Jožef Stefan Institute
Center for Technology Transfer and Innovation

TECHNOLOGY OFFER

NON-INVASIVE REAL-TIME CONTROL OF INNER BODY TEMPERATURE VARIABLES DURING THERAPEUTIC COOLING OR HEATING

Fields of use
Embedded Systems and Real Time Systems, Artificial Intelligence (AI), Applications for Health, Medical Technology/Biomedical Engineering, Physiotherapy, Orthopaedic Technology, Medical/health software, Therapeutic services, Other therapeutic (including defibrillators)

Current state of technology
Under development/lab tested

Type of cooperation
License agreement

Intellectual property
Patent(s) applied for but not yet granted, Secret Know-how

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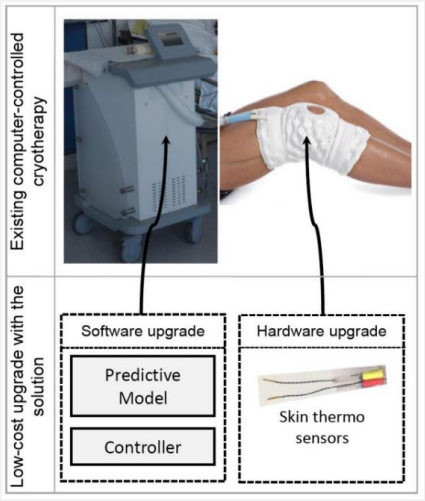
More information about the invention

Summary

A new method and a device for non-invasive real-time control of inner (hidden) body temperature variables during therapeutic cooling or heating which is not possible with today's classical cryotherapeutic devices. The solution allows for personalization of thermal therapy process to meet the demands of a specific patient and different therapeutic protocols.

Description of the invention

The patented solution is non-invasive real-time control of inner body temperature variables that are, for example, impossible to be measured non-invasively during therapeutic cooling or heating, based on the feedback for the individual patient's response provided by variables whose measurement is more feasible, i.e. temperatures on the body surface.



The method uses machine learning to construct a predictive model for estimation of the controlled inner temperature variable based on temperatures on the knee skin. The machine learning method uses data generated from computer simulation of the cooling or heating therapy for different input simulation parameters e.g. input signals, initial and boundary conditions, or any combination of them. A simple set of fuzzy logic rules constructs the controller that sets the temperature of the cooling liquid based on the predicted error between the desired and the predicted inner knee temperature.

The solution is an upgrade of the existing computer-controlled cryotherapy devices with pre-programmed protocols in terms of heat extraction intensity and treatment time, which is already in use for the purpose of thermal therapeutic treatments. The device upgrade includes small thermo sensors (thermistors) and a support mini on-board computer with very little additional cost.

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Clinical Study

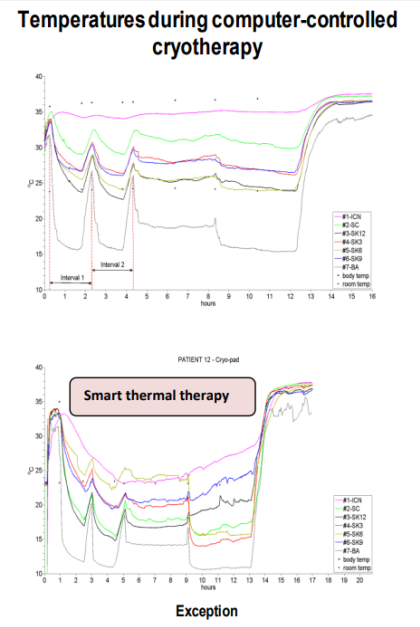
We performed long-term in-vivo knee temperature measurements with high accuracy on the skin, in the subcutaneous tissue and in the knee joint during cryotherapy after arthroscopic anterior crutiate ligament (ACL) reconstruction.

The study showed that the cooling is significantly more effective by computer-controlled cryotherapy than with frozen gelpacks. Moreover, another important finding of the study was that patients' responses to cooling differ considerably. Most of the patients with computer-controlled cryotherapy respond as in the upper figure, where the average measured temperatures are shown.

However, one of the patients is a significant exception, as evident from the figure below. The temperatures inside the knee in this case decreased significantly.

The result indicates that the cooling procedure preferably has to be controlled by feedback information from the cooled region, i.e. the thermal therapy should be controlled depending on the individual patient's response, which raised the need for "smart" or personalized thermal therapy.

None of the known approaches so far for thermal therapeutic treatment is able to perform such smart thermal therapy.



Publication of the clinical study: A. Rashkovska, R. Trobec, V. Avbelj, M. Veselko: "Knee temperatures measured in vivo after arthroscopic ACL reconstruction followed by cryotherapy with gel-packs or computer-controlled heat extraction" Knee Surgery, Sports Traumatology, Arthroscopy, 2013

The PhD thesis of Dr. Aleksandra Rashkovska concerns the practical implementation of the solution. The doctoral dissertation contains also the clinical study and the patent application.

At least two options for application are possible.

Low-cost upgrade of existing computer-controlled cryotherapeutical device with:

- two tiny thermo sensors (thermistors) placed anterior and posterior on the knee surface below the cooling pad,
- upgrade of the support mini on-board computer with a software consisting of the light-weighted predictive model and fuzzy logic controller.

New developed smart cooling device with:

- a controllable refrigerator for maintaining the temperature of the cooling liquid,
- cooling pad with circulating cooling liquid,
- two tiny thermo sensors (thermistors) placed anterior and posterior on the knee surface below the cooling pad,
- a mini on-board computer including software for cooling management and programming, with light weighted predictive model and fuzzy logic controller.

Main Advantages

The platform has the following advantages over the conventional CM and PHM systems:

- Non-invasive control of inner body temperature during thermal therapy.
- Controlled cooling procedure by feedback information from the cooled region of the body.
- Temperature measurements on body surface.
- Personalisation of thermal therapy to achieve maximal treatment efficiency.
- Simple implementation and easy to use.
- Cost effective upgrade of existing thermal therapy devices.
- More comfortable, more reliable and more efficient postoperative and post injury thermal therapeutic treatment with less complications.

Partner Sought

Rehabilitation and medical equipment manufacturers, especially in the field of thermal therapy for further joint development of the commercial application and licensing agreement.