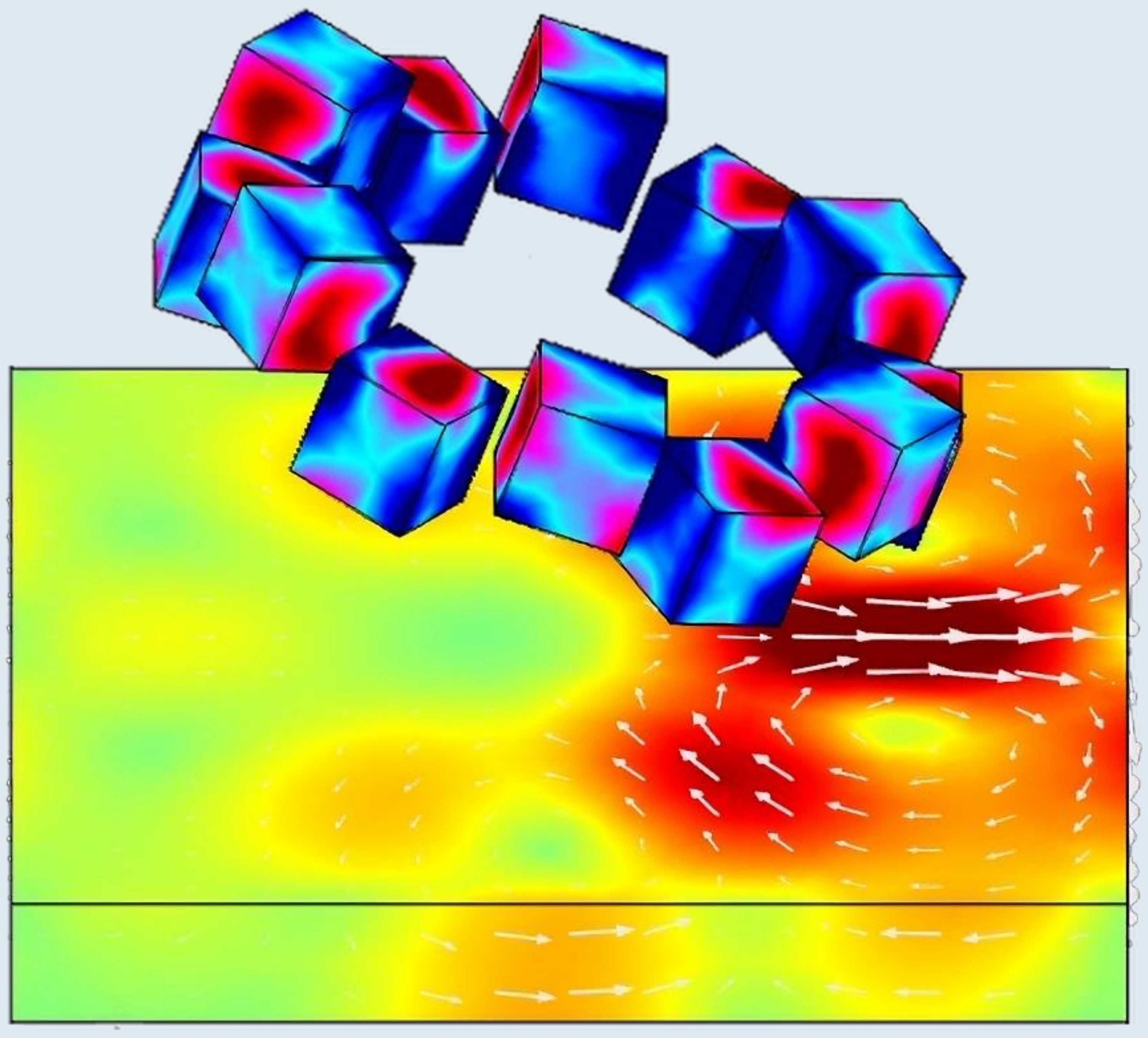

Analysis of Magnetically Levitated Hoverboards

Understanding the counterintuitive effects in induction-based magnetic levitation for the use in Hoverboards and Maglev trains.

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Abstract

A hoverboard can be seen as a small skateboard, that uses a set of magnetic Hover Engines instead of wheels. The magnetic levitation is created by arranging a set of magnets into the so-called Stabilized Halbach Array and being rotated above a sheet of a non-ferromagnetic metal. The movement of the magnetic field induces eddy currents within the metal, which themselves create an opposing magnetic field. The latter magnetic field is dynamic and creates a stable state of levitation for the magnets above. Using the Stabilized Halbach Array for this type of levitation is a novel idea based on a German patent[1] and has the defining feature, that the array is easily scalable in size without the development of destructive internal forces between individual magnets. The efficiency of the levitation was studied and the engine's peculiar behavior, when tilted.

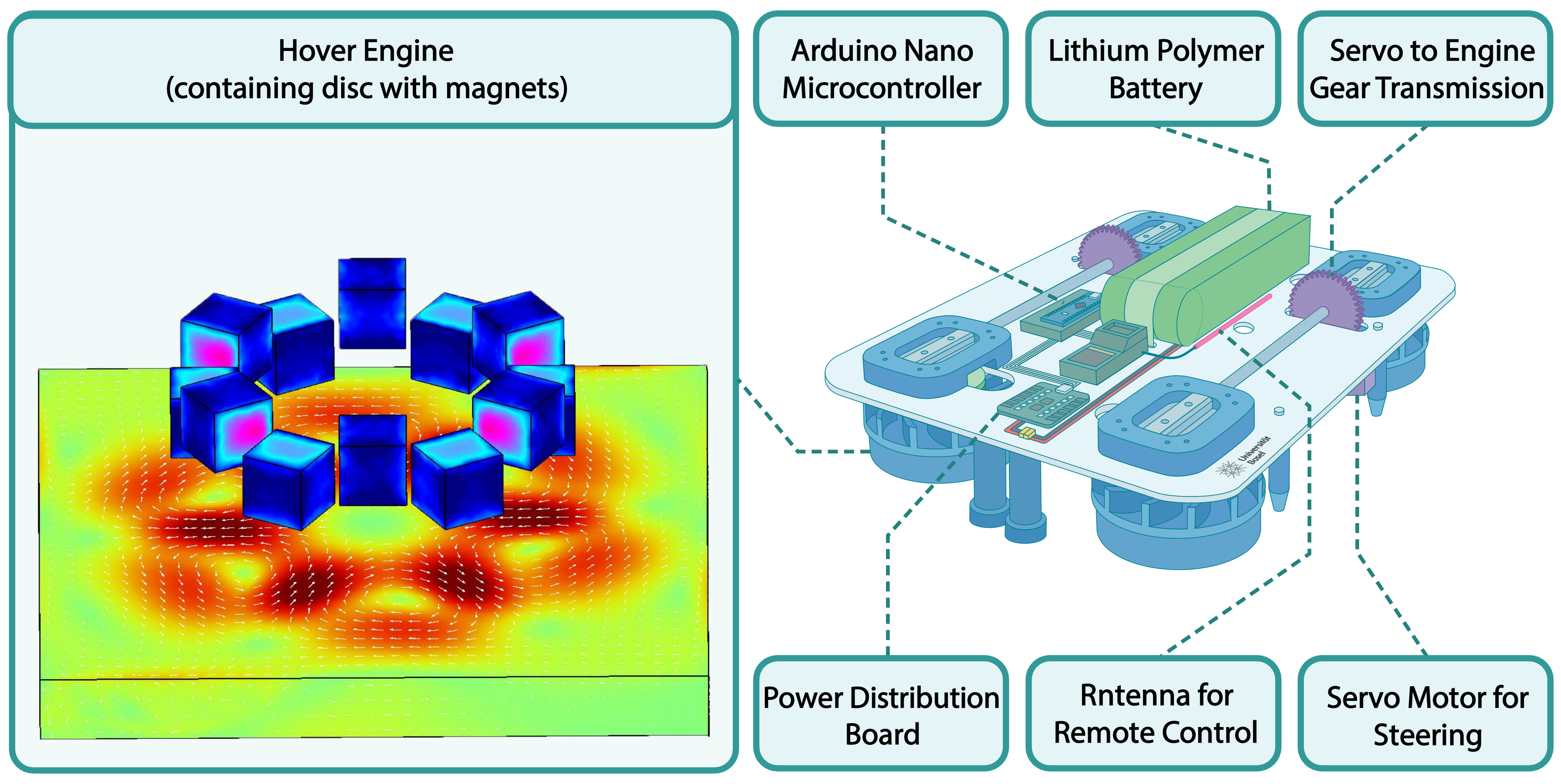

Figure 1: Schematics of a Hoverboard prototype. The 12 magnets contained in the Hover Engine are emphasized, and the induced currents in the metallic plate below are shown.

Methodology

To simulate magnetic levitation efficiently, we employ a quasistatic approximation to assess Hover Engine performance. We created a 3D magnet model and assigned a Lorentz-Term for metallic plate, in order to implement the rotational motion. Simultaneously, we conducted parametric sweeps for rotational velocity and levitation height, extracting Hover Engine forces and torques through global evaluations.

In order to reliably study the performance of the Engines with respect to their tilt, the Rotating Machinery interface is recommended. Parametric sweeps with respect to the tilting angle should give insight in the sideways thrust profile, in oder to be utilized for control purposes.

Results

The efficiency of the Hover Engine corresponds to the torque, that is acting against the rotation. The left plot in figure 2 shows how the torque initially increases and peaks, after which it drops and stabilizes. The peak corresponds to the lowest efficiency setup and has to be avoided during operation of the Hover Engines.

A small change in the tilt of the Hover Engine along an axis, creates linear thrust along the same axis. This is not intuitive and could only be understood after the simulations visualized the electric induction current shifts, that create the effect. The forces are quantified in the right plot in figure 2. The force profile can be used to tune the control software of the Hoverboard and allow for more accurate steering.

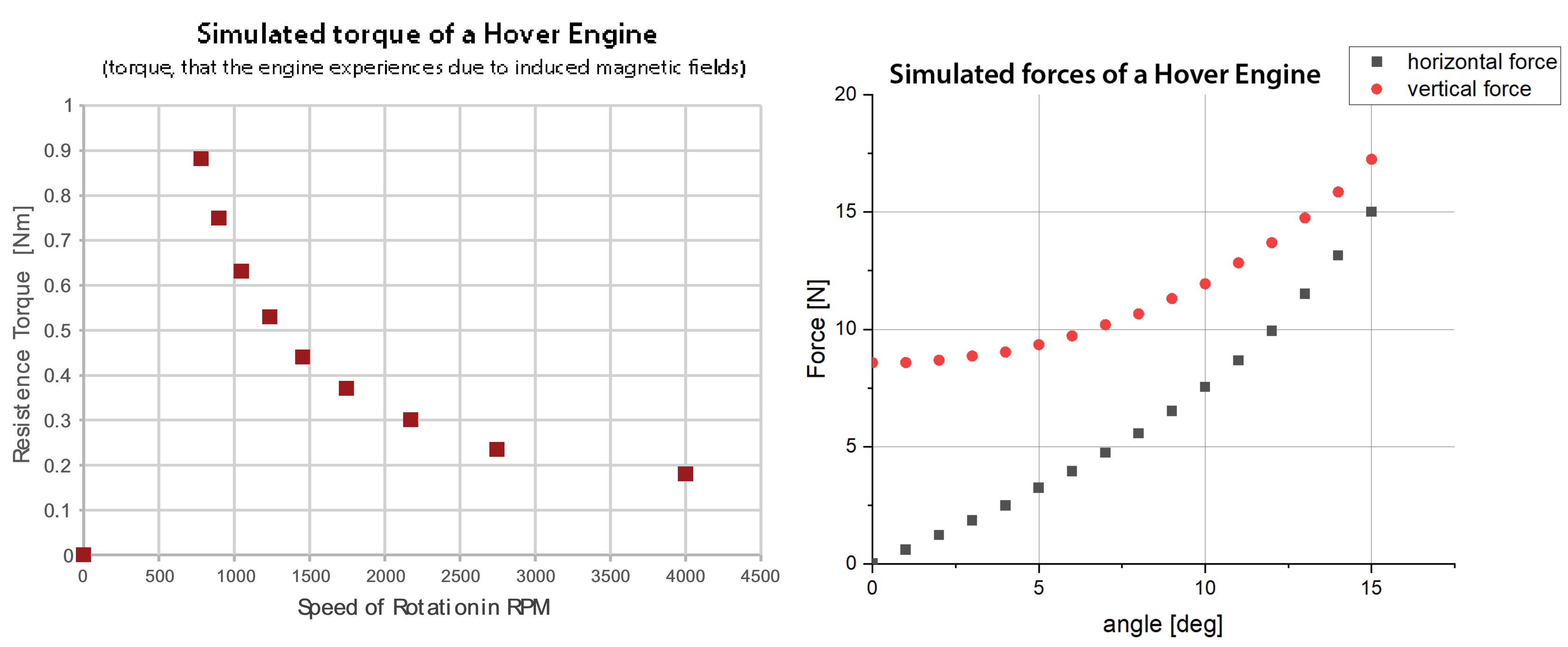

Figure 2: Left plot shows how the forces of a Hover Engine change depending on the tilting angle. The right plot shows the simulated torque with respect to the rotational velocity.

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Excerpt from the Proceedings of the COMSOL Conference 2023 Munich