Improving Pneumatic Artificial Muscle Performance Using Surrogate Model: Roles of Operating Pressure and Tube Diameter

Authors : Van-Thanh Ho, Jaiyoung Ryu

Abstract : In soft robotics, the optimization of fluid dynamics through pneumatic methods plays a pivotal role in enhancing operational efficiency and reducing energy loss. This is particularly crucial when replacing conventional techniques such as cable-driven electromechanical systems. The pneumatic model employed in this study represents a sophisticated framework designed to efficiently channel pressure from a high-pressure reservoir to various muscle locations on the robot's body. This intricate network involves a branching system of tubes. The study introduces a comprehensive pneumatic model, encompassing the components of a reservoir, tubes, and Pneumatically Actuated Muscles (PAM). The development of this model is rooted in the principles of shock tube theory. Notably, the study leverages experimental data to enhance the understanding of the interplay between the PAM structure and the surrounding fluid. This improved interactive approach involves the use of morphing motion, guided by a contraction function. The study's findings demonstrate a high degree of accuracy in predicting pressure distribution within the PAM. The model's predictive capabilities ensure that the error in comparison to experimental data remains below a threshold of 10%. Additionally, the research employs a machine learning model, specifically a surrogate model based on the Kriging method, to assess and quantify uncertainty factors related to the initial reservoir pressure and tube diameter. This comprehensive approach enhances our understanding of pneumatic soft robotics and its potential for improved operational efficiency.

Keywords : pneumatic artificial muscles, pressure drop, morhing motion, branched network, surrogate model
Conference Title : ICEFSCFD 2024 : International Conference on Experimental Fluid Science and Computational Fluid Dynamics
Conference Location : Boston, United States
Conference Dates : April 22-23, 2024