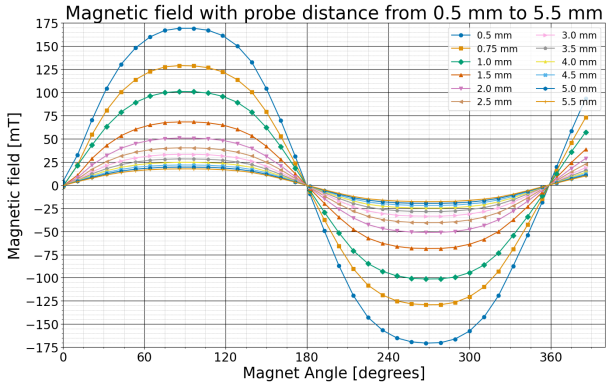
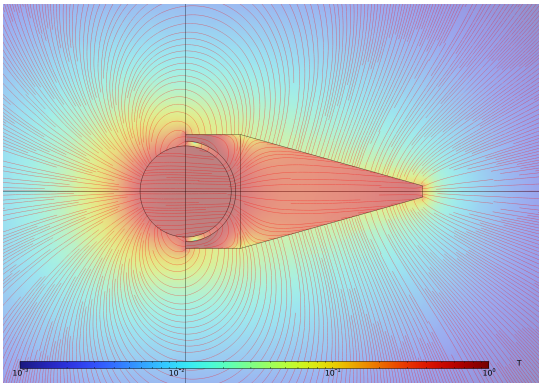
Automatic magnetic field alignement

In NV magnetometry, the electronic spins of nitrogen-vacancy (NV) centers in diamond are used as nanoscale magnetic field sensors. However, for calibration purposes it needs to be exposed to an external magnetic field, requiring tuning in direction and strength.



Experiment plot (full rotation of the magnet)



Streamline multi-slice plot of the COMSOL simulation

Task

The task of the project was to design, simulate, and produce a prototype device capable of generating a tunable magnetic field. The device was required to achieve a field strength above 50 mT at a minimum distance of 2 mm from the sensor.

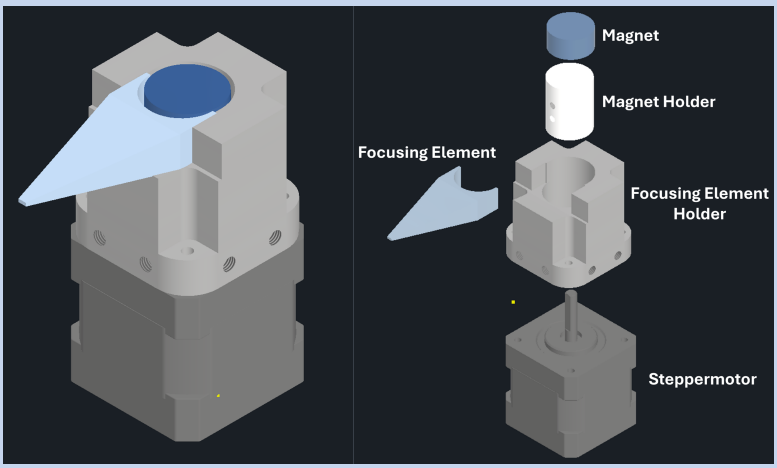
Implementation

The picture below demonstrates the implementation. The field of a diametrically magnetized cylinder magnet is focused on a specific point by a focus element. The magnet itself gets rotated by a stepper motor to tune the field strength. Additional parts were 3D printed to complement the setup. Measurements of the magnetic field in front of the focusing element were taken at different distances. The motor and the measurements were controlled by a Raspberry Pi using QCoDeS. The simulated and measured data was visualized through line plots, heat maps and vector plots.

Results

The project outcomes consist of the field focusing device and visual representations of the measurements and simulations conducted. The results of the project demonstrated successful achievement of the set objectives. The prototype was able to generate a tunable magnetic field with a strength exceeding 50 mT at the required minimum distance of 2 mm from the sensor. The comparison between the simulated and experimental data showed high precision and decent accuracy, validating the effectiveness of the design. While there were some minor deviations, the overall performance of the prototype exceeded expectations, providing a solid foundation for future improvements.

Setup of the field focusing device



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