Educational robots for teaching programming to youths

Introduction

Robots have been used in order to further education and increase engagement in a range of topics, for example, in secondary school mathematics robots have been used to demonstrate geometrical transformations. Many people struggle in computer science and one cause is a lack of motivation and enthusiasm. In this project I will make use of a user friendly programming language and integrate it with a robot in order to increase interest and motivation in computer science.

Objectives

In order to achieve the aim of this project stated above, I will need to complete several objectives. These objectives have been listed and explained below.

- To understand the Scratch and Thymio II software so it can be manipulated to create an interface.
- To create a usable and interface between the programming language scratch and the Thymio II robot.
- To adapt Scratch to use the Thymio programming structure and hardware with the use of custom procedures which are represented in scratch as "custom blocks".
- To run a focus group session. Materials and tutorials appropriate for the attendants of the session will need to be created and the event will need to be organised and advertised.
- To Evaluate the results of the focus group my compiling questionnaire results and analysing the answers to see if the Scratch and Thymio interface is usable.

Background

Programming and computer skills are becoming increasingly important as the influence of the internet and the power of computers grows, programming has even been called the 'second literacy'. Despite this there are still significant barriers to education in this field and few attempts to integrate it in to other computer related topics. This project will use the language Scratch and the Thymio II as they have both been shown to be good at introducing people to the topic of programming and robots as well as maintaining interest and creating enthusiasm.

Scratch is a language developed at MIT which has been used in education with broad success. Scratch allows for the use of most programming concept without requiring the user to be aware of syntax through the use of blocks. As well as being easy to use it is also free to use and has a large community with a wide range of users from 4 to 60 year olds meaning support can be found relating to the most basic of tasks to complex ones. One study found that during a Harvard Summer School for Computer Science course that 76% of students felt that using Scratch as an introduction help them when they later moved on to java, students also found it was more rewarding to have visual feedback on what they had programmed than just having a text window (Malan and Leitner, 2007).

Amongst the reasons why teachers don't accept technology in to the class as readily as they do other tool are stress and fear of failure. When a teacher tries to teach using methods in which they have little experience they often find that it can be daunting and cause stress. Introducing people to Scratch has both caused people to be more likely to include programming in lessons and to worry

about failing less when they consider programming courses or sessions. A study of students learning to become preschool teachers were given an introductory lesson in computer programming and found that interest in using technology in the classroom increased from 80% to 92%. As well as this they found that 65% found Scratch easy to use and 85% found it simple and understandable (Fesakis and Kiriaki, 2009).

One challenge facing robotics in education is the price of the platforms and how easy they are to use. The Thymio II can be bought for around £100 which is cheaper than alternatives such as the LEGO Mindstorm while still having most of the feature. Besides the LEGO robot there are few available robotics platforms that are simple enough that they can be used for an introduction to the topic while also being capable enough that they can perform complex programs. The Thymio II is a powerful system and with Scratch it would mean that it can be easily picked up by beginners while still being able to perform some complicated programs. Scratch include features such as the ability to create object orientate programs as well as use multithreading, and is seen to have one major limitation which is recursion which has been purposely left out so that beginners would not feel threatened by the complexity (Harvey, B. 2010).

Robots have been used before with other aspects of programming to create courses that have proven to create very enthusiastic students. For example, at the University of Lincoln robotics was taught alongside computer vision, this lead to positive results in practical sessions including some students ended up going far beyond the brief of their assignments with some advanced feature that they researched and implemented under their own direction. (Cielniak, G. et al, 2013), this suggests that enthusiasm can be created with practical assignments using robots.

The Thymio II is a programmable robot with a wide variety of sensors and methods for feedback. It has 2 wheels for movement, a speaker for audio output and several lights, some of which are programmable and others which indicate the feedback from the distance sensors. There are 9 distance sensors to prevent it from falling off objects and to detect thing in front or behind it. It also has a 3 axis accelerometer, a microphone and an infrared sensor for remote input. With these features the Thymio II is well suited to education as it can be applied to a lot of situations. The Thymio II is the result of testing amongst children with the Thymio II. After running courses with the Thymio 89.2% of parents thought the session was educational and 78.5% thought that it had increased their child's interest in robotics (Riedo, F. et al 2012)

Conclusion

Several conclusions can be drawn from this research. Firstly, that robots used in education can lead to increased practical achievement and can motivate students to go beyond the constraints of an assignment. Secondly, that Scratch is a very powerful but simple language with a majority of standard feature while still remaining user friendly and accessible to beginner programmers. As a result of this it can be used to introduce a variety of people to programming and to reduced their anxiety and discomfort with programming. Thirdly, that the Thymio II is the second iteration of a robot produced through extensive user feedback and as a result is very capable and adaptable platform.

Methodology

development

For the projects development method to be decided, the specifications of the project need to be understood. This project will be under taken by a single individual and shall occur within the space of 26 weeks including contingency time which is a relatively short amount of time. There is no client for this project, instead this shall be an exploratory project to attempt to find a way to interface Scratch with the Thymio II.

The waterfall method allows for single person projects and has no restrictions on the duration of the project. However the method relies on the project being rigidly structured and for there to be no unexpected changes or deviations (cms, 2005). As this is an exploratory project which will likely encounter unexpected challenges this frame work will not be acceptable.

A more flexible alterative to waterfall is the incremental development method. This method makes use of multiple mini waterfall stages which would allow for revisions to the plan as new challenges are faced (cms, 2005). As well as this it also maintains the single user compatibility and has no minimum duration for the project. As a result, this will be a very suitable method for managing time during this project.

Tools

For this project many tool will need to be used. In order to ensure the most efficient rate of work, appropriate tools need to be used. Below is a table of potential tools for this project listing positive points and negative points.

Tool	Pros	Cons
Microsoft Word	• Very familiar with its functionality • Widely used • Auto correct and spell check • can be saved as docx for cross platform support	
Open office	• Free to download • Auto correct and spell checking • Versions for Windows and Linux • Can save as docx	
Notepad	• Very simple • Universal format	• No spell check • Very few features
GitHub	• Useful when using multiple computers • Stores a back up so hardware loss isn't an issue	• Unreliable GUI which can cause freezing
Visual studio	• Supports many Languages • Lots of online support	• Not compatible with Thymio II platforms
Aseba	• Allows the Thymio II to be programmed using script	• Not compatible with other languages
MonoDevelop	• Can be used on multiple operating systems • Can be used to program in C++ and C#	• No robot support • Poor code assistance and auto complete

In this project Microsoft Word and Apache OpenOffice will be used to allow text editing on both Windows and Linux machines. GitHub will be used for version control of software, storage of documents and files and finally for backups in case of hardware failure. Microsoft Visual studio will be used as it allows for programming in C++, also Aseba will be used as it is the programming suite for the Thymio II.

Research

To determine the success of the project the usability and the user friendliness of the interface produced needs to be evaluated. To do this, qualitative research needs to take place in an environment where the users can have access to the hardware and software and their experiences can be recorded. To achieve this a focus group will be used. A focus group is when multiple individuals gather to perform 'focused' task and influence each other with their ideas. This will be used as it is easy to implement as compared to other methods, has a low cost to create and run and also because it allows for a large sample size (Freitas, H. et al, 1998).

The focus will use the software to complete a series of tutorials and task, they will then be handed a standardised questionnaire in which they will be asked about their experience with the interface. The results will then be compiled and analysed.

Risk assessment and contingency plans

During this project there will be several risks, the most common will be generic risks such as data loss and illness that are not unique to this project. Below is a table of risks specific to this project, detailing the risk, the likelihood, the severity and finally a paragraph explaining what will be done to reduce the chances of it happening and what will be done if it does happen.

Description	Likelihood	Severity	Contingency plan/ Mitigation
The Aseba software receives an update that changes the way it works meaning that previous research or code is no longer valid.	Low	High	The update notes shall be reviewed for changes that would affect the project, if the project can then it will be adapted to use the update within a reasonable amount of time. Otherwise the update will not be installed and the project will make use of the older version of Abesa.
The attendance of the focus group is low or there is no attendance.	Low	Medium	The focus group session will be rearranged and the method of advertising the session will be changed.
Robot specific hardware failure.	Low	Medium	Measures will be taken to ensure the robot is stored in safe and suitable locations when not in use. If a fault does occur then the robot will have to be replaced.
Focus group results are lost	Low	High	GitHub shall be used to store the files, meaning that they will be stored online, also I the data is overwritten or deleted then using GitHub the file can be reverted to previous version. If the data is lost then a secondary study will need to be performed.
Thymio II and Scratch are incompatible	Low	High	The language and the robot will need to be re-evaluated and alternatives will need to be considered.
A component or feature of the robot is incompatible with Scratch	Medium	Medium	Time will be spent considering work a possible around and alternate solutions. If none are available then the feature will have to be considered for its value to the operation of the robot. For example, the infrared received will not be required for the robot to work.
Whilst carrying out this project study will continue at university, as a result other assignments may interfere with the weekly work on the project.	Medium	Medium	I will manage my other modules to ensure that certain days are dedicated to project and plan and make use of contingency if need be.

Gantt chart

In order to plan the project a Gantt chart has been made showing all of the tasks in red and all of the contingency and breaks in blue. The chart is organised by week and considers Monday to be the start of the week. Some task such as the literature review and the write up will happen simultaneously.

	end on the week shown inclusively		weeks starting form the beginning of the project																							
Task	Start Date	End date	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12	week 13	week 14	week 15	week 16	week 17	week 18	week 19	week 20	week 21	week 22	week 23	week 24	week 25	week 26
Research relevant APIs	20/10/2014	10/11/2014																										
Create interface	17/11/2014	15/12/2014																										
Christmas	22/12/2014	29/12/2014																										
Continue creating interface	05/01/2015	26/01/2015																										
contingency	02/02/2015	02/02/2015																										
Create custom Scratch blocks	09/02/2015	16/02/2015																										
Create materials for focus group	23/02/2015	02/03/2015																										
Organise a focus group session	23/02/2015	09/03/2015																										
Run a focus group session	09/03/2015	09/03/2015																										
Evaluate the results of the test	16/03/2015	30/03/2015																										
Contingency	06/04/2015	06/04/2015																										
Print and submit	13/04/2015	13/04/2015																										
Literature review	15/12/2014	13/04/2015																										
Write up	15/12/2014	13/04/2015																										

References

Riano, L. and McGinnity ,T. (2010) Design and validation of a robotic system to interactively teach geometry, *AT&P Journal* (*2)* 91-96

Cms, (2005) *Selecting Developing Approach*. [Online] Available from: www.cms.gov/Research-Statistics-Data-and-Systems/CMS-Information-Technology/XLC/Downloads/SelectingDevelopmentApproach.pdf [Accessed 18 October 2014].

Malan, David J. and Leitner, Henry H. (2007) Scratch for Budding Computer Scientists, *ACM SIGCSE Bulletin* 39(1) 223-227.

Fesakis, G, and Kiriaki, S. (2009) Influence of the familiarization with Scratch on future teachers' opinions and attitudes about programming and ICT in education, *ACM SIGCSE Bulletin*, 41 (3) 258-262.

Harvey, B. and Mönig, J. (2010). Bringing “No ceiling” to Scratch: can one language serve kids and computer scientists, *Proc. Constructionism*.

Cielniak, G., Bellotto, N. and Duckett, T. (2013) Integrating mobile robotics and vision with undergraduate computer science, *Education, IEEE Transactions on* 56(1) 48-53.

Riedo, F., Rétornaz, P., Bergeron, L., Nyffeler, N., and Mondada, F. (2012). A two years informal learning experience using the Thymio robot, *Advances in Autonomous Mini Robots* 37-48

Freitas, H., Oliveira, M., Jenkins, M. and Popjoy, O. (1998). The Focus Group, a qualitative research method, ISRC Working Paper 010298, Merrick School of Business, University of Baltimore