

Adaptive Interpolation for Electronic-System Design

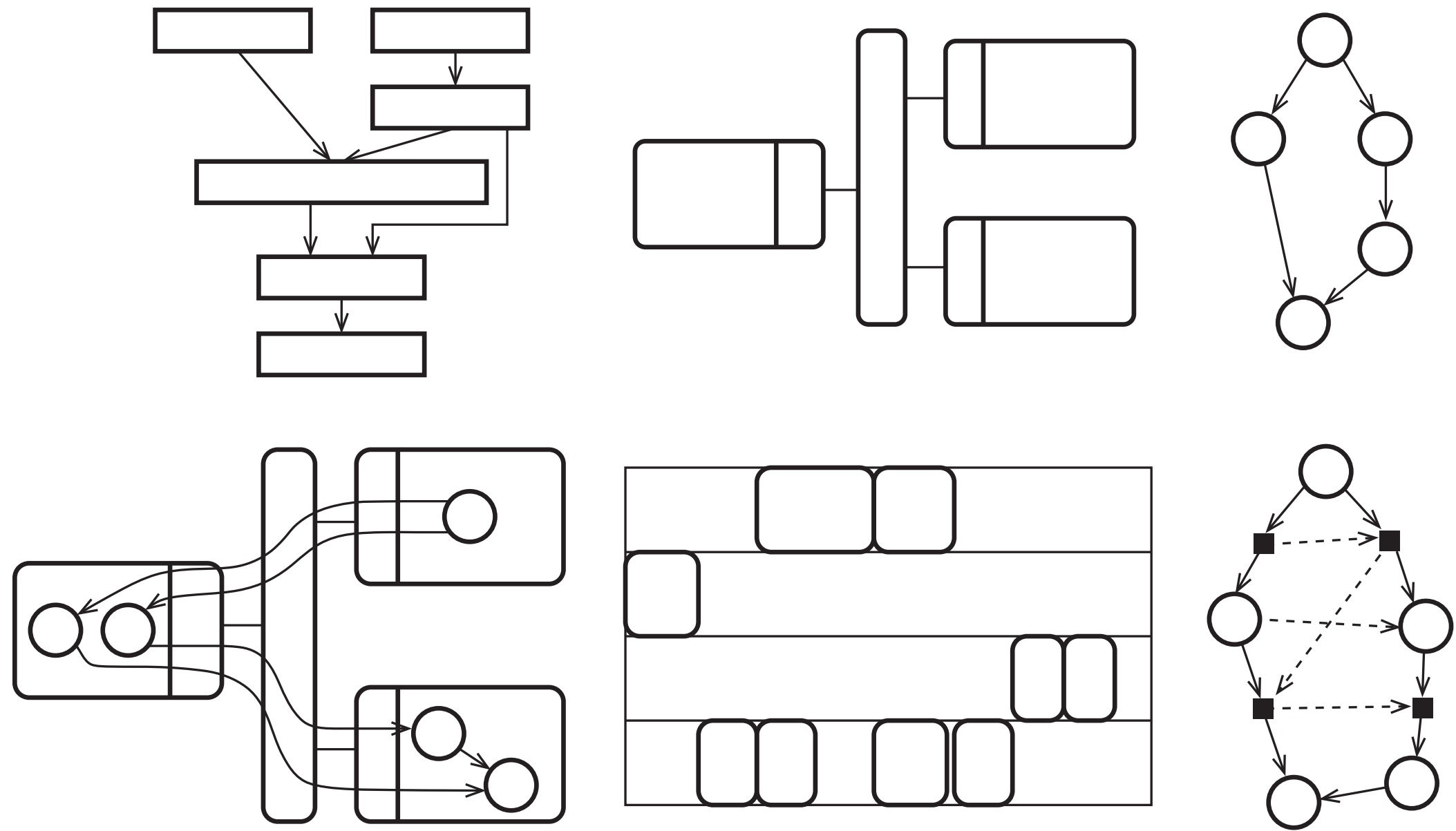
Ivan, Petru, and Zebo

April 2016

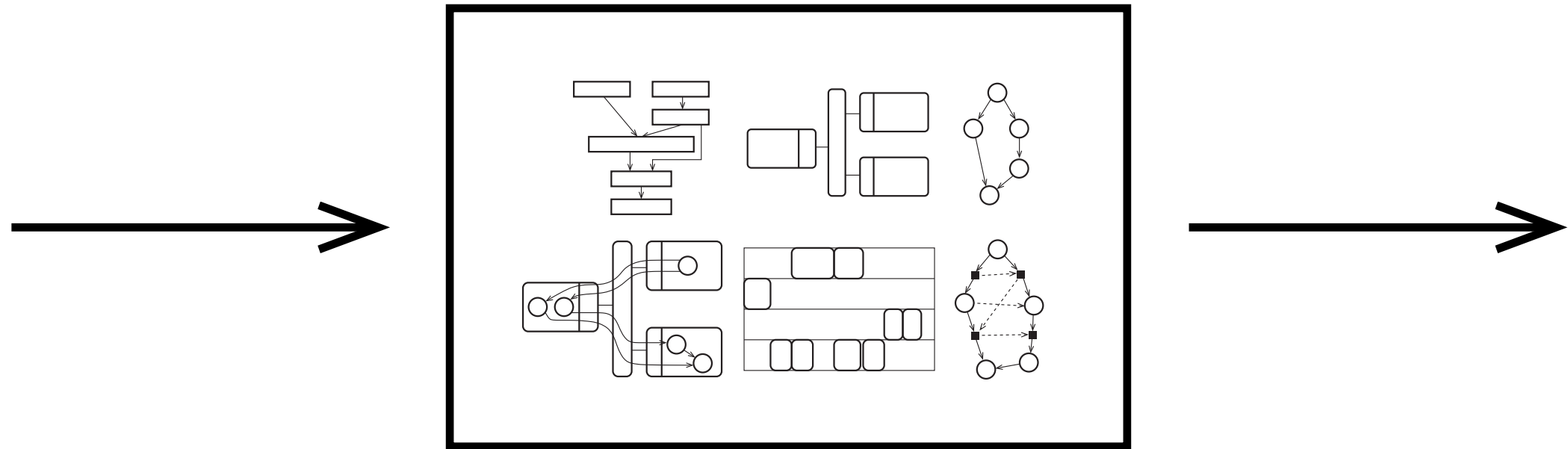
Outline

- Motivation
- Interpolation

Electronic-System Design



Electronic-System Design



Electronic-System Design

$$f(\mathbf{x})$$

Questions

- Range of outputs?
- Most influential inputs?
- Input values to agree with data?
- Probability distribution of outputs?

Optimization

$$\min_{\mathbf{x}} f(\mathbf{x})$$

Integration

$$\int f(\mathbf{x})w(\mathbf{x})d\mathbf{x}$$

Inference

$$p(\mathbf{x}|\mathcal{D}) \propto p(\mathcal{D}|\mathbf{x})p(\mathbf{x})$$

Evaluation

$$f(\mathbf{x})$$

Curse of Dimensionality

1	10	10 seconds
2	100	2 minutes
3	1,000	16 minutes
4	10,000	3 hours
5	100,000	1 day
6	1,000,000	2 weeks
...
20	100,000,000,000, 000,000,000	3 trillion years (200 × the universe)

Curse of Complexity

blackscholes	1	1 hour
bodytrack	1	2 hours
canneal	1	2 hours
dedup	1	4 hours
facesim	1	13 hours
ferret	1	3 hours
...
x264	1	3 hours

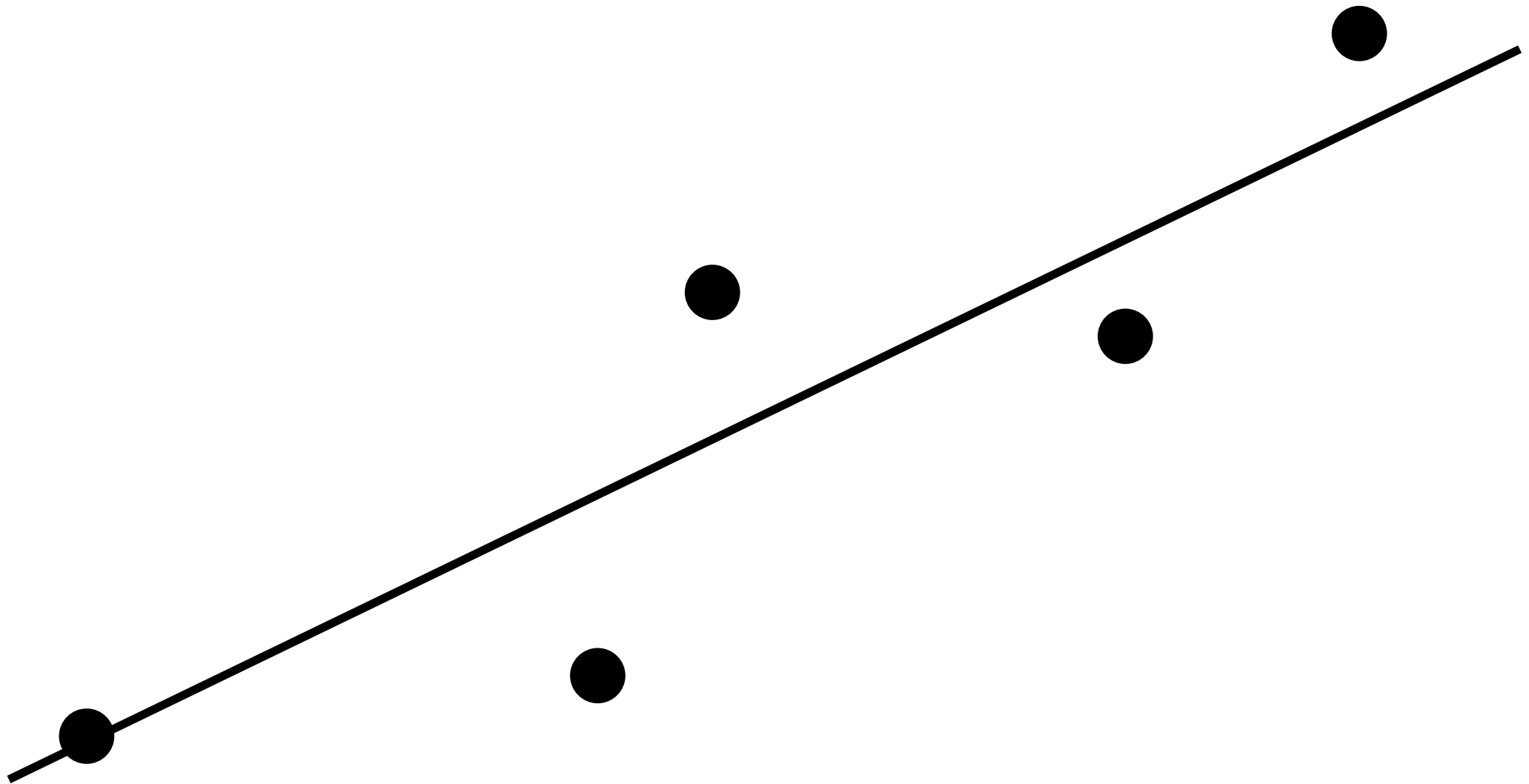
Approximation

$$\tilde{f}(\mathbf{x}) \approx f(\mathbf{x})$$

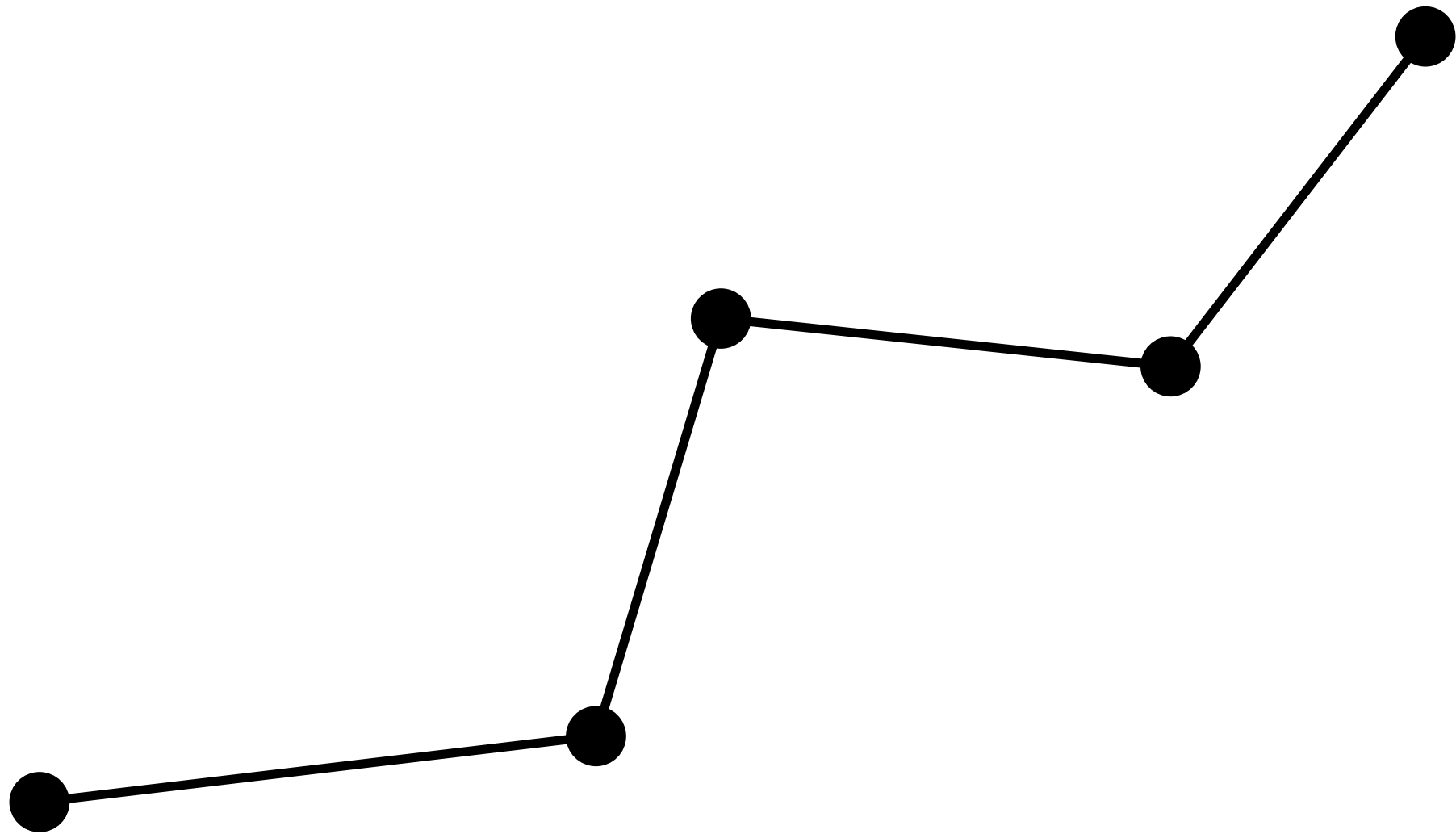
Approximation

- Regression
- Interpolation

Regression



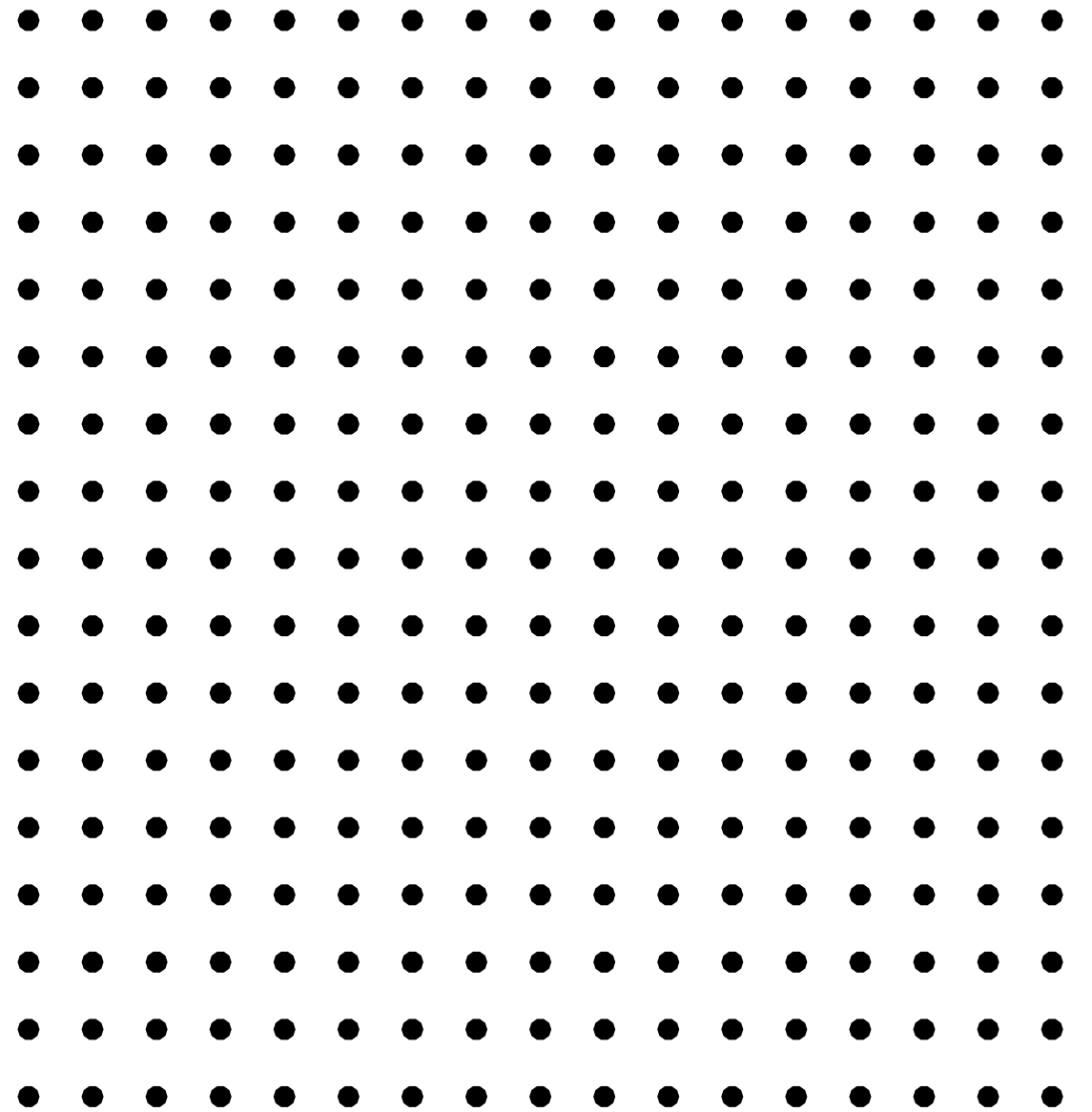
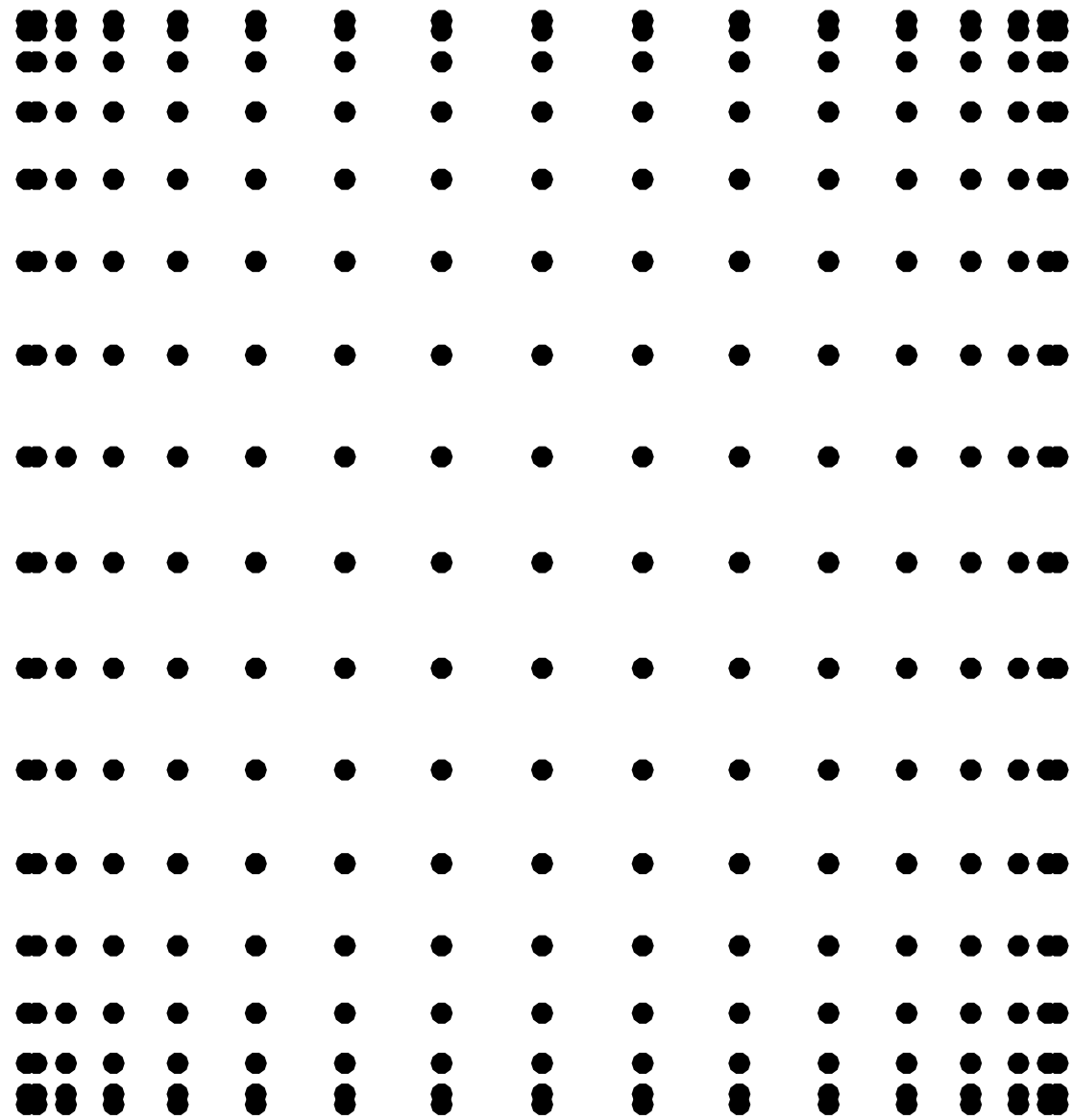
Interpolation



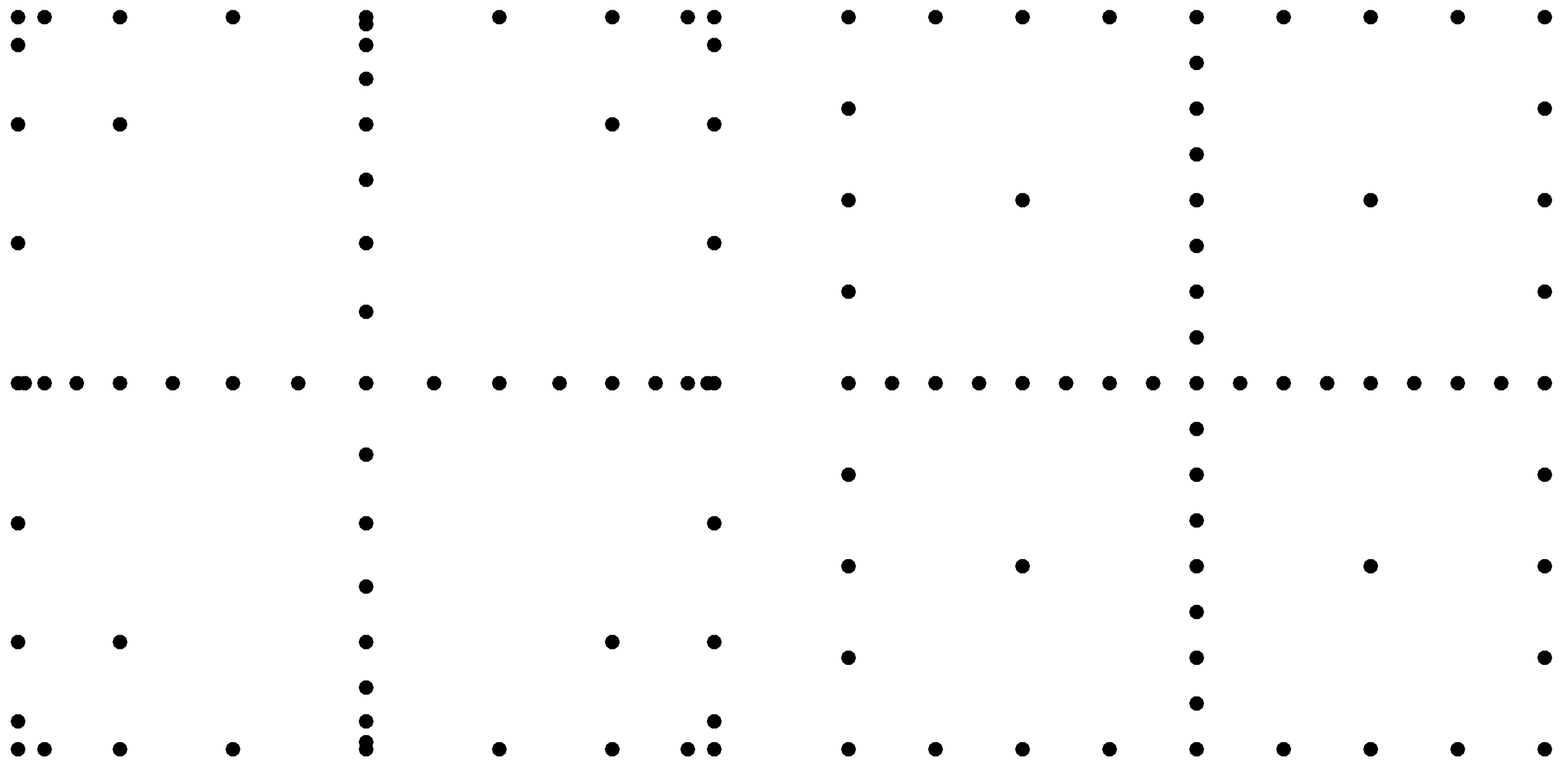
Interpolation

- Grid
- Basis
- Structure
- Adaptivity

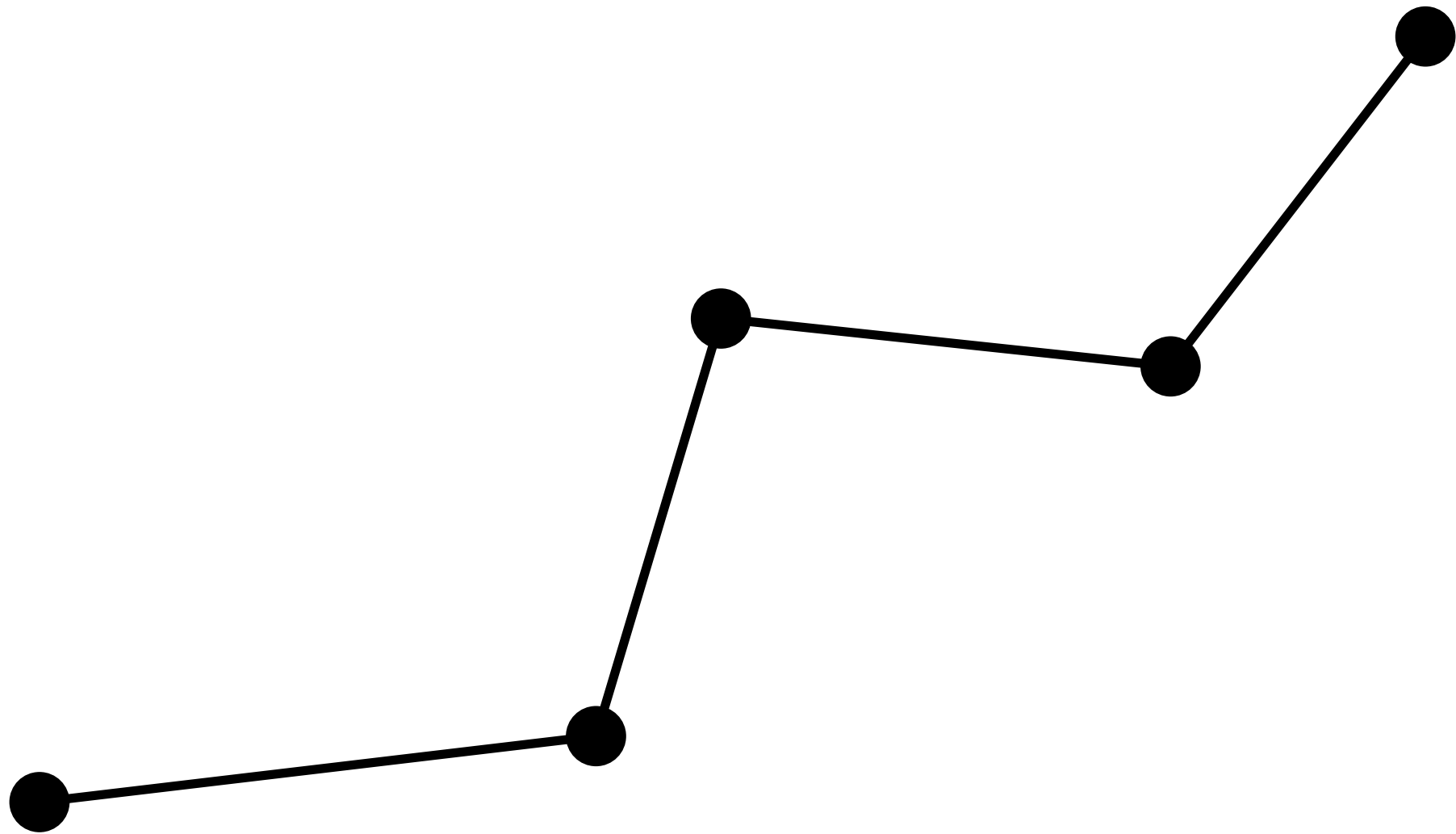
Full-Tensor Grid



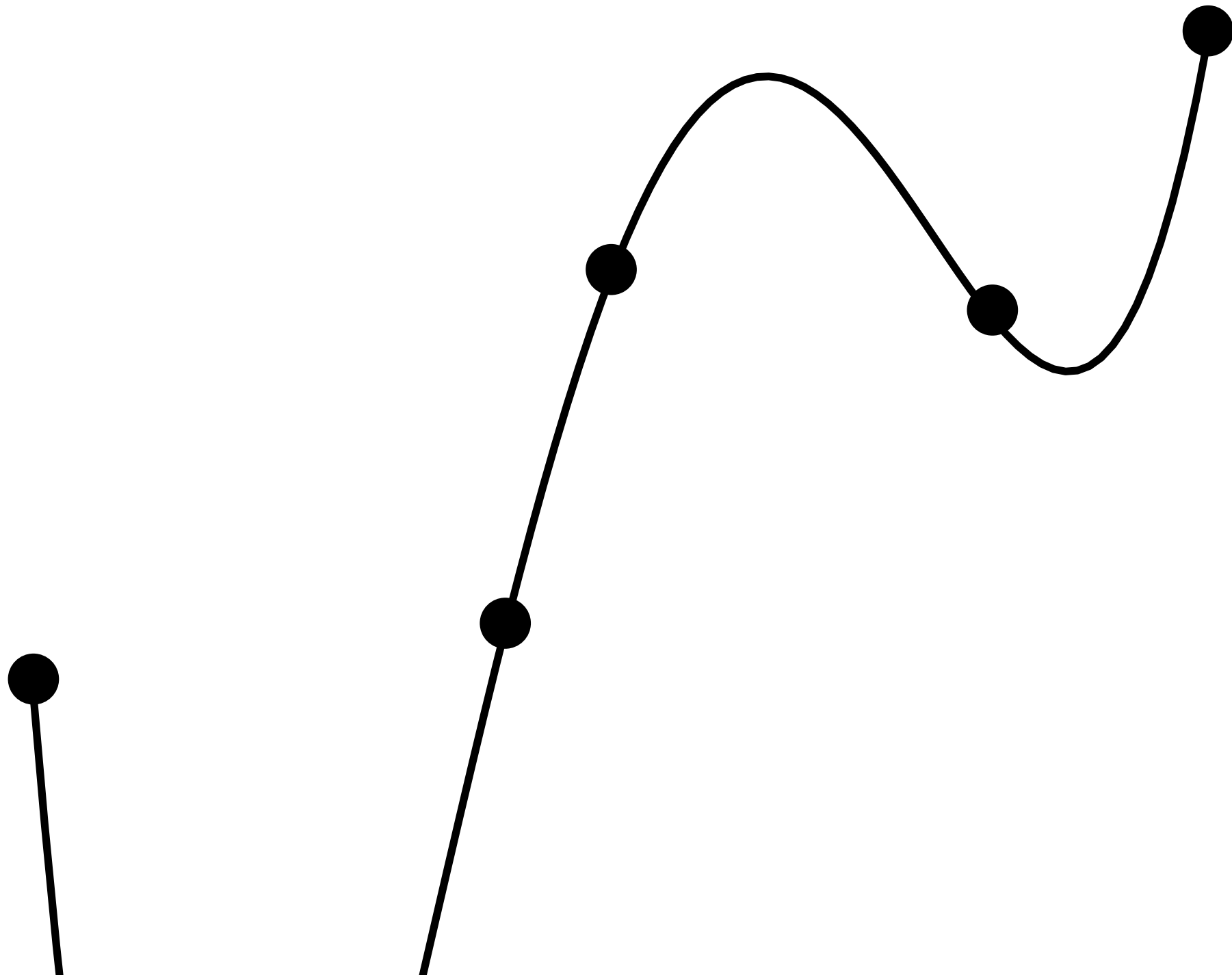
Smolyak (Sparse) Grid



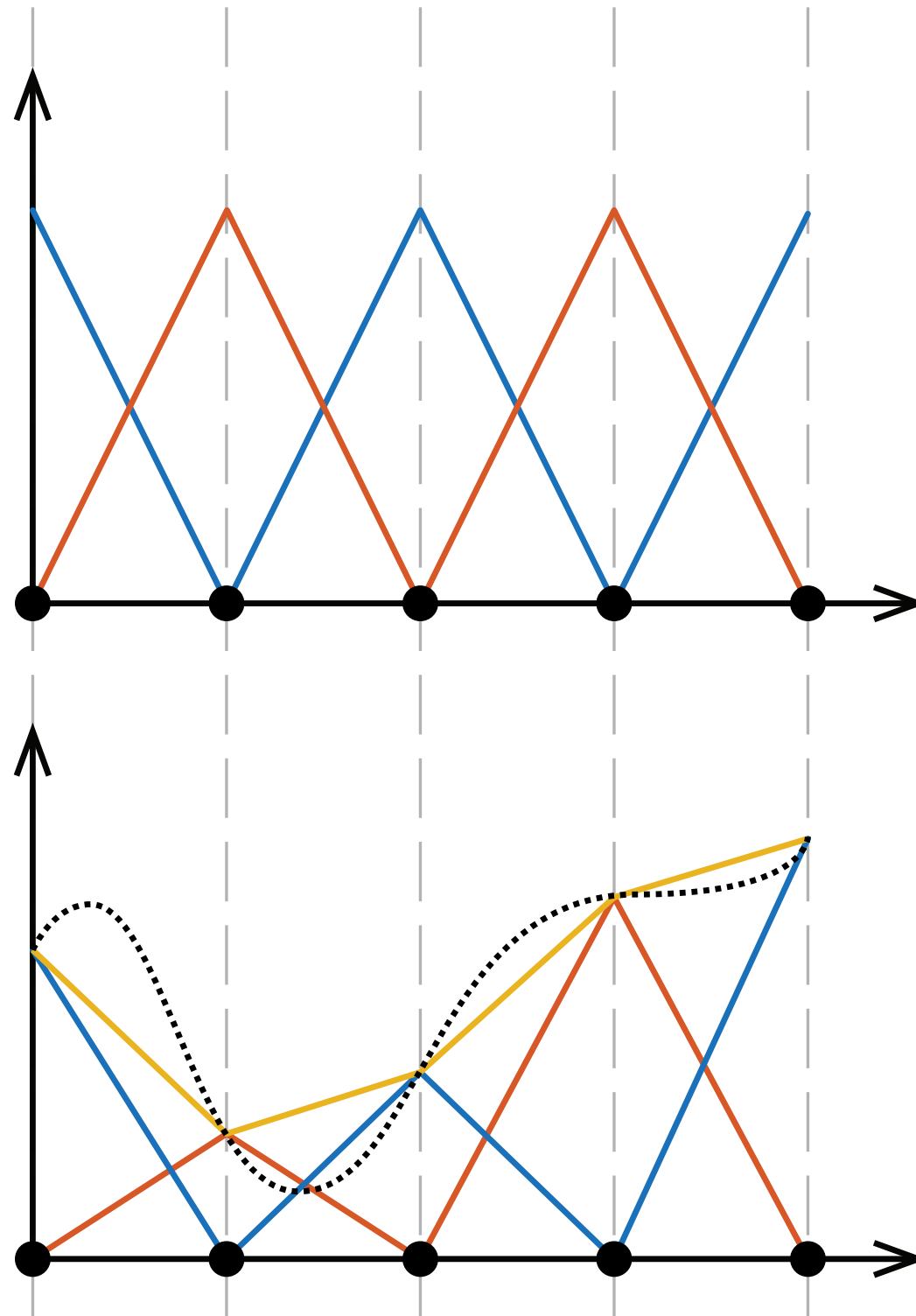
Piecewise Linear Basis



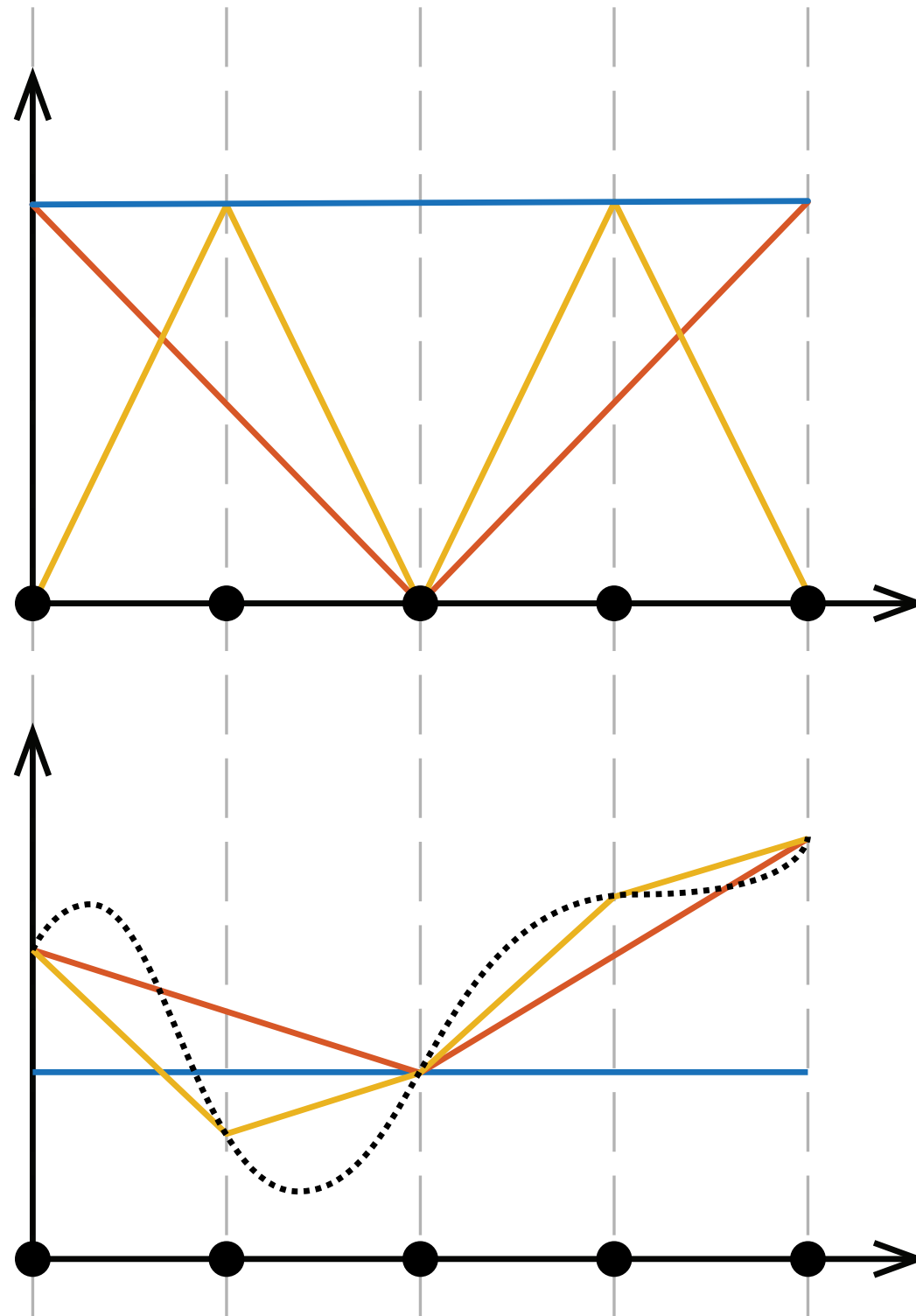
Lagrange Basis



Nodal Structure



Hierarchical Structure



Multiindex

$$\mathbf{i} = (i_1, \dots, i_n)$$

Nestedness

$(0, 0)$



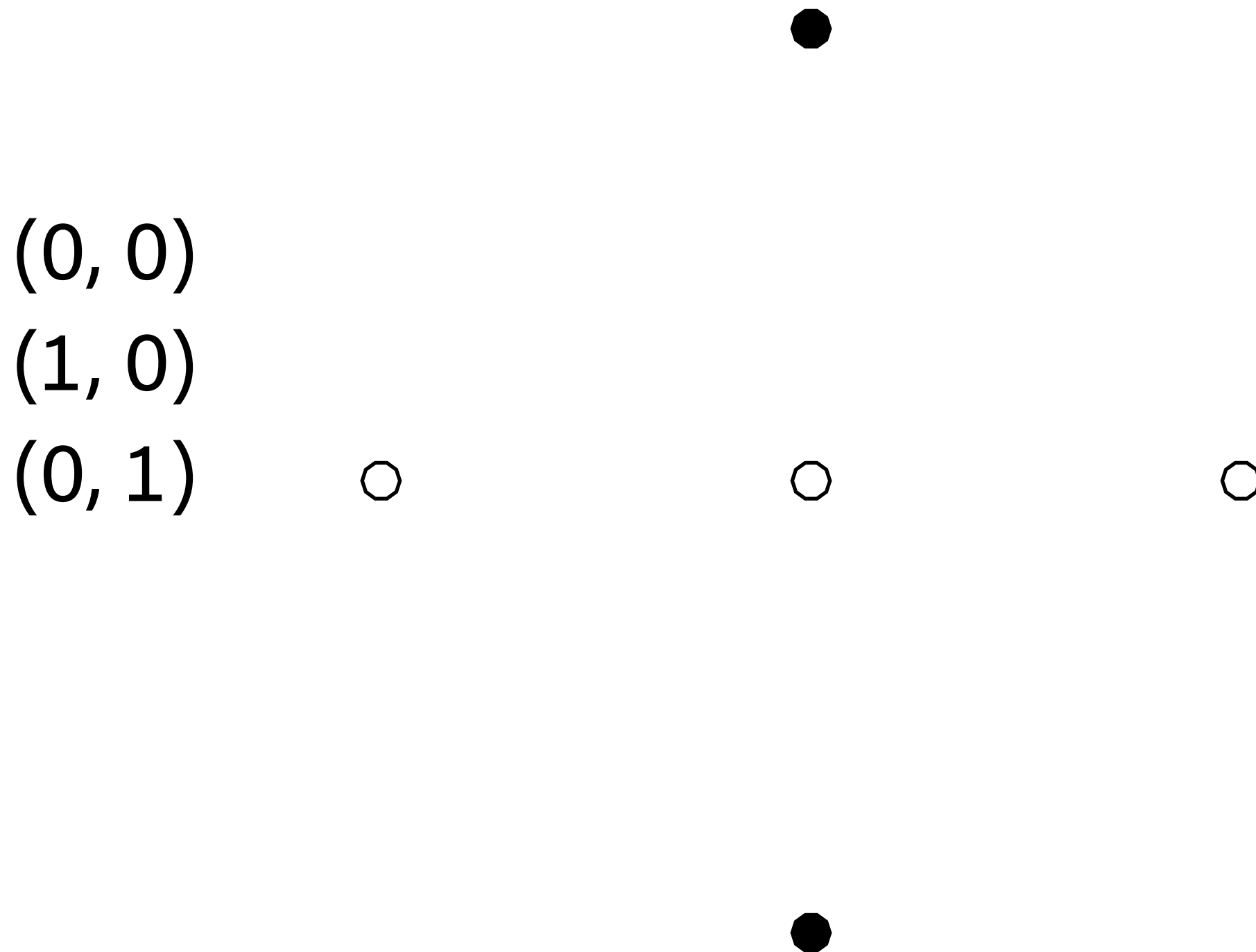
Nestedness

$(0, 0)$

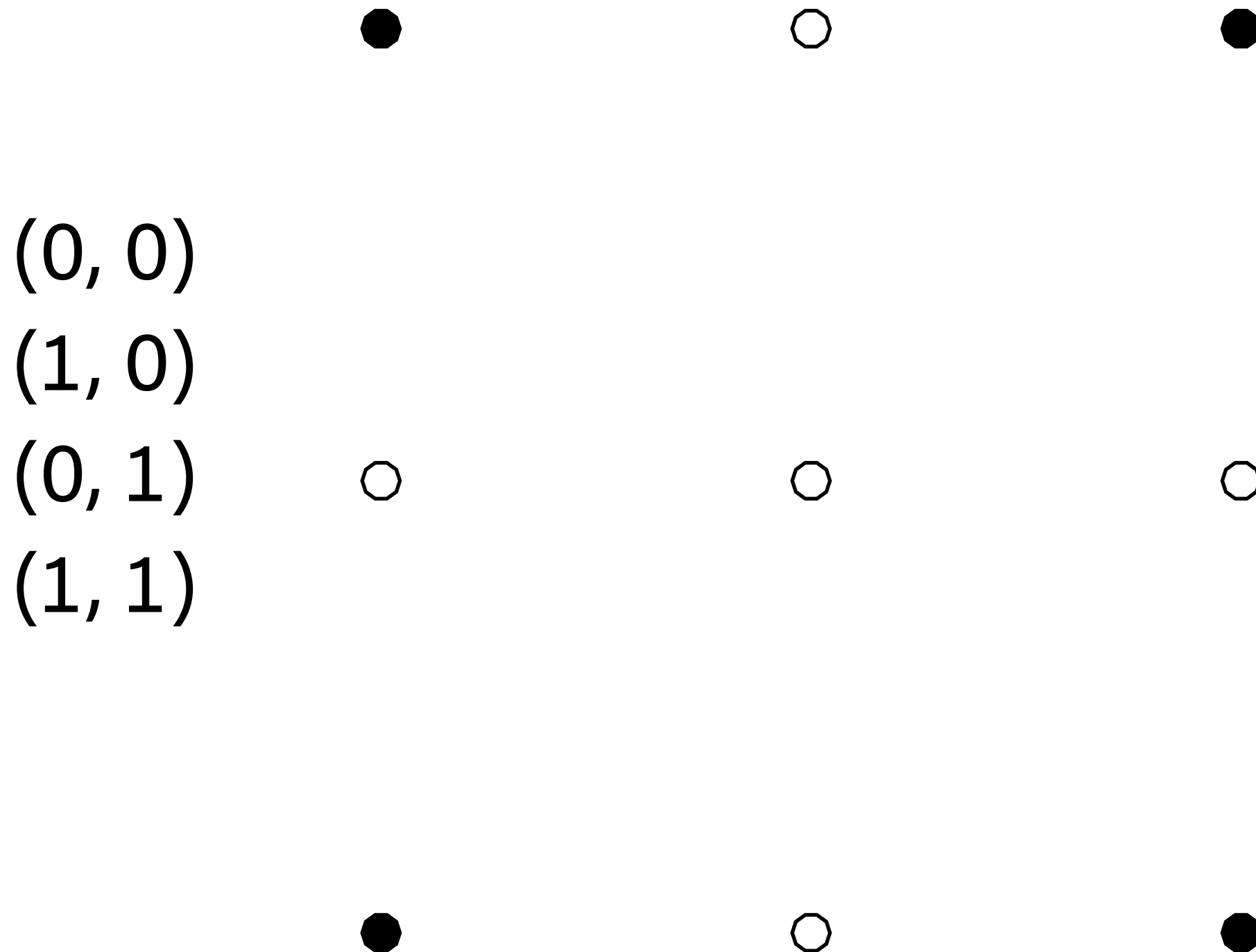
$(1, 0)$



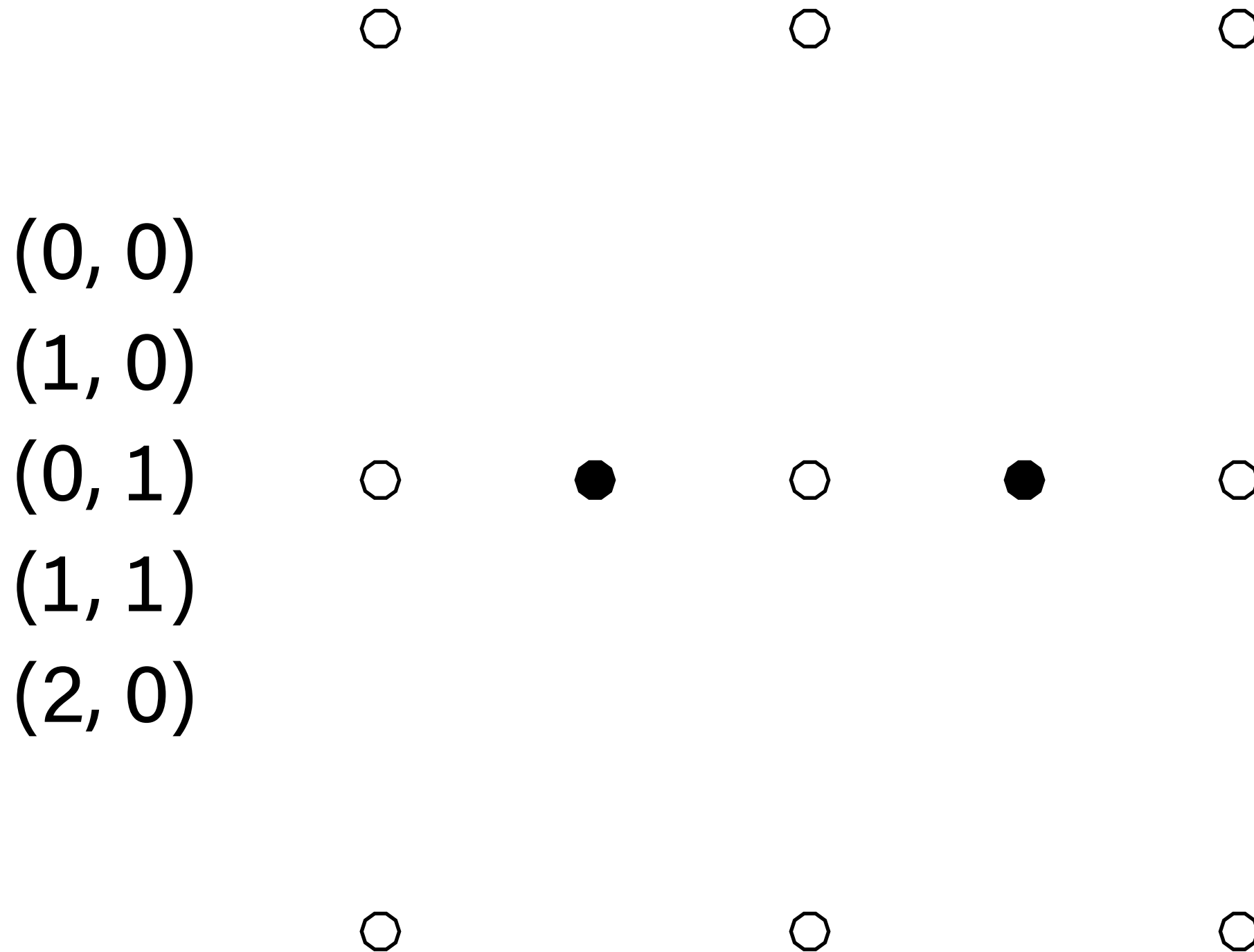
Nestedness



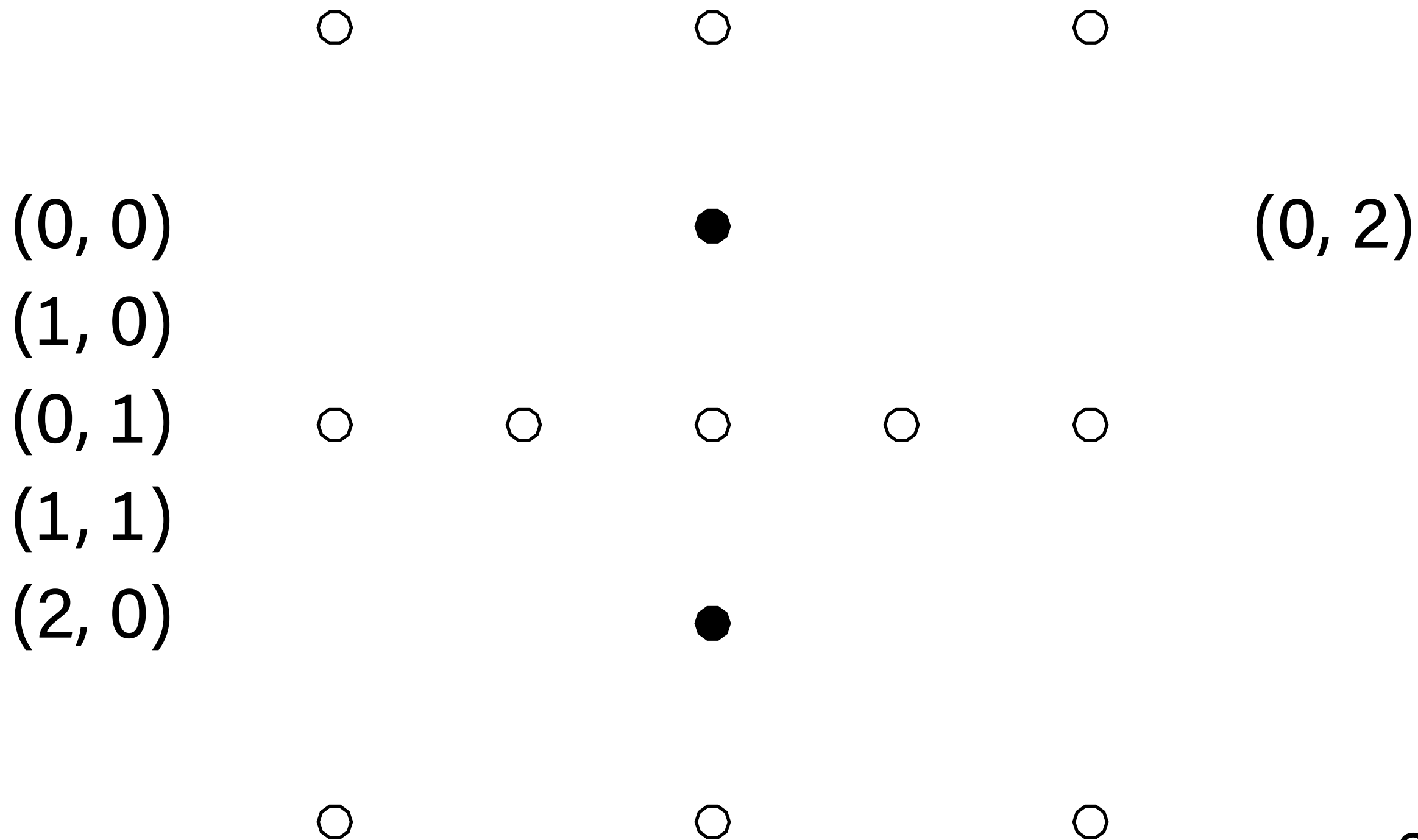
Nestedness



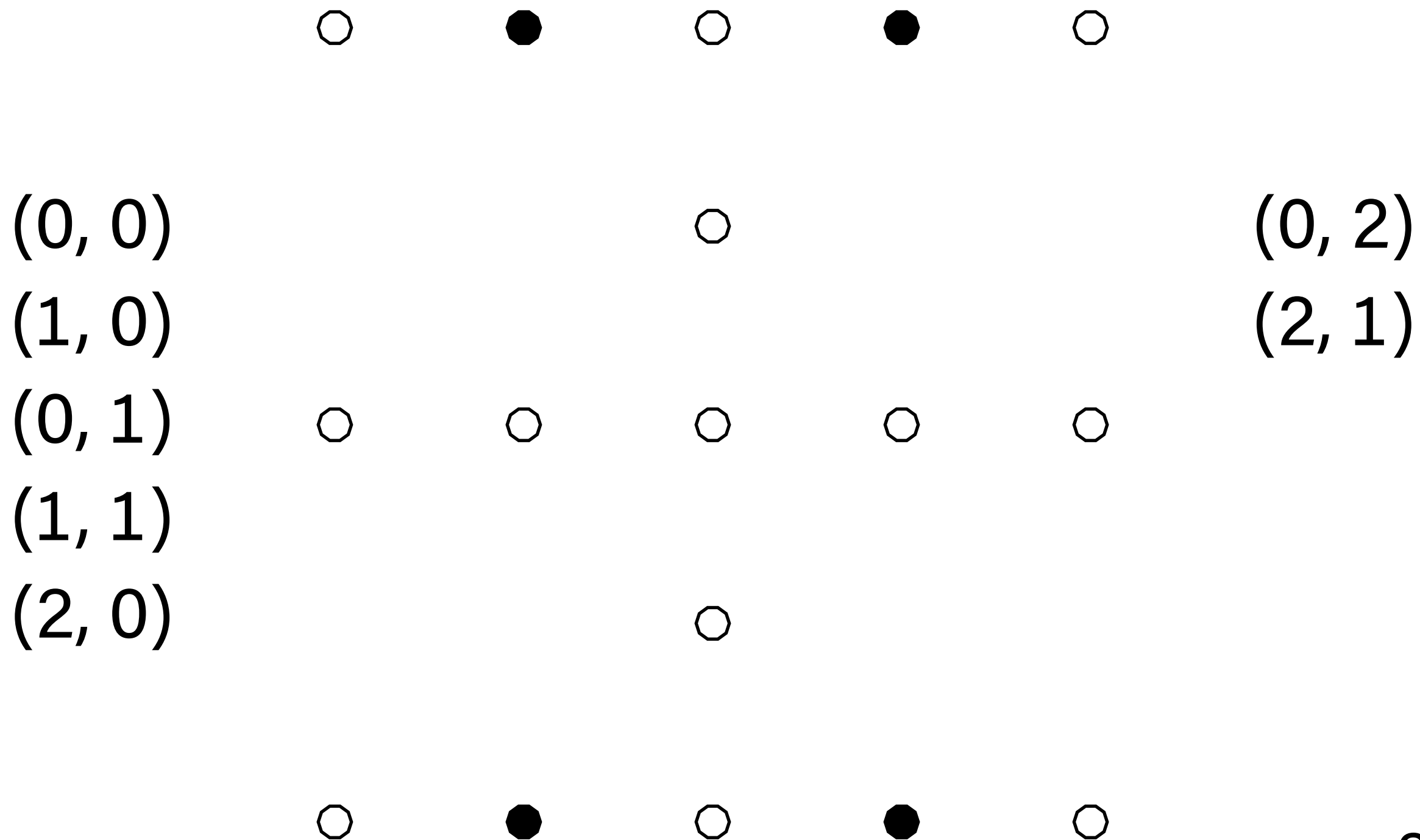
Nestedness



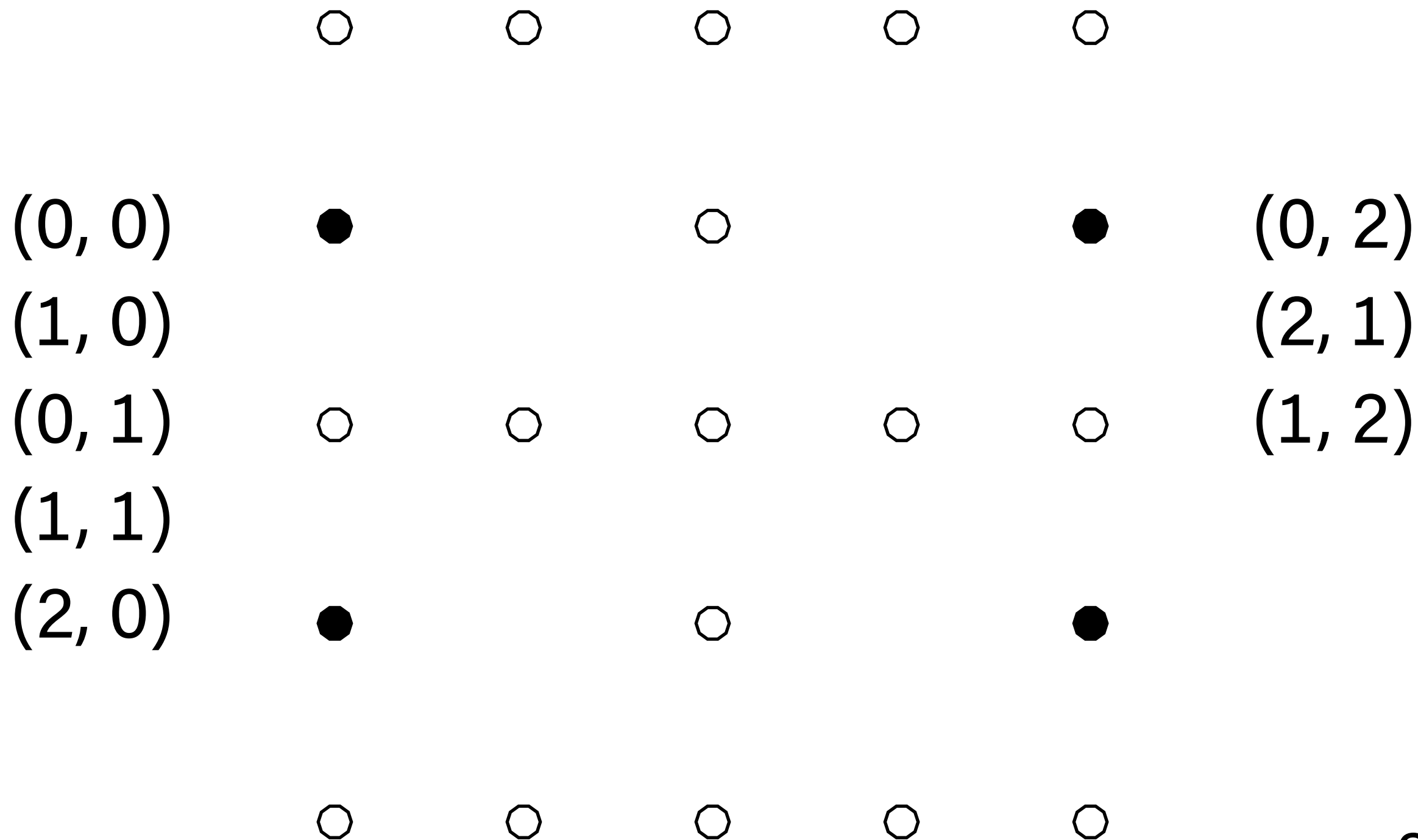
Nestedness



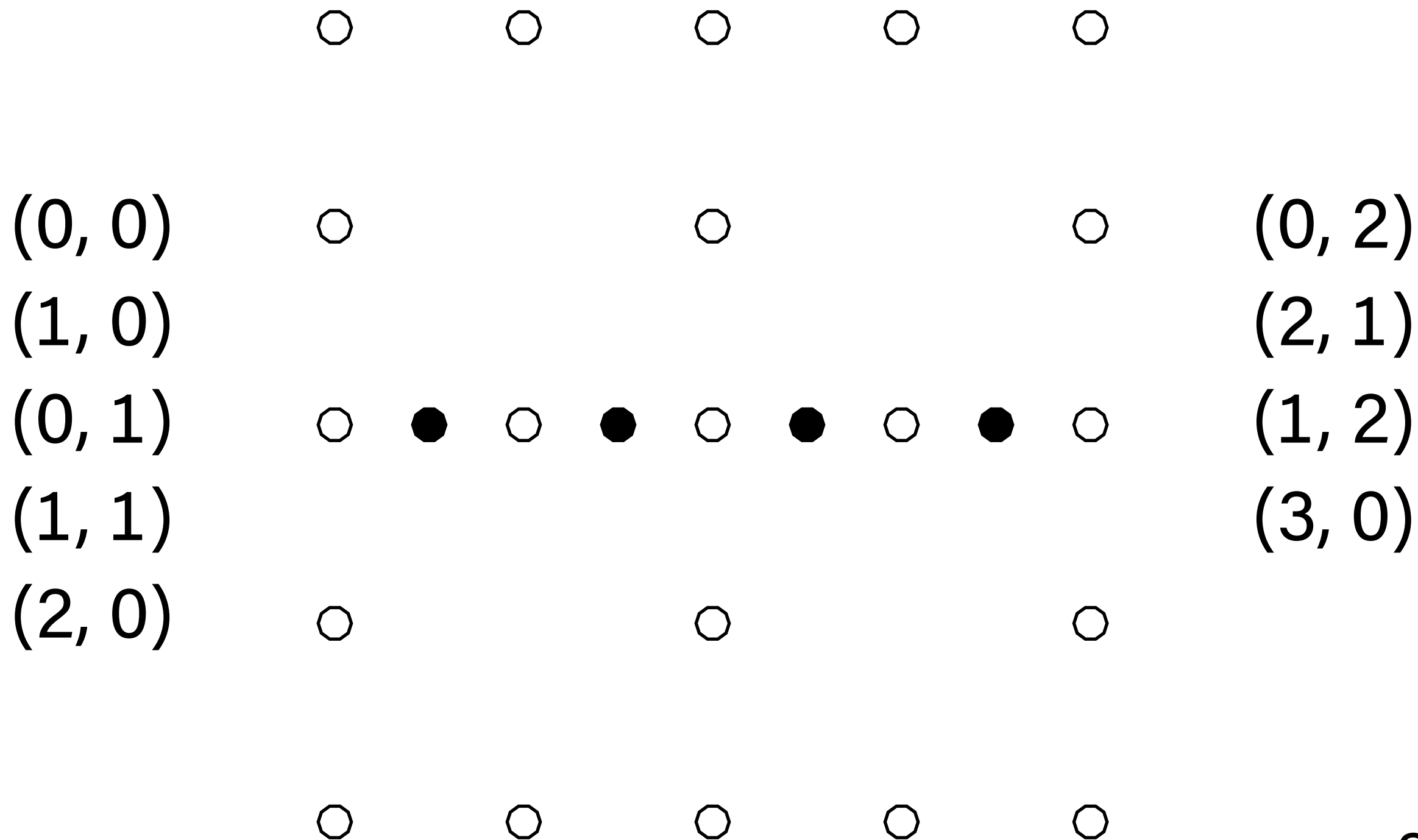
Nestedness



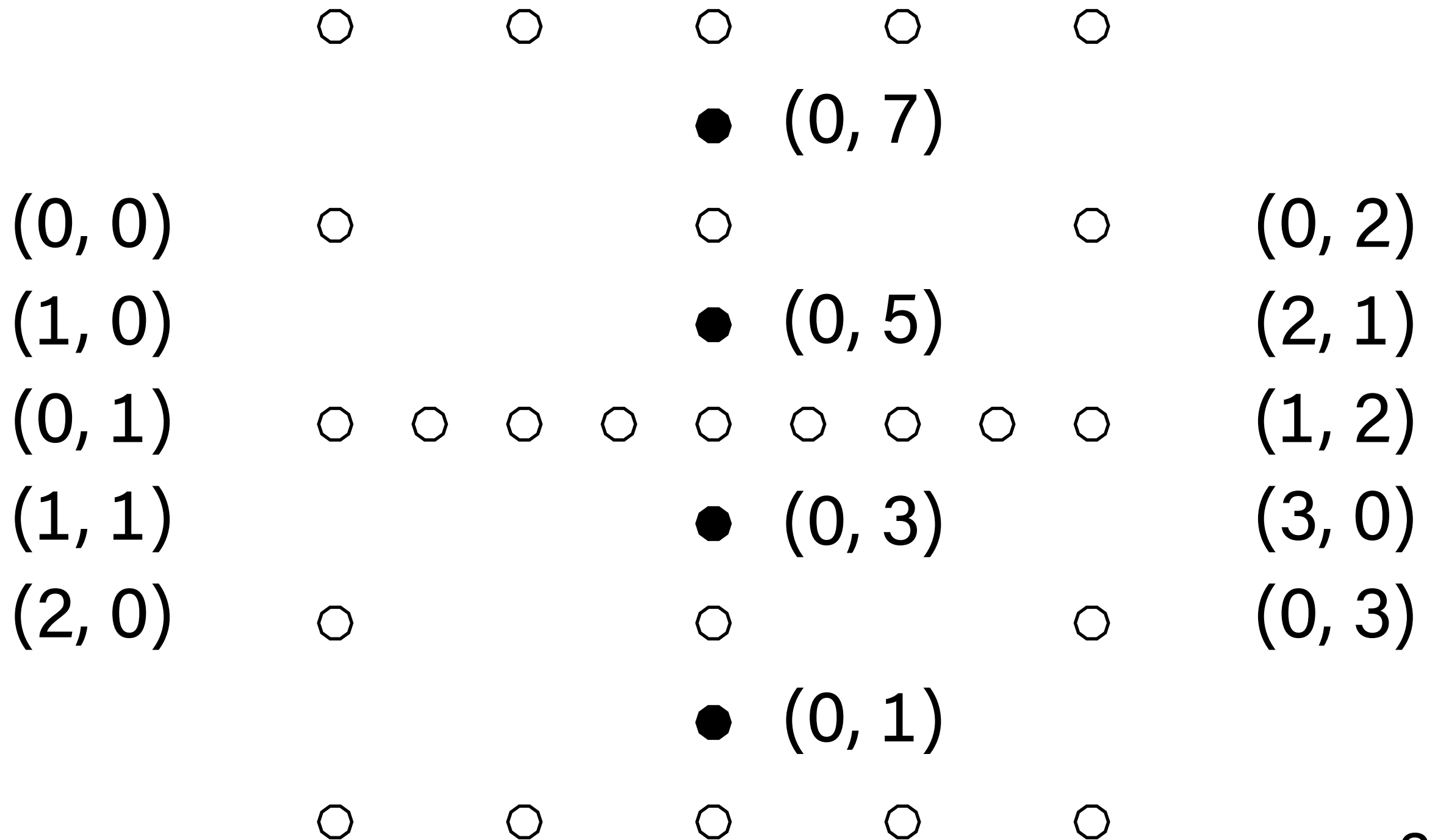
Nestedness



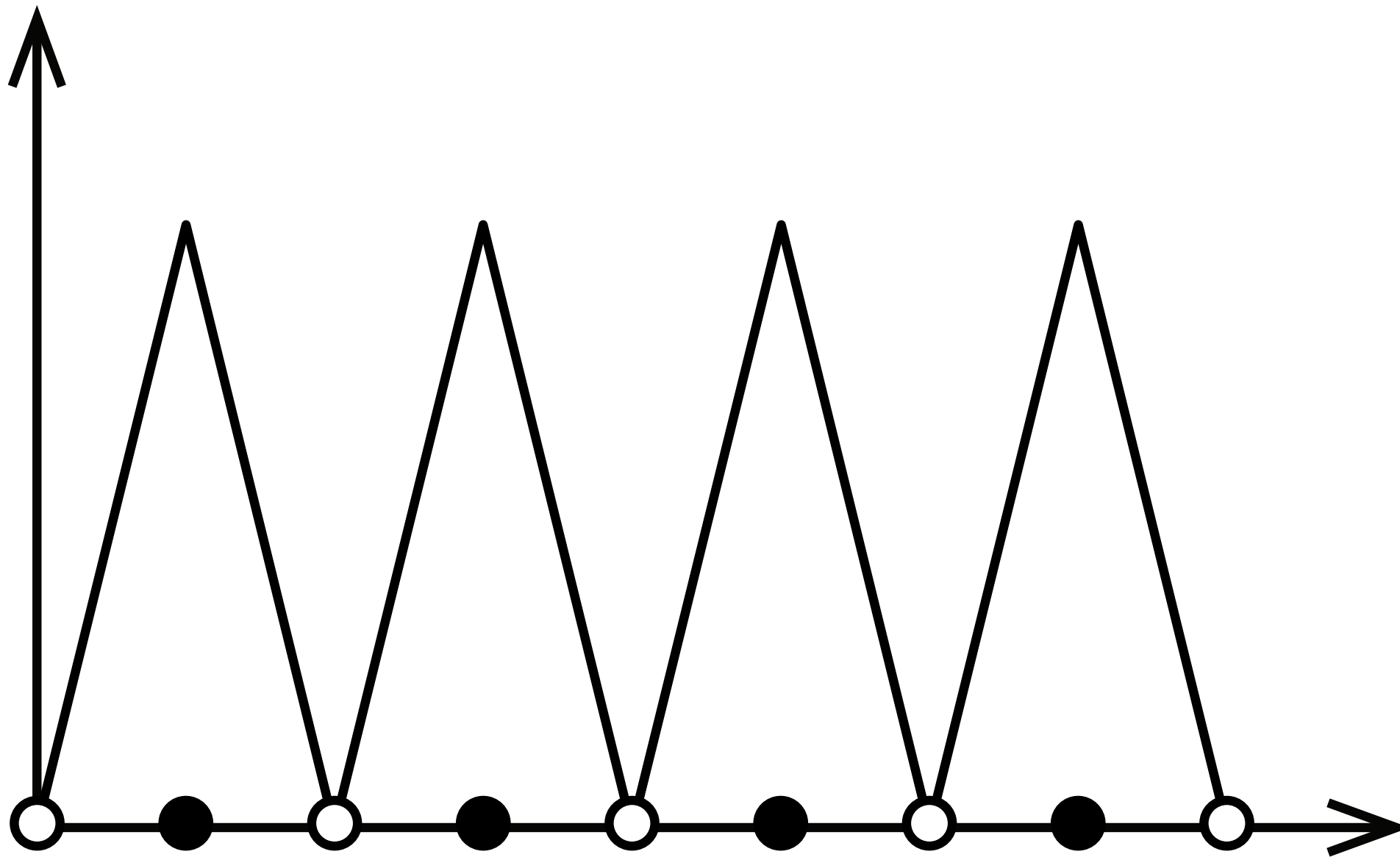
Nestedness



Nestedness



Locality



Surrogate

$$\tilde{f}(\mathbf{x}) = \sum_{\mathbf{i} \in \mathcal{I}} \sum_{\mathbf{j} \in \mathcal{J}_{\mathbf{i}}} \Delta f(\mathbf{x}_{\mathbf{ij}}) e_{\mathbf{ij}}(\mathbf{x})$$

Surrogate

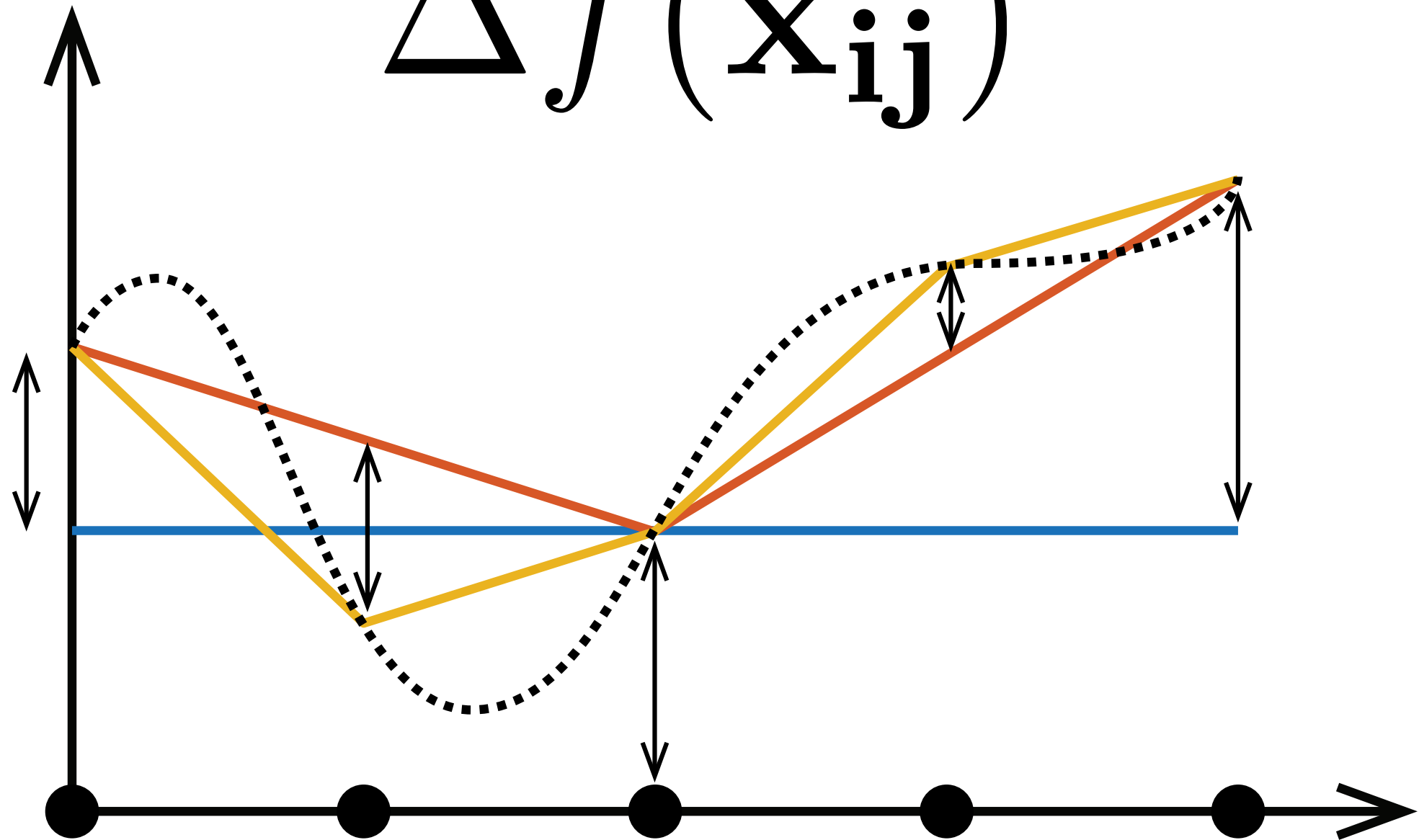
$$\tilde{f}(\mathbf{x}) = \sum_{\mathbf{k} \in \mathcal{K}} \Delta f(\mathbf{x}_{\mathbf{k}}) e_{\mathbf{k}}(\mathbf{x})$$

Adaptivity

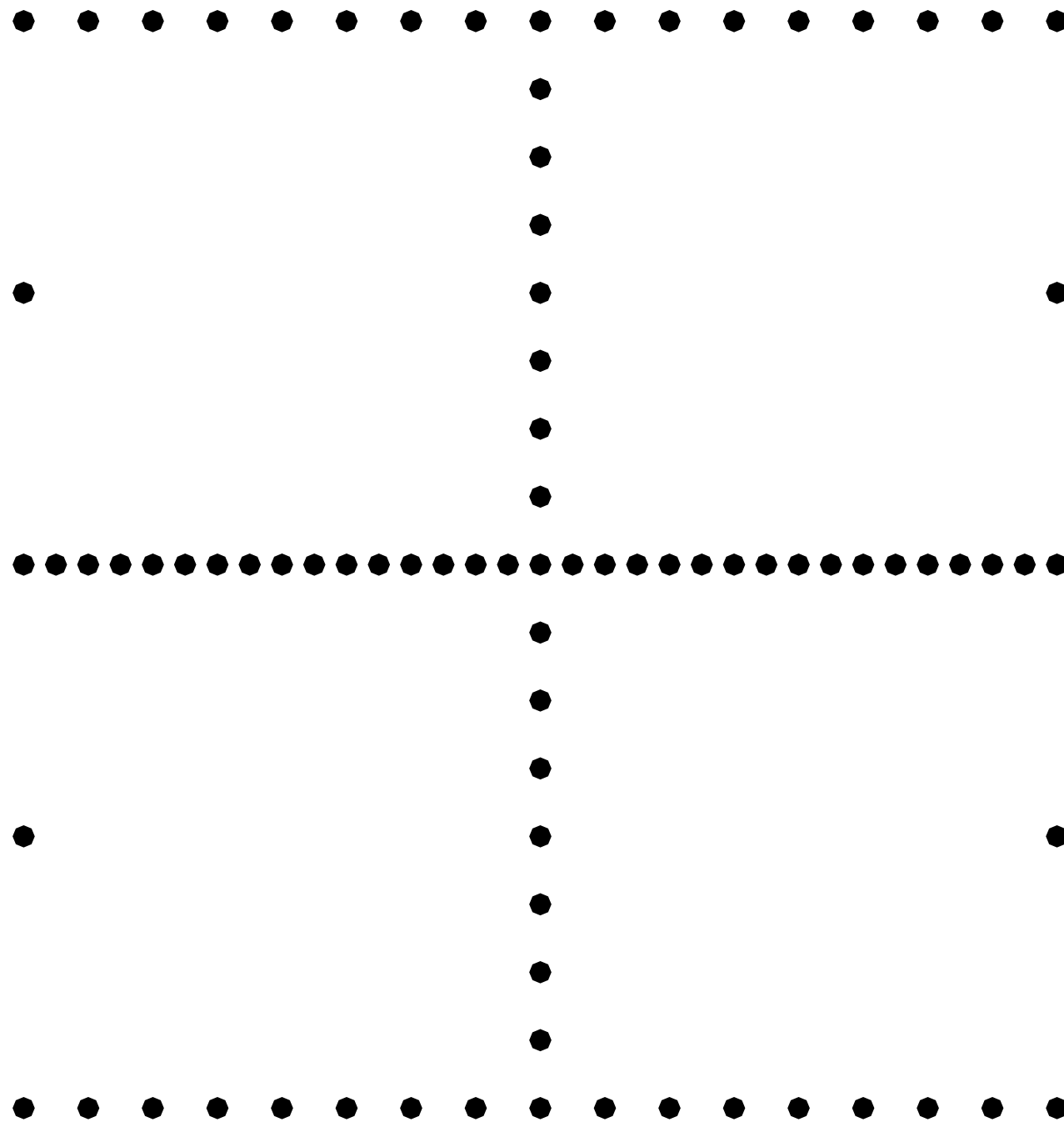
- Global
- Local
- Hybrid

Surplus

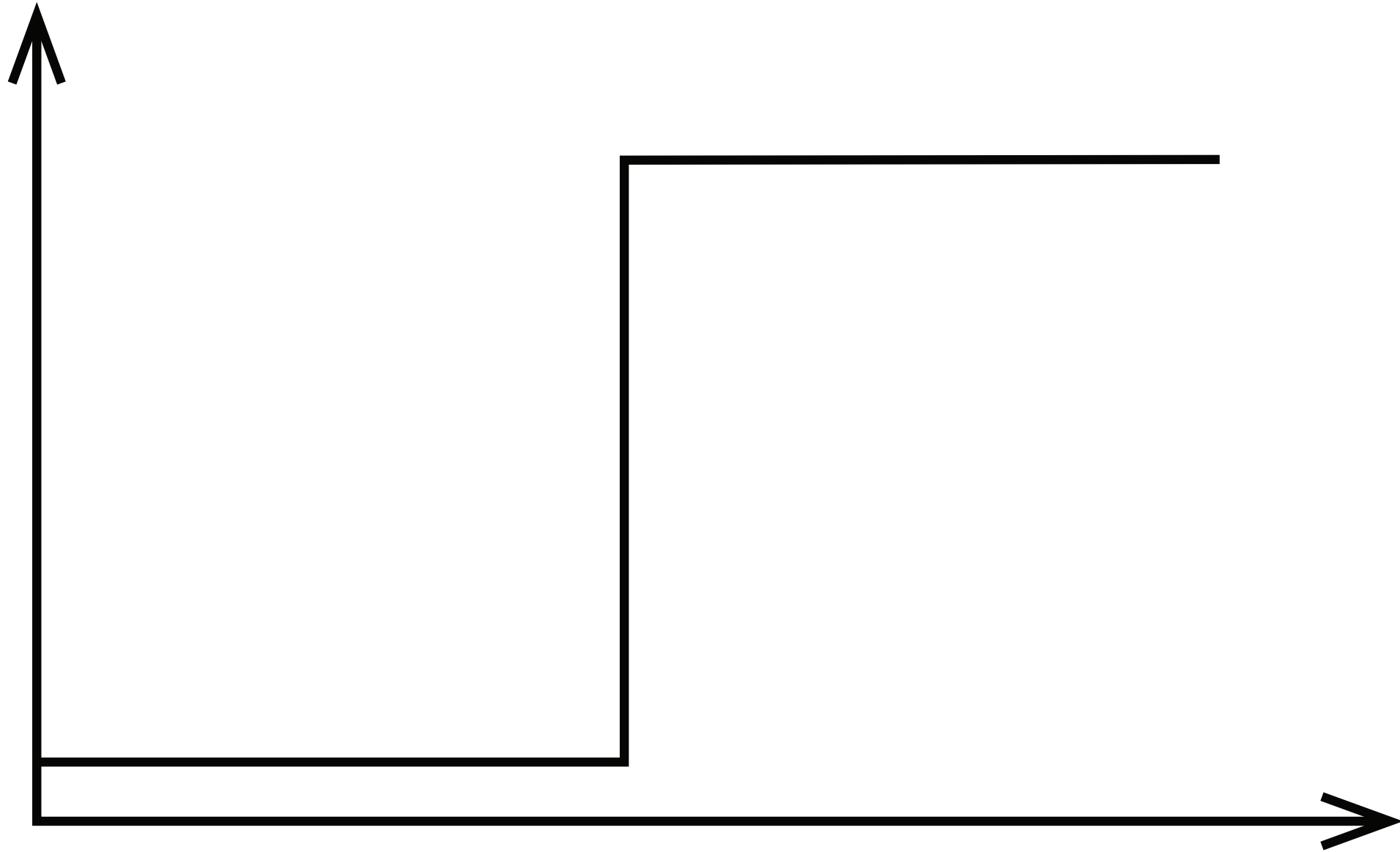
$$\Delta f(\mathbf{x}_{ij})$$



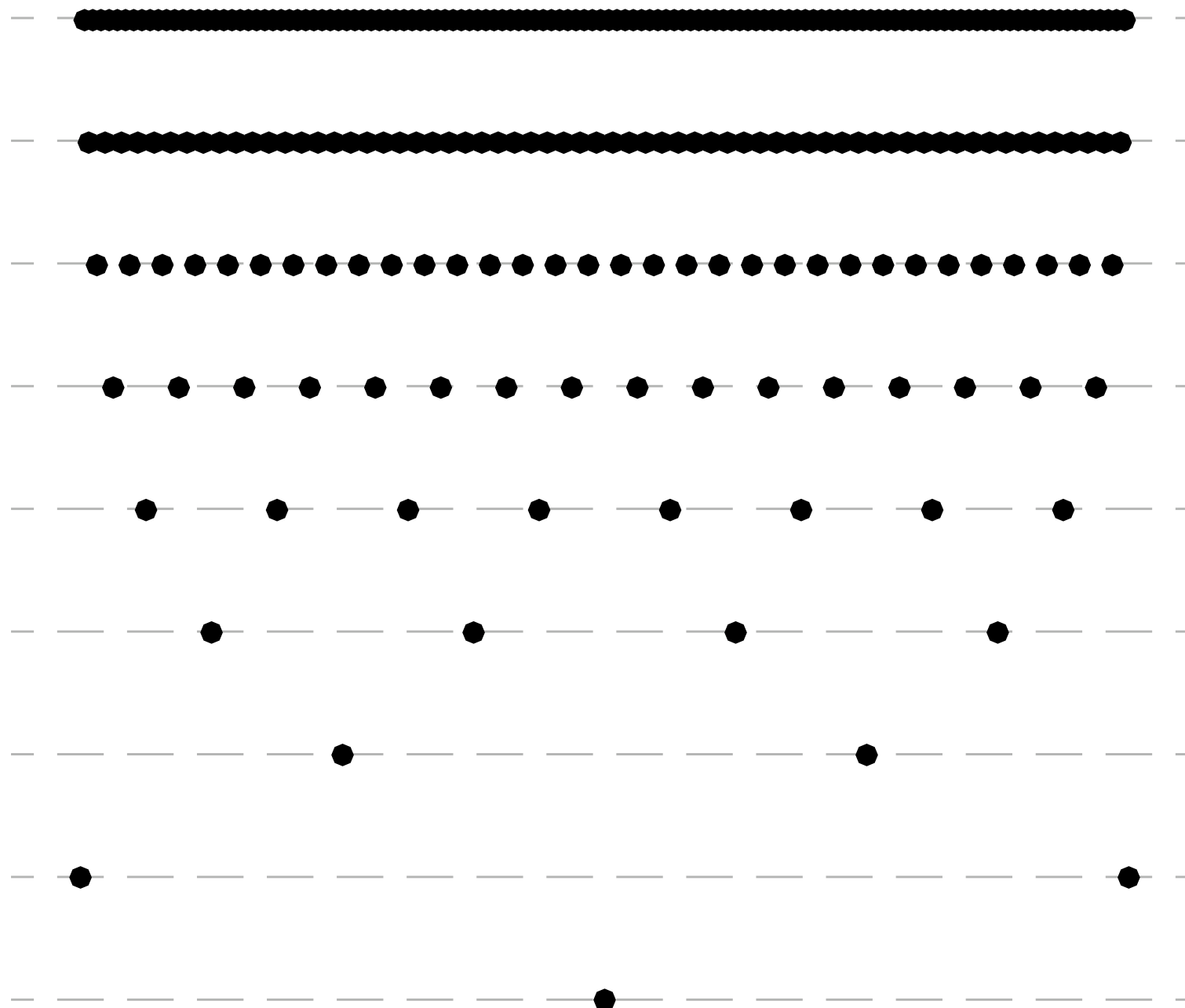
Global Adaptivity



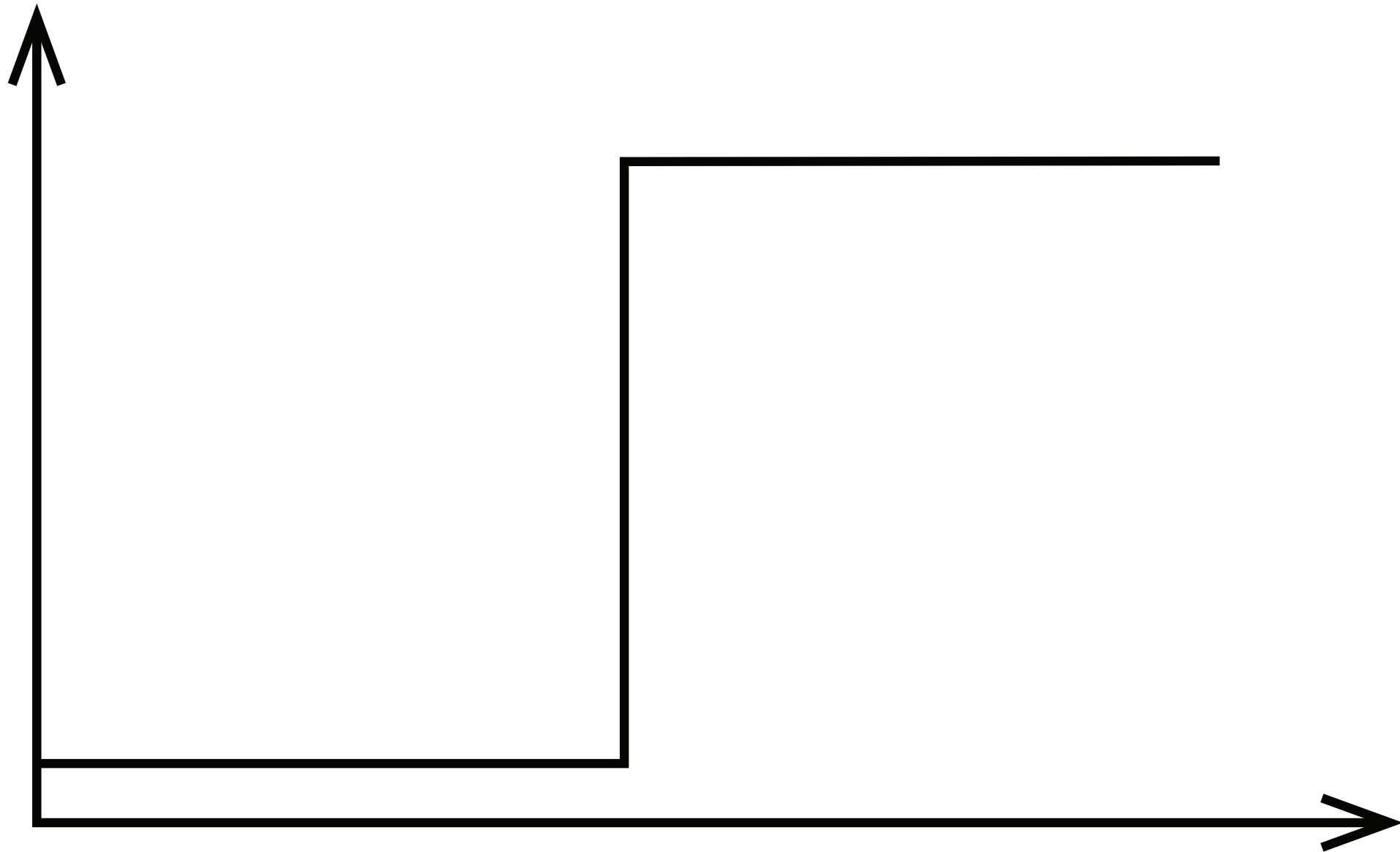
Step Function



Step Function

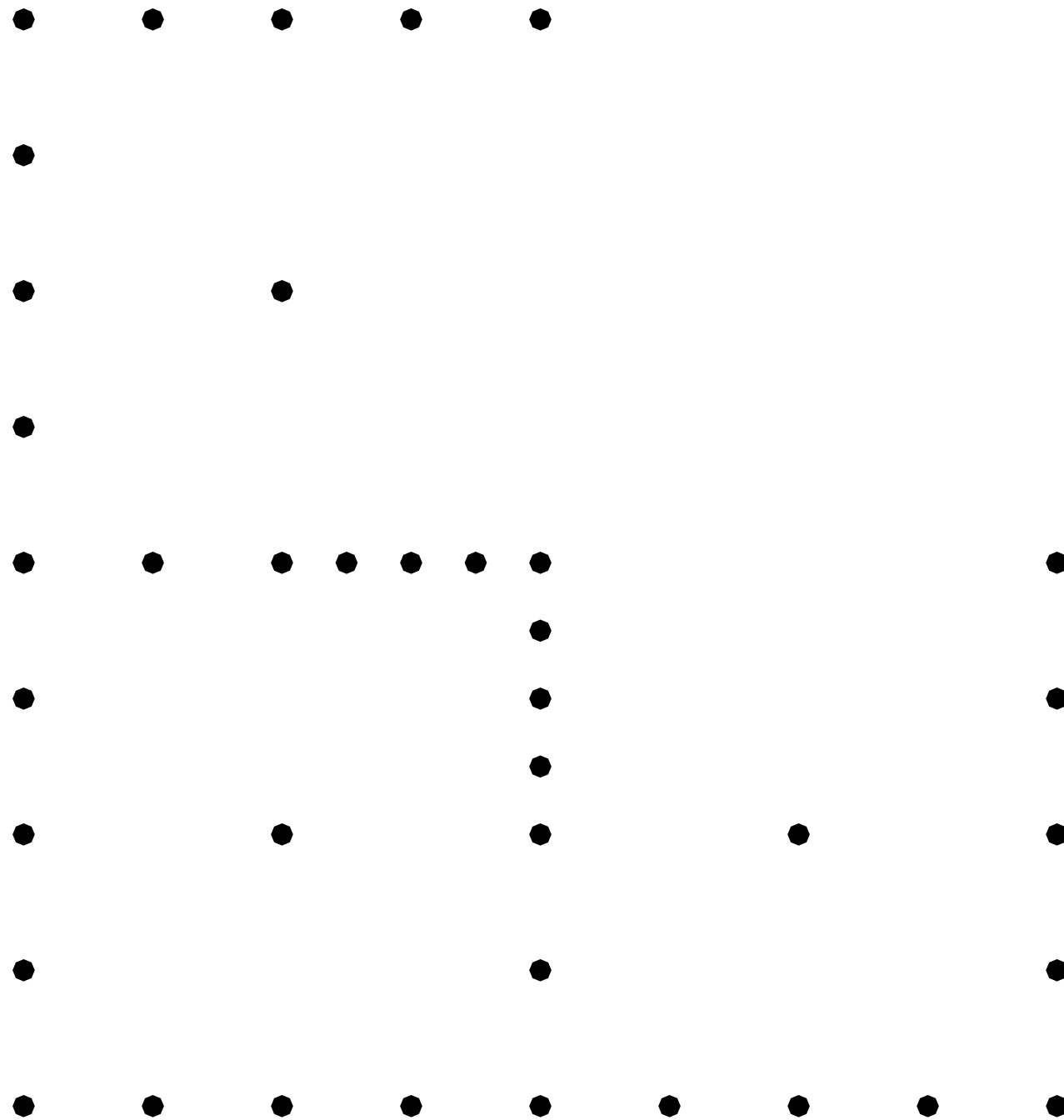


Where Is the Action?

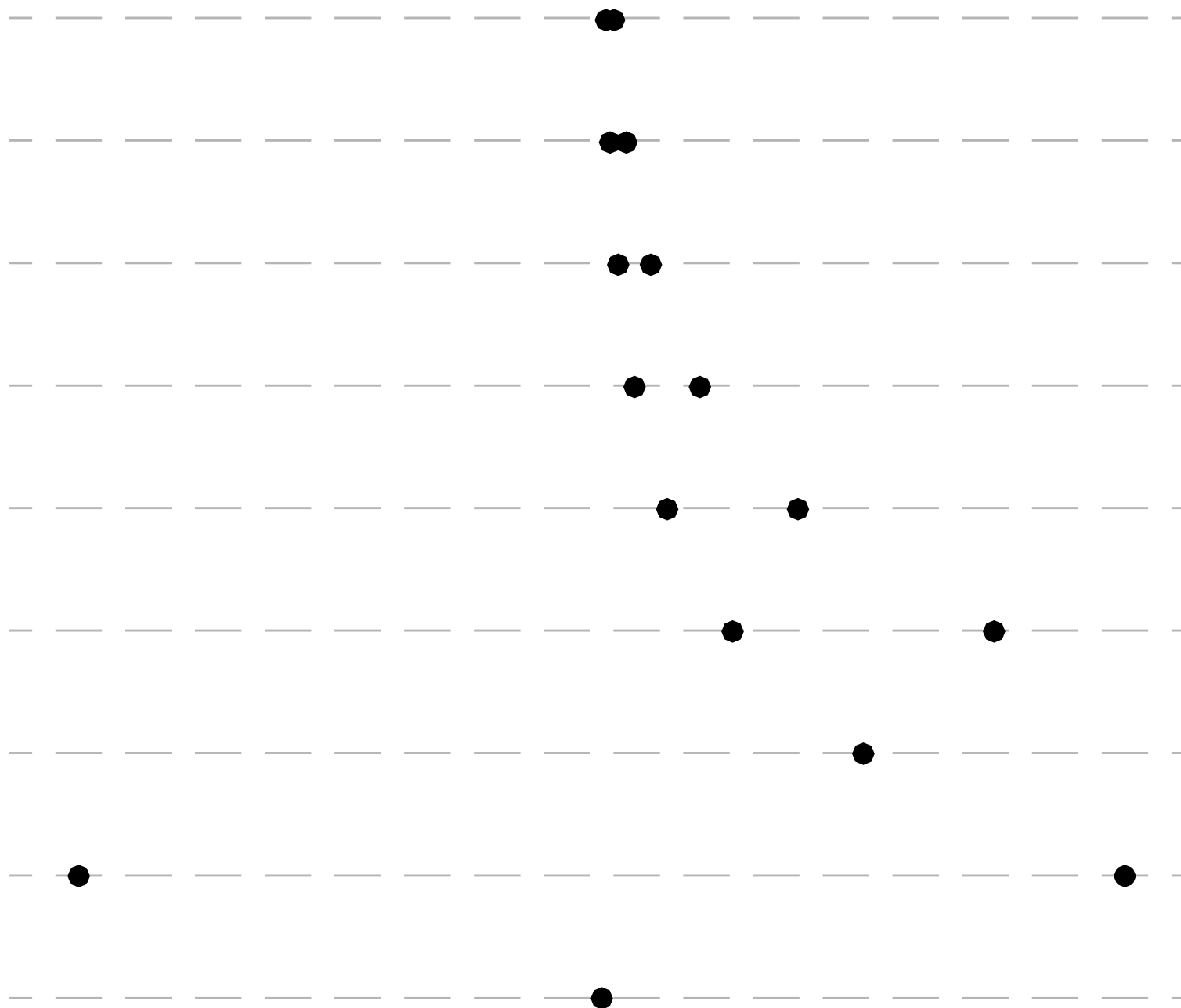


?

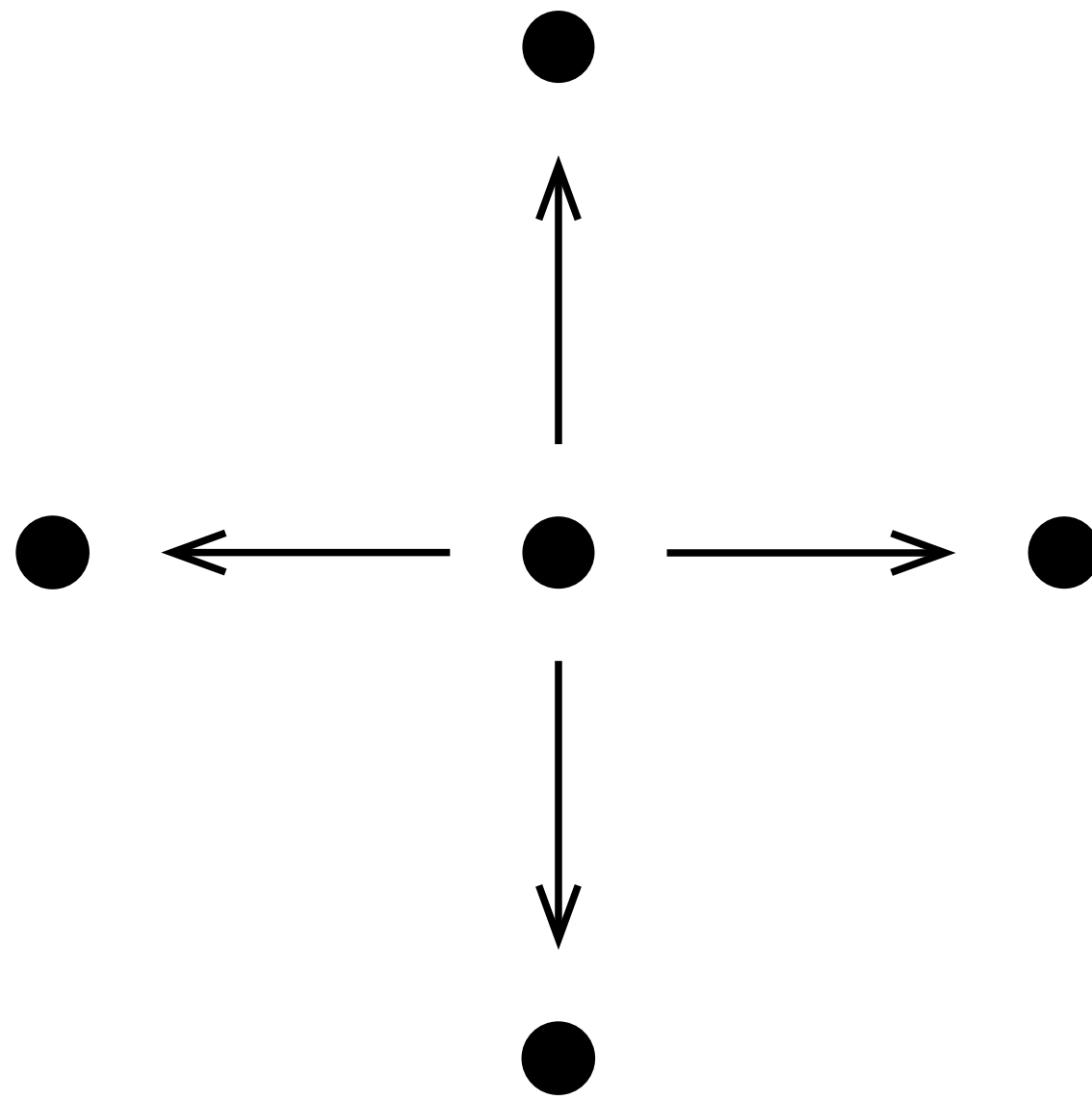
Local Adaptivity



Step Function



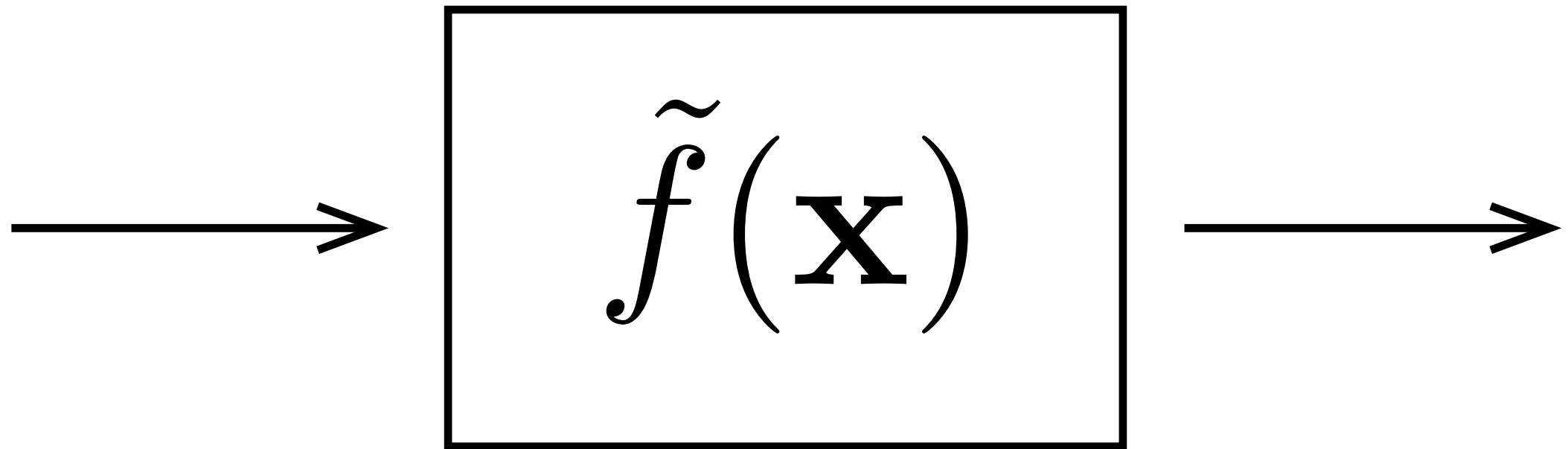
Which Direction to Go?



Hybrid Adaptivity

- Local refinements with respect to important dimensions

Conclusion



Conclusion

$$\tilde{f}(\mathbf{x}) = \sum_{\mathbf{k} \in \mathcal{K}} \Delta f(\mathbf{x}_{\mathbf{k}}) e_{\mathbf{k}}(\mathbf{x})$$

Thank you!
Questions?