Personal Decision Support System for Heart Failure Management

MONITORING PHYSICAL AND PSYCHOLOGICAL STATE

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 689660.
18 months after its launch, the HeartMan consortium met with the European Commission officials and external experts to present the project’s key milestones and achievements as well as receive feedback on the work ahead. The three external experts were very positive about the progress made so far and provided their recommendations, which mainly aimed at ensuring a successful commercialisation of HeartMan.

The recommendations included a careful consideration of who exactly the target end-users should be, as well as further involvement of patients in evaluating some of the system’s elements. It was also suggested to minimise (the need for) medical professionals interaction with the system as these may not be always willing to do it, and to develop a strategy for integrating HeartMan into healthcare systems.

Continuous blood pressure estimation

Taking into account that blood pressure is a significant indicator of the overall state of health and safety of chronic heart failure (CHF) patients, and one that needs to be checked before initiating any form of physical exercise, patients are likely to benefit from an easier and more comfortable measurement means than the traditional monitoring devices (inflatable cuffs).

With this in mind, the HeartMan partners reviewed available literature on photoplethysmogram (PPG) sensors (i.e., sensors that allow for an optically obtained volumetric measurement of an organ) and their potential role in measuring blood pressure. However, while today’s PPG sensors are able to register changes in blood volume (and thus indeed provide some information about blood pressure); they cannot be used to estimate the patients’ blood pressure.

The HeartMan consortium has therefore developed its own sensor for the wristband, which uses the PPG signal as input, ‘cleans it’, extracts several features describing its shape, and feeds the features together with the signal into a deep neural network. The testing of the device using a real neural network (populated with a small amount of data from a specific patient) has so far shown very encouraging results. The partners are thus optimistic that they will be able to include continuous blood pressure measurements in the final HeartMan system.

IoTool

Many eHealth projects use IoT platforms. Usually they consist of a controller collecting different types of medical or environmental sensor data; a gateway to send collected data to the cloud; an automation machine (to decide how to process data or how to control devices); deployment modules; and/or a cloud where the collected data is stored and analysed. Typically, these platforms are complex and only work with supporting devices that connect directly to internet and/or need additional processing power. As such, some manufacturers would rather use a smartphone as a gateway to collect data from devices and to send these to the cloud, often using a proprietary protocol which only works for their own devices. The advantage of using a smartphone is that it fits well with user’s ability and level of comfort with their smartphone.

IoTool is a solution that uses a smartphone as a data collector, as a dashboard, as a controller, and as a gateway to synchronize data to the Cloud. An IoTool API helps developers make customised solutions in a fraction of the time and cost than what is currently needed.

HeartMan therefore uses IoTool as an instrument to connect sensors, patients and doctors.
HeartMan Mobile App in progress!

The HeartMan developers are currently building the graphical user interfaces for both the mobile app (for patients) and the web platform (for caregivers). The applications are being developed and continuously improved following agile (software) methodologies thanks to close interaction with users. Watch this space for more details and updates on the HeartMan’s mobile app and web interface!

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Health data management

In today’s healthcare systems, it is important that different technology systems and software applications are able to transfer and receive data, as well as effectively use them. Therefore, the HeartMan system collects, processes and normalises data coming from varied sources, such as clinical data coming from the Hospital Information System (HIS), Decision Support System (DSS) notifications, wristband and other sensors, in order to send notifications to the patients to effectively manage their disease.

The integration component implements FHIR (Fast Health Interoperability Resources), an improved standard framework created by the Health Level Seven International (HL7). FHIR solutions, built from modular components (called ‘resources’), can be used in many contexts and shared easily and securely. At this stage in the HeartMan project, a first set of parameters from patients and sensors, such as heart rate, oxygen uptake, blood pressure and body weight but also notifications, have been modelled using different resources a server running an implementation of the HL7 FHIR specification.

Update on HeartMan’s Psychological Support

In the previous newsletter, the HeartMan consortium presented the innovative task of a semi-structured phone interview between an informal caregiver (family member) and a patient to assess automatically the psychological profile of the patient. Since then, we have developed a first prototype to interpret the psychological status of the patient. This prototype is based on artificial intelligence and analyses speech and physiological parameters.

A wearable, in the shape of a chest belt, was used to collect physiological features, such as heart rate and heart rate variability, to estimate the autonomous nervous system’s reaction to emotional and cognitive states. In addition, a microphone embedded into the smartphone recorded patients’ speech during a weekly call and registered the relevant prosodic features (i.e., intonation, tone and rhythm). Preliminary findings showed an interesting correlation between the results of the selected features and those of the patients’ self-assessment (done via psychological questionnaires). Given the positive initial results, this method is being integrated with a second model of cognitive dissonance, based on the assessment of thoughts, beliefs and attitudes, through a dedicated questionnaire, and compared with the weekly progress in physical exercise and nutritional habits.

The overall psychological model will assess possible changes in psychological status week-by-week and provide an appropriate psychological intervention based on cognitive behavioural therapy (CBT) strategies. This approach acts on cognitive processes and unhealthy behaviours in order to improve adherence to the therapeutic regimen. Specifically, cognitive principles based on “Free choice”, “Effort justification”, “Cognitive consequences of forced compliance” will be adopted, aiming to restructure the patient’s belief in successfully managing CHF. Moreover, other CBT strategies such as shaping, prompting and reinforcing will be adopted to improve the behavioural response towards physical exercise and diet.

Exercises of relaxation and mindfulness will also be developed by the end of 2017 and will be offered to patients through the mobile application. These exercises will be based on biofeedback games (i.e., games that will respond to a patient’s feelings of anxiety or fear, for example), mindfulness messages and experiential audio files to make patients more focused on the present moment (thus softening feelings of fear and anxiety) as well as to help them better cope with their disease.

An example of a biofeedback game is illustrated in the figure below. The objective is to support patients to engage in physical activity with a view to improving their overall health and physical performance. By analysing the physiological features, such as the heart rate, as registered by the wristband, the game provides real-time feedback to the users. For example, when the game starts, all the planets revolve around the sun at a speed proportional to the level of excitement of the patient (indicated by the aforementioned physiological features). The goal is to help patients manipulate their psychological functions through the game. So in this case, by breathing slowly, patients will unconsciously/involuntarily trigger a reduction of their stress levels, which will in turn reduce the speed of the planets.
HeartMan clinical trial protocol

Starting in January 2018, 120 patients with heart failure will be recruited to participate in the HeartMan trial. The target patients are outpatients who visit their clinic or general practitioner on a regular basis. The treating physician will indicate which patients are eligible: those who have been hospitalised due to CHF; and those who are not: if hospitalisation happened in the preceding 30 days. During the medical appointment, the physician will briefly present the HeartMan project to the patient(s) and will ask about their interest in participating. A treating cardiologist may also directly contact an eligible candidate by phone, if the patient does not have an appointment scheduled in the near future.

If a patient shows interest, he/she will be asked to sign an informed consent form and return it to the clinic or doctor’s practice to undergo a baseline assessment. This assessment will consist of a questionnaire on a variety of topics (e.g., therapy adherence and quality of life), and a physical exercise capacity test. Following the baseline assessment, 40 patients (randomised) in the control group will continue to receive the standard care, while those in the intervention group (80 patients) will be provided with the necessary HeartMan instructions and equipment. The HeartMan intervention will be implemented from April 2018 and patients will use the system for a minimum of six months. At the end of the intervention, patients will undergo a final clinical examination, identical to the baseline assessment.

Human-centred design in HeartMan - an update

In the previous newsletter the HeartMan consortium outlined the first phase towards ensuring a human-centred design approach: studying patients’ and caregivers’ current situation to identify user requirements and creating a first conceptual design of the HeartMan system, which responded to the needs expressed by the patients and their caregivers.

The evaluation of different mock-ups provided further insights into the users’ needs and how to fine-tune the design of the HeartMan system to better meet them. For instance, the consortium learnt that even if many of the patients had never used a smartphone before, they quickly felt comfortable in using the mobile app. This led to making further changes to the app’s menu structure in order to improve the user experience. The evaluation also indicated which of the HeartMan features are most important to patients and caregivers and should therefore be more prominent (these were medication reminders as well as easy-to-read insights into one’s own physical and heart condition).

After having created and evaluated three iterations of the mock-up design, the consortium is now in the process of developing the mobile app for patients and a web interface for caregivers. Similarly to the mock-ups, patients and caregivers will be involved in evaluating the working mobile app and web interface so that any issues with usability can be identified and solved before the field trial.
Overview of HeartMan publications

Because the consortium believes in the importance of collaboration in science and R&D, we want to share our HeartMan research findings with the world. We do this for example by publishing results in scientific journals and by presenting our work at academic conferences. We are very proud that only half way through the project – we have already been able to share quite a lot of our work. Below is an overview of the scientific publications so far, which are available for download at the HeartMan website (under Downloads).

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<tr>
<th>Publication title</th>
<th>Consortium partners involved</th>
<th>Conference/Journal title</th>
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<tr>
<td>Hospitalisation Prediction from Telemonitoring Data in Congestive Heart Failure Patients</td>
<td>JSI</td>
<td>• International Joint Conference on Artificial Intelligence, Workshop on Knowledge Discovery in Healthcare Data and • Information Society multiconference, Workshop on Electronic and Mobile Health</td>
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<td>Application for Exercise of Heart Failure Patients</td>
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<td>Predictive Factors for Health-Related Quality of Life in Congestive Heart Failure: Systematic Review</td>
<td>UGent</td>
<td>European Public Health Conference 2016</td>
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<td>Predictive Factors for Mortality, Hospitalisation and Health-Related Quality of Life in Heart Failure: a Systematic Literature Search</td>
<td>UGent</td>
<td>European Journal of Preventive Cardiology</td>
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<td>Mapping the Health Technology Needs of Congestive Heart Failure Patients: User Needs vs. Feasibility</td>
<td>KUL</td>
<td>Pervasive Health</td>
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<td>Sexual health in heart failure patients</td>
<td>UGent</td>
<td>23th Congress of the world association of Sexual Health</td>
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<tr>
<td>Predictive models to improve the wellbeing of heart-failure patients</td>
<td>JSI</td>
<td>Artificial Intelligence in Medicine conference, Workshop on Advanced Predictive Models in Healthcare</td>
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