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HUMAN-SUIT INTERACTION DURING EVA OF THE FOOT USING A FORCE SENSING SYSTEM

Abstract

During extravehicular activity (EVA) in current and future missions, astronauts perform a multitude of tasks outside of the spacecraft, relying on the extravehicular mobility unit (EMU), or the spacesuit. However, while EMUs provide a breathable environment in outer space, they can also limit or interfere with mobility, leading to increased discomfort and often injuring the arms, feet, and shoulders. Very little is currently known about the movements of an astronaut within the spacesuit, and countermeasures to avoid such injury are therefore limited. This work aims to study the relative interaction between an astronaut and their spacesuit by identifying high contact areas. A system comprising of force sensing resistors (FSRs) and linear potentiometers is being developed to demonstrate proof of concept. The FSRs are flexible electronics that include printed traces on a flexible substrate. Using supplier instructions, wires were soldered to the sensors and connected to the remaining circuitry. An Arduino Nano BLE 33 microcontroller has been programmed to transmit the force data real time over Bluetooth to an application. The sensors recognize force applied through a change in resistance, which can then be converted to a force-resistance relationship. Initial calibration has been performed to obtain the linear and logarithmic fit of this relationship, which can be added to the firmware for an end user force output. The system will be further expanded by adding force sensing linear potentiometers (FSLPs) that can measure both force and location of the force. The sensors have been integrated within a Lycra fabric to secure them on the user's body under the spacesuit. A sock prototype is in ongoing development to be used for initial testing of the interaction between the suit and the foot of an astronaut. The "sock" will be worn under an EMU suit and common EVA tasks will be performed. Contact analysis using the force data during various motions will provide details on the human-suit interaction. Future work aims to 3D model the resulting data in real time to demonstrate interactions while various EVA tasks are being performed. Furthermore, verification of proof of concept using the sock will direct the development of a full body internal suit.