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HARNESSING ARTIFICIAL INTELLIGENCE TO SUPPORT ASTRONAUT MEDICAL CARE WITH AUTOMATED AND INTERPRETABLE DIAGNOSIS FOR CARDIAC ABNORMALITIES IN SPACE

Abstract

Introduction: Long-duration space missions require advanced medical capabilities, including continuous and automated monitoring of astronaut vital signs, to ensure optimal crew health. The potential latent health effects induced by reduced gravitational loading, high-energy cosmic rays, altered nutritional patterns and social stresses, call for an expanded framework of medical decision support system with real-time diagnostic telemonitoring independent of ground-based support systems. The space medicine industry has a tremendous opportunity to reimagine the astronaut health monitoring paradigm in which Artificial Intelligence (AI) technology augments human performance. This work focuses on the development of a deep learning framework, the ECG Generator of Representative Encoding of Style and Symptoms (EGRESSS), which harnesses traditional machine learning to build a novel generative model for AI-enhanced cardiac monitoring. EGRESS synthesizes symptomatic wearable cardiac data while includes a novel feature extraction mechanism and generator for creating unseen classes of data for AI diagnostic tools. Since data on which machine learning (ML) models can be trained in order to detect or predict health conditions is sparse due to both crew confidentiality and lack of equipment for 24/7 wearable medical monitoring, it is of paramount important to employ AI and ML methods for the development of novel tools on board. Methodology: This work focuses on generating symptomatic data for cardiac atrial fibrillation-AFib, specialized in the Astroskin Biomonitor System, a wearable technology which has been tested at Human Research Exploration Analog Astronaut (HERA) missions and at the International Space Station Missions. We have developed an architecture with encoder-decoder components for learning different representations of ECG signals that we fuse to generate new data, as well as classes, of ECG signals.

The model merges both symptomatic features of AFib with wearable tech specific characteristics, thus taking advantage of style and content attributes to the time series domain for the evolution of a novel feature extraction component as a diagnostic mechanism. Results: The architecture that produced the best results after employing a grid search for the number, size and type of layers, activation functions and learning rate was for encoder: Conv1d(32)-LeakyReLU-Conv1d(16)-LeakyReLU-Dropout(0.4)-Conv1d(8)-tanh and decoder: Conv2DTranpose(32)-ReLU-Cov2D(32)-Relu-Conv2D(32)-Dense(256). This methodology based on both reconstruction and discriminators performs better than the baseline by reproducing signals that are 3.6X closer to the originals signals for wearable asymptomatic(healthy) ECG signals and 1.3X closer to the original signals for clinical symptomatic(AFib) ECG data by producing more accurate samples of unseen classes with a 1.6X improvement of mean squared error.