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TRANS-FUSIMO – A novel system for treatment support for FUS applications in moving abdominal organs

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Background: FUS treatment of abdominal organs like the liver is challenged by the target's breathing motion and its occlusion by the rib-cage. In the EU project TRANS-FUSIMO (www.trans-fusimo.eu) we developed a software system that connects to a FUS transducer and an MRI and allows for real-time beam steering in order to conduct safe, effective and efficient ablation of tumors in the moving liver.

Methods: The TRANS-FUSIMO treatment system (TTS) includes a real-time motion compensation pipeline which runs during a sonication. In update cycles of up to 8 Hz, patient specific image data is retrieved from the connected MRI which is on the one hand used to capture and track the motion of the liver and especially the target region and on the other hand to monitor the induced tissue effects . The real-time information from the motion tracking is fed into a motion model that calculates a short-time prediction of the movement of the target focal point. The predicted real-time information is sent to the transducer to steer the FUS beam accordingly. The real-time monitoring information enables the physician to stop the procedure when unwanted effects show up, e.g. heating of the near or far field. Furthermore, the TRANS-FUSIMO treatment system recognizes ribs that occlude the beam path and switches off transducer elements that would sonicate these ribs. The transducer power is then re-distributed to all remaining elements.

Results: To validate the TTS and its complete motion compensation pipeline and the models, phantom studies have been performed in static as well as moving scenarios first. We could prove that the software meets the defined requirements regarding system's safety as well as functionality. During each sonication, the complete pipeline of motion compensation and rib detection is running in the background in real-time and based on real-time patient specific information. Furthermore, we showed in our currently ongoing *in vivo* animal study that the software can sonicate safely in a living pig using an improved non-clinical prototype version of INSIGHTEC's conformal bone system (iCBS). We were able to introduce deep liver lesions that have been confirmed by contrast enhanced MR imaging and pathological examination.

Conclusions: In *ex vivo* as well as in *in vivo* experiments we could show that the TRANS-FUSIMO treatment system is capable of compensating organ motion through real-time motion detection, motion modelling and real-time beam steering. With the ongoing animal study we intend to prove that MRgFUS in moving organs can be performed safely, efficaciously and effectively. In the next step, we will show the feasibility of a treatment using the TTS in the clinical setting on human patients. To this end an adjuvant treatment with the TTS is planned for patients that will undergo surgical resection.

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