Reconstruction of sound field caused by unknown acoustic source localization inside the cavitation tunnel using deep neural network and reproducing kernel approximation

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In this research, we establish a complete computational framework which can reconstruct the acoustic field within the large cavitation tunnel caused by unknown sound sources. The large cavitation tunnel is located in the National Taiwan Ocean University (NTOU). And the usual task performed in this facility is to obtain the general hydrodynamic performance of propeller, ship or flow conditions with large Reynolds number. Because the measured acoustic data during the experiments are under steady state conditions, it is difficult to apply general sound tracking methods such as reverse beam method or matched field method under strong reflective signal. Therefore, we propose using the deep neural network (DNN) to identify the location and strength of sound source and using the reproducing kernel collocation method (RKCM) to solve the singular problem of sound propagation.

To construct the DNN network, we started by improving the Yangzhou's method and Shunsuke's method. In the test results, we find that the errors of the both can be reduced by using the min-max normalization to highlight the data characteristics of the low amplitude in some frequency. Then, we reset the diagonal numbers of the cross spectral matrix in Yangzhou's method to zero and replace mean absolute error to be the loss function for improving the stability of training, and get the most suitable neural network construction for our research. A total of 100 data sets were used for training, 10 sets for verification, and 5 for testing. The average error of the test result is 0.13 m. For the model test in cavitation tunnel in NTOU, the length of ship model is around 7 m. And the average error is sufficient to determine the noise source position. After finding the location and strength of the source, we use the

RKCM to discretize the domain and solve the Helmholtz equation. In order to impose the singularity of the sound source properly, we introduced the equivalent pressure boundaries surround the source point. Finally, our proposed method is tested by comparing with the numerical tank modeled by commercial code. The framework will be applied in the experiment in the coming year.

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