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Electrical capacitance volume sensor for microgravity mass gauging: advancements in sensor calibration for microgravity fluid configurations and propellant management devices

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Microgravity mass gauging has gained increasing importance in recent years due to the acceleration in planning for long term space missions as well as in-space refueling & transfer operations. It is of particular importance with cryogenic propellants where periodic tank venting maneuvers and leak detection place a special emphasis on accurate mass gauging. Several competing technologies have arisen, but capacitance mass gauging has several distinct advantages due to its low mass, non-intrusiveness, and whole volume interrogation technique. Capacitance based measurement has also seen recent success in measuring cryogenic liquid nitrogen and hydrogen volume fraction and flow rate. However, the effects of gravity on fluid behavior make the calibration and testing of these sensors difficult on the ground. In this paper a prototype sensor is constructed that can emulate fluid positions in microgravity and gravity configurations. Experimental propellant fills and drains are conducted using a simulant fluid with similar electrical properties to cryogenic propellants. This expanded dataset is compared with previous simulation results and used to construct a machine learning model capable of calculating the fluid mass in tanks both with and without propellant management devices.

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