Efficient Hyperparameter Optimization of Deep Learning Algorithms Using Deterministic RBF Surrogates

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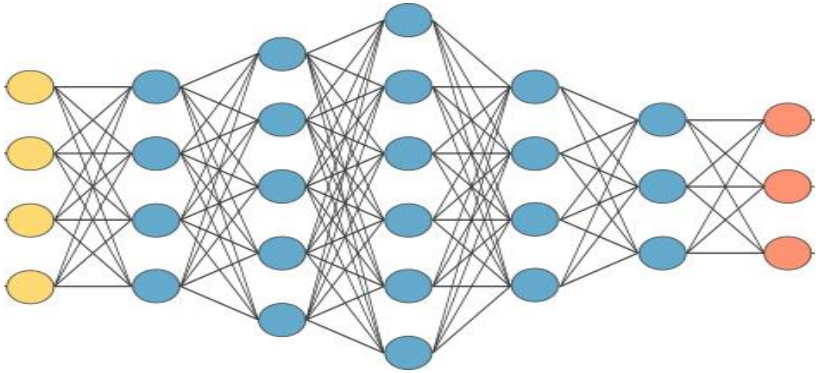
Deep neural networks are great but…

- They have **many hyperparameters**
- They are **very sensitive** to hyperparameter values
- Very **hard to guess** good hyperparameter values
- Solution: use **hyperparameter optimization algorithms**



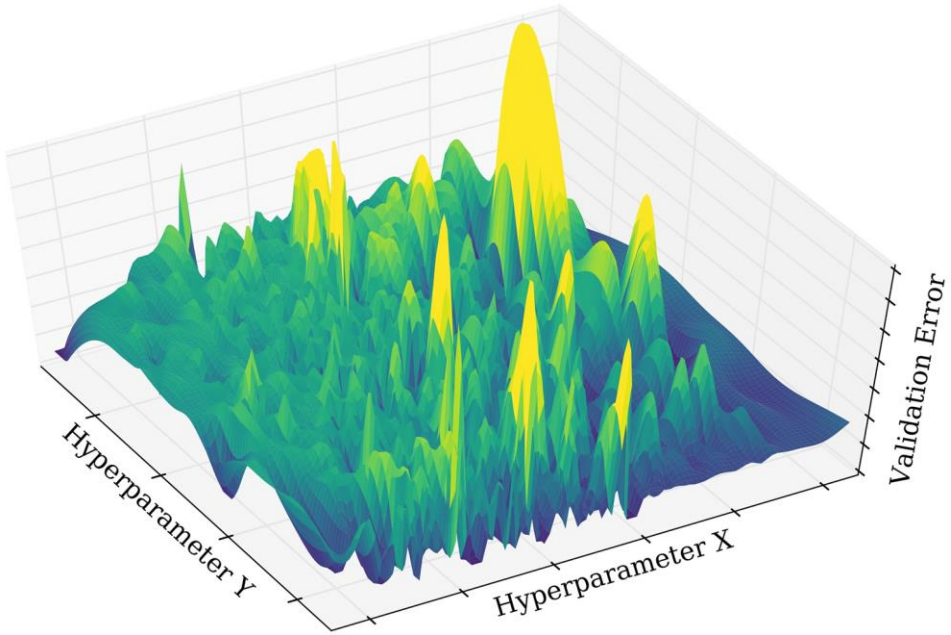
- number of layers and neurons
- learning rate and momentum
- dropout rate
- weight initialization
- and many others…

Hyperparameter optimization is not easy

$$E_{val} = F(\mathbf{x})$$

Validation Error Hyperparameters

- One **hyperparameter evaluation** requires DNN training to convergence that can **take several hours**
- The hyperparameter space has **large number of local minima**
- Difficult **non-convex optimization in high dimensions**



Our approach: Use surrogate model…

- **Approximate the expensive hyperparameter evaluation** with a surrogate model:

$$F(\mathbf{x}) \approx S_n(\mathbf{x}) = \sum_{i=1}^{n} \lambda(\|\mathbf{x} - \mathbf{x_i}\|)^3 + \mathbf{b}^\top \mathbf{x} + a$$

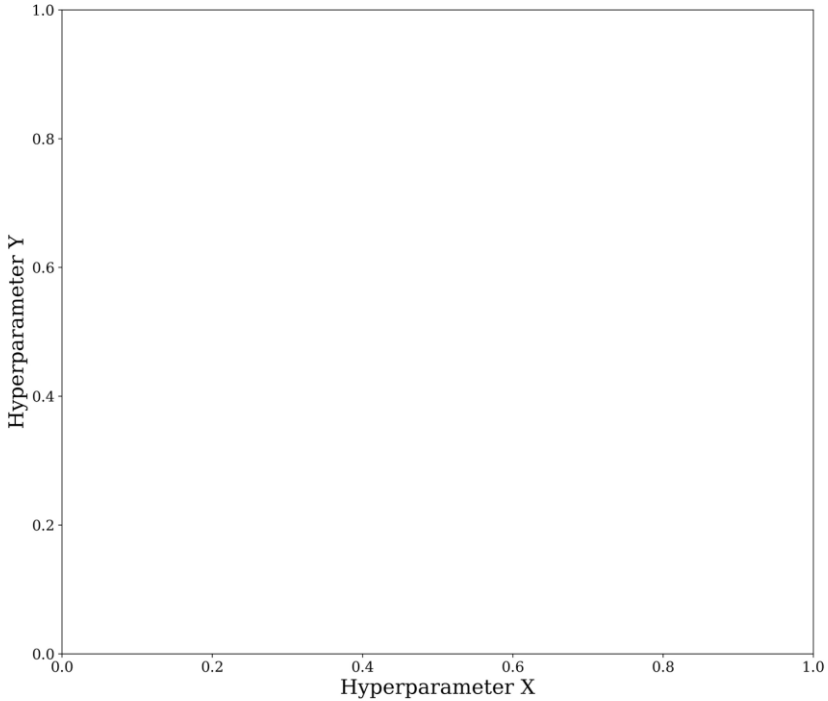
Cubic RBF

Polynomial tail

- Experiments show that **Cubic Radial Basis Function surrogate with polynomial tail** fits the highly non-convex and spiky hyperparameter space surprisingly well

and Dynamic Coordinate Search

Explore the surrogate space for optimal hyperparameter values by **evaluating candidate points around the current best found solution**:



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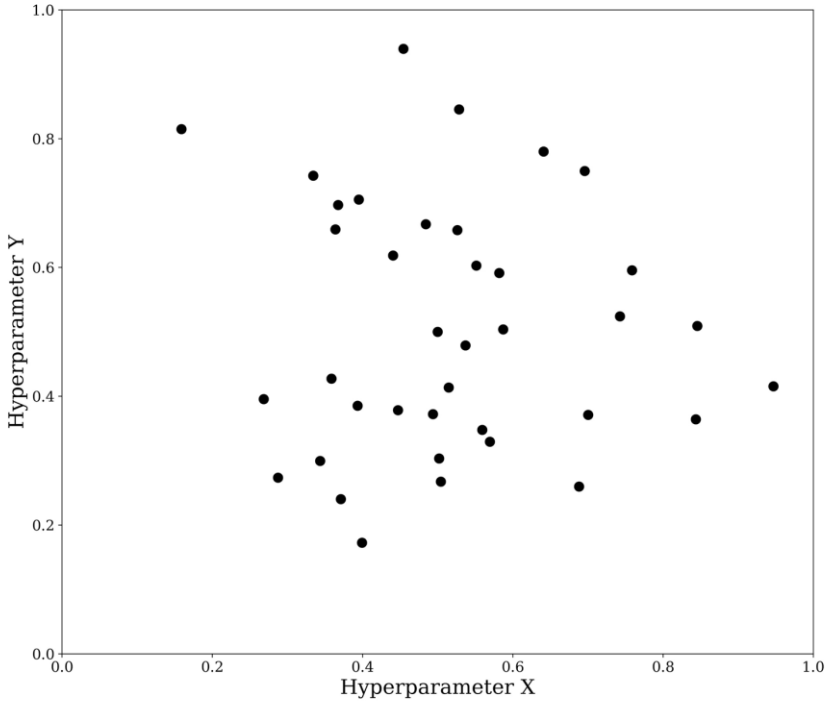

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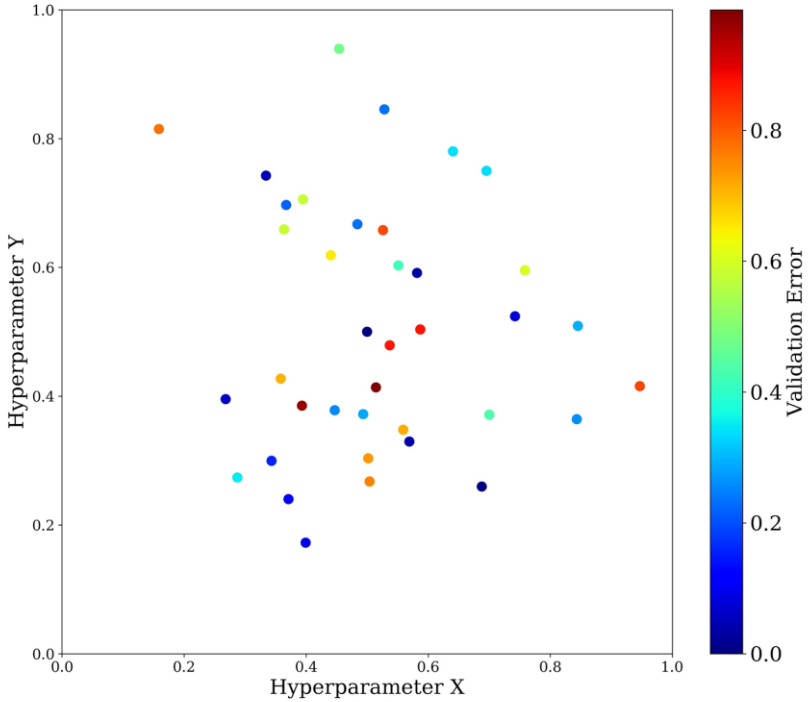

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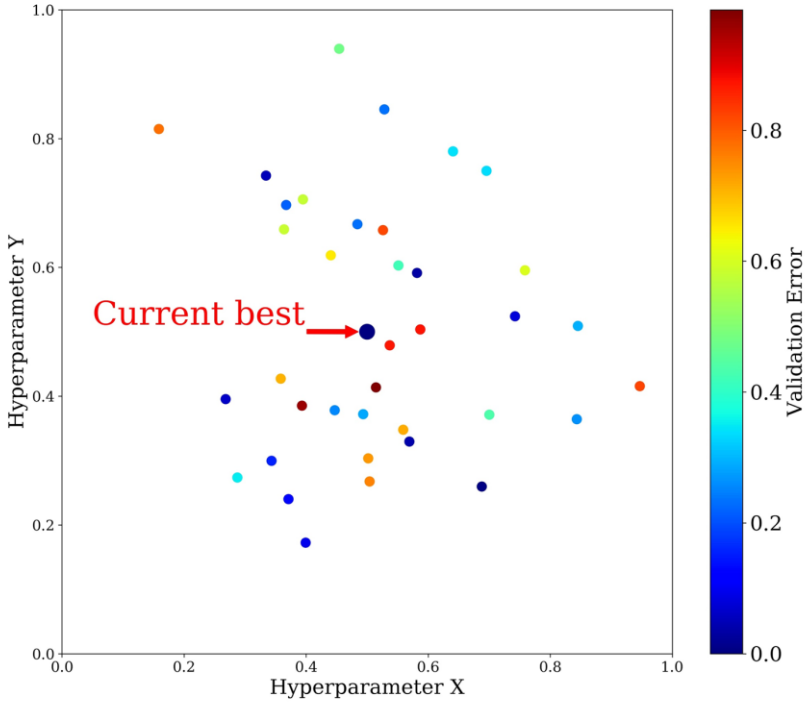

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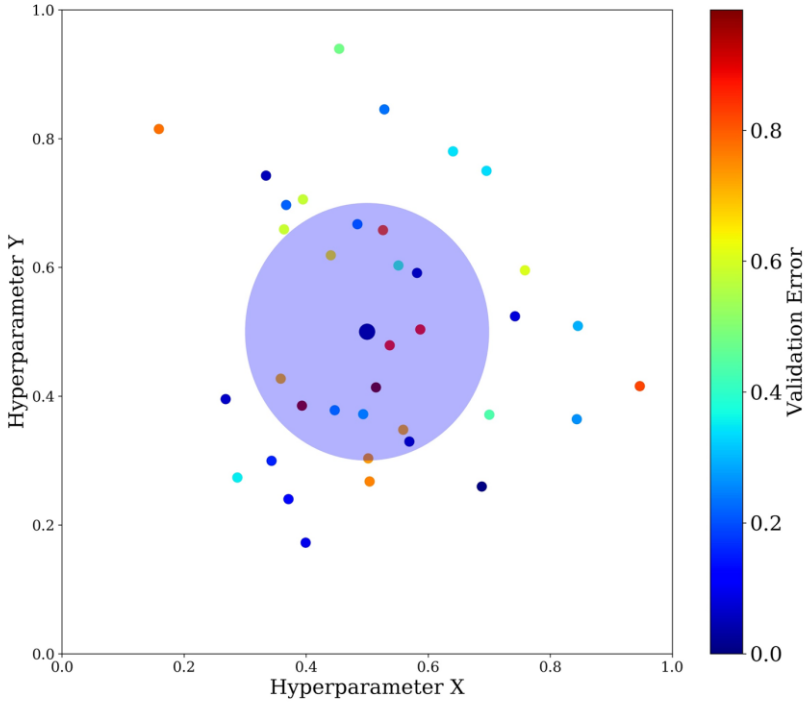

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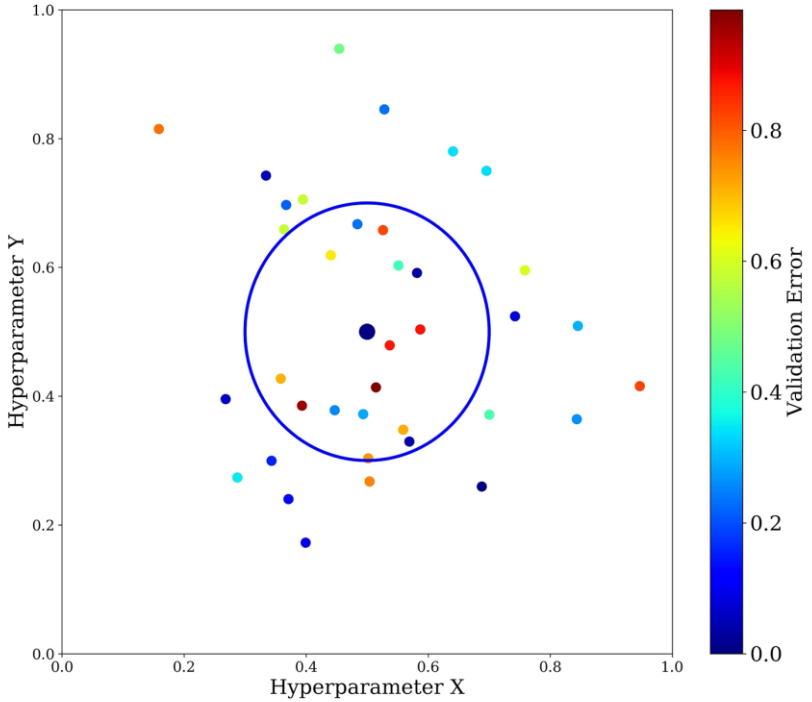

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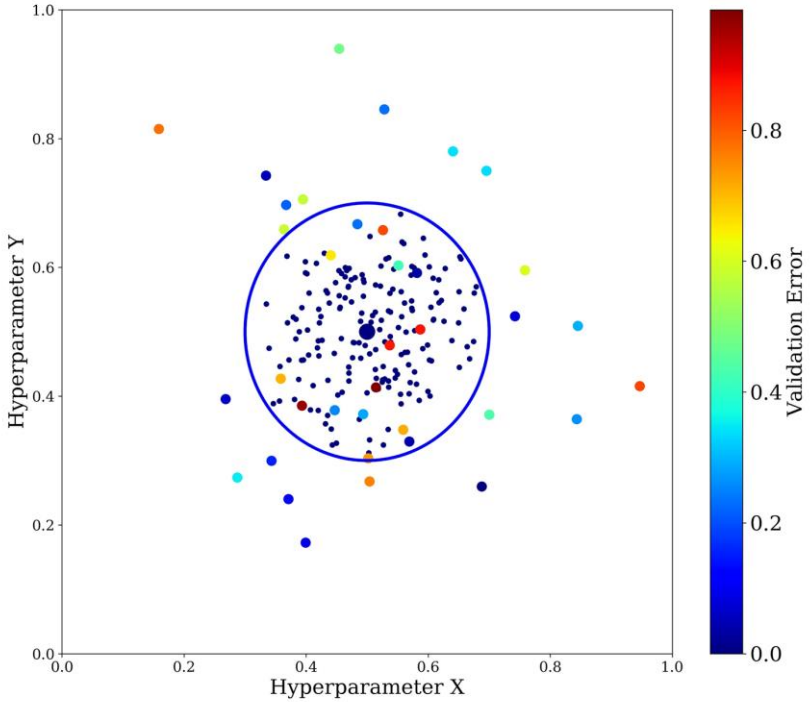
Explore the surrogate space for optimal hyperparameter values by **evaluating candidate points around the current best found solution**:

1. **Rank** the candidate points **according to weighted average of the surrogate value and distance** to the current best solution



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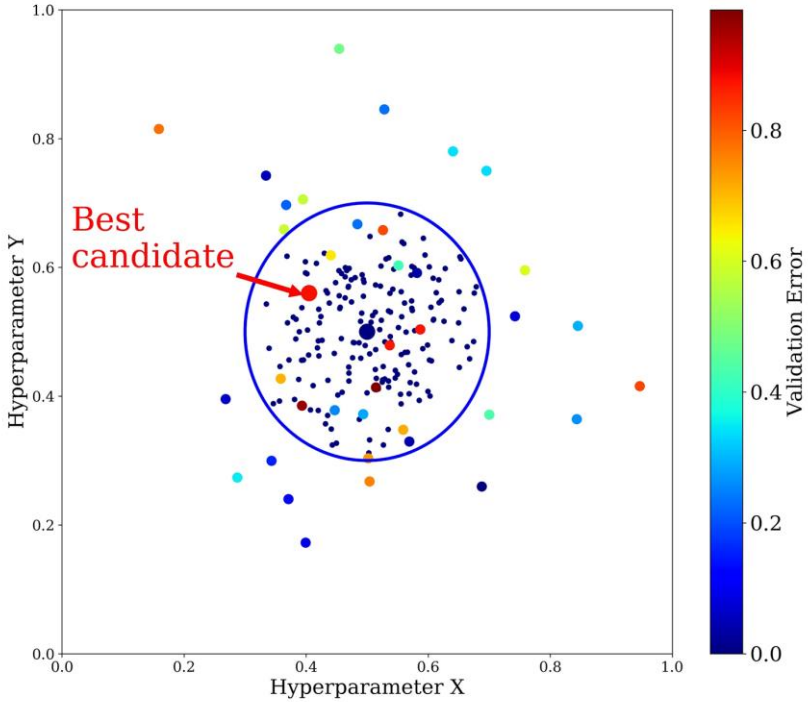

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Explore the surrogate space for optimal hyperparameter values by **evaluating candidate points around the current best found solution**:

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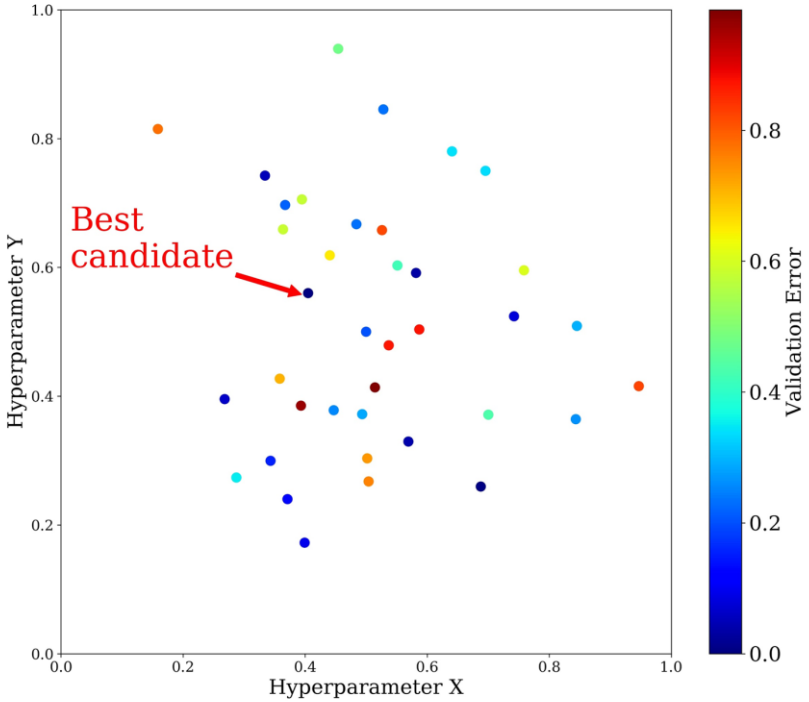

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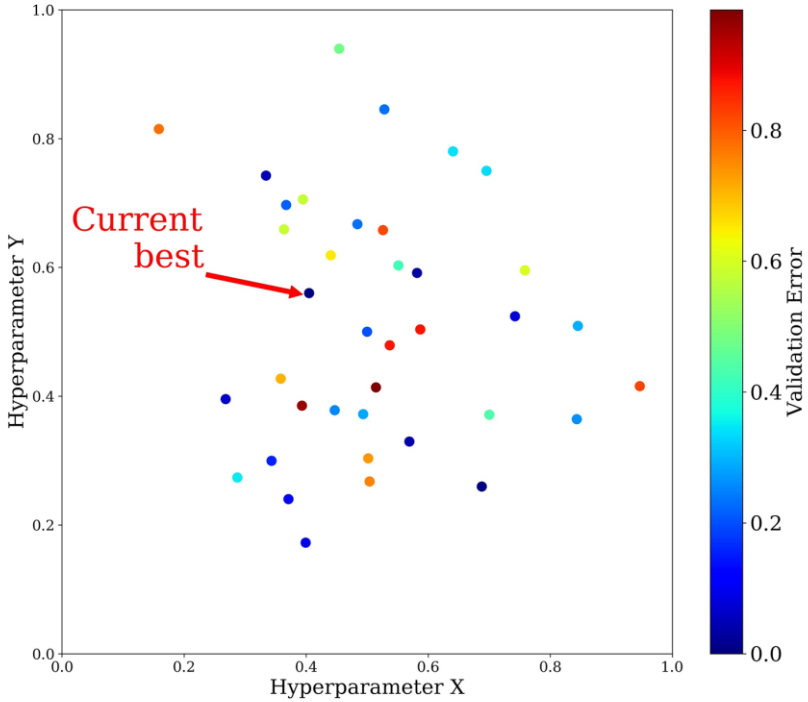

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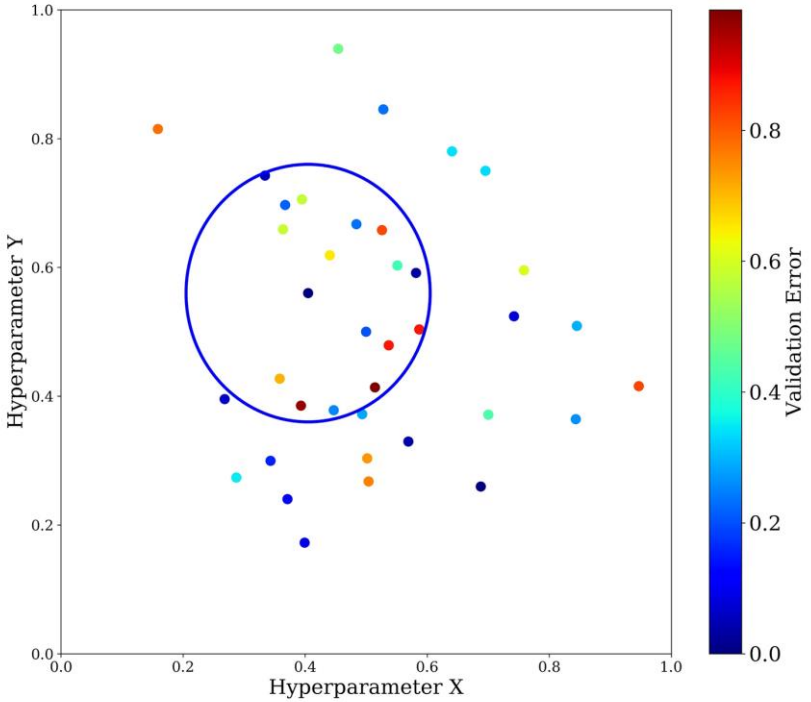

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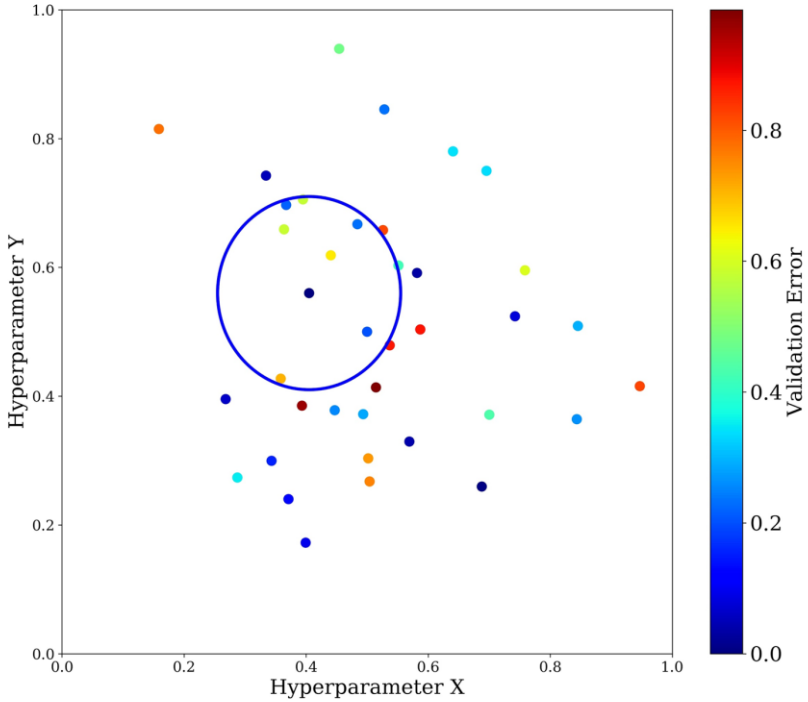
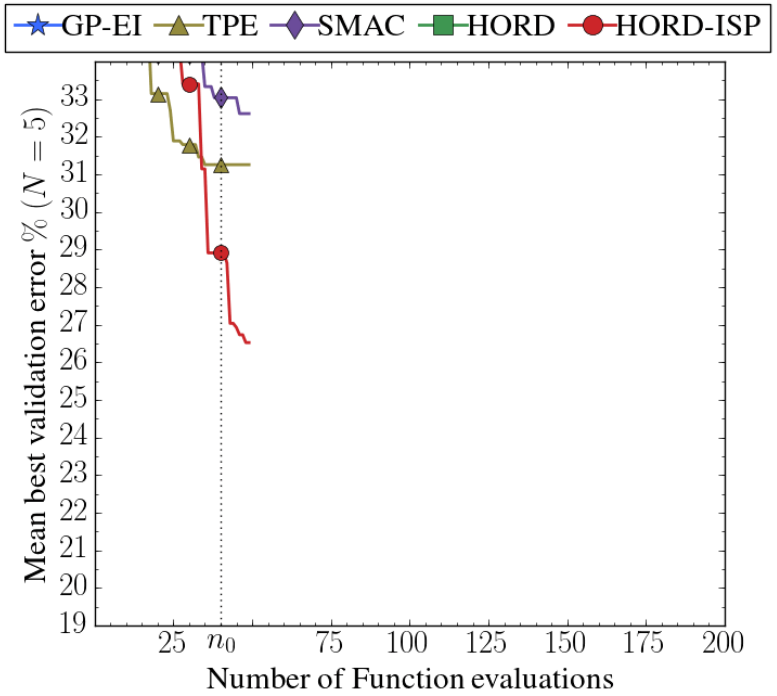
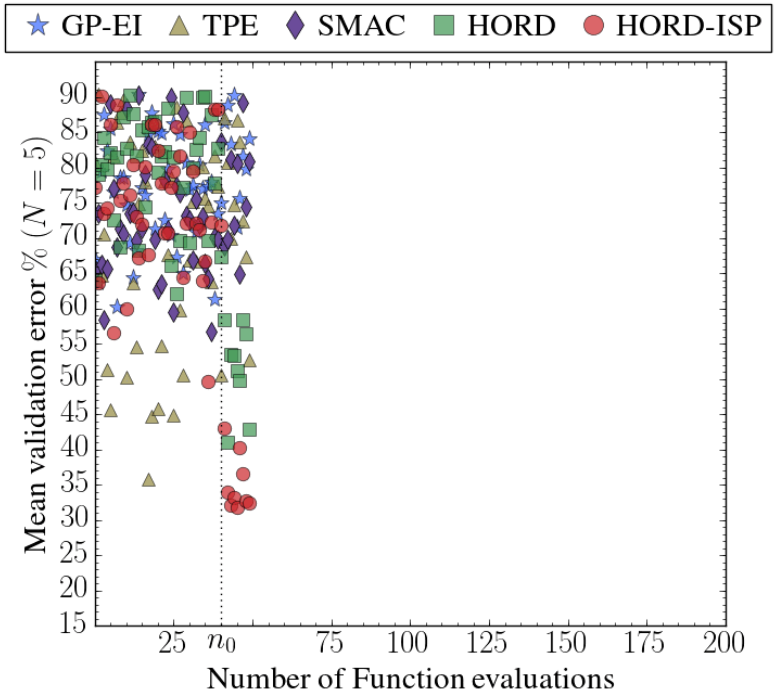


Results: Optimizing 19 **CNN** hyperparameters





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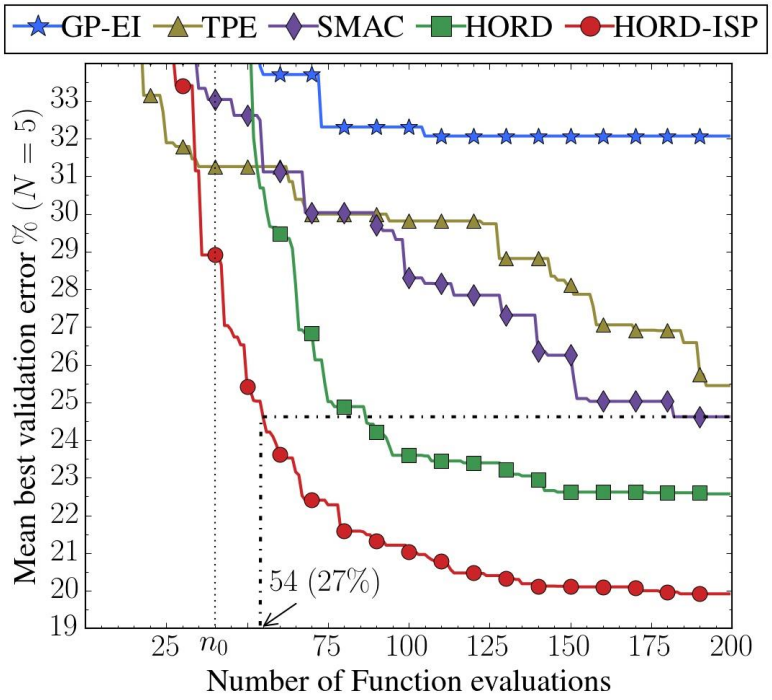

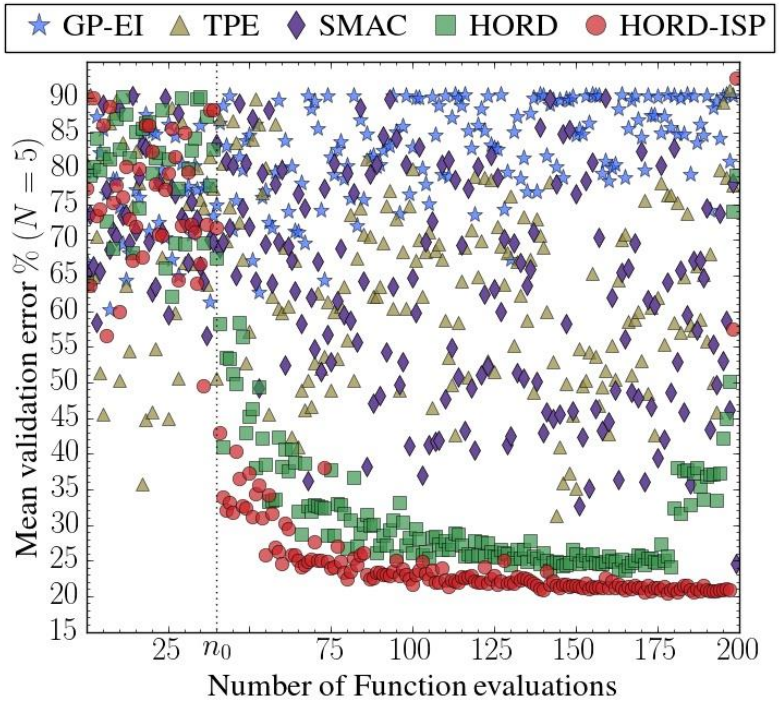

Thank you. Questions?

"Efficient Hyperparameter Optimization of Deep Learning Algorithms Using Deterministic RBF Surrogates", AAAI-17

Ilija Ilievski, Taimoor Akhtar, Jiashi Feng, and Christine Annette Shoemaker

Paper available at:
https://ilija139.github.io
Code:
https://github.com/ilija139/HORD