IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)
Medical Care for Humans in Space (3)

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A COMPACT PULSED NEAR-INFRARED LIGHT PROBE FOR NON-INVASIVE IMAGING OF THE SPACES BETWEEN THE SKULL AND THE BRAIN TO IMPROVE THE DIAGNOSIS OF BRAIN INJURIES DURING SPACEFLIGHT

Abstract

An intracranial hemorrhage (IH) is a medical emergency that needs to be managed within hours of the event. In the context of deep space travel, this signifies that an emergency evacuation back to Earth, which could take many days, would not be possible. Additionally, the gold-standard for diagnosis of IH, computed tomography (CT), is resource intensive and requires special training to operate and interpret. For these reasons, it is unlikely that CT scans will be available for astronauts in space for years to come. To address this problem, we have designed a novel diagnostic tool that will provide crew medical officers or their crewmates with information on the presence and severity of an IH by taking advantage of two recent advancements in the field of spectroscopy: time-domain diffuse correlation spectroscopy and terahertz spectroscopy. The device consists of a pulsed laser generator and handheld probe which is able to emit light and gather reflected diffuse light that has travelled through the skull. As the laser will be pulsed as opposed to a continuous beam, it allows us to determine the time-of-flight (TOF) and intensity of light. Additionally, the ultrafast femtosecond pulse will gather information on the composition of the biological tissue being examined. The end result will be data on the depth and absorbance of the tissue to an approximate maximal depth of 2-3 cm, as well as the amplitude and phase of the collected light. Because clots have unique optical properties, they will influence light absorbance in a predictable way, which we will feed into a custom machine learning algorithm to learn to identify bleeds. The overall design does not exceed the volume of a double ISS EXPRESS rack, making it compact enough to meet spaceflight requirements. The design also includes a framework that will enable the data to be quickly transmitted to healthcare providers off-site such as a flight surgeon on Earth managing a deep space mission. In addition to being able to quantitatively detect blood in and around the meninges which is indicative of an epidural, subdural, or subarachnoid hemorrhage, we also anticipate applications for diagnosis and management of abdominal injury and stroke. In conclusion, by reducing the reliance on medevacs back to Earth in order to perform CT scans, and by providing more evidence in the hands of the user, we can increase the autonomy of astronaut crews in deep space.