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Navigation Methods and Localization Techniques for Interventional Instruments with Ferromagnetic Components in MRI

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In this work a real-time MR pulse sequence and MR force control unit to perform magnetic navigation of an instrument with ferromagnetic component in endovascular interventions is implemented.
In MR-guided endovascular interventions ferromagnetic components can be used to navigate the devices. For example, the orientation of the device tip can be controlled by gradient forces. In this work, a 3D input device for interactive real-time control of the force gradient was combined with a dedicated real-time MR pulse sequence. The pulse sequence offered acquisition of FLASH images, force gradient and localization of the ferromagnetic tip with three projections. The technique for localization is a combination of off-set resonance excitation and gradient rephasing. According to the position of the ferromagnetic components from the projections, the imaging slice is automatically aligned with the ferromagnetic component. The navigation methods and localization techniques were assessed in phantom and animal studies.
At a reaction time of 24 ms and a frame rate of one image per second the orientation of a ferromagnetic catheter could be navigated in a complex vascular phantom. The localization of the ferromagnetic tip could be performed with an uncertainty of 1 mm in phantom studies and 4 mm in animal studies.
The use of deflectable catheter with a ferromagnetic tip to target the blood vessels and localize the position of device provides a novel method to use the MR system to simultaneously image the anatomy and steer an interventional device which help to increase the precision and speed throughout endovascular procedures.