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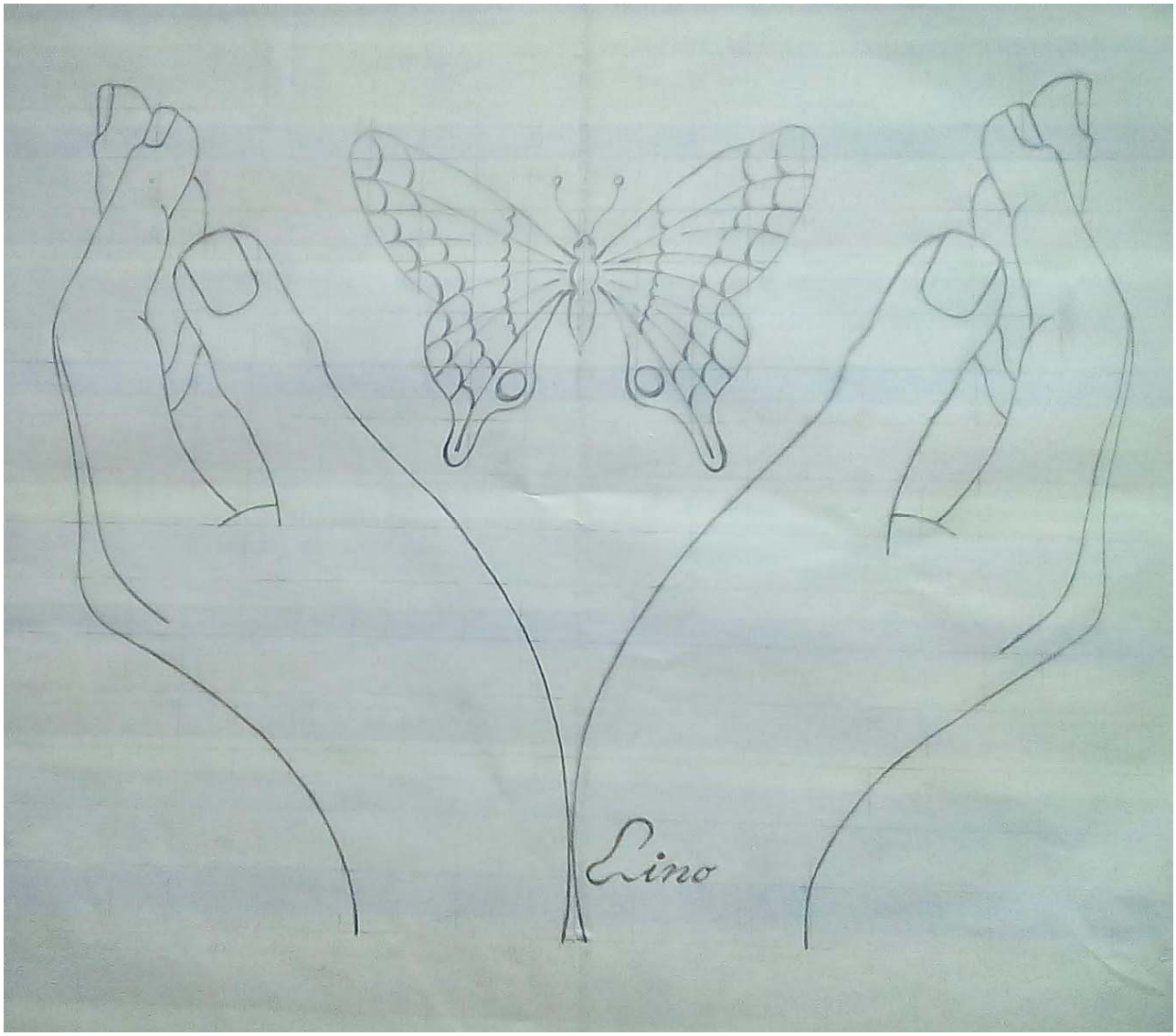

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INDICE GENERALE

LETTER TO THE EDITOR:

New device for the remote control in elderly patients.

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KEYWORDS: HRV Analysis, Telemedicine, Healthcare.

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LETTER TO THE EDITOR

The growing diffusion of wearable devices capable of measuring physiological parameters and the new possibilities offered by cloud computation are opening new scenarios for modern Healthcare and Medicine, allowing the continuous collection of huge amounts of data and their process in almost real time. This availability of an enormous quantity of information poses a new threat to physicians, because examining directly all this information often would not be possible because the flow of the information arriving to the system would be greater than the information a person can process. A possible solution is the automatic processing of the data, with algorithms that identify anomalies and notify the doctors, who can then analyze these data for their diagnosis.

OMNIACARE platform has been used to develop an automatic analysis process that analyzes ECG data on the cloud in real time, provides RR patient data slots on the 24 hours and performs the initial automated HRV analysis. In case of anomalies, doctors can manually examine each HRV slot, eventually alter the processing parameter and require a new analysis, upon their experience.

OMNIACARE is a hardware/software system developed specifically for the social welfare and healthcare sector, providing tools and functionalities for frail people and their caregivers.

The system uses advanced technologies that allow constant monitoring of the health status of the senior or frail users. Thanks to it, caregivers and health professionals are able to provide remote assistance, checking the situation at any time, receiving warnings in case of alert situations and being able to communicate directly with their cared.

The complete solution makes use of a wearable chest belt that can acquire ECG data H24. The data are transmitted to OMNIACARE Cardio App which sends then as a continuous flow to the OMNIACARE Cloud server, using the MQTT protocol. A specific OMNIACARE module for HRV analysis had been developed using cloud computation in order to offer a real-time hearth monitoring service to doctors for their diagnosis.

From the device we can obtain also a record of breath frequency, position and activity level; then in the day we have the possibility to have not only the ECG abnormalities (arrhythmias or conduction's defects) but also the neurovegetative assessment during the normal activity and the body performances.

However, the major effort of the project was to build signal analysis software.

Below we illustrate the complete architecture of the software with a description of its potential for use.The data transmission interface is designed to be Device Independent, being able to acquire ECG data from several devices, through the MQTT protocol. It is possible to develop specific modules for new devices, in order to have an input data flow with a common structure. The modules used for cloud processing have been designed to be Cloud-Agnostic, so that they can be implemented on any cloud vendor. The above data pipeline processes the ECG data flow in real time, extracts the RR data and also performs calculation of Tpeak to Tend interval [TpTe]. Prolonged TpTe has been associated with increased risk of mortality in congenital and acquired long-QT syndromes, so it's an important indicator for specific pathologies. This is still an experimental feature and has limitations, the determination of TpTe is possible at the moment only on ECG with a well-defined wave structure. The algorithm is being refined in order to increase accuracy and extend applicability.

Regarding the RR flow, it is calculated splitting the overall flow in slots of 10 minutes recordings. Each slot is available for further processing by the doctors which can apply filters in order to remove artifacts due to signal spikes and apply the HRV analysis algorithms. This processing can be applied in real time, scheduled or on demand and can be applied to each of the time slots which could potentially cover all the 24 hours of the day. The first step of OMNIACARE HRV analysis is the filtering of the RR data, in order to remove the fluctuations that could be caused by changes in heart rate due to cardiac rhythm and by conduction disturbances. Arrhythmic beats and artefacts that are undetected during the ECG signal preprocessing can in fact seriously affect the power spectrum of the HRV. Therefore the series of RR intervals is analyzed to remove spikes and other artefacts [1].

The system uses a predefined set of settings which have proved to effectively remove spikes and artefacts without an aggressive manipulation on the RR source.
The set of filters includes a specific filter, developed by prof. A. Martynenko.
It is possible at any time for physicians to alter the preset values in order to have a better filtering for specific cases and execute a new HRV analysis. In the case, OMNIACARE marks this analysis as “validated from physician” in order to keep trace that it has been examined and validated by a doctor. It is possible to see both the original RR track (in blue) and the filtered track (in red) and the corresponding ECG track. The analysis evaluates several parameters in the different domains. Time domain analysis quantifies the amount of variance in the interbeat interval (IBI) using statistical measures. Time domain measures do not provide a means to adequately quantify autonomic dynamics or determine the rhythmic or oscillatory activity generated by the different physiological control systems. However, since they are always calculated the same way, data collected by different sources are comparable, if the recordings are the same length of time and the data are collected under the same conditions. OMNIACARE not only reports all most important time domain measures, but it performs the calculation of entropy (EnRE) using a robust estimation algorithm developed by prof. A. Martynenko which performs the calculation with a much higher precision than traditional algorithms [2]. Frequency Domain Analysis is a complex analysis technique that shows how much of a signal lies within one or more frequency bands (ranges) that tend to correlate with certain physiological phenomenon, such as Parasympathetic nervous system activity.
In particular the LF/HF Ratio is often considered indicative of Sympathetic to Parasympathetic Autonomic Balance.
The Poincaré plot analysis provides a geometrical and nonlinear method to assess the dynamics of HRV.Last analysis are Nonlinear and Time Frequency.
Nonlinear analysis methods differs from the previous methods because it does not assess the magnitude of variability but rather the quality, scaling, and correlation properties of the signals. So it is related with the unpredictability, fractability and complexity of the signal.
Time-frequency analysis is commonly used to investigate the time-related HRV characteristics. An alteration of the autonomic regulation resulting in a change in mean heart rate induces a transient component in heart rate, which, with any analysis method based on signals from multiple beats, results in the apparent spread of the spectrum of frequencies.

OMNIACARE, thanks to the automatic execution, can automatically elaborate the HRV analysis and provide the reference parameters for patients for the whole day and can automatically notify to physician situations that could potentially related to hearth problems.

It also allows to have a single report with all the results together for a general overview, allowing single physician to check a high number of patients in a long monitoring interval. The parameters evaluated with the HRV analysis should allow the physician to have a clear view of a patient heart status, but could not cover specific cases where a customized in-depth analysis is needed. To cover those cases also, OMNIACARE allows to export the RR data to external system in CSV format, which can be imported in external programs or directly used in a worksheet.

Conflict of Interest: none declared

FIGURES

Fig.1. Data acquisition and transmission

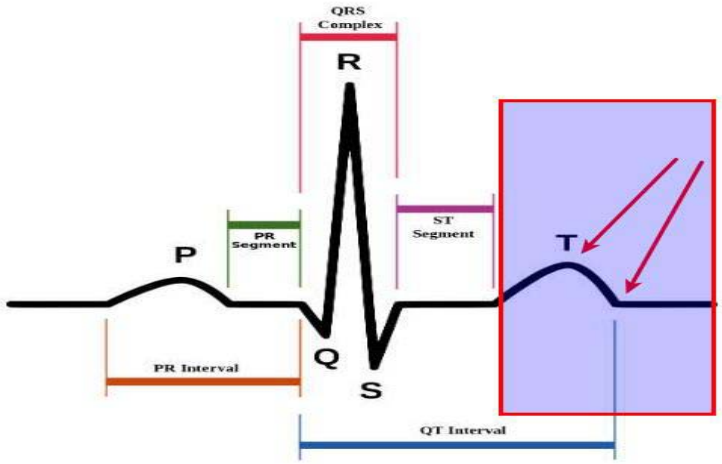

Figure 2: Descritpive representation of EKG analysis

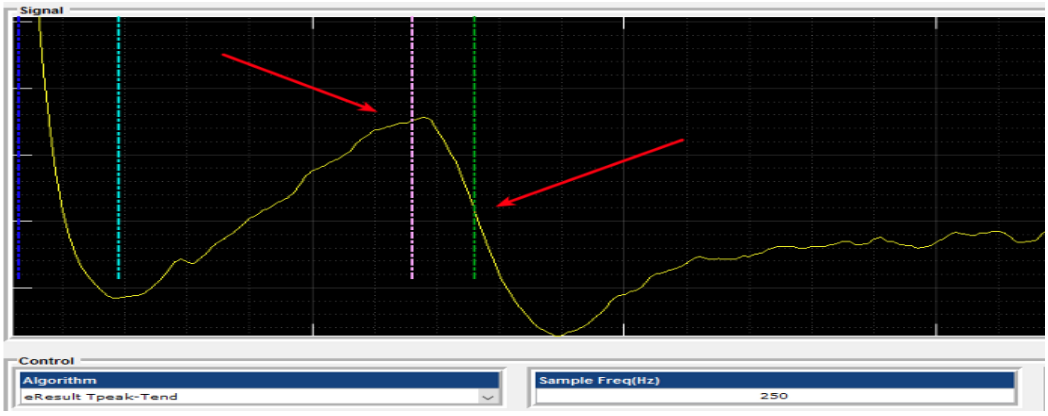

Figure 3: Real-Time representation of EKG analysis

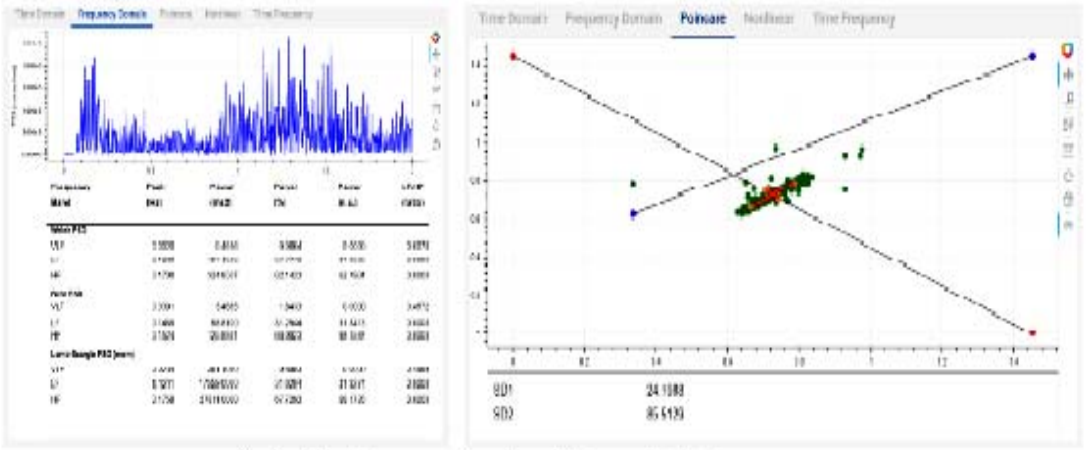

Fig. 4a - 4b: Frequency Domain and Poincare Analysis

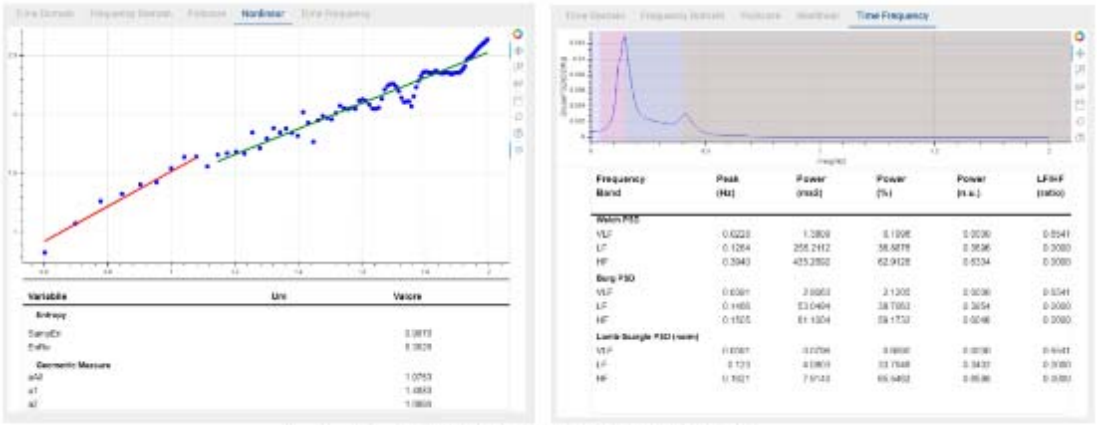

Fig. 5a - 5b: Nonlinear and Time Frequency Analysis

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