Hedgehog: A Smart Phone Driven Controller for Educational Robotics

Clemens Koza, Christoph Krofitsch, Wilfried Lepuschitz, Gottfried Koppensteiner
Practical Robotics Institute Austria
Vienna, Austria
[koza, krofitsch, lepuschitz, koppensteiner]@pria.at

Abstract—Robotics represents an ideal tool for teaching science, technology, engineering and math (STEM) due to its interdisciplinary nature and appeal for young people. This paper gives an overview of the Hedgehog controller, a robot controller developed with education as an explicit use case. Mobile devices are part of the architecture for increasing the appeal to students and decreasing the costs of the controller hardware. The peripheral interfaces in conjunction with the capabilities of today’s smart phones and an optional single-board computer make the platform suitable for sophisticated applications in and beyond the education domain.

Keywords—controller; smart phone; tablet; Android; iOS; app

I. INTRODUCTION

Robotics is a suitable tool for teaching science, technology, engineering and math (STEM) due to its interdisciplinary nature and its appeal for young people. The lack of adequately trained workforce in these domains make efforts to introduce students to STEM more important than ever [1], [2]. Early exposure to these fields increases the impact of taken efforts.

However, school budgets are often too small for introducing robotics at young ages due to the required investments in equipment. Furthermore, teachers trained adequately in robotics are often not available for these ages. As a consequence, only individual teachers’ efforts dominate robotics education [1], [2], [3]. This led to the development of Hedgehog [4], a low priced robot controller that involves smart phones and similar mobile devices.

Smart phones provide a rich user interface via touch screen, network capabilities, fast processors, a lot of memory, and internal sensors, such as gyroscopes, acceleration sensors, and cameras [4]. With smart phones getting increasingly common among even young school children, duplicating these capabilities in a robot controller unnecessarily increases costs.

At the same time, using the smart phone further engages students in the subject matter. Supplementary material and intuitive user interfaces support teachers without specific training and aid teachers and children in a shared learning and exploration experience.

Using mobile devices lets Hedgehog automatically benefit from innovations in the field of consumer electronics. Network capabilities and other features less important for introductory robotics courses open up a wide area of applications in and beyond the education domain [5], [6]. These benefits make Hedgehog less susceptible to obsolescence and thus a versatile long term investment.

II. CONCEPT

A. Modularization

Fig. 1 shows the Hedgehog architecture. The Hedgehog controller is composed of two layers, the high-level control (HLC) and low-level control (LLC), named so for their deliberative and reactive roles, respectively [4]. The HLC consists of the mobile device and its software; the LLC is composed of the hardware controller (HWC) and the software controller (SWC). Inter-module communication is done using a simple stateless protocol.

The HWC is responsible for time-critical tasks and is effectively a black box to the user. These tasks include generating pulse-width modulated signals for motors and servos, providing WIFI connectivity, or communicating with external hardware such as an iRobot Create via additional interfaces like universal synchronous/asynchronous receiver/transmitter (USART) or inter-integrated circuit (I²C). The SWC is a single-board computer on which the user can run arbitrary applications. The current implementation uses a Raspberry Pi as SWC and an Android device as HLC, but an iOS variant is currently in development.

B. The Hedgehog App

Like the SWC, the HLC can run arbitrary software – apps in the case of Android or iOS – but the use of the Hedgehog app is assumed for education purposes. It provides

- overview screens to test actuators and sensors. This eliminates the need for a screen found on most conventional educational controllers.
- an integrated development environment (IDE) with debugging facilities to create programs to run on the SWC. This makes separate development machines unnecessary for courses.

By writing applications for the SWC, development license issues, especially on the iOS platform, are avoided. All of these measures reduce costs for schools.

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III. HEDGEHOG IN USE

In its current stage, the Hedgehog app’s IDE supports programming in C. Support for other popular languages, such as Python or Java, is planned for the future. To accommodate for the heavy use of punctuation in most programming languages, additional code template buttons, e.g. for inserting loops, are provided in the IDE.

During deployment, the source code is sent to the SWC and compiled there. Compilation results, i.e. return code and any compiler messages, are sent back to the HLC. The alternative, compiling on the HLC, would require cross-compilation support. This is not viable on most mobile devices, and would introduce tighter coupling between HLC and SWC, which is not desirable.

For debugging, commands such as “Debugging Break Action”, which suspends the running SWC program, are available to the HLC. These commands correspond to commands and events of Gnu Debugger (GDB), although the use of GDB on the SWC is an implementation detail. Fig. 2 shows two screen shots from a Hedgehog debug session.

IV. CONCLUSION AND FUTURE WORK

The Hedgehog controller represents a powerful platform for educational robotics. Using smart phones facilitates existing resources and provides a well-understood, attractive working environment. At the same time, Hedgehog can leverage future improvements in those devices. Overall, this makes Hedgehog a worthwhile low-cost, long-term investment for schools.

As mentioned before, iOS support and debugging features are currently in development. Additional programming languages will make Hedgehog attractive to a broader audience. Graphical programming for the Hedgehog platform, based on Catrobat’s Pocket Code [7], is already in its planning stages and will make Hedgehog suitable for young children.

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REFERENCES

Using a standardized protocol for all communication allows supporting multiple mobile platforms.

The Hedgehog controller, plus a smart phone with the Hedgehog app, are all that is needed to program robots.

Easy calibration allows students to efficiently use the phone's camera.

Hedgehog works with the built-in sensors of the phone, such as accelerometer, gyroscope or camera.

The SCORE! project of the Practical Robotics Institute Austria aims to enhance robotics for the educational domain by providing a simple, flexible and affordable robot controller. This controller consists of the user's smartphone, an electronics board and software making robot programming intuitive and easy to learn.