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LUNAR LANDING NAVIGATION USING EVENT CAMERAS AND SPIKING NEURAL NETWORKS

Abstract

Recently, we have seen lunar landings sharply increasing in frequency and executed using progressively smaller vehicles. This creates a need for a lightweight and low-power navigation system, which can easily fit into compact landers or achieve redundancy on larger vehicles. With visual navigation becoming more popular, novel neuromorphic sensors and processors, in the form of event cameras and spiking neural networks, represent a very promising option for this purpose. The event camera provides a reliable and sparse output with very little latency and motion blur, and an extremely high dynamic range. These are significant advantages, with the dynamic range becoming especially important in regions with difficult lighting conditions, like the lunar poles. Spiking neural networks can very naturally interface with event cameras to output optical flow, which can then be used for navigation. When implemented on neuromorphic chips, these networks also exhibit substantial qualities in the area of low-power consumption and latency. Moreover, they are inherently recurrent, which makes them very suitable for a temporally sensitive task such as optical flow determination. Hence, a feasibility study, supported by ESA, was conducted on the topic of lunar landing navigation using event cameras and spiking neural networks. A synthetic dataset, based on a pipeline devised in previous work, was created to test this idea in a simulated environment. State-of-the-art spiking neural networks for optical flow inference were identified and trained on the dataset. A novel loss function term for training such networks was proposed to prevent overfitting to simple optical flow structures encountered during landing. It was also shown that continuous homography methods are applicable in this case as an appropriate step between optical flow and egomotion and impact of additional known variables was studied. The most suitable network types were identified and recommended for further study, and they are introduced together with key challenges in the paper.