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Author: Mr. Tom Mladenov
SES Engineering, Luxembourg

Mr. David Evans
European Space Agency (ESA), Germany
Mr. Tom Syndercombe
Telespazio VEGA Deutschland GmbH c/o ESA-ESOC, Germany, Germany
Mr. Georges Labrèche
United States

AUGMENTING DIGITAL SIGNAL PROCESSING WITH MACHINE LEARNING TECHNIQUES USING THE SOFTWARE DEFINED RADIO ON THE OPS-SAT SPACE LAB

Abstract

The OPS-SAT Space Lab is Europe's first publicly accessible hardware/software experimentation platform in Low Earth Orbit. Launched by the European Space Agency in 2019, the 3U spacecraft is open to European Academia and Industry and allows both new and seasoned players in the New Space domain to test out concepts on an orbiting satellite with a range of advanced payloads. This work further builds upon a previous in-orbit demonstration which used open-source Digital Signal Processing (DSP) techniques to perform direct in-orbit processing of transmissions from maritime and aviation emergency beacons, the first software defined and reconfigurable Search and Rescue transponder deployed on a satellite. The experiment has paved the way for a new chapter in operations of reconfigurable Software Defined Radio (SDR) and other Radio Frequency (RF) payloads to support multi-purpose missions. We combine the results of other OPS-SAT experiments which have demonstrated supervised and unsupervised learning approaches to Machine Learning (ML) for image classification: kmeans, CNN (TensorFlow), Random Forest, and Online ML on-board a spacecraft and use them in an entirely new context. There is potential to use such methodologies for other types of data such as complex RF samples, more specifically in-phase (I) and quadrature (Q) samples from the Software Defined Radio of OPS-SAT. We propose to use the lessons learnt from the already carried out Machine Learning experiments on OPS-SAT and apply them to the RF signal processing field. The original Software Defined Radio experiment on OPS-SAT uses a CPU intensive application to perform Digital Signal Processing of the I and Q samples to search for a preamble signal. This process can be improved by prefiltering the data using a ML model to look for the typical RF 'fingerprint' of a beacon transmission and pass it to the signal processor once a confidence threshold is exceeded. The experiment combines the recent advances of deploying Radio Frequency DSP applications on OPS-SAT with the successes of the operationalized machine learning experiments with the intention of improving operational efficiency and autonomy of data collection operations both in the visible and RF spectrum during the Mission.