LEARNING REDUCED-ORDER MAPPINGS BETWEEN FUNCTIONS

How robust are the PCA-neural network based approaches against noise in the data?

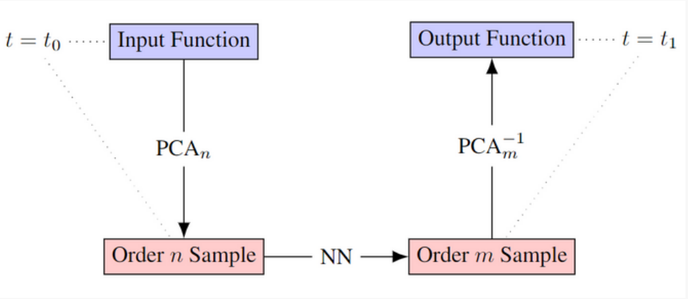
BACKGROUND

- Partial Differential Equations (PDEs)
  - Heat Equation
  - Shallow Water Equation (SWE)
- Techniques
  - Principal Component Analysis (PCA)
  - Neural Networks (NNs)
- Prior Research (Bhattacharya et al.)
- Noise in Sensor Data
  - Gaussian
  - Uniform
  - Salt and Pepper Noise

METHODOLOGY

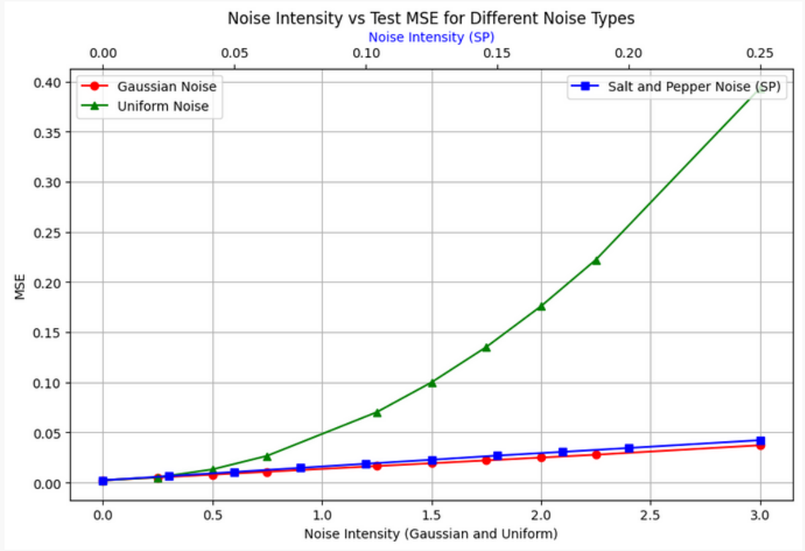
- Determine PDE
- Pre-process data into input and output
- Split into a train and test set
- Seperate PCA order reduction on input and output
- Train NN to learn reduced function mapping
- Evaluate against test set
  - Inverse PCA on output

PCA-neural network approach



RESULTS

- Results align with prior research
- Method can generally learn the mapping for SWE.
- Model is able to learn SWE but struggles in some areas.
- Inconclusive tradeoff between number of components and Mean Squared Error (MSE).
  - Could be due to model bias towards a certain implementation
- Varying accuracy against noise
  - Gaussian noise appears to scale linearly
  - Uniform noise appears to scale exponentially
  - Salt and pepper noise appears to scale linearly



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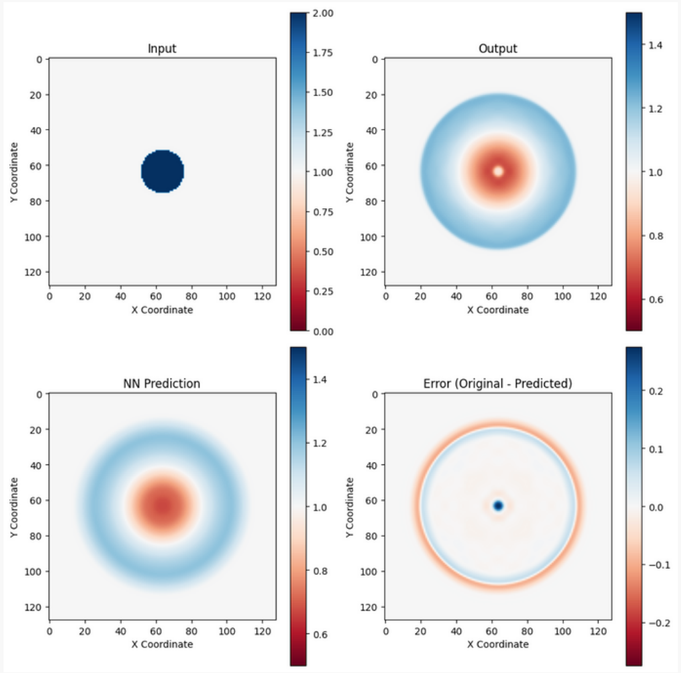
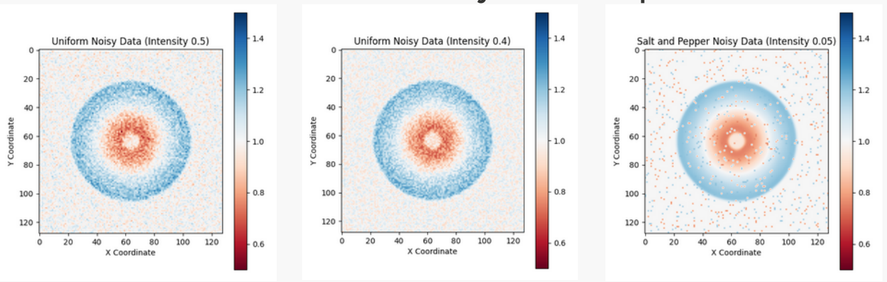
Visualisation of PCA-neural networks on SWE



Visualisation of Noisy SWE Samples



FURTHER RESEARCH

- Real world applications in fields like finance or biology
- Dynamic PCA application, exploiting known data patterns.
- Application to more challenging multi-dimensional PDEs like Reaction-Diffusion Equations

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