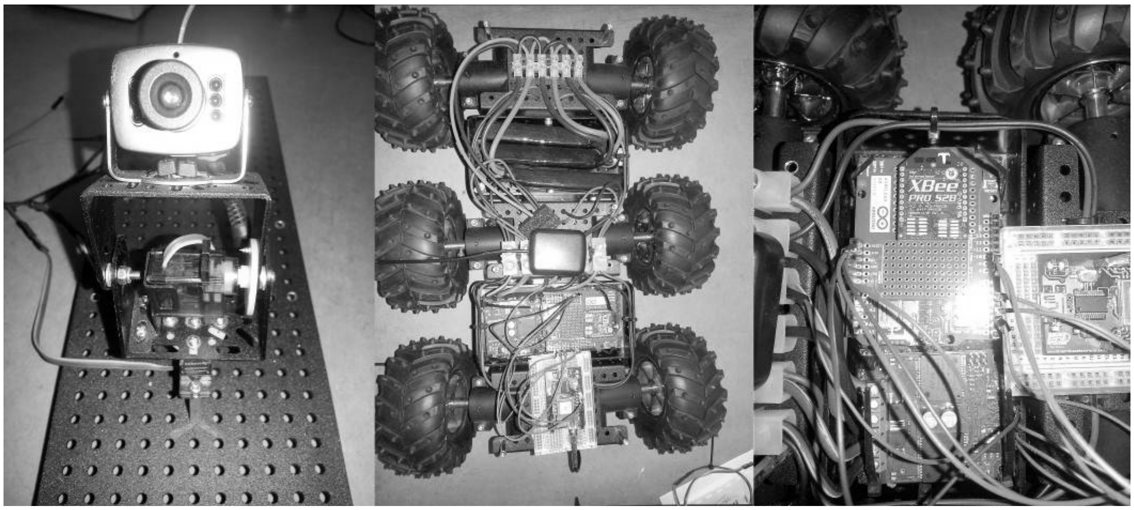

Figure 2. Left. Optical Sensor and camera / Cent. Dagu Will Thumper. Right. GPS A2100A, Shield Wireless SD, Polulo Kiq 2s12v10, Arduino Uno. Source: Own.

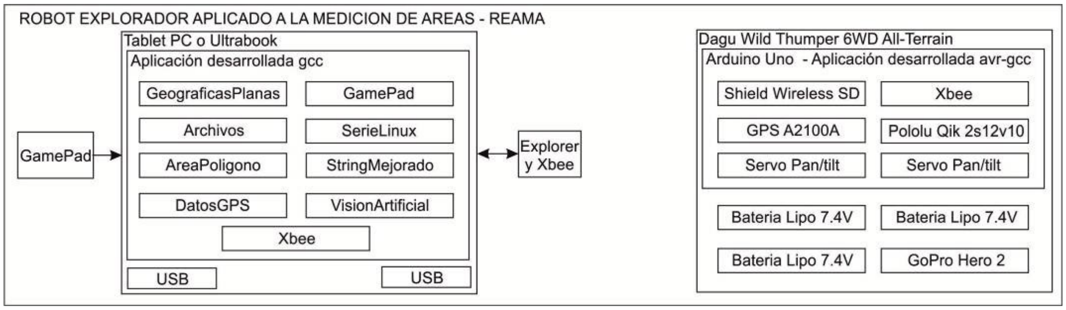

Figure 3. Block diagram. Source: Own.

to acquire data code and control the mobile robot.

After all modules integrated software and hardware to start compatibility testing between modules, the respective tests were conducted on field.

8. Conclusions

- Once integrated, all software modules and hardware of the mobile robot and made the evidence relevant field, it is concluded that it is possible to geo-reference areas of land with the support of the mobile robot tele-operated which allowed handling of the data submitted by the GPS in an orderly fashion and visual panorama, terrain, quality, thanks to the acquisition and transmission of video in real-time mobile robot to mobile.

- From the point of view of the electronics used in the development of the prototype, it is important to highlight the use of both open hardware and proprietary hardware, and especially emphasize the great ability of the ATmega328 on the Arduino platform one, as it manages to embed in it, an application designed under the concept of polling loop, fully functional and working in real time.

- From the point of view of software, the use of free software for the design of the final application of the mobile device, using Debian 6 Operating System Testing, and the programming part, machine vision library OpenCV 2.4 is highlighted, GCC 4.7 Compiler and IDE Eclipse Juno. For application embedded in the Arduino IDE 1.0.1 use thereof and AVR-GCC.

9. Perspectives and future Works

- Robot design is conceived as a device that can navigate autonomously through an area of land established under pre GPS coordinates.

- Study WIFI and WIMAX communication, thus extending the coverage and the possibilities of mobile robot control.

- Designing mobile telemetry and capturing environmental variables such as temperature and humidity.

- Seek funding to carry the application that is currently at the prototype to an agricultural vehicle (tractor).

Acknowledgements

This work was supported by the Universidad de los Llanos (UNILLANOS) and the

research institute of the Colombian Orinoco (COIT) and developed by the Research Group on Open Technologies (GITECX).

References

[1] A. Bedoya, G. Guzmán, J. Chaves, "Propuesta de desarrollo robótico para el desminado humanitario", *Scientia et Technica*, vol. 3, no. 49, pp. 239–244, 2011

[2] M. Godoy, "Diseño de sistema distribuido sobre robot móvil autónomo para caracterización de terrenos", Tesis MSc, UPM Autonomous Systems Laboratory, 2007.

[3] E. Alvarado, "Diseño e implementación de un vehículo no tripulado guiado por GPS y su controlador", Tesis de Ingeniería, Universidad de Costa Rica, 2008.

[4] M. Sánchez, R. Vaquero, C. Vásquez, "Control de un robot móvil con visión: rectificación de imágenes para agricultura de precisión", Proyecto de Sistemas Informáticos, Universidad Complutense de Madrid, 2012.

[5] F. Villa, J. Gutiérrez, M. Porta, "Vehículo robótico: autónomo y teleoperado con una PDA", *Ingeniería Mecánica Tecnología y Desarrollo*, vol. 3 no. 2, pp 46 – 54. 2009

[6] M. Arroyave, D. Mazo, J. Cano, M. Arias, J. Vergara, N. Londoño, C. Muñoz, N David, C. Sierra, "RTT: Robot para navegación en terrenos irregulares", *Scientia et Technica*, vol. 3 no. 32, pp 79–84. 2006

[7] P. Aguilar, G. Simba, "Diseño e implementación de un robot detector de obstáculos y navegación GPS", Tesis de Ingeniería, Escuela Superior Politécnica de Chimborazo, 2009.

[8] A. Guerrero, "Desarrollo de un robot 4x4 para la navegación por terrenos agrestes", Tesis de Ingeniería, Universidad Pontificia Comillas, 2011.

[9] T. Bakker, K. Asselt, J. Bontsema, J. Muller, G. Straten, "Systematic design of an autonomous platform for robotic weeding", *Journal of Terramechanics*, vol. 47 no. 2, pp 63–73, 2010.

[10] Catalog Dagu "Wild Thumper 6WD All-Terrain Chassis, Black", [Online]. Available: http://www.pololu.com/catalog/product/1563

[11] User's guide Qik 2s12v10. [Online]. Available: http://www.pololu.com/docs/pdf/0J29/qik_2s12v10.pdf

[12] M. Margolis, "Arduino Cookbook", O'Reilly Media, 2011.

[13] Catalog Arduino Uno. [Online]. Available: http://arduino.cc/en/Main/ArduinoBoardUno

[14] Catalog Wireless SD Shield. [Online]. Available: http://arduino.cc/en/Main/ArduinoWirelessShield

[15] Datasheet A2100A. [Online]. Available: http://www.mouser.com/pdfdocs/Maestro_Wireless_A2100A_Datasheet.pdf

[16] National Marine Electronics Association. [Online]. Available: http://www.nmea.org/

[17] Reference Manual NMEA. [Online]. Available: http://www.sparkfun.com/datasheets/GPS/NMEA%20Reference%20Manual-Rev2.1-Dec07.pdf

[18] G. Ortiz, "Aprende a convertir coordenadas geograficas en UTM y UTM en

geograficas". [Online]. Available: http://www.gabrielortiz.com/index.asp?Info=058a

[19] G. Bradski, A. Kaehler, "Learning OpenCV: Computer Vision with the OpenCV Library", O'Reilly Media, 2008.

[20] R. Laganiere, "OpenCV 2 Computer Vision Application Programming Cookbook", Packt Publishing, 2011.

[21] Reference Manual Xbee / Xbee – PRO ZB RF Modules. [Online]. Available: http://ftp1.digi.com/support/documentation/90000976_L.pdf