Executive summary
of the Semester Project for the 2009 GPR course

Version V06

Many real-life situations exist where humans should go through a physical rehabilitation program, for instance after bone injuries and fractures. In these cases, execution of the specification of the physicians should be strictly followed and executed, and the recovery condition and behavior of the patient must be supervised and controlled. Medical evidence proves that broken bones heal better when they are moderately loaded. Therefore, physical exercises are often proposed by physicians. For instance, in the case of a fraction of the collar of the femur, the patient must start walking carefully a few days after the operation.

But several things can happen related to the execution of rehabilitation programs. For instance, when a sportsman has suffered bone injuries, which prevented him from exercising for a long time, he may want to come back to the arena and take part in competitions. On the other hand, he is supposed just gradually load his body, and keeping this rule should be controlled. Or, if a common person has got leg bone fracture, he/she might walk too much and hard, or much less and less intensive than needed, not supporting his/her proper recovery this way. It may also occur that, though following the program correctly in the beginning, the patient may get bored or become lazy to do the necessary exercises, or may want to squeeze them into a shorter period of time. The patient should be monitored, and he/she should receive information about these deviations, as well as the physician, who can then give advices or even change the rehabilitation program.

The above explanation indicate the need for a product which would (i) monitor details of the patients behavior and measure specific characteristics, (ii) assess this information with a view to the specification in the rehabilitation program and recognizes deviations and possible problems, (iii) inform the patient about what he/she can improve or may do differently, and (iv) inform the physician about critical characteristics of the behavior and facilitate communication with the patient. In other words, it would be good to have a smart electro-mechanic device that could (i) measure the physical level of exercise (such as counting the steps), (ii) compare the registered data wit that has been set up by the physician in the

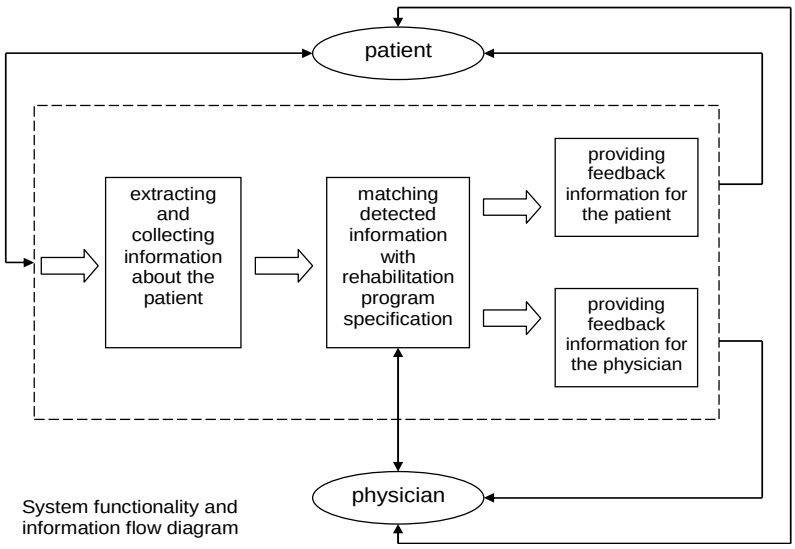

Figure 1 A functional scheme of the targeted electro-mechanic device

rehabilitation program, (iii) send timely and instructive information to the patient (e.g. to his/her laptop or mobile phone), and (iv) communicate with the physician, whenever there is a significant deviation from the optimal behavior. On the basis of this, the physician could also contact the patient to express either his/her satisfaction or dissatisfaction, and may initiate further action (such as inviting the patient to the hospital for a consultation or control). Graphical representation of these major functions of the target system (multi-functional electro-mechanic device) is shown in Figure 1.

This project should be completed in cooperation with the *UMC Utrecht*, which will also act as a mediator in between the company who can be considered as a potential manufacturer of the system and the student teams. Student teams are supposed to take into consideration various bone fracture cases (arm, pelvis, spine, foot, leg) and rehabilitation programs, according to the guidance of *UMC Utrecht*. The student teams are requested to realize not only the main functions in the electro-mechanic system (measuring, monitoring, reasoning, communication, etc), but also to design and work out the various physical and informational (cognitive) interfaces. The goal is to develop this solution in a way that it can be used in many countries and under all occurring practical circumstances.

The discussion between E-GPR stuff members and *UMC Utrecht* about the E-GPR 2009 course led to the formation of a problem, of a demand for a device which would help patients and physicians with the rehabilitation therapy. The main phases of the project executions can be as follows:

1. **Exploration and orientation**
   Investigate (i) the needs for control of the patients' behavior by consulting physicians and patients, (ii) existing structures of information flow in comparable situations (such as central controls of safety alarms), (iii) the infra structure of hospitals that will be concerned with such control systems. The analysis of this information will probably result in some pieces of missing knowledge and information, which should be explored or constructed by research activities which should be integrated in the product innovation process. This phase concludes with a concept for the system that provides the main function by fulfilling the posed operational, usability and business requirements.
2. **Detailed concept development**
   The students develop many different solutions according to the stated requirements, as approved by *UMC Utrecht*. Student should apply creative techniques and should intensively cooperate with the experts of *UMC Utrecht*. In the end of the conceptualization process, they have to pick up the best candidate and detail it to the level of physical prototyping. The concept to be prototyped should be chosen based on precisely formulated criteria.
3. **Detailing for prototyping**
   The students should work out the details of the whole system (based on the preferred concept) and its components. They have to model and simulate the functional components, work out the information processing workflow. The students work will be supported by some available part solutions which are provided by the manufacturer company and can be integrated into the whole system.
4. **Prototype fabrication**
   The students are requested to develop (partly) functional prototypes, and show and test the operation of the prototype. Technical drawings should be produced on the components to

be manufactured and sent to the company. Intense use of rapid prototyping technologies is envisaged. The components will be jointly realized by the manufacturing company and the universities, depending on the kind, size and complexity of the parts.

5. **Prototype assembly and testing**
   The students will assemble and test the prototypes during the E-GPR Final Workshop. They have to organize user tests too, and to check whether the collected knowledge was valid and correct. The workshop will take place at a location close to the Utrecht Medical Centre. In addition to the E-GPR Final Workshop, the students are required to disseminate information about the results and the course in the form of (i) conference papers, (ii) journal articles, or (iii) patents.

In Figure 1, the functionality of the active rehabilitation support device is shown together with the information flows between the device and the patient, between the device and the physician, and between the patient and the physician. The device is supposed to be an information collector, processor and transmitter in one, and as such a sort of midpoint of communication. It will consist of several sensor, digital processing, communication and mechanical components and modules. The first module has a function of gathering necessary information. This module represents some technical challenge due to the needed sensing and depends on the kind of information which should be provided. The second and other modules are more information processing and communication oriented. The second module analyses and matches the collected information with rehabilitation program specifications which are set by the physician. The third module provides feedback information to the patient and physician. The students should also consider the information channel (direct information connection) between patient and physician.

Figure 2 also puts the active rehabilitation support devise in interface and use contexts. The whole scheme actually represents the rehabilitation program management. The large block in the centre is the device to be designed, which is enclosed with dashed line in Figure 1. Before the use of the device physician sets the rehabilitation program specification. When patient starts using a device, a sensor arrangement start collecting information and forwards it to the processor of the device. The device then reasons, and if necessary, provides confirmative or

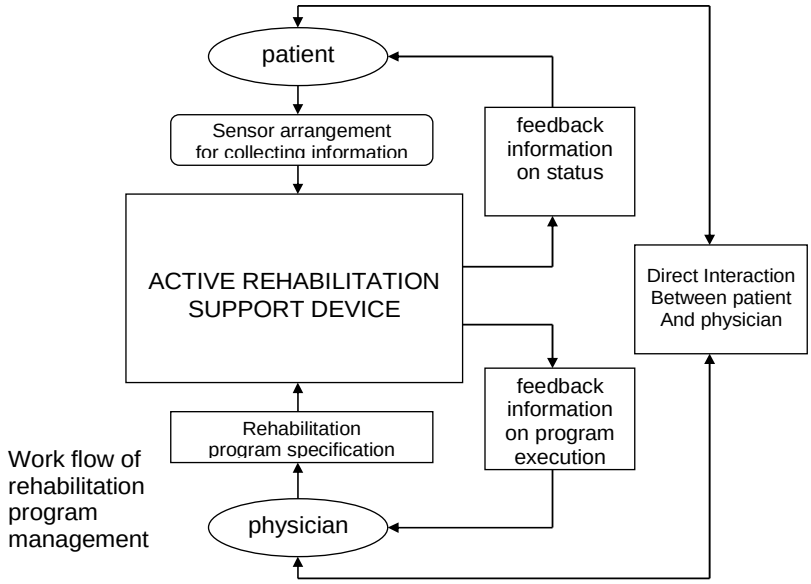

Figure 2 Work and information flow of the active rehabilitation support device

prescriptive messages to the patient, and status reports to the physician. This can be done by different media of communication, and in different time intervals, depending on rehabilitation program specifications. The direct interaction between patient and physician is still present and necessary for the rehabilitation process.

Technical aspects

Though the main focus of the project is on the electro-mechanical device for active rehabilitation support, couplings are made with standard rehabilitation devices, such as room bicycles, running belts and stepping pads. As long as there is a health care professional that wants to use these devices for telecare, it is fine. In a way these devices can be used as sensors. However, this option should not be enforced, but left open for the decision of the student groups (i.e. whether, after negotiating with the stake-holders, they intend to come up with such an option.

It seems that multiple companies may be involved in this project, in addition to the main contact institutions, *UMC Utrecht*. One of them is *Evalan* (an OEM company), and the other is *Protospace* (a FabLab company). Both of them cab deliver parts, services and expertise, based on agreements.

Evalan suggests using the following electronics board for communication and collaborative work: http://www.telit.com/en/products.php?p_id=3&p_ac=show&p=17. They have built up experience with it and can support the students in using it. Further more, *Evalan* has experience in setting up internet databases, programming algorithms for the databases and developing web interfaces.

Protospace is specialised in rapid prototyping and prototype engineering. They will fully contribute their service to the project. In addition, since FabLab is an international network, they have experience in working in video-conferencing environments, and might be able to provide internet-based lectures for the students.

UMC Utrecht has a far reaching experience in developing medical instruments. Most of the available expertise are in mechanical engineering and electronics. Clinical Physics is involved in providing clinical expertise. I am working to set up links with the rehabilitation department, but the first signs are vey positive. *UMC Utrecht* is negotiating with TNO Health and Sports to become a partner in the project as well.