MiDroid: An open mobile platform for learning focused on microcontrollers' education

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***Abstract*—This WIP exposes the design and implementation of *Midroid*, an open mobile platform focused on microcontrollers' education. The platform has been designed with the aim to address both the problems detected as the educational gaps associated to the acquisition of the algorithmic thinking needed in the conceptualization and structuring of a program or algorithm determined. To technical level, the platform consists in two elements: a mobile application for Android operating system and a development board which the students can debugging their algorithms. Thereby, the educational concept of the platform takes into account the challenges related to the mobility of technology, learning and the learner. As educational framework, it has selected the concept of *Computational Thinking* (CT) in the stages of design of the platform. The CT is a kind of process that allows solve a problem through procedures such as abstraction, modeling, arguing and algorithmic processing. Furthermore, the CT allows the use of computers or tools such as mobile devices or both computational and mathematical programs as way to resolve the formulated problems in a knowledge area. These aspects were needed in the design and implementation of the platform in the areas of hardware and software respectively. It is expected with this research, the design and implementation of a mobile platform related to microcontrollers' area which addresses the problems mentioned and also enhances the learning process in the students. The educational and technical validation of the platform will be developed through qualitative study between different groups of students in the subjects of the curriculum concerning the microcontrollers' area, thus, validating the impact of the platform.**

***Index Terms*—Platform, mobile, computational thinking, microcontrollers, education methodology, algorithmic thinking, programming.**

I. Introduction

Recently, the mobile devices have taken relevance in the educational context, mainly in engineering and technology sectors. Several researches[1],[2] have shown that the trends on higher education are oriented specifically in the concept of mobility and the acknowledgment of the student as *nomad*, that is, the student not only learns in formal spaces also this learns through the interaction with other friends, group-mates and learning materials such as videos, games or educational programs. In this context, this WIP exposes the design of *MiDroid*, a mobile platform focused on microcontrollers' education from both educational and technical perspectives. The proposal of the platform arises according to the educational problems detected in the microcontrollers' area relating to the algorithmic thinking needed to develop an algorithm or program that gives a determined functionality to these devices. Concerning the educational aspects, it was selected to the *Computational Thinking* as main concept in the methodology of the design and debugging of the platform. García-Peñalvo *et al.*[3] have defined the CT as a methodology focused on problem solving in which the students use processes such as abstraction, analysis, modeling or iteration and also they can create virtual or real artifacts. These elements are needed in the construction of a determined project and they allow to the students enhance their educational process through aspects as metacognition, reflection, arguing and the interaction with other group-mates. Therefore, the different stages of the design were oriented toward the development of these elements.

With respect to technical component, the platform has involved the interaction between diverse hardware and software elements. To hardware level, it has designed a development board, integrating a microcontroller AVR[4] as core and a Bluetooth module with the aim to manage the programming protocol that linking the development board with the mobile application. Regarding software level, it has designed the application using as interface to Blockly[5] in the mobile operating system *Android*. This type of interface providing a way for the construction of Visual Algorithms which help to improve the algorithmic thinking and allow to increase the motivational aspects in the use of the microcontrollers.

In accordance with the aforementioned, the present paper will be divided in the following sections: Section II exposes the main educational aspects related with the research. Section III indicates the technical aspects associated to the platform, segmented in hardware and software levels, respectively. Finally, the section IV concludes some considerations from educational perspective and the future work related with this WIP.

II. Educational background

A. Design perspective

The design and the implementation from the educational perspective was structured through the concept of computational thinking. Wing[6],[7] described the CT as a way for "solving problems, designing systems, and understanding human behavior by drawing on the concepts fundamental to computer science". A definition of this concept much more tied to the context of the present research is provided by García-Peñalvo *et al.*[3] who indicate that the CT is a kind of methodology in which the students use a set of elements such as abstraction, modeling, analysis, iteration among others, with the aim to solve a problem. The CT includes the following abilities and skills[7]:

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1) Formulating problems that allow the use of computers and tools in order to solve them.
2) Organizing and analyzing the data logically.
3) Generating solutions through algorithmic thinking.
4) Representing data through models.

These elements have direct relation to the skills and abilities in computer science and they can be extrapolated to other knowledge fields. In this fact lies the importance of the CT. In addition, the CT requires a series of attitudes that have been summarized by Barr *et al.*[7] as follows:

- Persistence in working with difficult problems.
- The ability to communicate and work with others in order to attain a common goal.
- Capacity to solve problems such as personal and technical.

In concordance with these skills, abilities and attitudes, the design methodology of the platform was organized using *tasks*, in which the students firstly, learn concepts, theories and tools related to the project. Secondly, they use the knowledge acquired in the development of designs that respond to the problems in the areas defined in the project, for instance, hardware and software. These tasks were thought in accordance with the stages of the project and the learning purposes of them. Thereby, the students started with the abstraction and modeling of the platform. In this stage, the students learned the different concepts relating to the Android applications and hardware design as well as they understood the purposes of the platform. Subsequently, the students developed and debugged several designs in order to find the more suitable of them in function of the technical and educational requirements. The students were divided in the groups of hardware and software in function of the skills detected in the beginning of the process of construction of the platform. The Table.(I) describes the structure of design of the platform by stages.

TABLE I
STRUCTURE BY STAGES FOR THE DESIGN OF THE PLATFORM ACCORDING TO THE ASPECTS OF THE CT.

Stage	Description
1. Problem fundamentals and research	The students learn the main technical concepts associated to the platform.
2. Selection of hardware devices and software tools.	The students choose the hardware devices and the software interface according to the requirements of the platform.
3. Learning focused on the design.	The students learn different theories, concepts and tools in accordance with the design and the elements chosen in the stage 2.
4. Prototype design	The students develop the User Interface and the development board in the groups of software and hardware respectively.
5. Debugging prototypes	The students debug their designs in the areas of software and hardware through an iterative process.
6. Final outcome	The students finish with the design of platform and they socialize their results to the academic community.

It is important to mention that each stage has a feedback process with the students in the technical and educational scopes. The feedback process is important because it helps to improve the skills of the students during their educational process.

B. User perspective

From user perspective, the platform was structured according to four main aspects: learner, Visual Algorithms (VA's), mobile technology and learning goals. One important learning constraint in the embedded systems is relating to the languages in order to program these type of systems. A novice learner in the microcontrollers' area can find a learning barrier due to this matter. An initial consideration in the elaboration of the platform was to eliminate this type of barrier. Attending to this issue, it has designed a visual programming User Interface (UI) focused on microcontrollers. The VA's have been defined as "a subclass of software visualization and it handles the illustration of high level mechanisms of computer algorithms, usually in order to help the pupils understand the function of the procedures of the algorithm better" [8]. Furthermore, the VA's allow to the students concentrate in the factors concerning the algorithms instead of the mechanics involved in writing of programs [3]. This enables that the students develop better skills and competences in the dimensions of the CT: computational concepts (the concepts that the students using when they program), computational practices (the practices that the students often use when they solve a problem through computer concepts) and computational perspectives (the students perspectives and their relationships with others and with the world)[9].

In accordance with the mentioned, The learning goals of the platform are:

- Improving the algorithmic thinking in the students in the microcontrollers' area.
- Allowing that the students understand the principles of configuration and handling of the peripherals and I/O ports of the microcontrollers.
- Fostering the use of programming languages as part of the improvement expected in the algorithmic thinking of the students.
- Reducing the educational gaps in the use of programming languages in embedded systems.
- Motivating to the students to learn and propose their solutions to the problems in the educational and technological fields.

The platform is totally *mobile*, the students install the application in their mobile devices such as tablets or phones and linking the application with the development board. This consideration takes into account the challenges on higher education in the inclusion of technologies that recognize that the student as the learning are *mobile*[2]. Concerning this, Callaway[10] has defined the learning using mobile technologies as any class of learning that happens when the student neither is fixed nor he or she has a specific location or also if the learning happens when the student drawing on the opportunities of learning provided by mobile technologies.

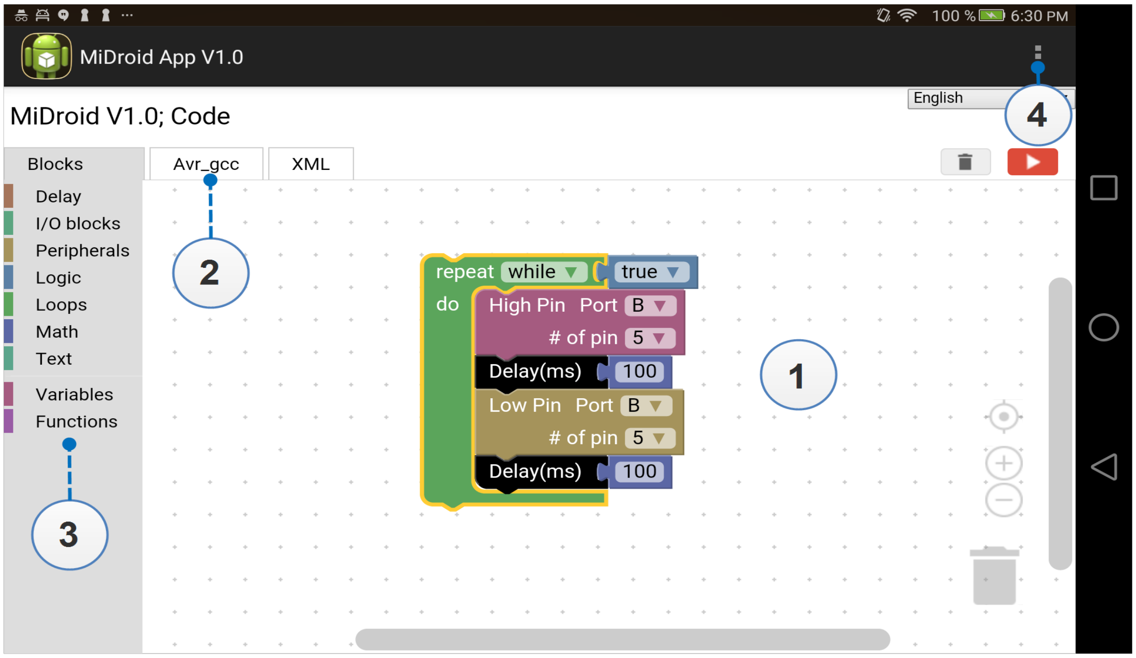


Fig. 1. *MiDroid* User Interface (UI). 1. Workspace. 2. Equivalent C code (avr-gcc) tab. 3. Graphical Blocks tab. 4. User menu (save, open and connect with Bluetooth module).

III. The *MiDroid* platform

This section discusses the current state of the platform from the elements of hardware and software that compound it.

A. Software structure

Attending to the requirements of VA's, the software interface was designed in its preliminary version in the mobile operating system (Android). The (UI) shown in the Fig.(1) consists in the interface Blockly[5] which allow the construction of a program through graphical blocks. Each block is converted in the equivalent code in C language according to the conventions of AVR-GCC compiler[11]. For instance, the VA depicted in the Fig.(1) has the following equivalent C code:

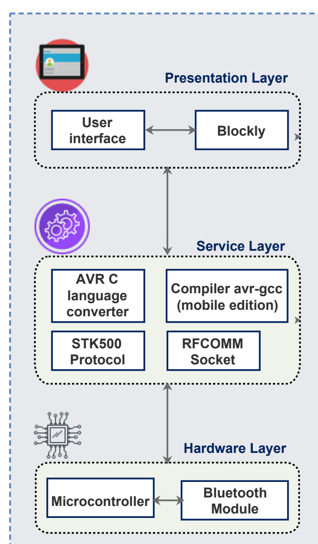
Algorithm 1 Equivalent C code for the Fig.(1). This code is shown in the avr_gcc tab of the application.

```
#include <avr/io.h>
#define F_CPU 16000000UL
#include <util/delay.h>

int main (void){
DDRB=1<<5; //Port configuration
        while(1){//Infinite loop
         PORTB=1<<PB5;//High pin PB5
         _delay_ms(100); //100ms delay
         PORTB&=~(1<<PB5);//Low pin PB5
         _delay_ms(100); //100ms delay
        }
}
```

The functions created in the interface are the following: *read digital pin, write digital pin, delay in milliseconds, Analog to Digital Conversor (ADC), Pulse Width Modulation (PWM) and Universal Asynchronous Receiver-Transmitter (UART).* The communication between the development board and the application is driven through *Bluetooth Protocol* with the feature Serial Port Profile (SSP)[12]. The Fig.(2) illustrates the software structure with the different components divided in the layers of hardware, service and presentation respectively.

Fig. 2. Structure of the (UI) by layers.



The microcontroller is programmed by means of the implementation of the protocol STK500[13] in the application. The protocol manages the programming of the flash memory of the microcontroller using the *.hex file* generated by the compiler AVR-GCC.

B. Hardware structure

The hardware structure consists in a development board in which the student can debug the programs made. The development board has the following features:

- An AVR microcontroller (ATmega16A).
- 32 I/O pins with multiple functionalities, e.g., interrupts, comparators, PWM, etc.
- Processor velocity up to 16 MIPS (Million of Instructions Per Second).
- 8 ADC channels.
- 1 Bluetooth module working at 115000 $\frac{bits}{sec}$.
- 1 UART module.
- 3.3V and 5V operating voltages.

These features are enough for any type of projects. The development board could be used for the designs that the user needs and also it could be modified in function of the requirements of them. The microcontroller contains a *Bootloader*[14] which allows to program it from the (UI) by means of the Bluetooth module. The development board could connect to an adapter or a 9V battery, guaranteeing the portability of it. The Fig.(3) shows the development board designed with its respective components.

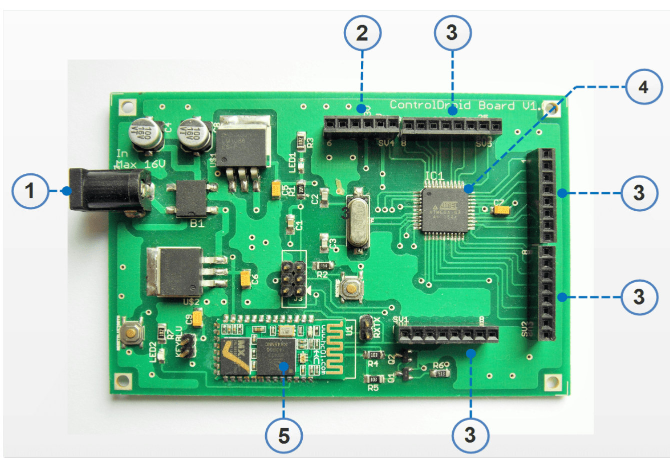


Fig. 3. Development board designed for the *MiDroid* platform. 1. DC input (Max. 16V), 2. Voltage pins (3.3V and 5V), 3. I-O Ports, 4. Microcontroller (Atmega16A), 5. Bluetooth module.

Recently, the version of the board shown in the Fig.(3) is submitted to the different tests related with its performance and the interaction with the (UI).

IV. Final remarks and comments

With relation to the stages described in the Table.(I), the current work of the platform is found in the stages of design and debugging of prototypes in the areas of hardware and software. The future work regarding the educational and technical aspects of the platform will be focused on the following elements:

- Design of the new PCB of the development board that corrects the errors found in the version (1).
- Conditioning of the (UI) in function of several elements such as ease interaction with the user and robustness in the connection with Bluetooth module and the Bootloader of the microcontroller.
- Creating new Graphical Blocks for new functionalities of the platform in relation to the (VA's). These blocks will strengthen the abilities and skills in the dimensions of the CT mentioned.
- Development of the educational materials of the platform: guides, lectures, workshops, laboratories and wikis.
- Generating the educational study in order to observe the relevance of the platform in the aspects concerning the algorithmic thinking in the students.

As mentioned, the platform takes into account the nature of the learner in relation to the concepts of *mobility* and *CT*. The new challenges in the education demand educational resources with the quality needed in order to improve the learning skills and abilities in the digital age through methodologies as the CT. As an engagement, the educational institutions should generate the resources and the infrastructure that cope the challenges mentioned.

V. Conclusions

This WIP presented the educational methodology and the technical aspects relating to the *MiDroid* platform which is focused on microcontrollers' education. The educational structure of the platform has taken as reference, on one hand, the new challenges regards to the mobility of the learner and the learning and by the other hand, the elements concerning the CT and its implications in the process of design. These elements have been gathered in order to generate a platform that provides to the students an alternative of learning with the aim to improve the algorithmic thinking in them. The interest by the construction of the platform arose according to the deficiencies detected in the microcontrollers' area, therefore, the platform intents to tackle the problems associated to this area in the context of our institution. As future work, firstly, it will be debugged the designs presented in the areas of hardware and software. Secondly, it will be created the educational materials that accompany the platform and subsequently, their inclusion into the curriculum. Finally, the platform will be tested to educational and technical level with the students, observing the relevance of it, using the aspects of the CT and its implications into the practice. With the information collected in this process and the suggestions of the students about it, it will elaborate a new version of the platform with additional functionalities, for instance, interrupts, digital control blocks or programming activity mode in which the students could write their programs using an editor embedded into the application. Thus, this fact will allow to contrast the learning implications of the Visual Algorithms in the consolidation of cognitive and metacognitive abilities in the students in relation to the CT.

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