FUSIMO

Patient specific modelling and simulation of focused ultrasound in moving organs

FUSIMO aims at developing a model for focused ultrasound surgery in moving organs, such as the liver. With support in planning of the intervention, monitoring of the treatment progress, as well as by assessing the therapy outcome, focused ultrasound can become a safe und successful non-invasive procedure for tissue ablation in moving abdominal organs.

Objectives of the Project

In recent years, High-Intensity Focused Ultrasound (FUS) under guidance of magnetic resonance imaging (MRI) has become a frequently applied means for non-invasive tumour therapy, e.g. in the treatment of fibroadenoma of uterus and of bone metastases. However, treating tumours in moving organs is still a great challenge due to several complexities.

FUSIMO will support doctors by predicting the processes involved in FUS therapy

Processes affecting the outcome of FUS therapy range from the movement of the target, the physiology of the organs down to the energy disposition in the tissue and the heat transfer within the body. To empower the physician to perform safe, effective and efficient ablation of tumours in moving organs requires technical support.

FUSIMO will establish a patient specific model of the relevant processes involved in the MR-guided FUS (MRgFUS) therapy to simulate the outcome of the therapy.

The benefits for the physician will include

- Assessing the feasibility of the intervention
- Predicting and optimizing the outcome
- Detecting potential risks and avoiding them
- Monitoring the progress and tracking deviations from the planned procedure.

Project Description

FUSIMO will develop, implement and validate a multi-level model for moving abdominal organs for use with FUS and Magnetic resonance-guided focused ultrasound surgery. The overall model will consist of several sub-models, which interact and describe aspects in a hierarchical manner. It will consist of:

- Abdominal organ model to simulate motion and the influence on ultrasound application. This model will include geometric structures of organs, muscles and bones relevant for the target region.
- Target organ/tumour model to capture organ/tumour physiology, and organ/tumour reaction to therapy
- Microscopic tissue model to simulate direct heat ablation, model energy distribution, tissue heating and cooling
- Model to evaluate first steps to simulate drug delivery, microbubble distribution and dynamics

This generic model will be individualized to the patient under treatment. Therefore, means for extracting relevant parameters to describe the patient-individual model characteristics will be developed.

The FUSIMO developments in the field of hardware and software will be combined into an integrated system, which will allow for abdominal FUS application to moving organs, as well as other treatment modalities such as radio frequency, laser or cryotherapy or other types of interventions based on high energy particles or fields in radiation therapy.

A particular emphasis in FUSIMO will be put on evaluation and validation of the model in both phantom ex vivo, soft embalmed human cadaver and animal studies. An existing abdominal ultrasound application system will be extended and motion-tracking capability will be integrated.

Therapy monitoring and outcome prediction will be compared to the physical lesion produced by FUS. Safety and workflow considerations are integrated in the project right from the beginning to allow smooth incorporation.

Practical Example

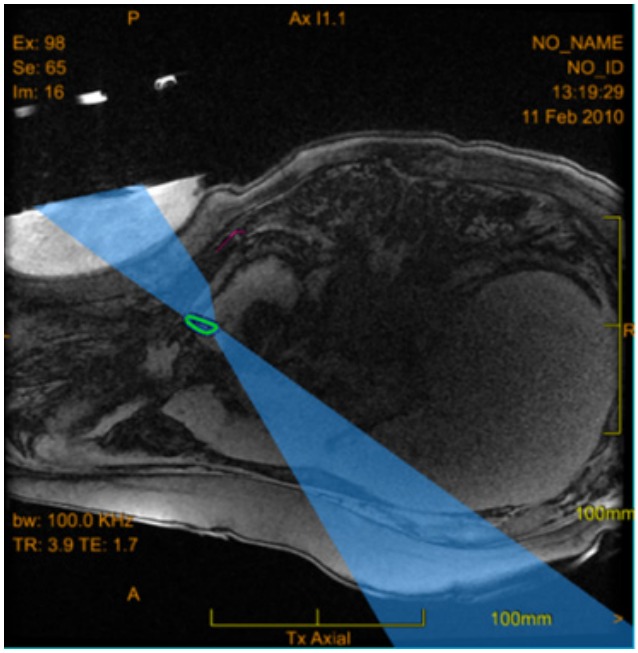
Liver cancer and liver metastases are among the most prevalent types of cancer. Unfortunately only about 30-35% of the patients suffering from liver cancer are suitable for surgical resection of the lesion. An alternative treatment is the thermal destruction of the tumour by heat, which can be induced by focused ultrasound (FUS). FUS therapy is non-invasive as it allows for heating of the tumourous tissue deep inside the patient's body without possibly harming healthy tissue. In the liver, however, the location of the tumour is difficult to reach due to the rib cage, lungs and intestines. Another major challenge is the motion of the abdominal organs as the patient breathes. With the support of the FUSIMO system, the attending physician is able to decide on the feasibility of the procedure. Simulating the procedure beforehand and obtaining information about the thermal effects on the tissue, the physician determines how the procedure can be conducted safely and successfully.

Expected Results & Impacts & Preliminary Results

The expected outcome of the FUSIMO project is a demonstrator software that incorporates the validated multi-level models for FUS application in moving organs. This software demonstrator shall support the physician in planning, monitoring and assessing the outcome of a FUS procedure in moving abdominal organs and therefore facilitate the use of MR-guided FUS. In fact, the results obtained in FUSIMO will have the potential to make FUS treatment in the abdomen a competitive alternative to the surgical gold standard.

FUSIMO's patient specific models will have a great capability for translation to other organs and different types of tumour treatment. In principle all thermal therapies like radiofrequency- and laser-ablation, as well as targeted drug delivery and radiotherapy applications can benefit from the organ- and motion-models created in FUSIMO.

The long-term impact of FUSIMO lies in improving the treatment of cancer and metastases in a variety of organs and for a wide range of patients. This will contribute to substantially reducing the estimated 1.7 million deaths in Europe each year. The reduced side effects (compared to conventional surgery, systemic chemotherapy and radiation therapy) of the MR guided focused ultrasound surgery and targeted chemotherapeutic drug delivery will reduce complications and consequently lead to a higher quality treatment of the patients at lower financial demand for health insurance and social welfare.



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- InSightec Ltd. (Israel)
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Clinical application, Medical image processing and analysis, Modelling of physiological processes, Patient Safety, Personalised health