Development of GPS Sensor for Lego Mindstorms NXT Using Arduino

Conference Paper · November 2017

CITATIONS
0

READS
251

3 authors, including:

Şükrü Ünver
Gazi University
1 PUBLICATION **0** CITATIONS
SEE PROFILE

Ugur Fidan
Afyon Kocatepe University
32 PUBLICATIONS **60** CITATIONS
SEE PROFILE

International Advanced Researches & Engineering Congress-2017
http://iarec.osmaniye.edu.tr/
Osmaniye/TURKEY
16-18 November 2017

Development of GPS Sensor for Lego Mindstorms NXT Using Arduino

Uçman ERGÜN[1*], Uğur FİDAN[1] and Şükrü ÜNVER[2]

[1] Department of Biomedical Engineering, Afyon Kocatepe University, Afyonkarahisar, Turkey
[2] Ph.D. Student in Electrical and Electronic Engineering, Faculty of Technology, University of Gazi, Ankara, Turkey
* Corresponding author. Tel.: +90 272 2281423, Fax: +90 272 228142, E-mail address: uergun@aku.edu.tr.

Abstract

Lego robot kits do not have GPS (Global Positioning System) sensors in their normal contents. In this paper, the Globalsat EM-411 GPS receiver module has been transformed into a sensor capable of working with the Lego NXT intelligent brick in order to open the way for academic studies on mobile robot navigation field with Lego robot kits. In the proposed methodology, the data obtained using the Arduino from the GPS module asynchronously was sent synchronously to the Lego NXT intelligent brick. As a result, the location information from the GPS receiver is compared with the location information from the Lego NXT intelligent brick and the performance of the sensor is shown.

Keywords: Arduino, GPS, Lego Mindstorms NXT, Sensor

1. Introduction

Robot development process is an interdisciplinary and challenging process that requires mechanical, electronic, and software components to be brought together. Lego robot kits are used in academic and scientific studies as well as in robotics education. Thanks to the use of these kits, the difficulties and costs of mechanical design are easily overcome [1], [2].

Robots with fixed duties are usually used in closed areas where factory and laboratory variables and reference points are fixed. Mobile robots are usually developed for serving purposes such as search and rescue and are generally used in open spaces where the variables are not fixed or linear, and there are no reference points. As a result, mobile robots need to be able to define their environments, collect data from their environment and decide what to do with them [3].

Lego Mindstorms kit contains broad variety of hardware components which are required to simulate, program and test the robotics systems in practice [2], [4].

All digital sensors connected to intelligent bricks in Lego kits communicate with intelligent bricks via i2c protocol, and the connectors to which the sensors are connected are specially designed. As a result, it is not possible for end users to install and use a sensor that is not included in the kit's content or is not specifically manufactured by third party hardware developers.

The most important problem addressed in the process of GPS sensor development for Lego kits is communication protocols. GPS receivers communicate asynchronously with the USART protocol when the Lego robot kit's sensor ports communicate with the i2c protocol, which is one of the synchronous communication protocols.

In this study, Arduino Uno development card was used to solve this problem. GPS data from the EM-411 GPS receiver module using the USART protocol and NMEA 0183 format was obtained using Arduino. The latitude and longitude information was separated from the obtained GPS data and sent to the Lego NXT robot kit with the i2c protocol.

Arduino software was used to retrieve, extract and send data from the GPS receiver. The NI LabVIEW Module for Lego Mindstorms platform was used to retrieve the position data via the Lego NXT intelligent brick.

2. Methodology

Developed the circuit using prototype shield on Arduino Uno, has two 82 KΩ Pull-Up resistors, EM-411 GPS receiver module and NXT cable connections. The power supply is made with the voltage of 4.3V taken from the power output of Lego NXT input ports. This voltage is sufficient for the operation of both the Arduino and the GPS receiver, and no external power source is needed. The open schematic of the developed system is shown in figure1.

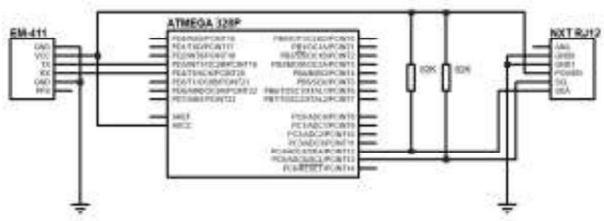

Figure 1. Electronic circuit diagram

2.1 Arduino Software

In the Arduino software, the SoftwareSerial library was used to initiate communication in the USART format, the TinyGPS++ library to separate GPS data from the NMEA 0183 format, and the Wire library to send the parsed data to the Lego NXT robot kit.

During the prototyping phase, after an indefinite period of time, the communication between the Arduino and the Lego NXT robot kit was interrupted, and Arduino did not resume as long as it was not reset. WDT (Watchdog Timer) is used to solve this problem. The avr/vdt library was used to enable WDT in Arduino. Communication between the WDT, Arduino and Lego NXT robot kit is restarted after a very short (18ms) delay. This also added a 100ms delay to the Lego NXT software in order to prevent the timing problem from arising between the Arduino and Lego NXT.

The software developed for Arduino first extracts the data received from the GPS sensor in NMEA 0183 format and converts it into a ten bit sequence after latitude and longitude data is obtained in decimal format and then sent to the i2c protocol. The Lego NXT robot kit is built in the i2c protocol, which will always be the master case [5]. Therefore Arduino is always a slave in the developed system. Lego NXT initiates data exchange between Arduino and Lego NXT by requesting the information they want. Arduino first determines whether longitude data or longitude data is requested after waiting for the request to arrive, and sends the determined data in the 10 bit sequence format with the i2c protocol. The sequence to be sent is redefined in each cycle to prevent data complexity from being created by writing new data coming from the GPS receiver into the directory during transmission.

In the i2c protocol, Arduino's slave address is set to 0x0A in hexadecimal and to 00001010 in binary. The Lego NXT system considers the first seven bits. Therefore, this address is set to hexadecimal 0x14 and binary digit 00010100 in Lego NXT software. As a binary, the last seven bits of the slave address of Arduino are identical to the first seven bits of the slave address specified in the Lego NXT software.

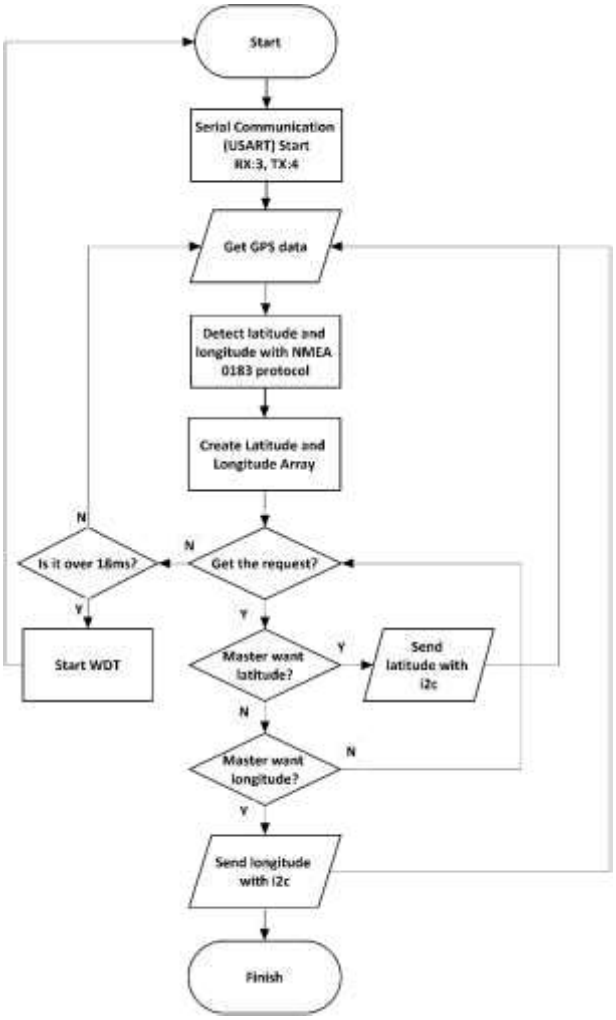

Figure 2. Arduino i2c algorithm

2.2 Lego NXT Software

In Lego NXT LabVIEW program, firstly it has been determined which port and in which format i2c communication will take place. Later, latitude was requested by sending 0x00 information to Arduino, and longitude was requested by sending 0x01 information. Latitude and longitude values are taken as a ten-bit integer array in Lego NXT software, and then the data in the array is converted into a character string representation.

As a result of this process, the coordinate information obtained as a character string dd.mmmmmmm (d: degree, m: minute) is separated into first two digits and the remaining seven digits. At the end of the breakdown, the first two digits are included in the collection process, while the remaining seven digits are divided by ten billion. As a result of these operations, the coordinate information is obtained as float. It has been observed during studies that the incoming data does not represent any numerical value in cases where it is incorrect. In order to filter out the coordinate information coming in this direction, it was checked whether the value was greater than 0.01, and the smaller value was rejected.

Finally, the filtered latitude and longitude information is displayed in the generated interface and assigned to global variables so that it can be used for different purposes in progressive stages.

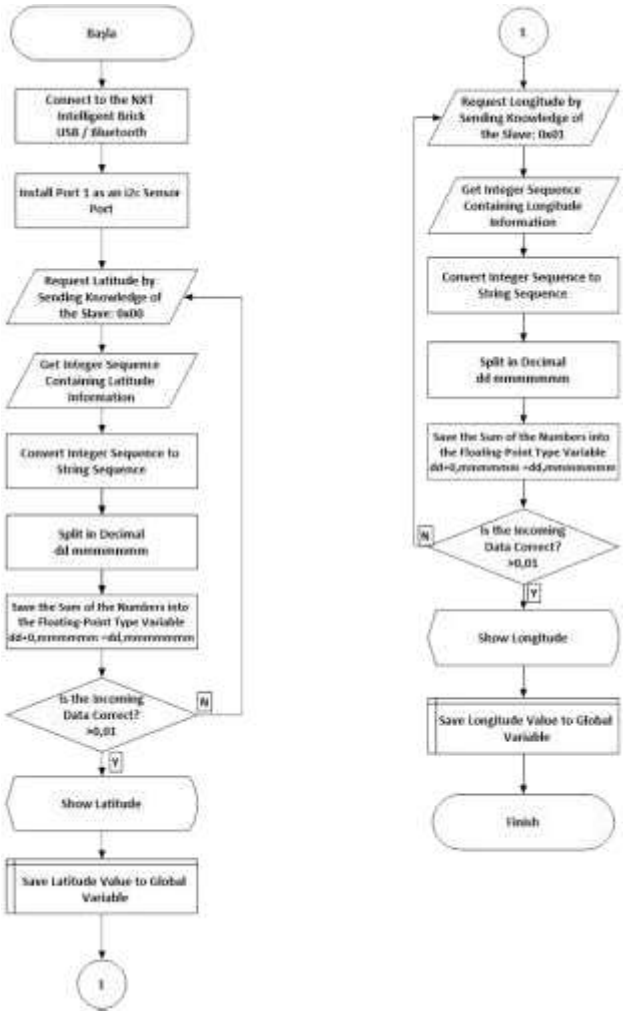

Figure 3. Lego NXT i2c algorithm

3. Results

In studying the performance of the GPS sensor developed for the Lego Mindstorms NXT robot kit, latitude and longitude information was obtained both over the Arduino and through the Lego Mindstorms NXT intelligent brick by keeping the position of the GPS receiver fixed to ten GPS satellites. The Arduino side received raw information from the GPS receiver and the decomposed coordinate information was not sent to the i2c protocol. On the Lego Mindstorms NXT side, the data coming from the i2c protocol is received. When the data were taken, both Arduino and Lego Mindstorms NXT robot kits were kept open for ten minutes to be connected to the computer and recorded, and the ambient conditions were kept as stable as possible.

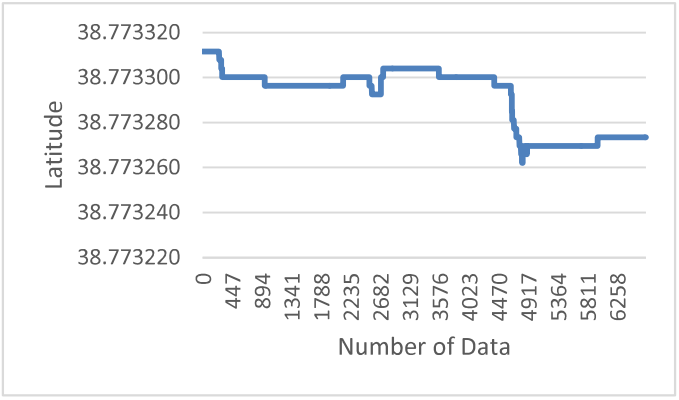

Figure 4. Latitude data from GPS receiver

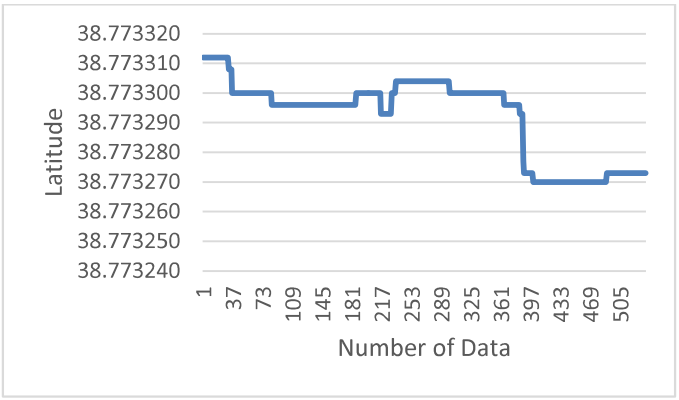

Figure 5. Latitude data from Lego NXT intelligent brick

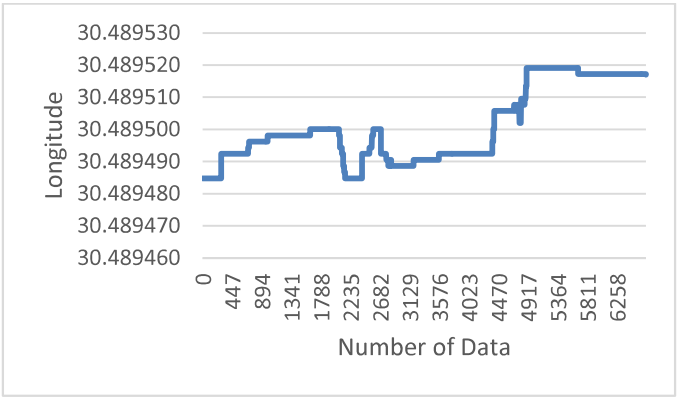

Figure 6. Longitude data from GPS receiver

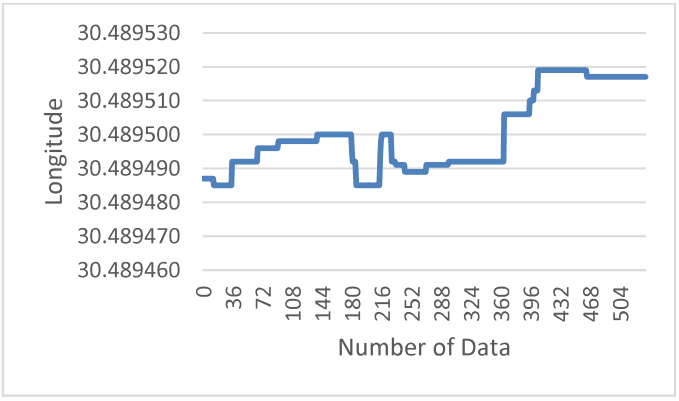

Figure 7. Longitude data from Lego NXT intelligent brick

As can be seen from the graphs (Figure: 4-7), over 6,000 pieces of data were taken through Arduino, while

over 500 pieces of data were taken through Lego NXT robot kit at the same time. If the graphs are examined carefully, it can be seen that there are data loss in some points. Similar situations can be seen in graphs of both latitude and longitude data. These data losses are due to the synchronization of the i2c protocol and are visible in graphs that can be ignored. According to the result obtained from the data obtained for ten minutes at fixed position over the Arduino, the position accuracy of the data received from the GPS receiver in the test conditions is within 2 meters.

4. Conclusion and Future Work

The Lego robot kits have almost eliminated the mechanical design process. The use of Lego robot kits in academic and scientific work to be done in the robotics field will ensure that the work is both more economical and less time consuming.

Arduino Uno is used because it is a prototype of the developed sensor, allowing many changes to be made. Instead, sensor sizes can be minimized by using development cards such as Arduino Nano or by creating a circuit from printed circuit.

With the improved sensor, Lego NXT robot kits can be used in the field of mobile robot navigation. With the methods and techniques used here, various sensors can be developed that are not in the content of Lego robot kits.

Acknowledgment

Thanks to the Department of Biomedical Engineering of Afyon Kocatepe University who prepared all necessary equipment and conditions for this study.

References

1. U. Fidan, Y. Yalçın, Robot Eğitim Seti Lego NXT, Afyon Kocatepe University Journal of Science and Engineering vol. 12, pp. 1-8, October 2012.
2. M. Pinto, M.P. Antonio, M. Anibal “Localization of Mobile Robots Using an Extended Kalman Filter in a Lego NXT,” IEEE Trans. On Education, vol.55, pp. 135-144, February 2012.
3. J. Hanzel, M. Kľúčik, F.Duchoň, J. Rodina, “Localization of Small Mobile Robot by Low-Cost GPS Receiver,” Journal of Mechanics Engineering and Automation, vol.3, pp.522 – 528, 2013.
4. M. Popelka, J. Nožicka, “Lego Mindstorms as a Simulation of Robotic Systems,” WASET Trans. Robotics and Mechatronics Engineering, vol. 8, pp. 1196–1200, 2014.
5. M. Gasperi, P. Hurbain, “Extreme NXT: Extending the Lego Mindstorms NXT to the Next Level.” 2nd ed., New York: Apress, 2009.