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# ReGrasp: a device to explore the neural correlates of grasp training

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Design and evaluation of a novel robotic finger interface for fMRI-based neuroscience studies

## Introduction

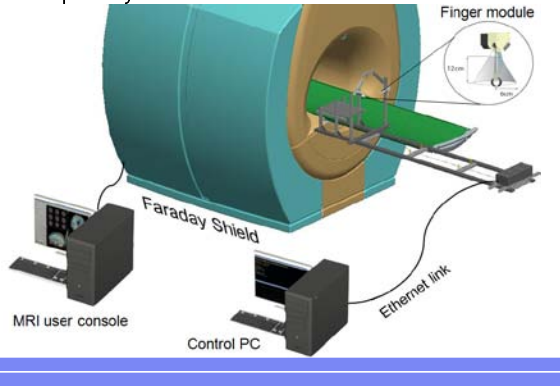
After a stroke, hand motor function, which is critical for many activities of daily living such as grasping and manipulating objects, is commonly affected. Nevertheless, during the first few months stroke patients can expect a certain amount of spontaneous recovery as a result of increased neuroplasticity, aided by physiotherapy and, more recently, robot-assisted therapy. The neural mechanisms behind motor recovery are, however, not fully understood, nor how these are influenced by different types of motor therapies, leaving potential for optimization of current rehabilitation strategies. We report here a new generation of fMRI-compatible robotic device, ReGrasp, which will be used to investigate the neural mechanisms of fine motor control of the fingers and explore the effect of different hand function therapies on the neural correlates of motor recovery after stroke.

## fMRI-Compatible Robotic Interfaces

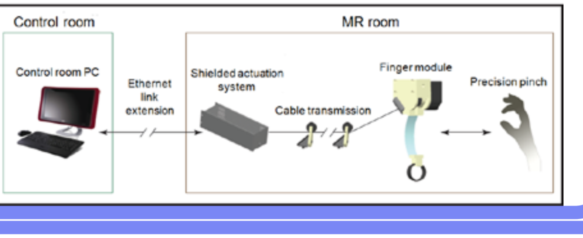
Current therapeutic methods in rehabilitation can be further enhanced by combining the new advances in functional neuroimaging (e.g. fMRI) with the use of robotic interfaces, providing a unique tool to investigate the link between motor training and neuroplasticity [1]. However, the harsh yet sensitive MR environment imposes severe safety and electromagnetic compatibility constraints on the mechatronic components, which requires the development of dedicated sensing and actuation technologies Previous systems were actuated over a hydrostatic transmission, which achieved acceptable force-feedback performance but suffered from non-linearities (right). Here, we present a novel approach based on conventional actuators, providing high bandwidth and low impedance, and thus allowing for high-fidelity haptics in an MR environment.

## System Description

The design of the ReGrasp combines the cable / spring blade approach proposed in [3], using cable transmission and improved cable guides to reduce friction and increase bandwidth, while taking into account MRI safety and compatibility issues.




With the aim of guaranteeing safety and compatibility within an MR environment, we propose a concept for a shielded high-performance actuation system, remotely controlled from a PC located in the control room over an Ethernet link. Detailed compatibility tests performed in a 3T scanner showed no evidence of interference of the shielded actuation system with the imager. The system can infer the force applied at the subject's fingertip from the motor current, and render various force effects to interact with the user through the finger module, by assisting or resisting the motion of the thumb and index finger in a spatially unrestrained movement.




## Performances

The performances of the system were evaluated by measuring the bandwidth and friction of the cable transmission. Excellent results were achieved, due to the direct-drive actuation with conventional electromagnetic actuators and the low inertia of the cables. Based on this proof-of-principle we are currently developing a prototype incorporating a real-time control system to be used in fMRI studies to investigate the neural correlates of stable/unstable grasp.

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|---|---|
| Maximal force generated at the fingertip | 28 *N* |
| Maximal force generated by the spring blade | 1.5 *N* |
| Control frequency | 1 *kHz* |
| Bandwidth in open loop control | 16 *Hz* |
| Bandwidth in closed loop control | 18 *Hz* |
| Friction force (transmission) | < 1.5 *N* |

## References

[1] R. Gassert, E. Burdet, and K. Chinzei. MRI-compatible robotics. IEEE Engineering in Medicine and Biology Magazine, 27(3):12–14, 2008.
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[3] L. Dovat, O. Lambercy, R. Gassert, CL. Teo and E. Burdet. Finger function rehabilitation device. US provisional patent US61/130/764, 2008

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