Dexterous Magnetic Manipulation of Non-magnetic Objects with Stationary Electromagnetic Dipole-field Sources

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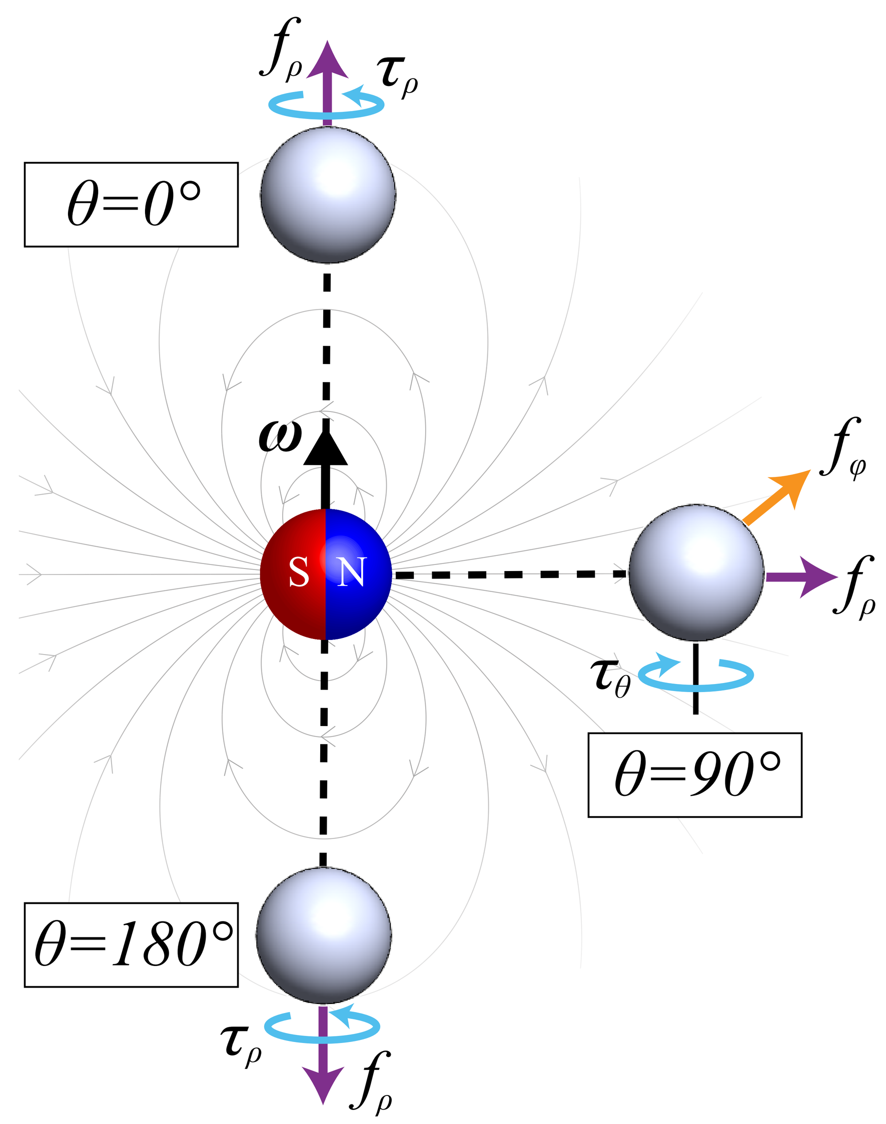
Review of State of the Art

- We previously characterized the force-torque wrench that a rotating magnetic dipole induces on a non-magnetic, conductive, solid sphere, in three canonical poses
- We showed that this model is sufficient to perform six-degree-of-freedom (6-DOF) manipulation, assuming a sufficient arrangement of magnetic field sources



Broader Impact: Benefit to Society

- Space debris is a serious problem facing humanity
- Most objects are made of aluminum
- Some objects could be repaired to extend their useful life
- Other objects could be de-orbited

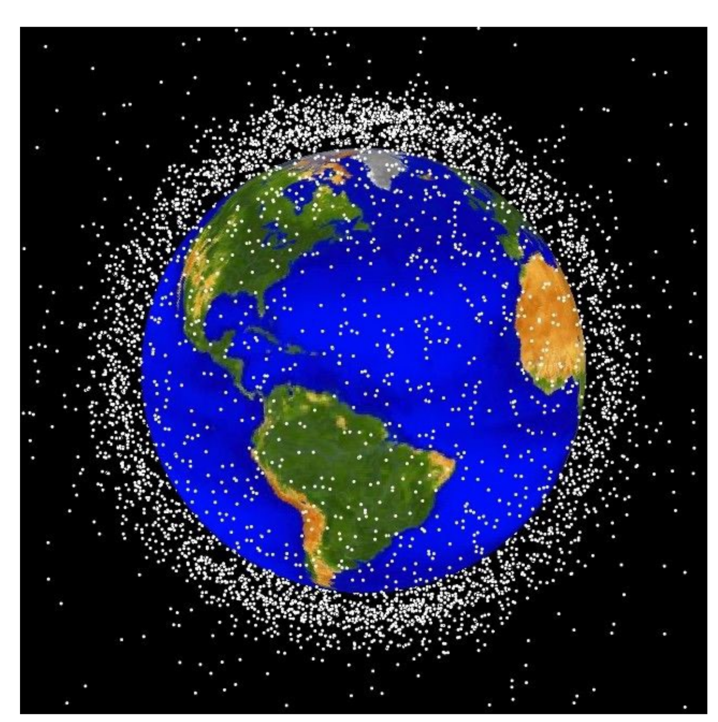


Image courtesy of NASA

Broader Impact: Education and Outreach

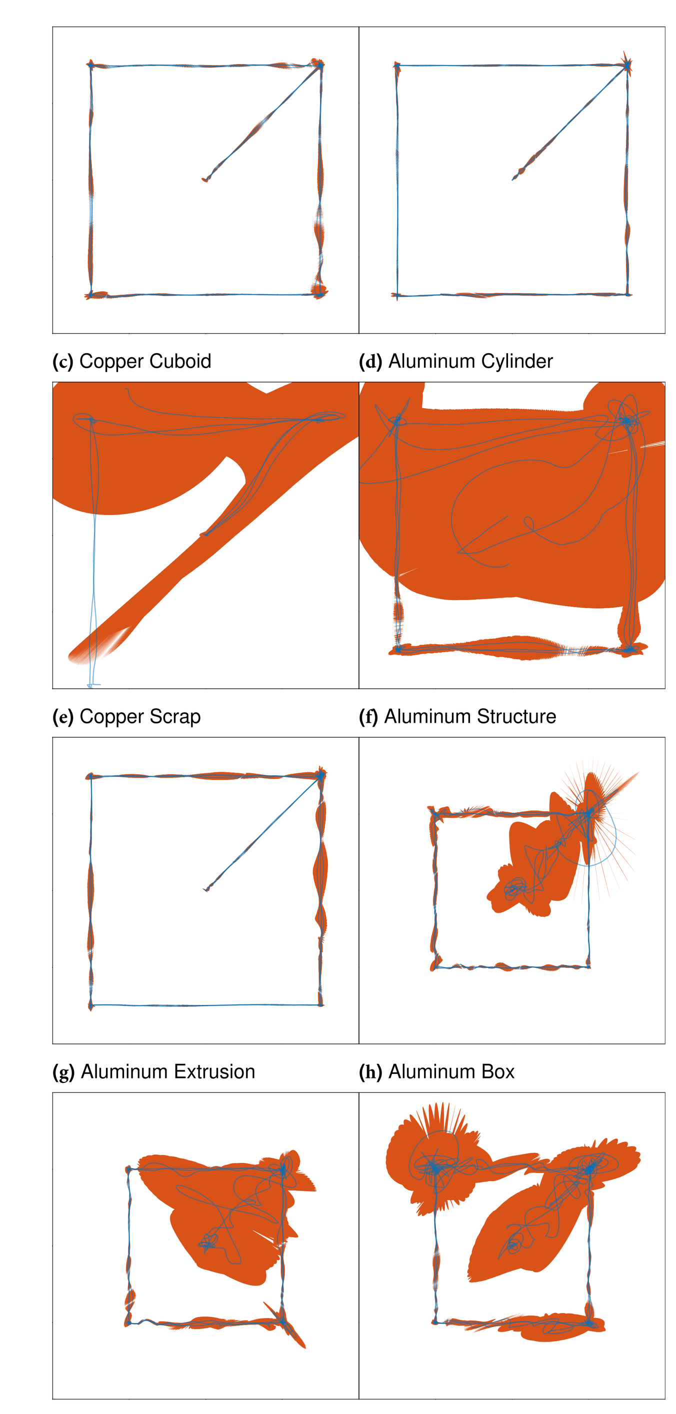
- Training for two Ph.D. students
- Undergrad participation through Capstone Senior Design of microgravity simulators
- Outreach to high-school students via STEM summer camp

Key Problems to be Addressed in this Project

- Improve/characterize our ability to generate any desired force-torque wrench on an object
- Evaluate manipulability/conditioning of different arrangements of magnetic field sources
- Improve model beyond solid spheres in canonical poses
- Develop a 6-DOF water-based microgravity simulator
- Develop/characterize adaptive control of non-spherical objects (with unknown properties)
- Actively learn global object dynamics

Key Results

- By adapting the conductivity and radius of a solid-sphere model, and representing our optimization loss function in terms of acceleration rather than force, we are able to manipulate a wide variety of objects.



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