DESIGN AND REALISATION OF A FRAMEWORK FOR DEVICE ENDCOMMUNICATION ACCORDING TO THE IEEE 11073-20601 STANDARD

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Abstract

The standardization of communication between different medical and sports devices needs to be addressed in order to simplify their development and versatile integration. This paper deals with the design and realisation of a framework which would enable medical and sports devices to transmit, post process (biosignal analyses) and store (statistics and trend) measured data according to the IEEE 11073-20601 standard. The first use of the framework is to handle the communication of a temperature sensor that can be used to monitor patients under hypothermic therapy.

1. Introduction

A core requirement for newly developed medical and sports devices is their interoperability with other equipment for exchanging information. To fulfil this requirement in the context of device end-communication, the IEEE 11073-20601 standard has been established. This standard aims to ensure data transfer between different types of medical and sports devices through a standardized data structure, data presentations capabilities and functionality needed for the data transfer [3].

By introducing the IEEE 11073-20601 standard into the health care sector, future applications could not only be the exchange of information between Agent and Manager, but also the forwarding of data to a Hospital Information System or a scientific database.

In addition to a standardized protocol for transmitting measured values from the medical or sports device (Agent) to a computer-based system (Manager), our framework allows for the inclusion of an analysis tool and software I/O interfaces to communicate with data bases. The analysis tool allows users or Agents to forward raw measurement data packages to be analyzed in terms of peak detection or to use signal processing features like low-pass filtering. The I/O interface is needed to read previously recorded biosignal data of already existing databases and to convert the data in compliance with IEEE 11073-20601. Afterwards the standardized data is transmitted to the analysis tool or to a standard conform Manager (e.g. graphical user interface).

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A new approach to out-of-hospital emergency care after cardiopulmonary resuscitation is to cool the body of the patient down to a certain temperature – induced hypothermia. This can be done by using devices which reduce the patients' body temperature. The aim of this procedure is to slow down metabolism, and this is supposed to minimize brain damage caused by a lack of blood circulation.

By using the developed framework, it will be possible to start recording the patient's body temperature when the induced hypothermic therapy is started as a part of local first aid. These measurements are continuously monitored and stored until the casualty is transferred to the emergency ward of the hospital. At that point, it will be possible to transmit the temperature values to the software systems of the hospital by using the Import/Export features of the framework.

Storm et al. [6] has stated that treating patients after cardiopulmonary resuscitation with mild hypothermia can significantly shorten the length of intensive care unit stays and their ventilation time. In addition, the long-term neurological outcome and the one-year survival rate has shown improvement. In contrast to these results, the group around Bro-Jeppesen [1] has shown that, apart from the improvement of the Cerebral Performance Category for people with out-of-hospital cardiac arrests who were treated with therapeutic hypothermia, no other improvements could be found in long-term observations, i.e. no improvement in the mini-mental state examination, the survival rate, the cognitive state or the quality of life.

This project is based on the results of a previous project [2]. The goal of the previous project was to develop the first use cases for communication in compliance with IEEE 11073-20601. The results were prototype systems applicable for weight measurement, temperature measurement, acceleration and inclination measurement in compliance with IEEE 11073-20601 and the required device specifications.

The framework developed during this project should provide easy implementation into medical and sports devices developed at the University of Applied Sciences Technikum Wien, as well as documentation for study programs at the University of Applied Sciences Technikum Wien.

2. Methods

The IEEE 11073-20601 standard only affects the communication between Agent and Manager. The shown framework infrastructure was our extension of the standard to implement an environment which also enables the information interchange, e.g. between a database and an analysis tool.

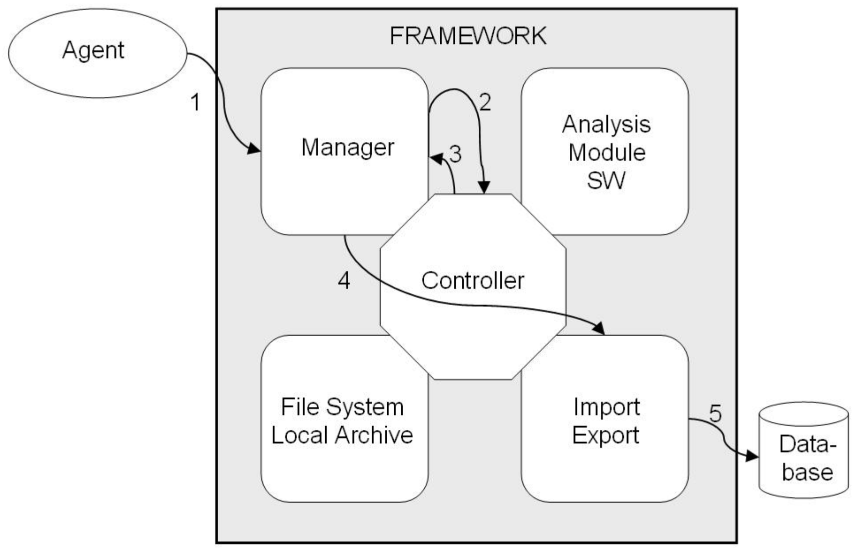
The framework illustrated in *Figure 1* consists of five main modules. The core module of the designed framework is the *Controller*. The Controller conducts the information flow within the framework, i.e. the Controller determines which two modules should establish an association. To comply with this requirement the Controller needs to be aware of the included modules at all times and requires a decision tree for selecting the right modules depending on specific attributes (Device-ID, Config-ID, …).

The *Manager* is the interface between framework and medical and sports devices. According to the IEEE 11073-20601, the Manager can elicit or receive data from the Agent when both Agent and Manager are in an operating state.

The *Analysis Module* is included to perform filtering processes (high-pass, low-pass, band-pass) or to gain additional information from the underlying data. For a biosignal analysis, elements of the BioSig open source software library will be used [5].

The *Import/Export* module serves as an interface for writing or accessing data in a long-term archive. Temporary measured data can be stored in the *Local Archive*. The local stored data can be accessed rapidly and statistics and trends can be derived from that.

The modules of the framework and the data flow for the hypothermia use case are illustrated in *Figure 1*.



1…The clinical thermometer establishes a connection to the Manager that conforms to IEEE 11073-20601. When the operating status is reached, the measurement values are transmitted.
2…The Manager informs the Controller that data has been transmitted and forwards the received Device-ID. The Controller checks for the programmed follow-up procedure by means of the Device-ID.
3…After the Device-ID is checked, the Controller instructs the Manager to associate with the Import/Export module to store the measurement data in a database.
4…The Manager establishes a connection to the Import/Export module that conforms to IEEE 11073-20601 and transmits the previously received data from the Agent.
5…The Import/Export module receives the standardized data stream and writes the data into the database after parsing.

Figure 1: Modules within the framework and pathway for hypothermic use case

3. Results

During this project a concept for a controller was developed which was able to connect to all the other components of the framework and handle the tasks of shifting data from one point to another. Important additions are signal processing software modules with Agent and Manager capabilities. Furthermore, the connection to the long-term archive is conceptualized that will enable long-term storage for signals and other measurement results.

The signal processing module may be implemented for different purposes: one example is filtering noise out of the signal. The other is a peak detection algorithm which is used to derive the heart rate out of the pulse oximeter's curve. In addition, the newly derived data can be stored in the local or long-term archive.

With the developed framework and the documentation it is now planned to implement a system that will support the hypothermic use case described above.

4. Discussion

In this work first steps were undertaken to develop a framework for building standards-based interoperable healthcare networks with speed and flexibility. The framework will shorten the development process for medical devices and sensors that conform to the new standard. It will also support additional functions like data analysis and long-term storage.

Due to the modular structure of the framework it is possible to implement additional protocols or interfaces with different databases. Within the clinical environment the import/export capabilities of the framework might be of special interest because this interface will make it possible to forward measured values of medical devices that conform to IEEE 11073-20601 directly to the hospital information system.

This flexibility is necessary to adapt systems for other applications when statistical information needs to be required. Body temperature, for example, is also necessary for the training of athletes. It has been shown that induced hypothermia before a competition has a positive effect on endurance performance in hot environments [4].

At the American Orthopaedic Society for Sports Medicine 2008 Annual Meeting, a study was presented showing that American football players have a lower body core temperature and a significantly lower heart rate when cool, dry air is blown underneath their uniform. This can reduce the risk of heat stress and their – sometimes – lethal consequences [7].

A standardized communication protocol will provide benefits for these and other use cases. Other vital parameters of athletes may be measured by adding hardware modules. Additional analysis modules may provide algorithms as the need arises. Implementation work has started, and we expect to be able to demonstrate many of the described functions before summer 2009.

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