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Prediction of Aerodynamic Flow Fields Using Spectral Convolutions on Graph Networks JAMES DUVALL[1], KARTHIK DURAISAMY[2], YASER AFSHAR[3], University of Michigan — In this work, spectral methods for performing localized convolutions on graphs are investigated to predict aerodynamic flow fields given the geometry of the surface, and flow configurations therein. Previous work has shown that convolutional neural networks (CNNs) can be used for this purpose. CNNs, however, are restricted to Euclidean domains, and their use requires interpolation from non-regular mesh representations typical of flow solutions to an evenly spaced Cartesian mesh. This represents a loss of information as flow solvers include a clustering of points near boundary layers and other regions of sharp gradients. We pursue graph convolutional networks (GCNs) which operate over non-Euclidean data represented by a graph. GCNs generalize many of the characteristics associated with CNNs. Localized filtering operations are defined in the graph spectral domain, and depend on the graph Laplacian, which is graph structure dependent. Although meshes for different geometries may be spatially distinct, they share spectral characteristics if a binary adjacency matrix is considered. GCNs operating directly on graph representations of spatial flow solver meshes are shown to predict aerodynamic flow fields on unseen airfoil shapes and operating conditions to a good degree of accuracy.

[1]Graduate Research Assistant, Dept. of Aerospace Engineering.
[2]Associate Professor, Dept. of Aerospace Engineering.
[3]Postdoctoral Research Fellow, Dept. of Aerospace Engineering.

James Duvall
University of Michigan

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