Federal University of Uberlândia
Fluid Mechanics laboratory

NEURAL NETWORK ASSISTED CAVITY CONVECTION FLOW

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Objectives

The present text seeks to document the development of this research work with detail. from mathematical and theoretical developments to progress in technical and organizational aspects.

The core topics of this study are:

- Theoretical and mathematical development of two-dimensional cavity flow;
- Development of artificial neural network machine learning in FORTRAN;
- Enhancement of the visualization methods with OpenGL in FORTRAN;
- Development of MPI methodologies.

Bidimensional convective flow in a cavity

- Natural convection is a classic cavity flow phenomenon. it represents many industrial and everyday situations;
- To simulate such a phenomenon a two or three-dimensional domain is necessary. Which brings new challenges compared to the previous poiseuille flow project;
- Despite dealing with fluid mass changes, the flow is considered incompressible, as volumetric changes are negligible;

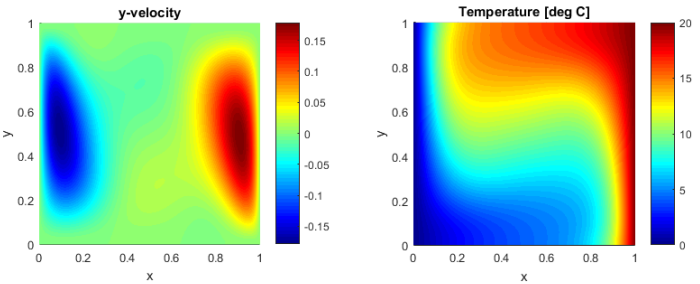

Figure 1: cavity convection example.

Artificial neural network

- They seek to mimetize the biology of brains to emulate it's learning capabilities.
- Its based on the neuron entities and it is defined by the structure of neurons and the weights of each connection.
- Training the network, or, the learning process, as it is called, consistis in determining the weights of each connection based on multiples tests and loss calculation. A gradient descent is used to obtain the weights with which the error is the minimal in a given training set.

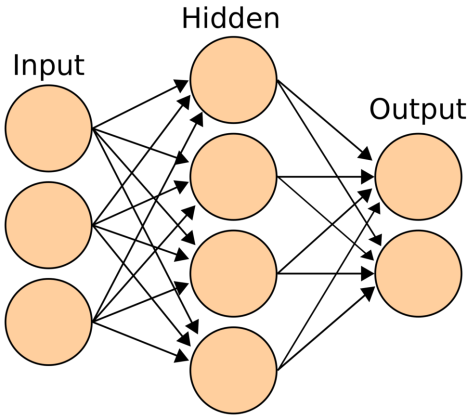

Figure 2: Simple neural network.

ANN applyied to cavity flows

- Neural netwoks can be described as neural operators that learn mappings between finite-dimensional euclidean spaces.
- The catch is that they are discretization dependent, which drastically affects the applicability of the method.
- As seen in "Fourier Neural Operator For Parametric Partial Differential Equations"... The problem can be solved by training the neural network in Fourier Space.
- Such approach enables the network to be used in a variety of mash sizes and geometries.

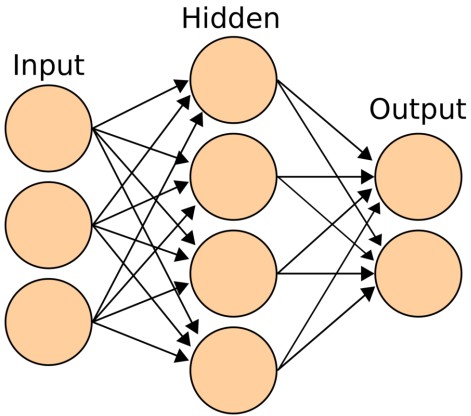

Figure 3: Simple neural network.

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Agradecimentos

Obrigado.