Team Project: Developing and testing a software-based prototype of an AED[1]

Due Fri December 8th at 11:59pm

Team work submitted individually on Brightspace as a tar or zip file named teamX.tar or teamX.zip, where X is your team number. **Mandatory demos** will be **individual** starting on Monday December 11th. The scheduling details will be announced the week before and the project review-demo times will be arranged between you and your assigned TA. The implementation and testing are to be in C++ using the Qt framework on the course VM (COMP3004-F23). You are required to use GitHub: make sure your repository is private and that you provide access to your assigned TA. You are encouraged to check your progress on a weekly basis with myself and the TAs. Do not wait until the last minute.

Deliverables (5 parts)

- **Use cases**
- **Design documentation** – structure and behavior
  - UML Class diagram
  - Sequence diagrams for scenarios covering normal and safety operation
  - State diagrams
  - Textual explanation of your design decisions
- **Implementation**
  - Source code of your Qt C++ project that builds and runs on the course VM (COMP3004-F23.ova found at https://carleton.ca/scs/tech-support/virtual-machines/
  - Tests based on scenarios specified in design
- **Video:** record a video of running your simulation through the above specified scenarios
- **Traceability matrix**

Project Overview: In this project, your team is tasked with designing and developing a software simulation of the AED Plus (Automated External Defibrillator Plus) system, a life-saving medical device used to assist individuals in cardiac emergencies.

The goal of this project is to design and implement a simplified software simulation of the AED Plus device to demonstrate its functionality and provide user interaction.

[1] This project has been specified by Igor Radonjić, with minor changes by Vojislav Radonjić.

Fig 1.

Objective: The objective of this project is to create a software simulation that mimics the core functionality of an AED Plus device, as seen in Fig 1, allowing users to perform actions such as analyzing heart rhythms, providing electric shocks, and offering guidance during an emergency.

All the technical information you require to model the AED Plus is contained in the AED Plus Administrator's Guide.

Background Information:

What is an AED?

An AED, or Automated External Defibrillator, is a portable electronic device that automatically diagnoses and treats life-threatening cardiac arrhythmias, specifically ventricular fibrillation and ventricular tachycardia, through defibrillation, delivering an electrical shock to the heart to restore a normal rhythm. AEDs are used in cases of sudden cardiac arrest, which is a condition where the heart suddenly stops beating effectively, and the person is unresponsive and not breathing or breathing abnormally. AEDs do not work if there is no detectable electrical activity and the patient has flatlined.

Key features and functions of an AED include:

1. Automated Operation: AEDs are designed to be user-friendly, even for individuals without extensive medical training. They provide clear and simple instructions to guide users through the defibrillation process.
2. Cardiac Arrhythmia Detection: AEDs can analyze the heart's electrical activity to determine if a shockable rhythm, such as ventricular fibrillation or ventricular tachycardia, is present. If such

a rhythm is detected, the AED advises the user to deliver a shock. See the heart signal shapes in Fig 2.

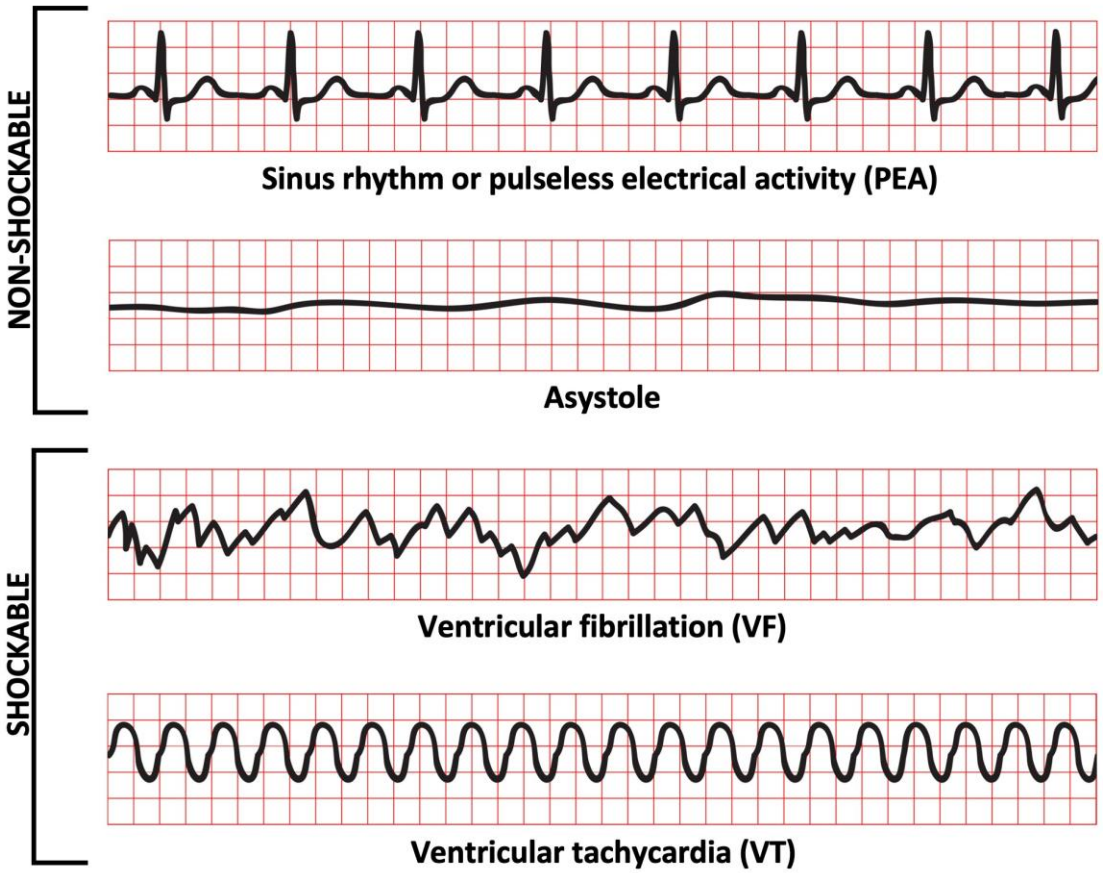

Fig 2.[2]

3. Electrode Placement: AEDs come with adhesive electrode pads that must be correctly placed on the patient's chest. These pads are equipped with sensors to monitor the heart's activity.
4. Voice and Visual Prompts: AEDs provide step-by-step voice and visual prompts to instruct users on the proper actions to take, including when to initiate CPR and when to stand clear during defibrillation.
5. Real-Time CPR Feedback: Some modern AEDs, like the AED Plus, provide real-time feedback on the quality and rate of chest compressions during CPR. This feature helps rescuers administer effective chest compressions.
6. Safety Features: AEDs typically have safety features to prevent accidental shocks, such as assessing the patient's heart rhythm before delivering a shock and advising against shocking if the rhythm is not shockable.

[2] https://oscestop.education/acutely-unwell-patients/adult-advanced-life-support/

AEDs are commonly found in public places, such as airports, shopping malls, schools, and sports facilities, to increase the chances of survival in the event of sudden cardiac arrest. When used promptly and correctly, an AED can greatly improve the chances of restoring a normal heart rhythm and saving a person's life during a cardiac emergency.

How does it work?

Here's how an AED works in more detail:

1. Power On: When you turn on an AED, it initiates a self-test to ensure that the device is functioning properly and ready for use. It will often provide a visual and audible indication that it is operational.
2. Electrode Placement: The AED typically comes with adhesive electrode pads that have sensors. The first step is to place these electrode pads on the patient's bare chest. The pads are typically labeled "Adult Pads" and "Child Pads" to ensure proper placement for different age groups.
3. Heart Rhythm Analysis: The AED analyzes the patient's heart rhythm through the electrodes. It monitors the electrical activity of the heart to determine whether a shockable rhythm is present. The primary shockable rhythms are ventricular fibrillation and ventricular tachycardia.
4. Voice and Visual Prompts: The AED provides clear voice and visual prompts to guide the user through the process. These prompts may include:
    * "Stand clear" to ensure no one is touching the patient.
    * "Analyzing" as the AED evaluates the heart rhythm.
    * "Shock advised" if a shockable rhythm is detected.
5. Shock Delivery: If a shockable rhythm is identified, the AED will prompt the user to deliver a shock. The shock is administered by pressing a button on the AED. It's essential to ensure that no one is in contact with the patient when the shock is delivered.
6. CPR and Post-Shock Care: After delivering a shock, the AED often instructs the user to perform cardiopulmonary resuscitation (CPR) for a specified duration. The AED may continue to monitor the patient's heart rhythm and provide feedback on the quality and rate of chest compressions during CPR.
7. Continued Evaluation: The AED may continue to monitor the patient's heart rhythm and provide further shocks or CPR instructions as needed.

It's important to note that AEDs are designed for ease of use, even by individuals with minimal medical training. The voice and visual prompts provided by the AED guide the user through the process, making it possible for bystanders to respond effectively to a sudden cardiac arrest situation. The use of an AED, along with timely CPR, significantly improves the chances of survival for individuals experiencing cardiac arrest.

How to operate an AED?

The following are the general steps in operating an AED:

1. Regardless of which brand of AED is used, the only knowledge required to operate it is to press the "ON" button.
2. Once the AED is turned on, it actually speaks to you in a computer-generated voice that guides you through the rest of the procedure.
3. You will be prompted to place a set of adhesive electrode pads on the victim's bare chest and, if necessary, to plug in the pads' connector to the AED.
4. The AED will then automatically analyze the person's ECG rhythm to determine if a shock is required. It is critical that no contact be made with the person while the machine is analyzing the ECG. If the person is touched or disturbed, the ECG may not be accurate.
5. If the machine determines that a shock is indicated, it will automatically charge itself and tell you when to press the button that will deliver the shock.
6. This shock is the same shock that would be delivered by a physician in the emergency department or a paramedic in the ambulance if the patient were being treated there.
7. Once the shock is delivered you will be prompted to resume CPR.

Requirements:

The modeled unit of the AED Plus must contain the core functions of an AED outlined above and a user interface to administer them. They can be organized into the following modules:

1. User Interface Design:
    - Design the software for a graphical user interface (GUI) that resembles the AED Plus's display.
    - Develop visual elements to display essential information, including:
        - Real-time CPR feedback.
        - Cardiac arrhythmia diagnosis results (see the shockable-non-shockable)
        - Device status indicators (e.g., battery, electrode placement).
        - Simulated user interaction controls (e.g., buttons for electrode placement).
        - Include a display panel to show the simulated ECG (electrocardiogram) waveform and device status.
2. Cardiac Arrhythmia Detection:
    - Develop a module to simulate the AED's capability to diagnose cardiac arrhythmias, specifically ventricular fibrillation and ventricular tachycardia.
        - Refer to Fig 2. for the shockable and non-shockable rhythms.
        - Simulate the analysis process where the AED Plus detects the heart rhythm.
        - If a shockable rhythm is detected, display a message on the screen and provide textual instructions on how to prepare and deliver a shock.
        - If a non-shockable rhythm is detected, provide appropriate textual guidance for CPR (Cardiopulmonary Resuscitation).
3. Real-Time CPR Feedback:
    - Create a system that emulates the real-time CPR feedback feature of the AED Plus.

    - Simulate the measurement and assessment of chest compressions, delivering visual and textual feedback to guide the user.
4. Visual Prompts:
    - Specify scenarios of a simulated cardiac emergency with visual prompts and their timing to guide the user through a rescue situation.
5. User Interaction:
    - Implement an interactive system that allows users to perform actions mimicking real-world AED operation.
    - Provide input mechanisms for electrode placement, shock delivery, and CPR initiation.
6. Simulated Scenarios:
    - Develop scenarios with varying patient conditions, user responses, and outcomes to test your software.