NEURALPHY

Implementing Physics through Neural Networks

Based On
PINNs: Physics Informed Neural Networks

Mentors:

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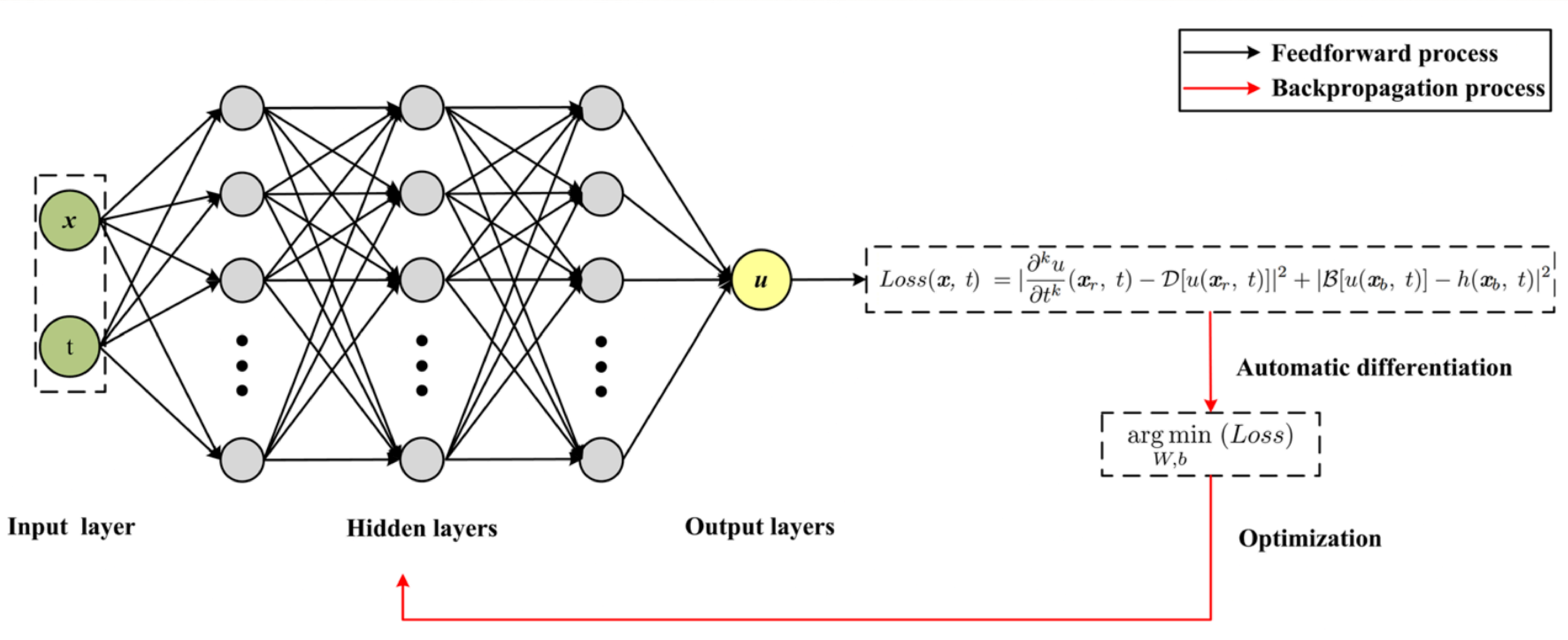
WHAT ARE PINNs ?

- PINNs are a type of neural network that can be used to solve differential equations, which are used to model physical systems in fields such as physics, engineering, and materials science.
- PINNs have shown to be more efficient and accurate than traditional methods, and can handle complex geometries and incomplete or noisy data.

INTRODUCTION TO PINNs.

- PINNs use a neural network to learn the relationship between inputs and outputs of a physical system, and then enforce the governing differential equation as a constraint on the network's output.
- This allows the network to predict the behavior of the system under different conditions, while ensuring that the predictions are physically consistent.
- PINNs use a neural network to learn the relationship between inputs and outputs of a physical system, and then enforce the governing differential equation as a constraint on the network's output.
- This allows the network to predict the behavior of the system under different conditions, while ensuring that the predictions are physically consistent.
- PINNs have several advantages over traditional methods, including the ability to handle incomplete or noisy data, the ability to handle complex geometries, and the ability to scale to high-dimensional problems.

PINN ARCHITECTURE



https://www.researchgate.net/publication/356872602_Transfer_learning_for_deep_neural_network-based_partial_differential_equations_solving

PINN ARCHITECTURE.

- A PINN typically consists of an input layer, an output layer, several hidden layers, and a physics-informed layer.
- The input layer receives the input parameters, such as time or space coordinates, and the output layer provides the predicted solution.
- The hidden layers perform nonlinear transformations on the input to generate a high-dimensional representation of the input.
- The physics-informed layer enforces the differential equation constraint on the network's output, and can include additional parameters to be learned by the network.

PINN APPLICATIONS.

- Solving partial differential equations for fluid dynamics and turbulence modeling.
- Modeling and predicting the behavior of materials under stress and strain.
- Designing and optimizing complex mechanical systems, such as engines or aircraft components.
- Predicting and controlling the behavior of complex chemical reactions.
- Estimating the parameters of physical systems, such as the diffusion coefficient in a reaction-diffusion equation.

LEARNING OBJECTIVES.

- Understand what Physics Informed Neural Networks are and how they work.
- Recognize the advantages and limitations of PINNs compared to traditional methods.
- Explain the architecture and training process of a PINN.
- Identify real-world applications of PINNs in physics, engineering, and other fields.
- Appreciate the potential impact of PINNs on solving complex physical problems.

PROJECT LOGISTICS.

- This project will run for 8 weeks.
- We are going to recruit around **~30 mentees.**
- There will be a test for recruitment for which syllabus will be **Basic Python and Linear Algebra.**
- This project will cover theory as well as application of neural networks on physical systems.
- The time commitment will be around **8-10 hours per week.**

PROJECT TIMELINE

Week 01
Intro to Python Libraries.

Matplotlib, Pandas, NumPy, sci-kit learn, etc.

Week 02
Intro to Deep Learning.

Basic regression, gradient descent, etc.

Week 03
More about Deep Learning.

Activation function, bias, error, Neural Network, etc.

Week 04
Intro to Torch.

Introduction, Workflow, Transfer Learning.

Week 05
PINNs.

Physics Informed Neural Networks.

Week 06
Implementation of PINNs.

Harmonic Oscillator

Week 07
Evaluation

Heat Equation

ASSIGNMENTS

Assignment 01

Based On Python and Python Libraries.

Assignment 02

Machine Learning (Regression)

Assignment 03

Neural Networks and Linear Algebra

Assignment 04

Torch (Code Completion of Half Baked Colab File)

Assignment 05

PINN - Differential Equations and Mathematics for Physics.

Assignment 06

Final Evaluation:

Heat equation using torch

THANK YOU!

CONTACT DETAILS

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