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Cluster of Excellence *liv***Mat**S
FIT – Freiburg Center for Interactive Materials and Bioinspired Technologies,
IMTEK, University of Freiburg

Magnetic interaction in Physics and Game Engines for mechanical metamaterials and self-assembling systems* (HiWi, BSc, MSc)

The insertion of magnets (both permanent and electromagnets) as a tool to program and control mechanical metamaterials' energy landscape looks very promising. The involved interplay between elastic and magnetic energy enables the realization of very peculiar behavior unachievable for conventional materials. Currently, the vast majority of the studies that deal with magnetic interaction in mechanical metamaterials use finite element modeling (FEM). Being a well-established and highly accurate method, FEM is extremely computationally heavy, especially for direct modeling of magnetic interaction that usually requires meshing of the free volume around the material. As an alternative, it seems possible to employ physics/game engines to simulate the behavior of mechanical metamaterials or self-assembling systems with magnetic interaction. By design, game engines (such as Bullet, Box2D, etc.) provide enormous speed-up compared to FEM, sacrificing some accuracy of the latter. This is one reason why such engines are very actively employed in the research associated with robotics.

This project explores the applicability of game engines to simulate the behavior of mechanical metamaterials and self-assembling systems with magnetic interaction. Unfortunately, the mentioned game engines do not have the default tools to take into account the interaction between magnets, and such interactions should be programmed manually. Initially, we will avoid the sophisticated integration over the magnets' surface and limit ourselves to the model of dipole-dipole interaction at the first steps. After realizing the magnetic interaction using game engines, the corresponding predictions will be compared with the lab experiments. In particular, using a high-speed camera, we will study the interaction of two cubic magnets that moves towards each other and determine the critical speeds when two different configurations can be formed. The results will be beneficial for the effective design of new mechanical metamaterials and self-assembling systems. We will prepare the scientific publication and will try to publish the developed code in GitHub repo.

The skills that you can acquire during this project:

1. Programming for game engines (using Python and Blender for rendering)
2. The basic theory of interaction between magnets
3. Design of experiments/post-processing of the results
4. Basic mathematical modeling skills

Please feel free to contact us if you have any questions.

Dr. Viacheslav Slesarenko, PI

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