Transportable Research Instrument: a PDA-based Laboratory for Science Experiments

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Abstract

We introduce the Transportable Research Instrument (TRIcorder) System, an implementation of a PDA-based laboratory (PBL). The hardware component uses PDAs and wireless sensors to conduct and collect data for high school laboratory experiments. The software component, Experimental Assistant uses a gesturing user-interface to lead students through the experimental procedure and graphically present the experimental results. The TRIcorder system design attempts to capitalize on the unique PDA's affordances of portability, context sensitivity, and individuality to implement a PBL.

1. Introduction

Many students enter college without an adequate grasp of how relationships are depicted by graphs [2]. They misinterpret graphs as pictures [1], and have difficulty connecting graphs to physical concepts and the real world [6]. Because of the computer's ability to acquire and rapidly disseminate data, students using microcomputer-based laboratories (MBL) can interactively explore and experience science and mathematics [8]. Because of the portability of calculators, students using calculator-based laboratories (CBL) can collect data while they interact with the real world, but the calculator's limited screen size and poor user-interface frequently requires students to upload the data to a computer [9].

We propose the use of personal digital assistants (PDA) for the graphical data presentation and analysis in PDA-based laboratories (PBL). The PBL combines some of the best features of MBL and CBL. The gesturing interface and high-resolution display of the PDA allows PBL to display more information than CBL, and supports direct manipulation for exploring the graph as in MBL. Because of wireless communication with sensors the portability of PBL exceeds the portability of CBL, and students are free to view the experiment from any perspective and simultaneously manipulate the graph.

PDAs have been used in education ranging from kindergarten [4] to medical [7] education. We describe the hardware and the software being developed for our implementation of a PBL, the Transportable Research Instrument (TRIcorder) System.

2. Implementation

The Integrated Microsystems Enterprise [3] is developing the TRIcorder (the data acquisition device), telemetry cube and Experimental Assistant (EA) (the software package with student user interface). The Enterprise is a multi-year project undergraduate students and faculty advisors.

Currently the hardware of the TRIcorder System is composed of an unmodified PDA with a docking unit and a remote data acquisition sensor, depicted in figure1. The PDA and sensors communicate via a radio link operating at 915 MHz. The only modification to the external configuration of the PDA is the addition of the detachable docking unit, which connects to the serial port of the PDA. The docking unit is housed in a package similar to the modems for PDA and does not impede the portability of the PDA.

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The enterprise has constructed inertial sensors, which includes both the telemetry and kinematics sensor. The sensor uses 2 low cost 10-g/50-g dual axis monolithic integrated chips accurate to 0.1-g and capable of 1-KHz sampling rate. The radio transmitter/receiver has a range of 500-meters. The total size of the telemetry and kinematics sensor is 2 x 2 x 4 cm and weighs less than a 100-gm. So the TRIcoder with kinematics sensor is suitable for low-
altitude rocket-telemetry experiments, and sub-audio oscillating mass-spring experiments.

The Experimental Assistant software directs the students through the experimental procedure, graphically displays the experimental results in real-time and assists in uploading the data to a desktop computer. From the initial form, a screen on the PDA, the students select the experiment from a list by tapping. Sequential forms direct the students through the experimental setup, which includes instrument calibration and initialization. The final form is a graph depicting the experimental data in real-time. The student can choose to track the experiment in real-time or fix the graph for a specific time interval. Gesturing on the graphical components changes the displayed graph. The student chooses the variables to display by gesturing on the axis' variable label, cycling through the experimental variables. The graph can be and zoom into a specific part of the curve by circling the data with the pen.

The user-interface uses the Simple Gesturing User-Interface (SGUI) API developed by the authors for use on small display devices, such as the PDA. The basic design principle of the SGUI is that the display is divided into regions representing gestural interface-objects, which can accept specified gestures as user inputs. The gestures that are identified are simple strokes, such as taps, slashes, and closed curves. The direction and magnitude of the stroke provides additional information to the gestural interface-object. The interface is context sensitive because the same stroke can have different computer responses depending on the gestural interface-object.

3. Evaluation and Conclusion

Klopfer et. al. [5] recommend that PDA software designer consider the unique PDA's affordances of portability, context sensitivity, and individuality. Using wireless communication the TRICorder system design capitalizes on portability, and offers individual exploration of the data through graphical manipulations. Currently our software does not support a network between PDLs; this feature would add to the social interaction and connectivity of the PBL.

We plan to introduce the TRICorder system into local high schools, and study the pedagogical effectiveness of the PBL due to the increase portability and the usability of SGUI as a context sensitive gesturing user-interface for the PDA. In additional we improving the hardware by compartmentalizing the sensors into telemetry cube and sensor cards. This modular design standardizes a platform for regular improvements to the sensor cards, and allows the same sensor cards to be directly inserted into the TRICorder via an expansion port in the docking unit.

4. Acknowledgements

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5. References


