THE CHALLENGE OF ACCURACY:

COMBINING OPTICAL SIGNALS WITH ALGORITHMS IN A WEARABLE MEDICAL DEVICES

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Starting with newborns and up to the elderly not remembering their own name and age, the hospital identification bracelet is the ID card of every patient.
It stores information such as the patient's name, age, sensitivities to drugs or contagious disease potential, However, it has no part in assessing clinical state, let alone alerting physicians in real time on any emergency.
Remote digital health is moving forward at a fast pace. Demand is growing for wearable devices that will allow continuous monitoring of body metrics.

The good news is that we already have the technology for monitoring heart rate as accurately as ECG, as well as detection of arrythmias as atrial fibrillation or life-threatening situations as cardiac arrest.
These abilities along with blood pressure monitoring, respiratory rate and oxygen saturation level provide a wearable monitor-like capability.

Developing this type of technology relies on a precise combination of algorithms and sensors, which allows continuous and long-term monitoring of vital signs.
We implemented optical and mechanical sensors in a medical watch designed to monitor changes in the blood volume in peripheral blood vessels and collect information continuously.
The unique algorithmics are designed to verify the reliability of the information and provide accurate individual data. The end result is a measurement of vital signs at the level of reliability and accuracy of a hospital monitor.

Error free, clean Information

The basic signal from which essential metrics are extracted is called PPG (Photoplethysmograph).
PPG is an optical signal, which tracks volume changes in the peripheral blood vessels by the absorption profile of light projected on tissue.
The light source illuminates on one side and the sensor captures the light reflected from the tissue.
This allows formulating a real-time profile of the change in the blood vessels volume that enables accurate pulse measurement and raise a timely alert of cardiac arrhythmias.

While most such devices are based on light projected from LED passing through the tissue and absorbed by a photodiode located on the other side, our technology is based on light reflected from the tissue to a photodiode located on the same side as the light source.

This unique optical design takes into account the optimal wavelength and best spatial configuration for a noise-free signal. This signal is the input to a chain of algorithms created to verify reliable and reproducible information that is not corrupted by motion artifacts.
Therefore, the ability to produce information free of the noise which leads to erroneous results, stems from using additional sensors and integrating the information collected from all of them.

The optical sensor is joined by a sensitive mechanical sensor, designed to detect small movements and cancel out their effect on the PPG signal. Figure 1 shows the source signal obtained from the optical sensor and finger movements affecting the signal.
This fine motion is not detected by standard accelerometers, but this mechanical sensor is highly sensitive to small movements and therefore provides a more accurate measurement.

The clean optomechanical information obtained from the sensors undergoes simultaneous real-time analysis by dedicated computational algorithms, each extracting specific metrics, including pulse, respiration rate, blood pressure, and blood oxygen saturation. Additional algorithms detect arrhythmias, and even cardiac arrest.

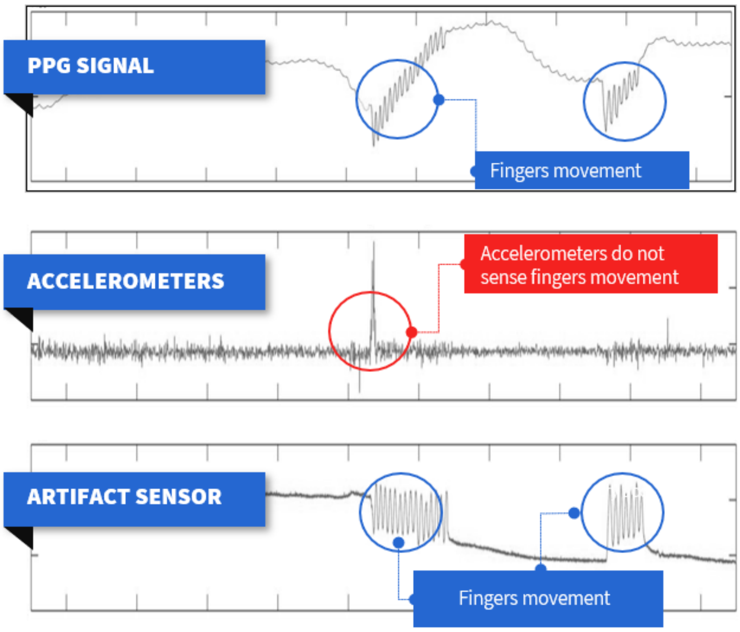

Figure 1. PPG source signal, noise detection capability by a unique mechanical sensor. These noises are not always detected by the familiar sensors, such as accelerometers

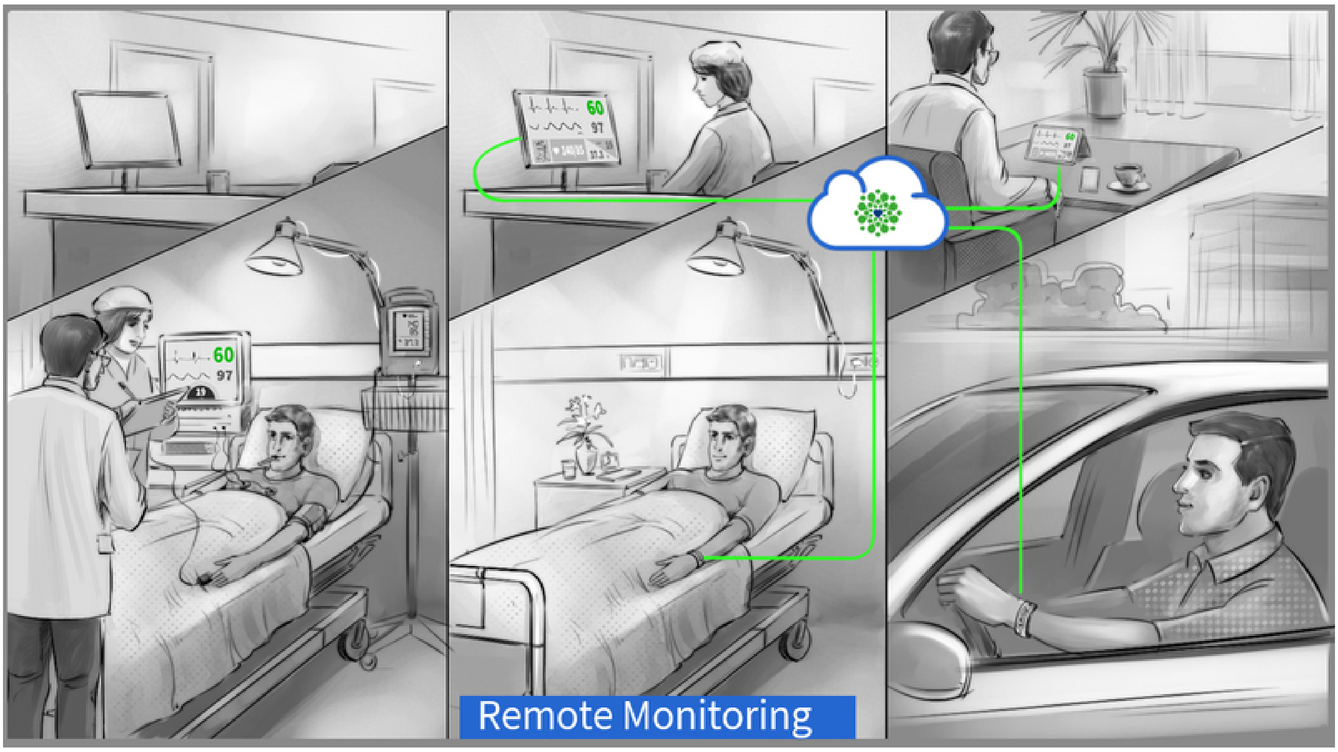

Figure 2. Connectivity to a Cloud from anywhere by wireless technology that enables monitoring and control at all times

The patient as a control point

The sensors' measuring is continuous, as are the calculations. More importantly, the technology enables continuous transmission of the data through a wireless WiFi network to a remote control point, which may be a nurse or a doctor.

This technology offers comprehensive monitoring just by wearing a watch or a wristband not much different from the identification bracelet currently used in hospitals. In fact, this watch not only contains all the data currently available in the hospital ID bracelet, but also displays vital signs as described. Thus, it obviates the need to connect patients to a stationary monitor, which limits them in terms of comfort and mobility. The medical watch will monitor the patient's condition without cumbersome devices or restrictions.

Moreover, the medical watch makes the patient a point of control, instead of the nurses' station, the doctor's office, the clinic or the hospital. This is the true meaning of Remote Digital Health. Such a medical watch allows monitoring and continued medical follow-up even after the patient is discharged from the hospital. This feature is expected to significantly alleviate current loads on health systems around the world, which always face budget deficits and difficulties in personnel management.

It will also help to cope with the shortage in monitoring units, which are designed to monitor patients during the period immediately after discharge from hospital, along with allowing long-term follow-up aimed to prevent clinical deterioration.
The current shortage in monitoring units leads to longer hospitalization for the purpose of supervision, and to repeated hospital admissions due to deterioration not detected in time.
Remote monitoring will fill the need for medical follow-up while allowing patients to keep their daily routine uninterrupted, in a comfortable environment which is less prone to infections.

If the COVID-19 epidemic proved one thing to the medical community, it is the need for technological development for real-time, individual medicine that is transparent to the patient, as opposed to remote, general discussions held by healthcare professionals.
The current pandemic has led to online appointments with HMO doctors, and has significantly expanded the use of biomedical technologies for monitoring and follow-up.

The right combination of dedicated optical sensors together with custom algorithmics integrated to a user-friendly wearable device will provide the patient's necessary vital monitoring in real time and alert his healthcare professionals before a life-threatening condition occurs.

Figure 3. The medical watch developed by CardiacSense is the only one that has proven in clinical trials that can monitor and track users' vital signs with an accuracy of 99%