INNO4HEALTH

Continuous monitoring for both patients and athletes

In healthcare, remote monitoring can lead to better outcomes for patients. In sports, it can optimise competition preparation and performance. Thanks to the ITEA project INNO4HEALTH (Stimulate continuous monitoring in personal and physical health), unified approaches to continuous monitoring now exist for both groups.

The challenges of physical preparation and recovery are now known to be similar for patients and athletes, opening up opportunities for continuous health and fitness monitoring across both domains. Unobtrusive monitoring is currently migrating to smaller forms, such as smart wearables, which creates fresh challenges in areas like energy consumption and communication. However, if realised efficiently, remote monitoring could provide greater insights to patients, clinicians, athletes and coaches for improved recovery and performance.

INNO4HEALTH aimed to stimulate innovation in continuous health and fitness monitoring with two main goals: (1) informing patients and their treating physician of their readiness for surgery and ability to recover from invasive treatment and (2) using the same technology to provide information to athletes and their coaches to help them optimise their performance during competitions. While the project's innovations have taken a wide variety of forms, the underlying commonality lies in taking sensor data, extracting key information, and providing clinicians and coaches with a productive means to apply this in the situations affecting their patients or athletes.

Technology applied
From a technical perspective, INNO4HEALTH applied hardware and/or software innovations to six pilots:
1. Cognitive preparation of athletes

2. Screening for sudden cardiac arrest and monitoring functional capacity of patients and recreational athletes
3. Recovery monitoring in claudication, venous ulcers and diabetic foot patients
4. Recovery monitoring after orthopaedic surgery
5. Holistic preparation for football competition and management of athlete recovery after injury
6. Sleep analysis and support application for a healthy life

This resulted in demonstrators that are being used to develop new products and services or improve existing offerings. Regarding hardware, the consortium focused on wearable devices for electrocardiogram (ECG) analysis of the heart, inertial motion units (IMUs) to collect motion data, and insoles to collect physiological data from the feet. The software developed included a data collection platform and mobile apps for sleep tracking, wearable device

management, and cognitive preparation for athletes.

The intersection between these technologies and domains can be illustrated with two examples. Firstly, WISEWARE developed hardware to monitor aspects such as gait and foot temperature. Sensor data is transmitted via Bluetooth and Wi-Fi to a processing platform, where it is interpreted to extract relevant physiological information. This is visualised in a user app or accessed by healthcare professionals for remote monitoring and analysis. Secondly, Karel developed a button-like device that can be placed anywhere on the skin and measures muscle strength. This is coupled with a docking station that offloads the device's data, saving

< INNO4HEALTH's remote monitoring solutions

the energy that would be expended by sending information in real time. Both of these innovations work with open ecosystems and are equally applicable to healthcare and sports, demonstrating the project's broad scope.

Making the difference
Prior to INNO4HEALTH, no solutions existed for unified patient and athlete monitoring. The project is therefore at the forefront of a shift from closed systems

– in which companies own sensors, algorithms, gateways, apps, and cloud infrastructure – to open systems through standard interfaces. This enables devices to be interchangeable across applications and encourages the sharing of data and algorithms, thereby reducing the costs of remote monitoring for end-users and improving the quality of products and services through collaboration. This will also allow smaller companies to expand their business in markets that are traditionally gated, such as the global remote patient monitoring market – projected to reach USD 117.1 billion by 2025 at a CAGR of 38.2%.

Given INNO4HEALTH's dual focus, consortium members are also uniquely positioned to exploit the same results in distinct domains. Work is now ongoing to turn the pilots and demonstrators into products and services. For instance, Philips has developed an Outpatient Monitoring Study Kit that incorporates the common functionality of remote monitoring applications for healthcare and sports via a communication hub at home. This collects information from devices and broadcasts it to the cloud for storage, serving as a generic platform in terms of storage, triggering mechanisms and safety mechanisms but offering application-specific processing and visualisation via a dashboard. This platform has been tested in clinical studies and will be adapted into a service that is open and extendible with regard to monitoring devices, algorithms and applications.

Finally, INNO4HEALTH has improved the state of the art in some areas and created an excellent foundation for future research in others. ECG signal quality, for instance, formerly degraded after three or four days but the project has increased this to more than seven days. This continuous monitoring over a week is crucial to detecting sporadic arrhythmias, potentially saving lives. Such results have benefited from the active involvement of university partners in dissemination, with 47 scientific contributions so far. This significantly boosts both knowledge sharing and the legitimacy of the project's innovations, helping to ensure a lasting impact for INNO4HEALTH.

Major project outcomes

Dissemination
> About 10 publications (e.g. European Heart Journal, PAAMS'22, MDPI Sensors).
> More than 35 presentations at conferences/fairs (e.g. an exploitation event at the ELIS Innovation Summit Eindhoven).

Exploitation (so far)
New products:
> SleepBell: an iOS mobile application combined with smart alarm that tracks and analyses sleep.
> A button-like device that can be placed anywhere on the skin and measures muscle strength. This is coupled with a docking station that offloads the device's data, saving the energy that would be expended by sending information in real time.
> Ankle band for offline long-term monitoring.
New services:
> A wearable ecosystem of sensors, user app and processing platform for venous ulcers diseases monitoring and reporting.
> Outpatient Monitoring Study Kit: A data acquisition & processing platform for home monitoring.
> A remote monitoring solution to guide athletes with cardiac conditions.
New systems:
> A platform for testing and training cognitive functions of athletes.
> A system for 24/7 remote monitoring of vital signs to promote player readiness for elite athletes, consisting of a device, an application, and a dashboard.

Standardisation
> 6 contributions to standardisation, related to patient tracking, wireless communication, and privacy.

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