

Proactive Assistance for Device-Integrated Training Adjustment in Outdoor Rehabilitation Training

Emrich, Andreas, German Research Center for Artificial Intelligence (DFKI), Germany
andreas.emrich@dfki.de

Leonhardt, Frederik,
German Research Center for Artificial Intelligence (DFKI), Germany
frederik.leonhardt@dfki.de

Werth, Dirk, German Research Center for Artificial Intelligence (DFKI), Germany
dirk.werth@dfki.de

Loos, Peter, German Research Center for Artificial Intelligence (DFKI), Germany
peter.loos@dfki.de

Introduction

The multitude and variety of information available through smart wearables enables intelligent assistance scenarios for rehabilitation training. Cardiac rehabilitation patients especially are worried to exceed their maximum heart rate. Especially outdoors training is problematic as patients have to deal with various dynamic factors such as weather conditions, terrain characteristics, etc.

This paper presents an approach for an intelligent assistance system that leverages data from ECG monitors and engine data from an engine-supported bike, a pedelec, and adjusts the engine power accordingly. The approach is evaluated with a field test at a large rehabilitation facility in Germany.

Methods

The concept is called MENTORbike and comprises a pedelec that is equipped with sensors for speed, pedalling cadence and pedalling load. A smartphone mounted to the MENTORbike captures this data and vital data gathered by smart devices such as heart rate, ECG, oxygen saturation level, blood pressure, etc. MENTORbike can either be self-sufficient for post-rehabilitation or be part of a group of MENTORbikes in a closed, stationary rehabilitation setting. In the latter case, a therapist rides along with a group of patients on the MENTORbikes. The therapist has a tablet that shows the current vital data of the patients in real-time and gives him/her the opportunity to adjust the training settings accordingly. Two major support mechanisms provide intelligence assistance in this scenario:

Engine power adaptation: A proportional-integral-derivative (PID) controller uses the patient's pedalling load as major input as it directly correlates to the actual user load and is not a derived measure such as the heart rate. With a weighted moving average, forecasts are made over the patient's route. By doing so, fierce slopes can be identified and historical data of the route and similar users can be leveraged to adjust the engine power even before a peak in the user load occurs.

Speed recommendations: As the power adaptation is naturally limited by the engine's capabilities (for MENTORbike it can support up to a speed of 25 kph due to safety reasons), speed recommendations can recommend the therapist to slow down with the group of patients. This can be especially helpful when very steep slopes are on the track or some patients willingly exceed their maximum pedalling load.

Results

The concept has been evaluated in a three month field test at a large cardiac rehabilitation facility in Germany. Four therapists and a total of 32 patients have performed daily training sessions with three MENTORbikes and a therapist bike equipped with a tablet in groups with up to 3 patients. As a primary evaluation metric, recall has been chosen. It comprises the percentage of situations in which a recommendation should be given. As safety comes first in our cardiac

rehabilitation scenario, we aimed at a recall of 100%. However, the field test has shown that the recall was 96.1 %. The outliers have occurred in situations, in which the ECG belt was not mounted correctly, a patient willingly exceeded the recommended power or a patient was already above the heart rate threshold without any physical activity. In the latter case, the respective patient has been excluded from the study afterwards.

Conclusion

The MENTORbike approach has proven to be an innovative solution for assisted physical training for rehabilitation patients. The evaluation has shown that rehabilitation patients can have a safe outdoor training experience that motivates them more than classical indoor cycle ergometer training. It is also an interesting approach for post-rehabilitation, in which patients could pursue personal physical training without the fear of overstressing their body. However, marketable implementations of the MENTORbike concept should come along with specific recommendations for exclusion criteria, cycle route selection and safety instructions.