IRACST - International Journal of Computer Science and Information Technology & Security (IJCSITS), ISSN: 2249-9555
Vol. 5, No1, February 2015

Robotic Car Controlled by Soft-Processor NIOS II Implemented in FPGA and Android Device as Remote Controller

F Jair Diaz-Colorado
Electrics and Electronics Department
Veracruz Institute of Technology
Veracruz, Mexico

Ricardo F Martinez-Gonzalez
Electrics and Electronics Department
Veracruz Institute of Technology
Veracruz, Mexico

Abstract—Nowadays Android devices are a good form to implement remote controllers but App programming can be in some occasions troublesome. For App programming a tool named App Inventor was used. Once App was done, utilizing HC06 module a Bluetooth connection between App and microcontroller was established. At Microcontroller, a soft processor Nios II was implemented. Soft processor works as processing unit, receiving and interpreting sent data and transmitting signals to motor drivers, at same time drivers control rotation of a pair of gear-boxed motors ergo robotic car movement.

Keyword-Robotic Car; Soft-processor NIOS II; Bluetooth Connection; Android Device App

I. INTRODUCTION

Android is an operating system (OS) focuses on mobile devices; it is based on Linux kernel [1] and currently is managed by Google Inc. In recent times, Android has suffered an explosive growth, partially because of its applications, also known as app. For developing apps there are several options, the most used is Java [2,3]; however, there are other easier options.

App Inventor is an open source on line application provided by the Massachusetts Institute of Technology (MIT). It was developed for app programming newcomers [4], it has a graphical interface and it is based on drag and drop programming atmosphere, where user can program just dragging correct blocks, dropping them on design area and then, configure them according to required action.

Despite its limitations, App Inventor is easy-use and quite intuitive; hence, it is good enough to produce well done apps. In addition of its easy drag and drop interface, it has possibility to integrated several peripherals as accelerometers, wireless local area networking (WiFi), Bluetooth, camera, global positioning system (GPS), et cetera; using peripherals augment app possibilities.

For the project, two peripheral are used, accelerometer and Bluetooth. Accelerometer measures acceleration that it experiences [5], such measurement can be made by different components depending on manufacturer. The most common components are capacitive and piezoelectric; nonetheless, other components able motion conversion into electrical signal can be used; in recent times, micro electromechanical systems (MEMS) are also used for measuring purpose [6, 7].

On the other hand, Bluetooth is a technology used for wireless data exchanging and it is managed by the Bluetooth Special Interest Group (BSIG). Bluetooth was originally designed for cable substitution through building a personal area network (PAN) [8].

Bluetooth has several profile usage; and depending on profile is how device behaves. For the project, it is used to emulate a RS232 serial port and to have a connection with a robotic car controlling hardware. The nucleus of controlling hardware is the soft processor NIOS II, which is an embedded processor designed by Altera Corporation [9].

A soft processor is a microprocessor completely implemented using logic synthesis and it can be contained in different digital programmable devices [10,11,12]. There is a program named Qsys; and at the same time, it is part of Quartus II suite. Qsys is a tool to incorporate and interconnect elements and create a specific design embedded system.

II. SOFT-PROCESSOR NIOS II IMPLEMENTATION

Field Programmable Gate Array (FPGA) technology continues been carry by different designers not only digital electronic but communication, security and control system ones. Designers found in FPGAs an opportunity for minimizing costs, getting easier and quicker their designs, reducing debug times, and others.

For current project, control system was implemented in a DE0-Nano development board from Terasic Technologies, such board has a Cyclone IV EP4CE22F17C6N FPGA. A FPGA brought opportunity to design a custom system. General purpose microcontroller has several peripherals, and not all of them are used; besides they cannot be used at the same time.

The custom designed microcontroller (μC) has a soft processor NIOS II, which works as central processing unit (CPU) in μC. It also needs a RS232 serial port to outside communication. The μC has a program; such program is stored at SDRAM, so a SDRAM controller is needed. And for motor controlling, four digital outputs are disposed. The complete design is shown at Figure 1.

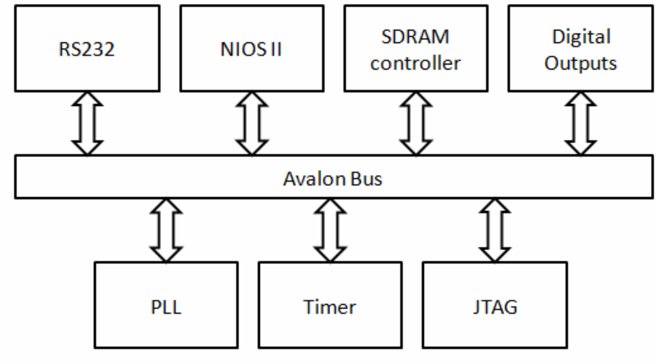

Figure 1. Designed microcontroller compounds

There are also three elements: JTAG, timer and clocks. Joint test action group (JTAG) is IEEE standardization for testing, it allows debugging procedures. Timer is an interval timer and it is used for programming interruptions. And PLL is a phase locked loop, which is in charge of produce necessary clock signals for board peripherals, as SDRAM.

Finally last component, Avalon Bus, sticks together every previously mentioned elements and peripheral. The Avalon Bus coordinates and distributes clock signals, interruptions and data. And they are all component for designed µC.

Once µC is synthesized, it is loaded in FPGA and programming labor starts. For programming, Quatus II offers an application named Eclipse. At beginning, Eclipse uses a hardware profile; such profile contains what hardware is and how it is connected.

Having in account hardware profile, Eclipse is able to compile correct program for the very specific hardware, and it will not work with other hardware. Eclipse uses ANSI C, and it has already some testing programs.

For robotic car, to made program is quite simple. µC receives a character and according to it, µC sends corresponding signal to motor by its digital outputs. Complete functioning appears on Figure 2.

III. Hardware Design

Hardware design was divided in two, mechanical structure and electronic hardware.

A. Mechanical structure

The structure has two wheels, each one activated by a 5 volt gear-boxed motor. A freewill wheel provides stability, and it is on other side. The wheels and electronic hardware are supported using a plate. Complete mechanical structure is depicted in Figure 3.

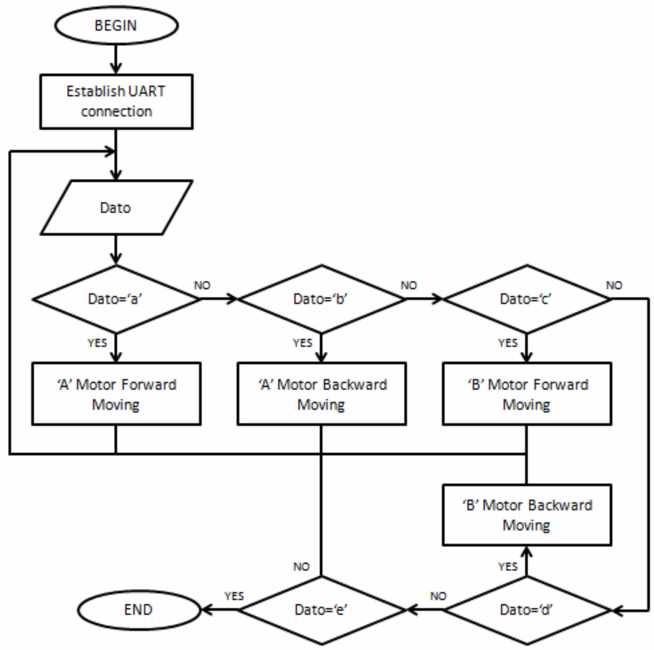

Figure 2. Flow diagram for microcontroller developed program

B. Electronic hardware

Electronic hardware contents three parts: motor driver, voltage regulator and Bluetooth module. Motors needs to move in both senses, so an H bridge was selected, L293D. Moreover, a 9 volts battery supplies robotic car; however, every electronic circuit uses 5, ergo a LM7805 regulator sets voltage down from 9 to 5 volts

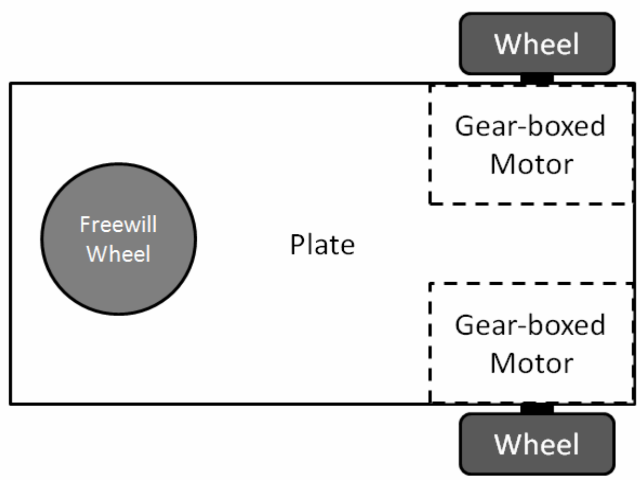

Figure 3. Mechanical structure

HC06 module enables Bluetooth connection with Android device; and as module has a serial port, also µC connection is possible. Summarizing, µC is connected module via to Android device.

IV. App Developing

By itself Android device is useless; an app uses device featuring and makes connection possible. App was developed using App Inventor, following next flow diagram on Figure 4.

Following flow diagram; firstly, Bluetooth connection is established and accelerometer enabled. Then, program checks if canvases were touched, and according to them send corresponding character Bluetooth via to µC. If "Exit" canvas is touched, program ends.

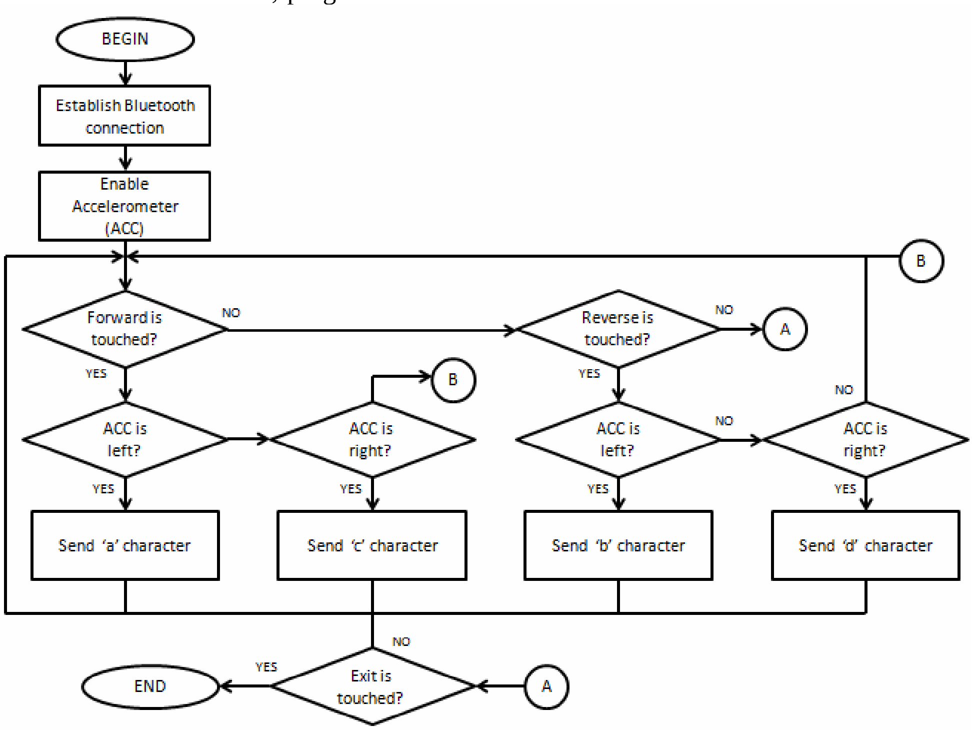

Figure 4. Flow diagram for app

V. Results

Controlling app was successfully developed; using accelerometer functioning, driving sensation was bluntly emulated. As is shown in Figure 5, app is quite simple for setting user free, and do not saturate user with a lot of controls. App also was tested in various Android devices and it worked correctly in every case. It always established connection between Android device and µC.

Figure 5. User interface for controlling App

Using an FPGA, a µC was correctly implemented. It is a custom design, and it has a soft processor as computing unit. In addition, µC was programmed for carrying its duty out in C language.

Microcontroller's duty is to receive data from Bluetooth module and send corresponding signals to motor drivers. Motor drivers work perfectly delivering power toward motors, and they also are able to change rotation according to needs.

Recapitulating, system integrated by app, microcontroller and gear-boxed motors, works as one and it appears in Figure 6. The system was controlled by untrained students, and they experienced enjoyment and amusement, mostly because robotic car interacts fluently and it is an interesting idea.

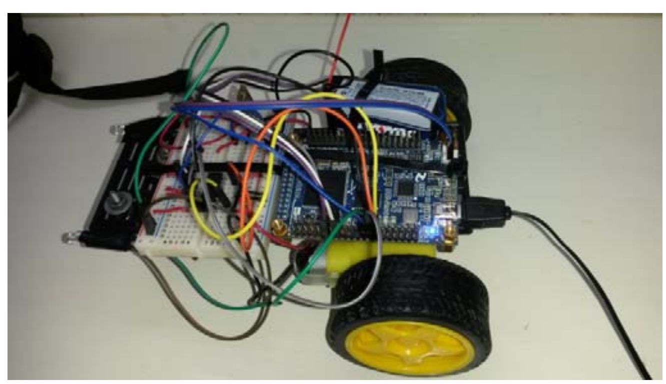

Figure 6. Robotic car

VI. Conclusions

It is feasible to elaborate custom μC following requirements, maybe it could be arduous; nonetheless, it is not better to have extra and useless components, if an application-specific integrated circuit (ASIC) is designed.

Developing apps for Android devices is not as laborious as it was firstly thought; only using correct tools. Other thought was, how hard would be to establish? Nevertheless, looking for elements HC06 module was found, its usage reduces to basics every obstacle.

As final conclusion, using soft processors is a little bit troublesome, owing to lack of available information; however, full of satisfactions.

References

[1] Maker, F., & Chan, Y. H. (2009). A survey on android vs. linux. University of California, 1-10.

[2] Naik, Y. M., Deshpande, C. M., Shah, R. R., & Kulkarni, R. R. (2013) ANDROID CONTROLLED SPY-ROBOT, International Journal of Software and Web Sciences, 54-57.

[3] Göbel, S., Jubeh, R., Raesch, S. L., & Zündorf, A. (2011). Using the android platform to control robots. Kassel University Germany.[Online]. Available www. innoc. at/fileadmin/user_upload/_temp_/RiE/Proceedi ngs/65. pdf.

[4] Morelli, R., de Lanerolle, T., Lake, P., Limardo, N., Tamotsu, E., & Uche, C. (2011). Can android app inventor bring computational thinking to k-12. In Proc. 42nd ACM technical symposium on Computer science education (SIGCSE'11).

[5] Bouten, C., Westerterp, K., Verduin, M., & Janssen, J. (1994). Assessment of energy expenditure for physical activity using a triaxial accelerometer. Medicine and science in sports and exercise, 23(1), 21-27.

[6] Hopkins, R., Miola, J., Setterlund, R., Dow, B., & Sawyer, W. (2006). The silicon oscillating accelerometer: a high-performance MEMS accelerometer for precision navigation and strategic guidance applications. Technology Digest, 4.

[7] Sung, S. K., Hyun, C., & Lee, J. G. (2007). Resonant loop design and performance test for a torsional MEMS accelerometer with differential pickoff. International Journal of Control, Automation and Systems, Vol. 5, No.1, pp 35-42.

[8] Sonawane, N. K., Waghchavare, P. D., & Patel, K. A. (2014). Bluetooth Based Device Automation System Using Cellphone. International Journal of Computer Applications & Information Technology, Vol. 7, Issue 7, 136-141.

[9] Ball, J. (2005). The Nios II Family of Configurable Soft-Core Processors. Hot Chips, Altera.

[10] Glette, K., Torresen, J., & Yasunaga, M. (2007). Online Evolution for a High-Speed Image Recognition System Implemented On a Virtex-II Pro FPGA. In AHS (pp. 463-470).

[11] Balwaik, R. R., Nayak, S. R., & Jeyakumar, A. (2013). Open-Source 32-Bit RISC Soft-Core Processors. In IOSR Journal od VLSI and Signal Processing, Vol. 2, Issue 4, pp 43-46.

[12] Wadhankar, V. R., Raut, M. N., & Satpute, R. (2006). Soft Core Processor for Embedded System. In the 18th International Conference on Microelectronics, pp 170-173

AUTHORS PROFILE

F. Jair Diaz Colorado, student of B.Sc. in Electronic Engineering.

He was born on Xalapa, Mexico. He started to study his B.Sc. degree in 2010 at Veracruz Institute of Technology. Nowadays, he is writing his thesis about RFID technology implementation. He has written an unpublished article named “Design and implementation of system for making android device a robotic arm controller”, his interests are more focused on digital application; nevertheless, other aspects have caught his attention as programming, operating systems, embedded system design, and other subjects of computer science. Recently, he has expressed his interests to be part of a M.Sc. program and he is looking for an adequate option.

Ricardo F. Martinez-Gonzalez, PhD.

He was born on Veracruz, Mexico. He received his Bachelor of sciences degree from Veracruz Institute of Technology. Next on, He studied his M.Sc. degree at National Institute for Astrophysics, Optics and Electronics, in this place He started to get involved with Chaos issues. For obtaining his degree, He wrote how design pseudo random number generators using one-dimensional chaotic maps. Once He obtained the degree, He got into Veracruz University for a five month period; nevertheless, He returned to continue his research in Chaos subject, and get it to the next level, designing ciphers. He took several courses about digital communications and communication protocols; such courses help him out to finish his research and finally obtain his PhD degree. At this point, He took the choice of return to his basics; since then, He works at Veracruz Institute of Technology, where he has been enrolled into a research crew.