Virtual Reality Physio Monitor

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Abstract

Nurse education currently consists of theoretical learning and practice with patient models. In the ER Trauma Bay simulation in the Cave Automatic Virtual Environment (CAVE) at the Wisconsin Institutes of Discovery, one goal is to allow nurses to practice proper skills and techniques in a realistic scenario. Professor Robert Radwin and Dr. Benjamin Mandel are working with the CAVE to produce an ER tension pneumothorax (severe oxygen shortage and low blood pressure, progressing to cardiac arrest) scenario[1]. Currently, the vitals monitor in the simulation displays vitals that do not change. In order to simulate a real-world clinical environment for training purposes, a dynamic virtual monitor display system must be created for the CAVE. The monitor should display electrocardiographs (EKG's or ECG's), respiration rate, blood pressure and SpO2 levels that respond to changing physiological conditions in the virtual ER trauma bay. In order to complete the monitor design, three alternative programming languages were evaluated. The programming languages examined were Java, MATLAB, and C++. Based on chosen design criteria, the advantages of Java significantly outweighed the advantages of the alternate programming languages. Currently, the team has implemented a user interface for the monitor, which includes an ECG signal data and graph, a photoplethysmograph (PPG), *S*p02, respiration numerical readings and graphical representation, temperature, blood pressure and patient condition descriptions and images. The team has developed an efficient way to create and load scenarios onto the monitor. The tension pneumothorax case has been researched and implemented so that the monitor responds to vitals changes and nurse actions for the tension pneumothorax scenario in the CAVE. The team has tested the monitor with students in the nursing program and has received approval from the clients. Although the generated vitals could be fine-tuned, the program is ready for implementation into the CAVE.

Background

- 10x10x10 ft. cube: 3D virtual environments
- CAVELib programming languange
- Tension pneumothorax: accumulated air in the lungs
  - ➢ Heart rate and Respiration increase
  - ➢ Blood pressure decreases [2]

Motivation

- Nurse training in CAVE-ER scenario
- Simulate real conditions in the ER trauma bay
- Patient monitor must be displayed clearly
- Change according to patient's physiological condition

Existing Devices

ANGIO Mentor, produced by Simbionix and Anesoft [3]

- No tension pneumothorax scenario
- Specific to certain scenario

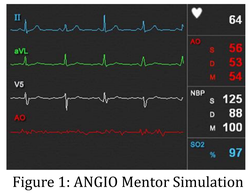


Figure 1: ANGIO Mentor Simulation

Final Design

Monitor User Interface

- Utilizes a combination of Java and MATLAB in order to create a realistic monitor
- Displays patient vitals, pictures of the scenario and text describing the patient's condition
- Accepts input via the "Actions" menu and the "Set Parameters" option under "Options"
- A tension pneumothorax scenario has been built and can be loaded under "Options" menu
- After loading the tension pneumothorax scenario, the user has five minutes to insert the angiocatheter. Otherwise the vitals drop and the virtual patient dies

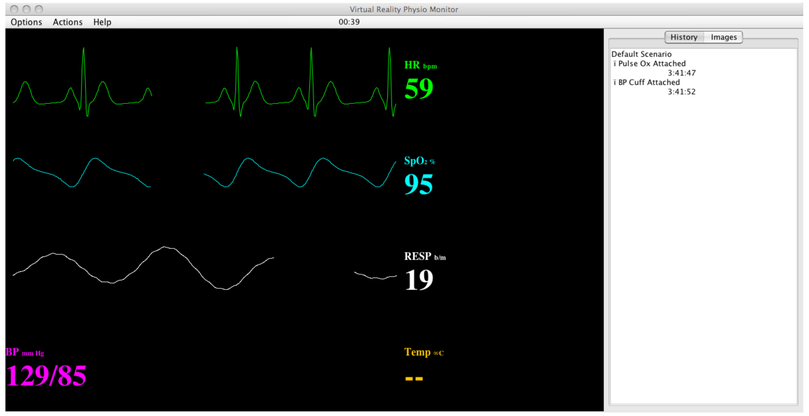


Figure 2: Vitals Monitor Final Design and User Interface. The sweeping bar updating the vitals is visible as a dark gap in the graphics. Blood pressure in mm Hg is displayed on the bottom left and the ECG, photoplethysmograph and respiration graphics and values in beats per minute, percent oxygen and breaths per minute are displayed respectively. The history log is displayed right of the monitor and the timer, options menu, actions menu and help menu are displayed above the monitor.

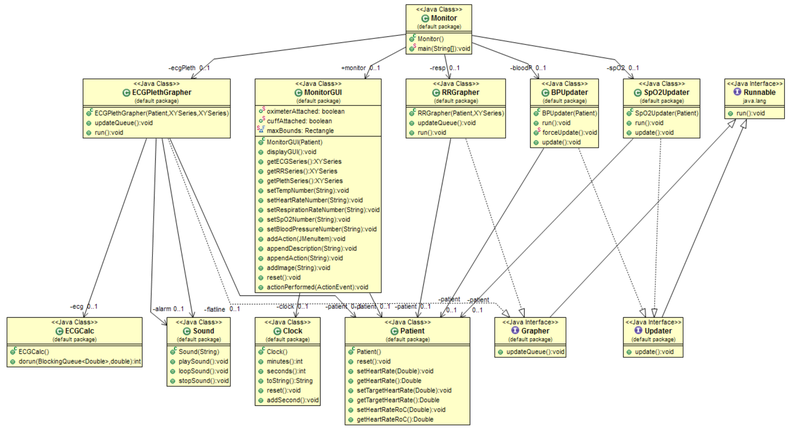


Figure 3: Class diagram of the Virtual Reality Physio Monitor Java program. Each box represents a unique class, its public variables and public methods. The classes are organized in hierarchical order, with the main class, Monitor, at the top.

A ——▷ B
Class A has an instance of Class B

A - - - - - ▷ B
Class A implements Interface B

A ——▷ B
Interface A extends Interface B

Wave function

- The monitor displays dynamic heart rate, SpO_2, respiration rate , blood pressure and temperature vitals
- The vitals are shown when the user selects the "Attach Pulse Oximeter" or "Attach Blood Pressure Cuff" option under the "Actions" menu
- The ECG waveform is generated using the algorithms from ECGSYN [4], while the PPG and Respiration signals were simulated using sinusoids
- Each waveform is loaded one cycle at a time

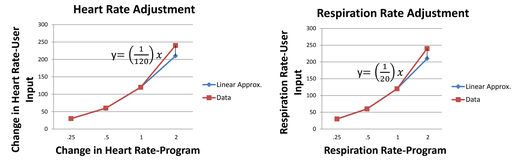
Design Criteria

- Compatible with current virtual reality ER trauma bay in the CAVE
- Respond to a changing physiological environment
- Clear and legible display
  - ➢ Display dynamic, realistic graphical readings for heart rate, respiration rate and SpO_2
  - ➢ Display dynamic, realistic digital readings for blood pressure, heart rate, respiration rate and SpO_2
- Sound an alarm if vitals cross a dangerous threshold
- Accommodate new physiological scenarios

http://en.wikipedia.org/wiki/Cave_Automatic_Virtual_Environment

Testing

- Quantitative: Verification of Monitor Capabilities
  - ➢ Worked out bugs in the programming class used to calculate ECG
  - ➢ Adjusted rate of change inputs for blood pressure and respiration



- Qualitative: 14 Surveys completed
  - ➢ Nursing students and Health-care Professionals
  - ➢ Adjusted ECG scale
  - ➢ Added Monitor labels

Future Work

- Variability in ECG signal
- Improve respiration waves
- PPG wave variation
- Translate the program into CAVELib

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