Qeios

Peer Review

Review of: "Physics-Informed Neural Networks for Exterior Potential Flow Around a Circular Cylinder Without Far-Field Boundary Conditions"

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This paper brings an interesting proposition of solving a partial differential equation that has far-field conditions without the use of artificial far-field numerical conditions. However, the explanation of how the method works is almost non-existent, and the equations given would lead to an ill-posed problem, to which no satisfactory solution was given. As this is the main point of the paper, my recommendation is to reject it.

In the introduction, it is said that the flow will be solved using only the wall boundaries. This seems inaccurate, as a far-field boundary condition is, in fact, needed for a well-posed problem. Just by reading the abstract and the introduction, it gives the impression that some other method will be used to impose the far-field conditions instead of just using a "far enough" point, as is often the case. Authors should clear this up and avoid mixing the physical far-field condition (which is needed for a well-posed problem) with the numerical far-field condition (which is an approximation).

Some equations would benefit from extra spacing between their terms, such as "$\psi \sim Uy$as $r \to \infty$.". Adding space around "as" (perhaps with \quad) would improve readability. A similar issue is found in inline equations, many of which lack a space before the next word.

Figure 2 shows connections directly from the inputs to other layers of the NN besides the first. It also shows connections from layers besides the last straight to the output. This is not the conventional fully-connected architecture that is described in the text. Furthermore, the figure is very low resolution, and part of the text is unreadable.

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At no point in the paper is the neural network architecture discussed. There is no information on the number of layers or perceptrons. The SiLU activation is only disclosed in section 6.4.

Section 4 is dedicated to explaining how the exterior flow condition is met without the use of boundary conditions. However, no explanation is given apart from "Within the PINN framework, however, uniqueness is promoted through the combined influence of the governing equation residual, the solid boundary condition, and the inductive bias of the neural network". The governing equation and the solid boundary condition do not promote uniqueness, as they alone define an ill-posed problem. Furthermore, I fail to see how the inductive bias of neural networks would come into play here. For instance, the trivial solution would also satisfy all conditions, as would the flow coming from any direction at any velocity. One possible explanation I can think of is that some solution points (such as surface pressure or ψ somewhere else) are also present in the training dataset to ensure uniqueness, but this is not mentioned in the paper and would invalidate its main point.

In section 8, there is some more discussion on the uniqueness of the solution. However, there is still no explanation of how it is achieved other than relying on the neural network to reach a smooth solution. At no point was a way of setting the external flow velocity discussed. If the energy-minimizing hypothesis is correct, then a trivial solution would be reached.

Unfortunately, this point alone is enough reason for rejection, as this would be the main novelty of the paper.

I would only recommend reconsideration if these sections are majorly reviewed and the method is satisfactorily modified and/or explained.

Declarations

Potential competing interests: No potential competing interests to declare.

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