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Fluid-Structure and Electric Interaction Analysis of Piezoelectric Flap In a Channel Using a Strongly Coupled FEM Scheme

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Mimicking insect flapping flight for MEMS based MAVs is actively pursued in the recent years using finite element coupled algorithms [1]. The flexible wing of an insect-like MEMS-based MAVs surrounded by air is actuated by piezoelectric actuator. It is imperative to analyze the interaction between the fluid-structure and electric fields. Therefore, we propose the flexible piezoelectric bomorph flap in a channel to illustrate this novel interaction. Note that the original flap in a channel has been described in [2], which is known as one of the typical problems to test the convergence properties of computational fluid-structure interaction.

In this study, we present a numerical study of fluid-structure and electric interaction (EFSI) using a strongly coupled finite element algorithm applied to our novel EFSI problem. Here, the flexible piezoelectric bimorph flap is made of PVDF material and it is actuated by means of AC voltage as defined in [3, 4] along with the inlet fluid velocity boundary condition in a converging channel as defined in [2]. We employed a projection method for the monolithic coupling of incompressible fluid and a structure [5]. The electro-mechanical coupling in a bimorph actuator is solved by employing block Gauss-Seidel scheme [3]. They are combined via the novel forces, moments and displacement translations [4] following the field decomposition approach [6, 7]. The results obtained from the proposed method are very close to thoes in [2, 5] when a very low input voltage is applied to the actuator as the fundamental validation.

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