Hand-held Doctor for Children

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ABSTRACT
We describe an ongoing project to design health-monitoring devices and software that in combination help children better understand how their bodies work. The health-monitoring devices we have built monitor, analyze, and record pulse, breathing, temperature, and galvanic skin response. A small PIC-based device digitizes the sensor signals and sends the data to a PC or a toy. A PC program animates a cartoon character that visualizes the physiological parameters. A LEGO castle and a moving robot also respond to changes in the physiological parameters.

Keywords
Children, sensors, physiology, medicine, health, games.

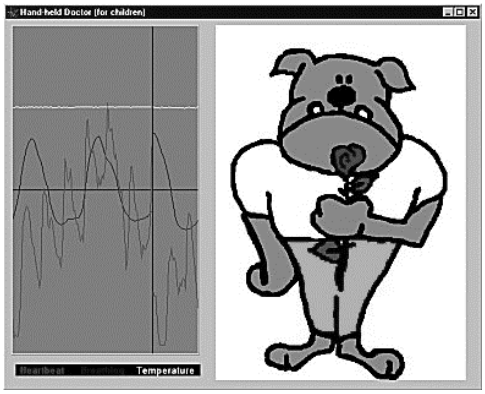
INTRODUCTION
The goal of the project is to design hardware and software for children's education and entertainment that will allow them to explore and understand the dynamic physiological parameters of the human body. Rather than simply proving the detailed results of a physical examination, we have adopted a "constructionist" or "learn-through-doing" approach to engage the children in a learning activity. [4] The computer serves as a tool to visualize, analyze, and explain the processes going on inside human bodies. We expect that the children will use this tool to actively observe and interpret data, to reason about why the parameters change as they engage in different activities and why the data vary amongst individuals. Finally, we expect that this activity be immersive and on-going. The children, routinely gathering data over an extended period, weeks or months, will perhaps see that their initial hypotheses are in need of reexamination.

The hardware consists of a set of sensors, a device to digitize and preprocess the sensor signals, and a serial-port device to receive the information on a PC or a robot. The sensors measure pulse, breathing, temperature, and galvanic skin response. All the sensors are connected to a pocket PIC-based device that performs A/D conversion of the sensor signals and uses RF-transmitter to send the data to a PC or a robot.

The software is designed such that it can be used by children wearing or holding the sensors to visualize physiological parameters by directly controlling animated figures or robots. Children can build their own robots and write their own visualization programs that interact with the measured physiological parameters. Also, the software enables them to examine longer-term trends in the data and compare data with others through the medium of games.

SENSOR SYSTEM
An important component of the system is a pocket data transmitter with A/D converters. It is built with PIC 711 microcontroller and Abacom 418 MHz FM transmitter. The device is powered with a 9V battery. The microcontroller has 4 A/D converters, and, thus, can handle up to 4 independent sensors simultaneously. The temperature sensor uses a high-precision thermistor assembly to get acceptable body temperature data. The breathing sensor has a small thermistor that detects changes in temperature between inhaled and exhaled air. The pulse sensor uses IR LED and photo diode assembly to detect the change in IR reflectance of human skin at different phases of the heartbeat. The reflectance changes as blood vessels expand and contract. The galvanic skin response sensor is a two-electrode probe connected to a high-impedance resistor bridge. All the sensors have operational amplifiers, resistor bridges, and filters to fit the output voltage range into the A/D converter range and to reduce the noise.

THE DOG

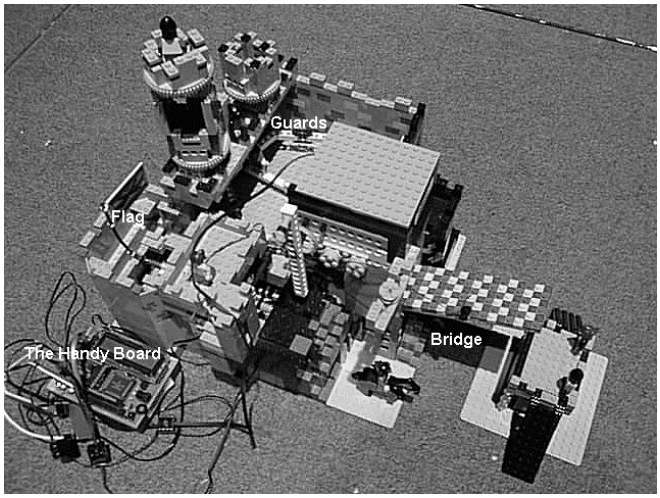


The dog is a cartoon character that visualizes three physiological parameters: pulse, breathing, and

temperature. The dog's chest expands and contracts to show the breathing. The dog's skin changes color depending on the temperature. When the temperature is low the dog is gray, when temperature is high it's red. The color gradually changes in between. The pulse is shown with a pulsating rose held by the dog. The program also displays the graphs of all the parameters on a separate pane.

The program receives information from the sensors with an Abacom receiver connected to the serial port and powered up thought the keyboard or mouse port.

THE CASTLE



A high school child has built a LEGO castle. It is used to visualize the same parameters as the dog animation. The castle has a flag over the back tower, a group of guards inside the yard, and a bridge. The guards move around yard with each heartbeat. The flag waves when the child exhales. The bridge moves up or down as the temperature measured by the temperature sensor changes.

The castle is controlled by the handy board [2] with an Abacom receiver connected to the serial port. The handy board analyzes the signals and activates the motors to respond to changes in physiological parameters.

FUTURE PLANS

Web Interface

The system has a web interface to the sensor system to allow children to compare their physiological parameters and discuss their findings about health. The database may store parameters taken at different time from different people. Children will be able to compare and contrast parameter recordings in the database, and find explanations of different physiological phenomena.

Sensor Enhancement

The designed sensor system can be significantly expanded and enhanced. We are planning to add new sensors to widen the set of measured parameters. For example, children may be interested in exploring their brain waves. An EEG sensor can be built and connected to the system for that purpose. Other interesting parameters to measure include ECG, blood pressure, and blood sugar level. Besides, the system can also detect and measure the body motion with accelerometers and gyroscopes. The new sensors will improve the scope of analyzed parameter and allow the system to give more interesting and precise information to children.

The sensors are being embedded in various toys such as a toy motorcycle helmet or a teddy bear. Pediatricians may use the toys as non-obtrusive tools to evaluate health of their patients.

Games

Another direction of the research is to find activities for children, which exploit the designed system to encourage the exploration of health issues. For example, children may play a game where they control the action by trying to alter their breathing or pulse. They can also play virtual diving and check who can hold his breath longer. Repeated playing would show improvement over extended periods of time. Children can also participate in various competitions where they build health-aware robots or computer programs.

The system is capable of detecting long-term changes in relations among the parameters, so that children can, for example, see how exercising affects their health possibly increasing their interest in exercising. Typical of sports activities, people improve certain motor skills and train certain groups of muscles. By giving children general evaluation tools, they may compare people engaged in different sports. For example, a child may choose to compare a baseball player with a football player.

Children can engage in health improvement competitions similar to sports games, but that last for months. The health-monitoring system tells who makes most progress or who is the best in absolute health values.

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