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A Port Hamiltonian model of the human outer, middle and inner ear, and its application

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Abstract

The objective of this research was to develop an integrated Port Hamiltonian model of the human outer, middle and inner ear. The developed Port Hamiltonian model of the human ear is based on the Dirac structure. The outer, middle and inner ear are developed in segments, tested and validated prior to the system being coupled. The outer, middle and inner ear are validated against existing literature and the results are found to be comparable. The application of the developed Port Hamiltonian model is illustrated using a developed feedback based noise policy management model for mine workers. This feedback based measurement system can be used to monitor mine workers in the mines hence provide the mine administrators with the current state of hearing of the individual worker. The information obtained from the system may be used by the administration to provide an early intervention and as a result the mine workers are protected from experiencing significant hearing threshold shifts. A control engineering approach is then used to formulate the mining noise occupational policies as a control law. Both social and measurements aspects of this system are explored. The International Standard Organization guide ISO:1999 is used to generate data and develop a basic feedback model. The basic feedback model is further refined into a dynamic model which includes a Port Hamiltonian integrated ear model and the mining policies. The feedback based noise policy management model is validated using real data from the mine documented in open source literature. The models are implemented using MATLAB as a modelling platform and the results are generated using the Simulink model. This research work has been given an ethical clearance certificate by the Human Research Ethics Committee (Medical), therefore, allowing for the findings of the investigations to be published. In conclusion,to be developed is an integrated Port Hamiltonian model of the Human outer, middle and inner ear to be used for estimation of Noise induced hearing loss. The use of this model is then illustrated using a feedback based noise policy monitoring system for mine workers.