Abstract:

Move magnetic objects inside the human body by external magnetic fields

Modern medical procedures replace open surgery by the use of endoscopes and catheters. These are manually pushed from outside, while their flexible heads are mechanically by wires, manually operated. Small "USB endoscopes" are easily available at very low cost. Permanent magnets can be attached to such devices easily. With the TAPAS boards we want to test a coil scheme, where a magnetic field is used to align/orientate and move such small permanent magnets.

As shown in literature, a rotatable head on the endoscope with a magnetic moment can be rotated by slowly alternating external fields. If the head has a screw-like outer shape, it can be propelled ie. in a rubber tube, simulating tissue. We plan to develop a measurement and a feedback to ensure that the head is rotating with 3 axis Hall modules. This would result in a servo-motor like "driver" for endoscopes or catheters.

These tests will be done in a ~1:8 small-scale demonstrator on "hobby scale". The device has 6 independent powered Helmholtz-coils in 3 axes. According to our calculations currents of 5 to 15A are needed for the proposed application in this scale. Powering the coils by TAPAS boards will allow concentrating on the development of feedback and intuitive steering systems with the sub-scale demonstrator.

We are a team of 3 people Dr. Asim Araz, Dr. Martin Bräuer, Klaus Hörcher and will conduct this project as a team outside our professional affiliation.

Move magnetic objects inside the human body by external magnetic fields

Dr. Asim Araz, Dr. Martin Bräuer, Klaus Hörcher

In modern medical applications open surgery is often replaced by minimal invasive procedures. These include endoscopes or catheters, which are manually pushed into the human body. The devices are maneuvered manually by mechanical elements, which are operated from outside.

The basic concept of our idea is the addition of small but powerful permanent magnets to endoscopes or catheters. Having relatively large external coils, surrounding parts of the patient, magnetic fields will allow orienting the device remotely from outside. If field gradients are generated in addition by the external coils, even forces to move the devices can be applied.

Using text-book theory of Helmholtz-coils it is easy to see that a future medical device will need several milli tesla fields, requiring currents in the 100A range for realistic fields and gradients. Computing gradients for Helmholtz-coils shows also that larger forces might be hard to generate with reasonable currents. Alternatively we suggest using an endoscope with a rotating head attached to it, which has a spiral outer shape and magnet(s) arranged perpendicular to its optical axis. This device will rotate as a synchro-motor if the outer coils generate a sinusoidal field. The spiral shape will lead to a motion along the optical axis of endoscope when it is put into a flexible tube. There is some literature published on this. E.g.:

M. Sendoh, A. Yamazaki et. al., 2004: "Spiral Type Micro Actuators for Medical Application", Proceedings of the 2004 Int. Symposium on Micro-Nanomechatronics and Human Science, ISBN 0-7803-8607-8

The aim of this project is to use the TAPAS board for a feasibility test of the idea on a small "hobby-compatible" scale. If the magnets are scaled down by a factor 8, the currents of the coils scale linearly down by the same factor to around 15A. Gradients will scale down in quadrat, resulting in rather high gradients also at moderate currents. The 1:8 scale allows an open accessible space in the "field-cage" which can comprise a 1L standard plastic water bottle, making experiments easy.

Especially a synchronization of the rotating part to the outer fields are planned to be implemented using e.g. small 3 axis hall chips.

In a first approach a pure Helmholtz setup with 6 coils in 3 axes will be tested. In a later stage more coils are planned to test the feasibility of movements and forces in 5 axes. For the final stage a setup with up-to 15 coils is foreseen.

The existing Helmholtz setup is shown in figure 1. The system is planned / designed for 2A currents, resulting in low temperature coils. The coils are made for elevated temperatures to reach higher currents eventually with cooling to be added.

Current generation and control is still a problem. In the model-making area there are high-current BLDC motors with controllers existing, however it is not clear to control quasi DC currents with these. Ready-made H-Bridges with control environment are not easy to find and might require own PCB layouts, which will bring a lot of work before the core ideas could be tested.

TAPAS boards will be a great help to realize the power supplies for the coils and will allow concentrating on the essential test of a prototype and working on the field-sensing and synchronization issues.

Initially a single TAPAS board will allow the control of a single Coil. For the existing hardware 6 coils need to be powered. If one of the three half-bridges on a TAPAS board can be combined with that of another board, 4 boards will be sufficient to power the 6 Helmholtz coils and an electrical test setup.

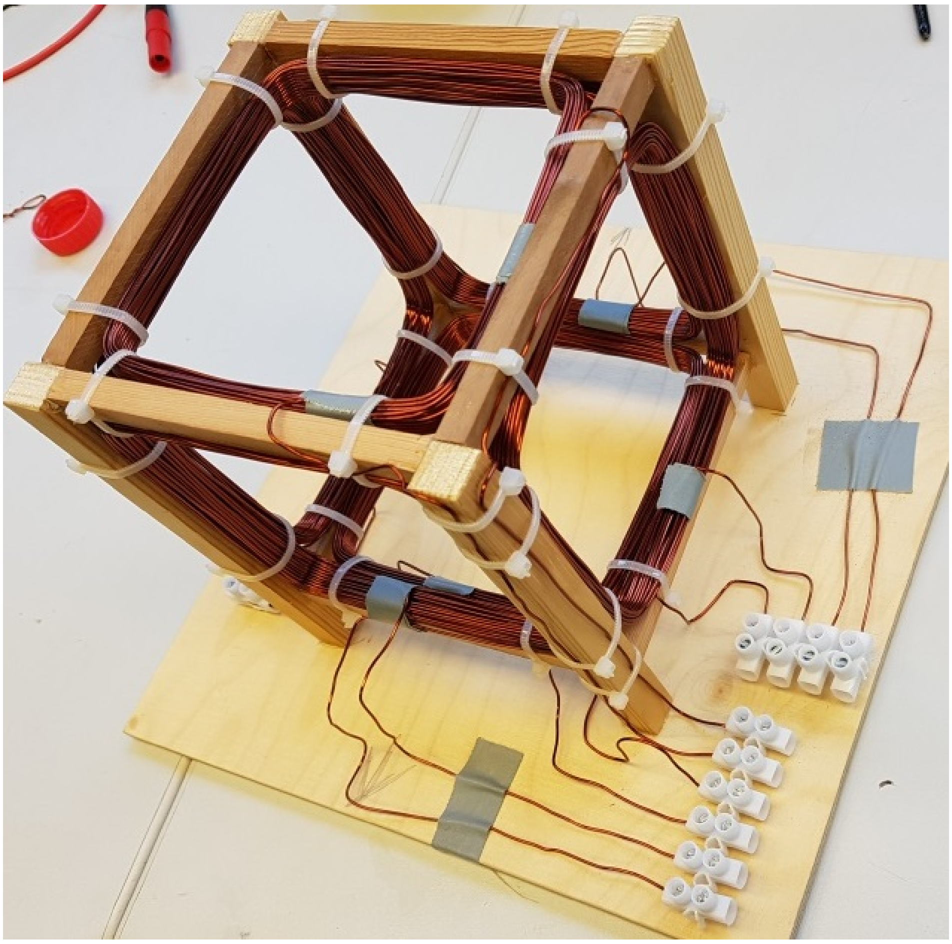

Figure 1: A 6-coil Helmholtz setup with 80mm free space for tests. The coils are foreseen to be operated at temperatures below 40°C with the given test-frame.