Title: Computational Modeling in Support of NASA's Human Research Program

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Abstract: Computational Modeling is an important component of NASA's Human Research Program (HRP), enabling in-depth predictive and analytical studies of astronaut health and performance. In support of HRP, NASA Glenn Research Center's Cross-Cutting Computational Modeling Project (CCMP) creates integrated mathematical and simulation models of physiological and human-in-the-loop hardware systems in order to integrate analyses of risk factors to enhance mission planning and preparation, inform spacecraft design, and provide input for countermeasure development to counteract the effects of long-duration human spaceflight.

Machine learning and numerical optimization are becoming increasingly important to the work performed by CCMP, as these techniques enable data driven simulation and tuning of complex phenomena that would be difficult to capture with *a priori* models. Work presented in this talk describes machine learning and numerical optimization techniques used to create a personalizable model of human volumetric bone mineral density in response to microgravity-induced bone unloading and in-flight exercise. In this approach, a probabilistic classification scheme is first used to automatically segment computed tomography (CT) images of bone in order to create subject-specific finite element models. The resulting finite element models are then used in a simulation model of bone remodeling dynamics, whose parameters are tuned using stochastic numerical optimization, to estimate changes in volumetric bone mineral density during flight. The developed toolchain reduces both the time required to create subject-specific finite element models from 8 hours to 10 minutes, and also enables accurate prediction of post-flight volumetric bone mineral density with a mean error of 1.16%. With further development, results suggest that this model can be useful for future mission planning by aiding in the development of customized in-flight exercise regimens for astronauts on long-duration spaceflight missions.