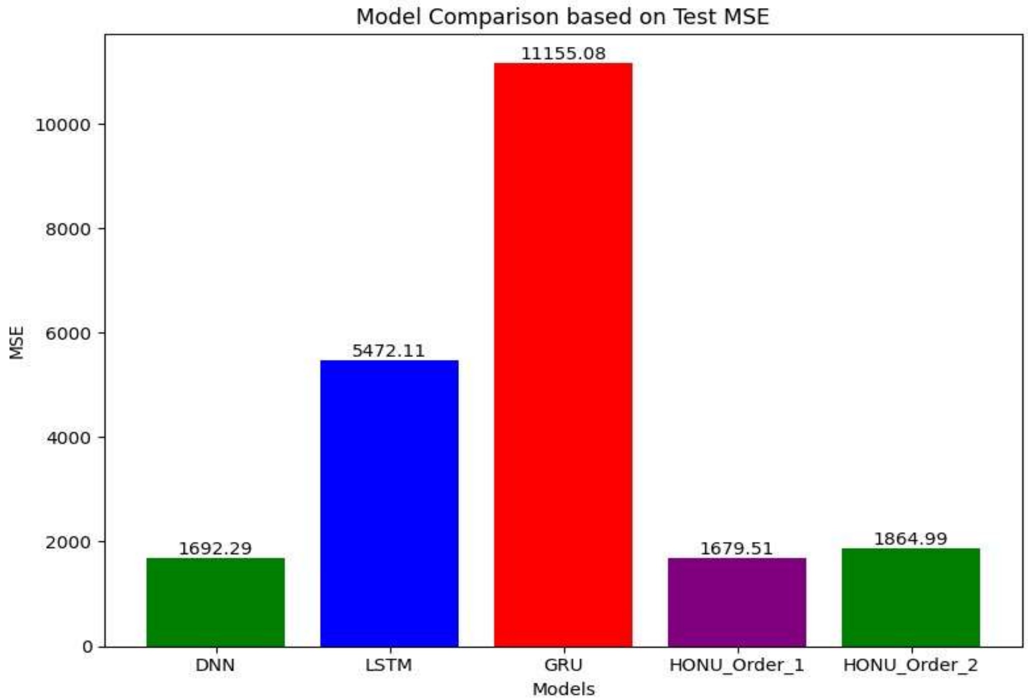
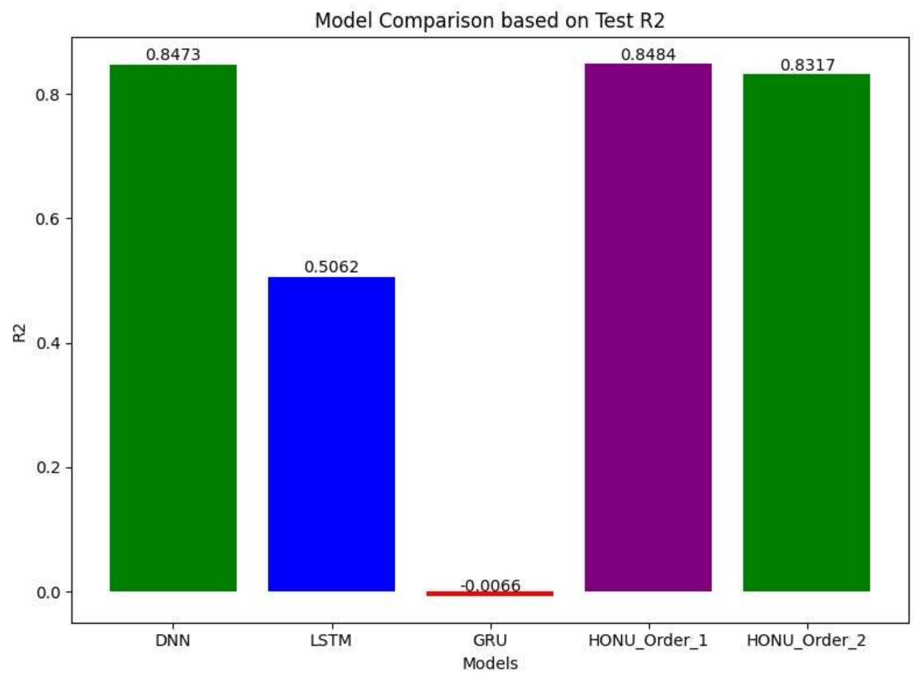
IPLNA - In-Parameter Linear Nonlinear neural Architectures
Comparison to larger Neural Networks
“Explainability” , “Physics-Informed”
Learning Weight Convergence,

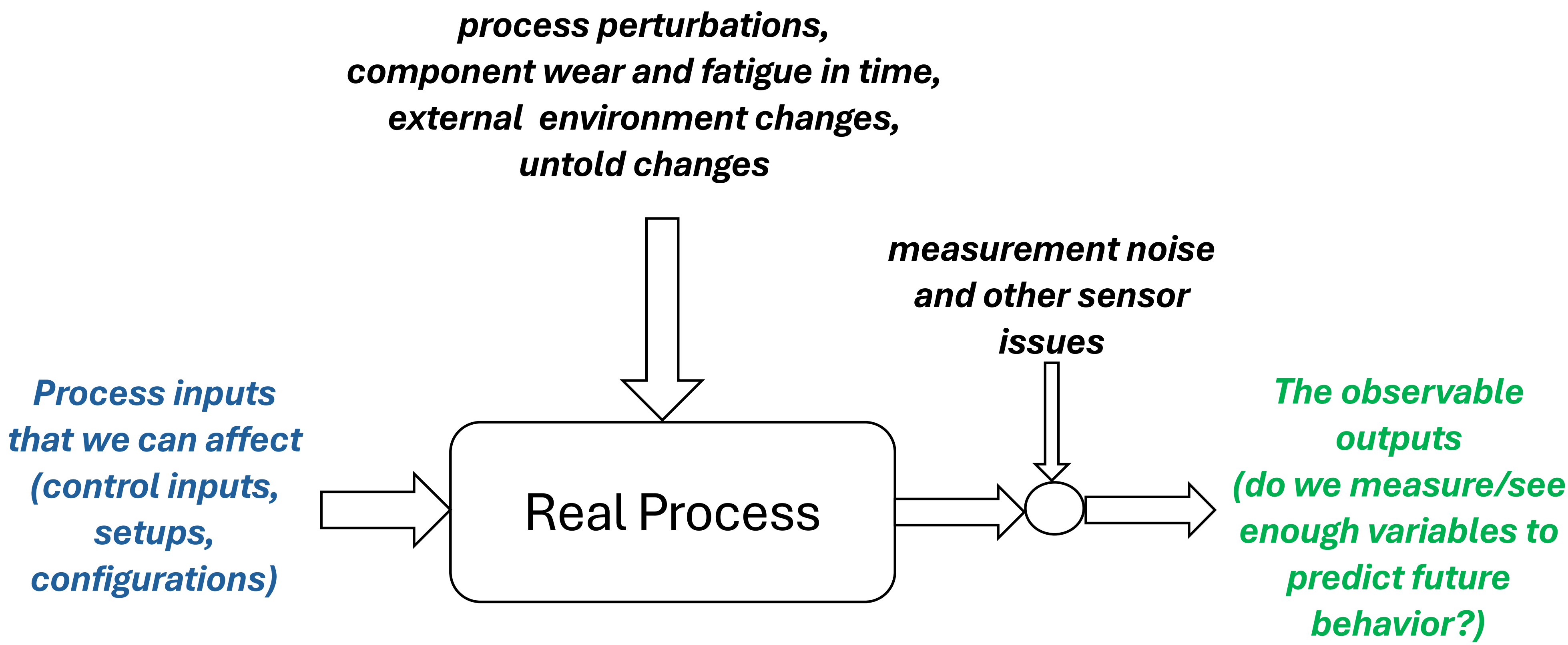
Ivo Bukovsky (FSci, USB), Moritz Sontheimer (NTUST), Vladimir Maly (VM-Engineering)

Photovoltaic Power Prediction Model Comparison (Deep vs Shallow Neural Networks)



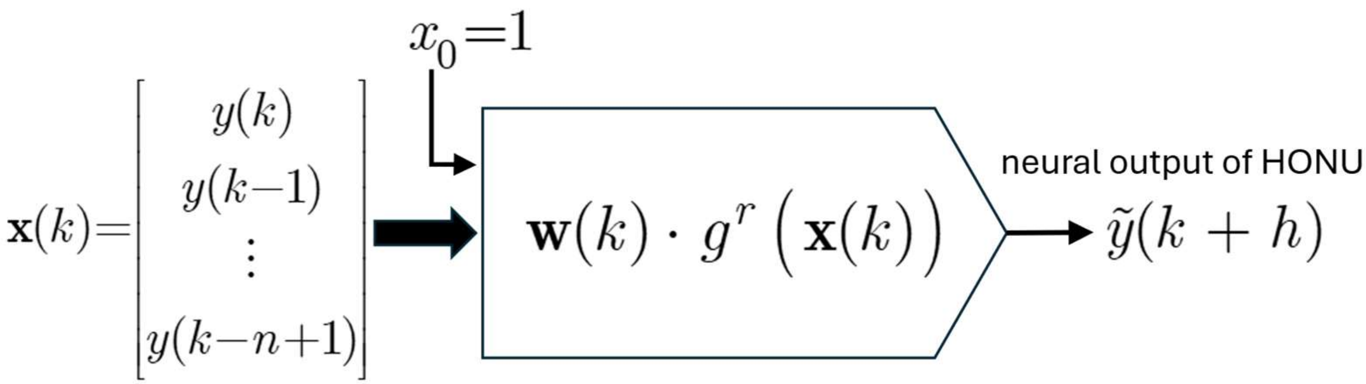


Nonstationarity, Perturbations, Incompleteness of Process Observations



Mini AI (?)
IPLNA
HONU

HONU ... **Higher-Order Neural Unit** is a standalone neuron, i.e, merely a polynomial of r-th order nonlinearity [7-9,14]



$$g^r(\mathbf{x}) = \begin{bmatrix} \left\{x_i \cdot x_j \cdot x_\kappa \cdots\right\}_{\substack{i=0\ldots n \\ j=i\ldots n \\ \kappa=j\ldots n \\ \vdots}} \end{bmatrix}$$

$$r = \begin{cases} 1 \ldots \text{Linear Neural Unit} \quad (\text{LNU}) \\ 2 \ldots \text{Quadratic Neural Unit} \quad (\text{QNU}) \\ 3 \ldots \text{Cubic Neural Unit} \quad (\text{CNU}) \\ \vdots \end{cases}$$

$$\text{LNU:} \quad g^{r=1}(\mathbf{x}(k)) = \mathbf{x}(k)$$

Some Considerations

- Larger NN (LSTM etc)
  - “have memory” so they can learn long data without changing all weights (parameters) of the model seasonally
  - But they are not analyzable (explainable, convergence/stability,…)
- Simpler (single “neuron” model, IPLNA, HONU)
  - All weights respond to current data (learn and forgets quickly temporal dependency in data, no memory for long data)
  - The data behavior is encoded into a vector of neural weights
  - We can use them if not enough data, if noisy data,…
  - We may explain system states according to learn weights
  - We can analyze/guarantee model convergence (learning stability) for any gradient learning
  - We can analyze stability of a real system from learned data
  - We can apply learning Entropy

  - IPLNA have one global minima (we solve set of linear equations); however, the input data must be linearly independent (no collinearity (redundancy) in **x**)

University of South Bohemia in České Budějovice
Faculty of Science

IPMAI

Interpretable Prescriptive Maintenance using Artificial Intelligence

Interreg Austria – Czechia

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