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IMPLEMENTATION OF MACHINE LEARNING TO GAUGE HUMAN RESPONSE TO NOISE TO ELIMINATE ITS ADVERSE EFFECTS ONBOARD SPACECRAFT

Abstract

Crew compartments onboard spacecraft are very confined spaces designed to support the presence and functions of its inhabitants around-the-clock. As such, these compartments include extensive hardware and machinery for life support, climate control and vehicle operations [1]. This makes crew compartments very noisy spaces posing adverse physiological and psychological effects to its inhabitants.

The relationship between noise as stimulus and human response is extremely complex, as noise may include numerous features, each evoking a different degree or type of response from different observers. Still, precisely relating human response to noise and its causes is extremely valuable for the design of systems that limit the adverse effects of noise. Recent research by the author has demonstrated the feasibility of using machine learning algorithms to predict human response to complex sound originated from various sources. Learning algorithms are ideal for modeling the complex behavior of subjective parameters and identifying new hidden trends in perception and response. To that end, four learning algorithms – linear regression (LR), support vector machines (SVM), decision trees (DTs), and bagged DTs/random forests (BDTRF) – were used to construct models capable of predicting annoyance due to complex sound. Construction of these models relied on annoyance responses of 38 subjects to 103 sounds described by five predictors (loudness, roughness, sharpness, total tone prominence, and fluctuation strength). Comparison of these models in terms of prediction accuracy, model interpretability, simplicity and versatility indicates that BDTRF is the best algorithm for this task.

The BDTRF learning algorithm is ideal for analysis and prediction of annoyance of noise in close spaces such as habitable volume within a crewed spacecraft, module, or habitat, or other types of crewed enclosures used in a space environment. Here sample noise from such environments may be presented to a group of subjects and their response may be used to identify and rank predictors dominating annoyance, or other response of interest. This ranking is directly related to the physical design of sources (e.g., motors, fans, pumps, blowers) and habitable volumes, and may be used during design to precisely eliminate critical sound features responsible for the adverse effects of noise.

References 1.NASA/SP-2015-624: “Acoustics and noise control in space crew compartments,” Edited by: Jerry R. Goodman and Ferdinand W. Grosveld.