Abstract

Magnetic levitation actuation has proven to be a viable solution in many applications where high performance actuators are needed that can achieve fine manipulation and position control. Advantages of magnetic levitation include elimination of friction, backlash, vibrations and wear of components due to contact. Many such systems have been developed so far for applications in photolithography, magnetic bearings, haptic interaction and manipulation of micro-robots.

Owl Tech has developed a prototype device of a 3D printer with a novel platform printer head, equipped with permanent magnets that is suspended under an array of electromagnets using magnetic levitation. The device aims to deliver higher accuracies while reducing power consumption and maintenance costs with respect to the mechanical counterparts.

Using finite elements analysis a magnetic force/torque model is developed. The model is verified by a force measurement setup. The dynamics of the levitating platform are expressed by combining the magnetostatic model with the equations of motion of a rigid body.

For the localization of the levitated platform a sensing methodology is proposed based on an array of hall-effect sensors. The sensing system is designed to be able to detect both the translational motion of the platform and the rotational motion for small deviations around the planar configuration. For the absolute static estimation problem an algorithm based on Non Linear Least Squares was developed and subsequently extended to the dynamic case using the Extended and Unscented Kalman Filter.

In order to model the dynamics of the electromagnets, verify their linearity and the superposition of magnetic fields, a procedure was developed based on system identification experiments. This allowed also for the development of a very accurate open-loop estimator that can predict the generated magnetic field and remove its effects on the hall-effect sensors used for localization.

While only two degree-of-freedom planar xy motion is desired, the system must be controlled in six degrees-of-freedom. For the control of the platform in six degrees-of-freedom a feedback linearization and decoupling algorithm is developed. The simplified system is subsequently controlled separately in each axis with state feedback along with a reduced order observer to compensate the joined effect of disturbance, modeling error, and cross coupling.