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TRACKING THE MOTION OF AN INTRUDER PARTICLE IN A THREE-DIMENSIONAL GRANULAR BED ON-BOARD THE CHINESE SPACE STATION

Abstract

Tracking particles in three dimensional (3D) systems is a challenging task that demands specialized equipment, algorithms, and techniques to achieve precise and dependable measurements. The complexity arises from the inherent variability and noise in the data, as well as the necessity to accurately trace small and swiftly moving particles. Current methods offer nondestructive capabilities and high spatial resolution, but drawbacks include high costs, dependency on specific radiative sources, and bulkiness. This work presents a novel approach using Hall-effect magnetic sensor arrays to reconstruct the trajectories of a magnetic sphere within a vibro-fluidized three-dimensional granular bed housed in a centrifuge for reduced gravity aboard the CSS. We introduce a new algorithm capable of precisely tracking particles under the evolving external geomagnetic field. The method's temporal fluctuations and spatial accuracy are demonstrated, showcasing a 3D trajectory reconstruction of an intruder immersed in the vibrated granular bed in reduced gravity within the CSS. At the sampling rate of 30 fps, the spatial accuracy of the measurements of two perpendicularly placed Hall sensor arrays are cross-checked. The spatial accuracy measured by both arrays is 0.035 cm, showcasing a 3D trajectory reconstruction of an intruder immersed in a dense vibrated granular bed in reduced gravity within the CSS. The algorithm proposed here is much simpler than the previous ones and is more time-efficient to implement. With the current reliability and robustness, future developments aim to reduce the array size while increasing precision through adjustments in data sampling rates. The method is applicable to intruder tracking tasks in dense granular bed as long as geomagnetic influence is negligible compared to that of particle collisions or frictions. If rotational degrees of freedom are not of the concern, the method can also be applied to intruder tracking in granular gas.