Innovative wireless patient simulator for use in resuscitation training

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Abstract

PATRES (PATient simulator for RESuscitation training) is a flexible, modular ECG simulation system designed for the use in resuscitation trainings of laymen, first responders and medical staff. It provides measures for programming realistic reanimation scenarios. ECG data to be put out to the connected defibrillator is transmitted via Bluetooth® to a shock-proof output hardware. Applied shocks are detected and the simulation changes rhythm states according to the loaded scenario.

1 Introduction

Since the clearance of laymen defibrillation using Automatic External Defibrillators (AED) by the Bundesärztekammer [1] the need for training of first responder groups, ambulance, other medical staff and relatives of risk patients on AEDs has increased significantly. Still, the trainings often show a lack of realism due to the great differences between the medical education of the trainees and the equipment that has to be used. In many cases the training becomes very stereotypical and therefore unrealistic, because of the limited features of the used ECG simulation devices. Very elaborated, but also very expensive patient simulators are available [2], so they can only be used at special centres, where a top-level education of small groups of specialists is indicated. Therefore there is great need for an affordable, very flexible system which can be used with any AED, offering realistic training opportunities for a great variety of target groups.

2 Materials and Methods

In [3] a first version of the PATTient simulator for RESuscitation training (PATRES) system was presented, which was developed at our department in collaboration with the German Red Cross, section Karlsruhe. The basic system concept is the “state-machine-like” programming of resuscitation scenarios with two possible transition conditions for changes of the current ECG rhythm: A pre-defined number of applied shocks or a timeout reached without the sufficient number of shocks detected. By this the instructor can program large and realistic tree-alike scenarios reflecting the dynamics and different outcomes in real-world resuscitations. Scenario data is stored in a XML-file either accessible on the file system or via a XML database.

For ECG data, a XML-based data format has been defined, which allows the storage of rhythm segments used for the programming of resuscitation scenarios as well as beat annotations besides the ECG data itself. Conversion from proprietary binary data formats can be performed by specific converter plugins.

A major feature of the PATRES system is the wireless transmission of the ECG data to the output device (Fig. 1). This communication is realized using the Bluetooth® wireless technology. A special protocol which is easy to extend to match future needs is used atop the Bluetooth® Serial Protocol Profile (SPP).

![Material used in resuscitation training. The box on the right side of the AED in front of the manikin is the PATRES ECG output hardware with an integrated Bluetooth® link.](fig1.jpg)

All PATRES software applications are realized in Java. Some specific features are implemented using JNI. These components have to be recompiled when the application are intended to be used on other plat-
forms than Microsoft® Windows®. The simulation module is realized using the Model View Control design pattern for easier porting to devices with smaller displays like PDAs etc.

3 Results

The PATRES system comprises these four components:

**PATRES Viewer**: This application is used for converting ECG data from other ECG data formats in an own XML-based data format. After conversion, segments of the ECG data can be labelled with one of the predefined rhythm categories. Currently the following rhythm types are available: “VF”, “VT”, “SVT”, “NSR”, “Asystole”, “noisy ECG”, “pathological ECG” and “ECG after defibrillation” (Fig. 2).

**PATRES Editor**: This application is used for the programming of the resuscitation scenarios. New states can easily be created, moved, deleted and linked to each other in a drag-and-drop manner. The assignment of a specific ECG rhythm to one state is done by choosing the most appropriate rhythm from a list of data records holding a segment of the desired rhythm type. Also, the two conditions for state changes, a timeout and a maximum count of detected shocks, can be assigned to each rhythm state.

**PATRES Simulator** (Fig. 3) is the main application and can load pre-programmed scenarios, play them on- and offline (i.e. transmitting the ECG data to the output hardware or not) and automatically react to shocks reported by the output hardware, switching the scenario states if necessary. The scenario tree itself is also displayed and the current state is high-lighted, to give a good overview how the training proceeds. A third feature is a variety of event buttons, which allow for the quick documentation of relevant events (like “starting chest compressions” or “infusion needle in place”), from which an overview of the resuscitation process can be derived for later discussion. Timeouts and shocks are automatically logged.

**PATRES ECG output hardware**: This hardware is shock-proof for use with mono- and biphasic defibrillator output stages and can withstand shocks with energies up to 360J at a frequency of three shocks per minute and can detect shocks down to 15J. It measures approximately 12.0cm x 6.5cm x 4.0cm.

4 Discussion and Conclusions

The PATRES system is a complete suite of software tools that enable resuscitation instructors to program elaborate scenarios for most realistic trainings. The wireless communication and universal output hardware make up a very a flexible system for use with virtually any available defibrillator. The PATRES system has already been tested several times by resuscitation instructors with very good feedback. Future developments will mainly concentrate on the development of data converter modules for different ECG data formats and porting the Java-based simulation application to PDAs.

5 Literature

