GameBlocks: an Entry Point to ICT for Pre-School Children

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Abstract: We propose a system designed for pre-school children that offers an alternative introduction to the world of Information and Communication Technologies (ICT), specifically computer programming. Illiterate children can construct simple controlling sequences that control a toy humanoid robot, using acrylic instruction blocks placed onto intelligent programming trays. The system does not make use of a traditional computer and is potentially well-suited for communities where there is no easy access to computers. Initial results from workshops are discussed and areas for improvement highlighted. The instruction blocks are described in terms of the material used, how the functions are encoded using magnets, and the symbols used to represent these functions. The programming trays are described in terms of the sensors used and their interconnection to the controlling electronics which is at the heart of GameBlocks. The associated electronics implement simple logic that detects which blocks, together with their sequence, have been placed on the trays. It then sends appropriate commands to the toy robot. The principles on which other systems function are briefly given. Our system differs from those of other researchers because of its simplicity. Informal results on how adults interact with GameBlocks are briefly given.

Keywords: concretizing tools, intelligent tangible learning objects, illiterate programmer, TUI.

1. Introduction

GameBlocks is a programming system which allows the coding of simple sequences without the use of a personal computer. A simple physical syntax [1] is used to represent the programming logic, with coloured blocks representing the actions to be executed, and the mechanical constraints of trays and blocks help reduce syntax errors.

The system was developed as an aid to introduce young, illiterate children to the exciting world of computer programming. If it can be shown that a child can develop logical thinking abilities even before reading and writing has been mastered, then surely the child should also be able to construct a computer programme using a physical syntax. Unfortunately, designers of modern programming systems have the prerequisite that the programmer should be literate. What would happen if a programming environment, that does not have this prerequisite, was made available to an illiterate person? If such a system is based on objects and actions familiar to the user, then it would be adapted more easily [2, p129]. It is for this reason that GameBlocks is based on large blocks and a toy robot, objects familiar to the pre-school child.

Another objective was to develop this as a toy that encourages physical activity, as opposed to the passive interaction with technology so often observed in today's youth.

Numerous workshops have been held with children to determine how intuitive and robust the system is. Adults have also attempted to use GameBlocks, with unexpected results as reported on in the conclusion of this paper.

2. Related Work

Embedding electronic circuitry in toys is not a new concept. Also, using blocks to aid teaching has been used in many research projects. What is unique in GameBlocks though, is the use of low-cost magnets and simple electronic circuitry to introduce children to programming principles.

Other experimental systems make use of sophisticated mechanisms to detect blocks and their associated functionality. Previous mechanisms used include wired connections, infra-red communication, radio frequency identification, and optical recognition using video cameras [3]. Although these all provide improved functionality over GameBlocks, it is with additional electronic circuit complexity and increased manufacturing cost.

3. System Description

The current experimental version of GameBlocks consists of instruction blocks, programming trays, controlling electronics, and a toy robot (Figure 1).

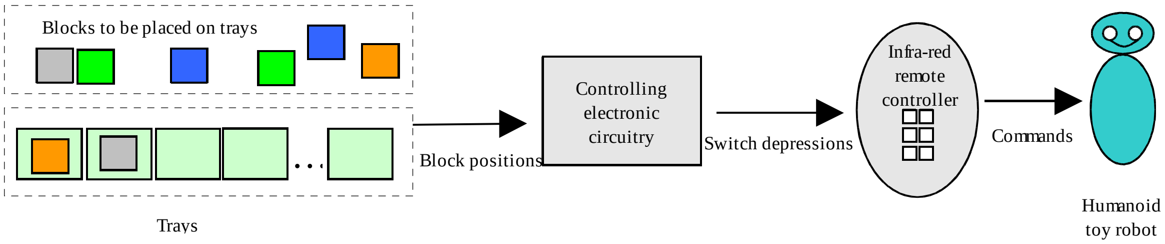

Figure 1: System diagram.

Instruction blocks and programming trays are made from acrylic sheets cut on a laser cutter, with the blocks assembled in the form of a cube. Blocks have up to five magnets embedded, with the number and positions of the magnets representing the block's functionality [4]. The blocks are also colour-coded, with a colour implying the function (Figure 2).

The programming trays have five magnetic switches embedded which sense when a magnet has been placed over it (Figure 3). When a magnet is placed over a sensor, the sensor closes an electric circuit and this is detected and interpreted by the electronic circuitry. Magnets are glued into place on the bottom plate, on the inside of the instruction block. Using the four corners, plus the centre position, up to 31 functions can be encoded. Magnetic switches are placed in corresponding positions in the programming trays, five per tray. Custom-engineered electronic circuitry sense the relative positioning of the blocks and send commands to the toy robot which correspond to the function represented by the blocks. Programming trays are connected to the electronic circuitry with multi-core flat cables. The electronic circuitry uses an infra red signal to communicate with the toy robot.

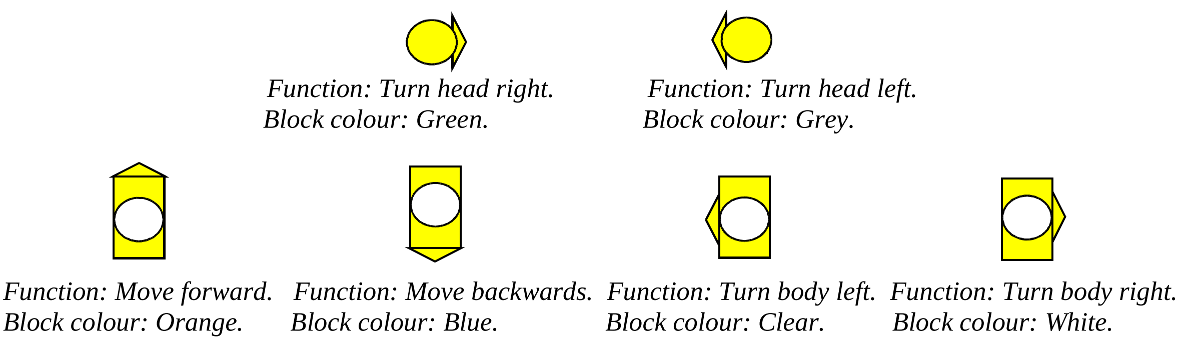

Figure 2: Symbology on blocks, the actions they represent, and the colour of the block.

(a) *(b)* *(c)*

Figure 3: (a) A programming tray with the five magnetic sensors and six interlocking mechanisms visible. (b) A transparent instruction block (inverted) with two magnets visible at the top of the photo. (c) An instruction block placed on a programming tray.

To construct a programme, the child selects an instruction block and places it in the desired sequence on the programming trays. The sequencing of the blocks on the trays determine the sequence of actions to be executed by the toy robot. Instructions include forward, reverse, left, and right movements.

4. Evaluation

We contracted a professional testing company to evaluate the efficiency of the system and the satisfaction experienced by the users. These parameters are indicators of how easy it is to learn using the system, and how likely the children are to use it in the future. Evaluations took place at a science show (Figure 4). Ages of testees ranged from 10 to12 years.

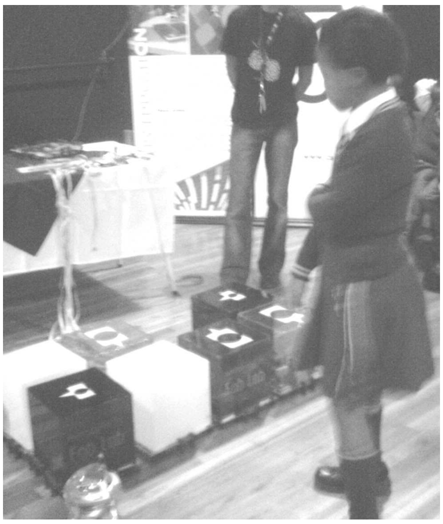

Figure 4: Evaluation at a workshop during a science show. Seven instruction blocks on eight programming trays (in two rows) are visible. The humanoid toy robot is just visible in the bottom left corner. The controlling electronic circuitry is positioned on the table.

Results from the evaluation [5] show that a number of aspects can be improved. As an example, the design reported on in this paper is not very efficient. It took the first user 15 minutes to master the system. Subsequent users, who had observed the first, required an average time of 6 minutes to master the same system. This is an improvement of 60%.

The level of satisfaction reported by the users also varied. Most reported a positive experience in using a system never encountered before. Some of the negative reporting include the wish for larger instruction blocks, and for the system co-ordinates to be located on the robot, and not on the programming trays.

5. Conclusion

We have described a system that provides an alternative introduction to computer programming for young children, without the requirement of using a computer. The system interfaces with a real-world object, such as a toy robot. Physical blocks, each magnetically encoded to represent an action, are placed on a programming mat. The sequencing of the blocks is interpreted by an electronic circuit which in turn sends infra-red instructions to the humanoid toy robot for execution. We reported on the efficiency of the system and the levels of satisfaction experienced by the children.

It is interesting to note that some of the adults who have used GameBlocks exhibited an efficiency lower than most children. The most evident reason for this is the dis-orientation the adults experience when the toy robot changes direction. This is because the orientation of the robot changes as it moves, and no longer corresponds to that of the programming trays. Some adults have difficulty in aligning their mental orientation of the toy robot to the programming trays.

The evaluation [5] shows that the meaning of the symbols used on the instruction blocks are not clear to the novice user. A study is required to determine what symbology clearly illustrate the robot movements to the target age group. Because this system is also aimed at illiterate children, and children from various backgrounds, it would be advisable to develop symbols that do not contain text, and are culturally neutral. Current evaluation data contains very little information on how pre-school children experience GameBlocks. More evaluations are needed for this age group.

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