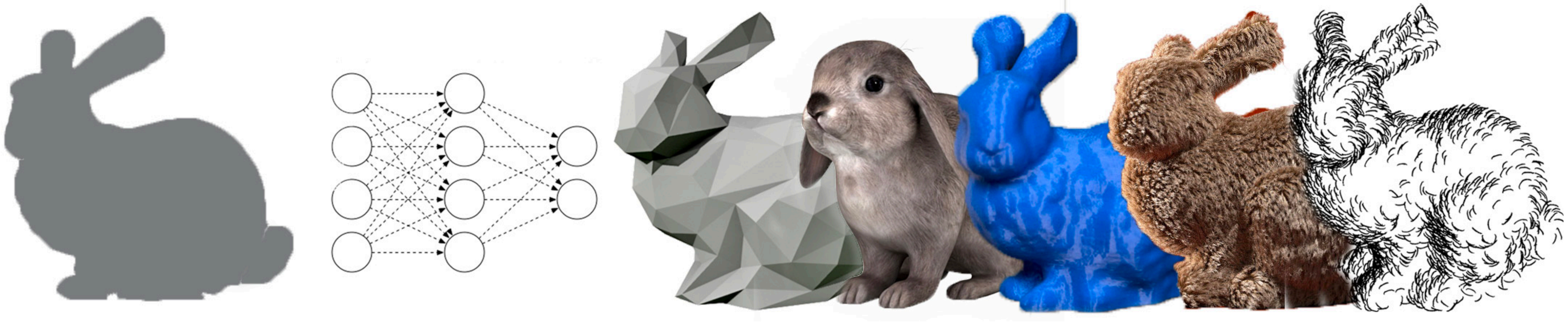
COMP0169: Machine Learning for Visual Computing

Linear and Nonlinear Models (Optimization)



Lectures will be Recorded

Last Week

Last Week

- Introduction and applications

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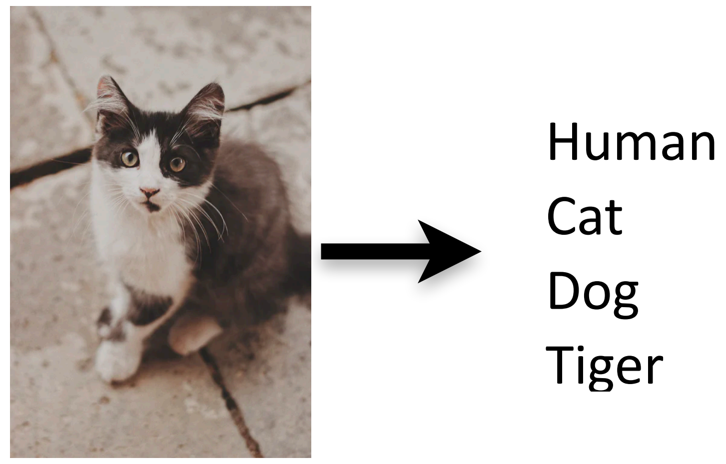
- Image classification



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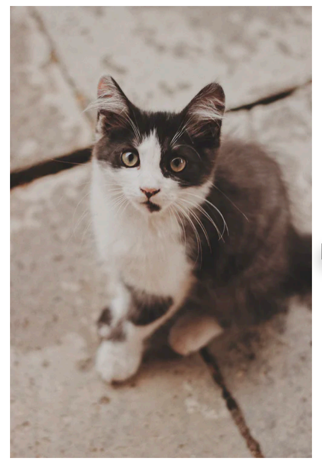
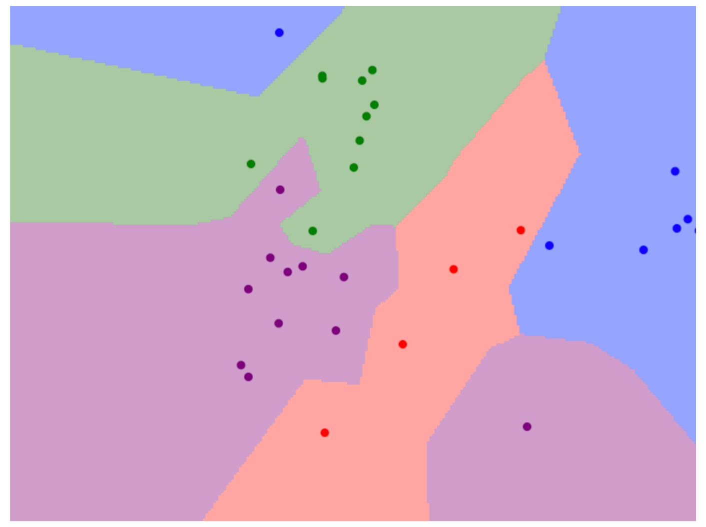
- kNN classifier



Human
Cat
Dog
Tiger



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- Introduction and applications
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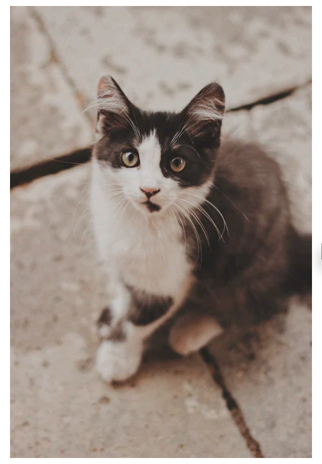
- LS Fitting



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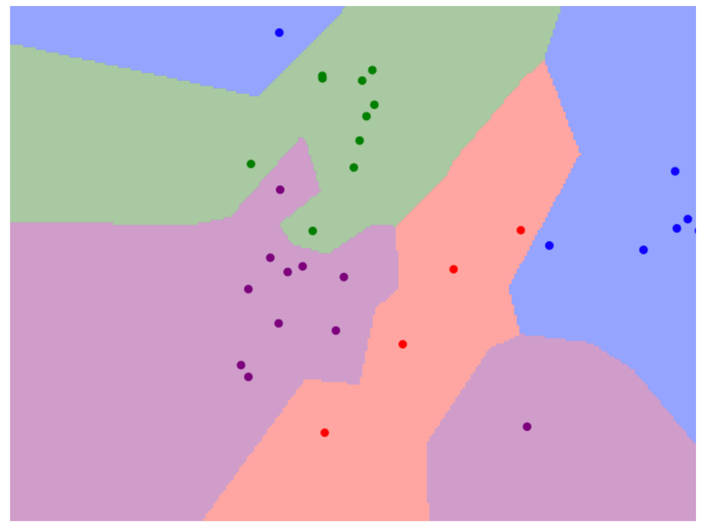

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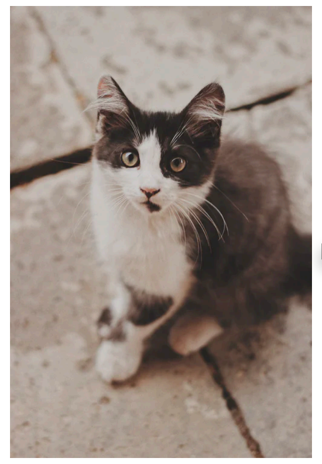
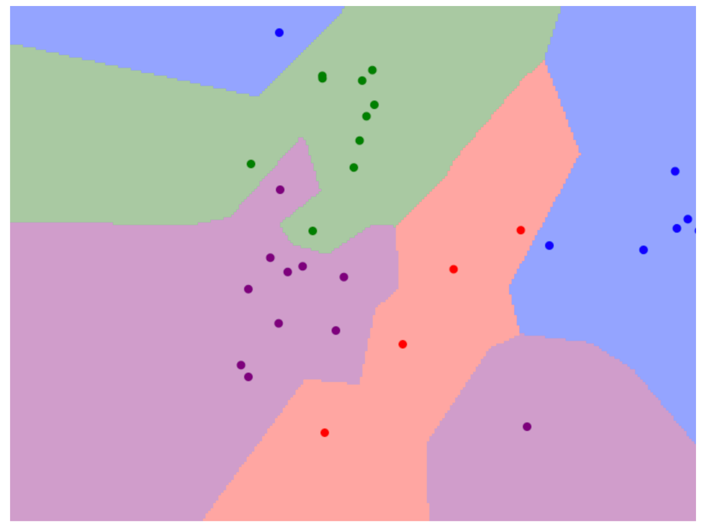


- kNN classifier



- LS Fitting
- Normal equation

$$\mathbf{w} = (X^T X)^{-1} X^T y$$

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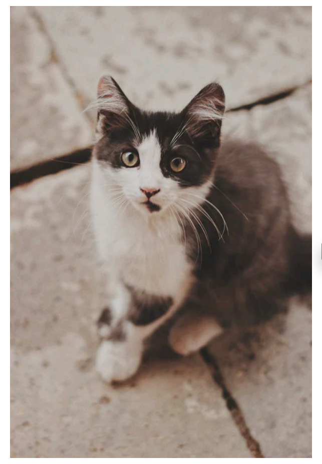

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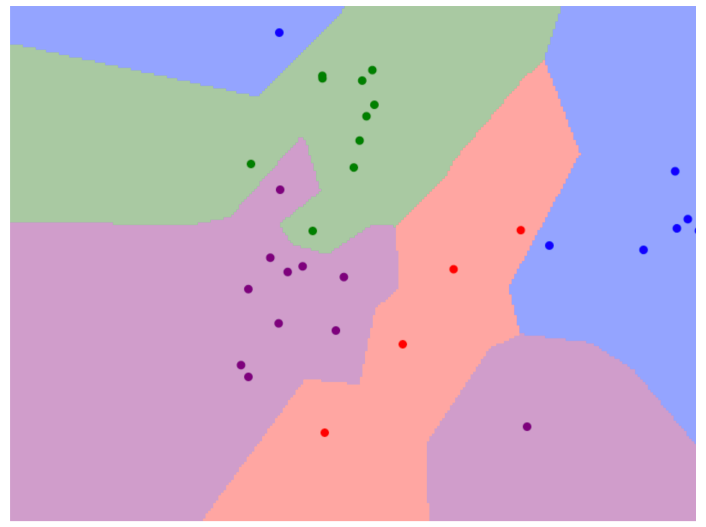
- Image classification



- kNN classifier
- LS Fitting
- Normal equation

$$\mathbf{w} = (X^T X)^{-1} X^T y$$

- Hyperparameter search (k-fold validation)

Image Classification

Image Classification

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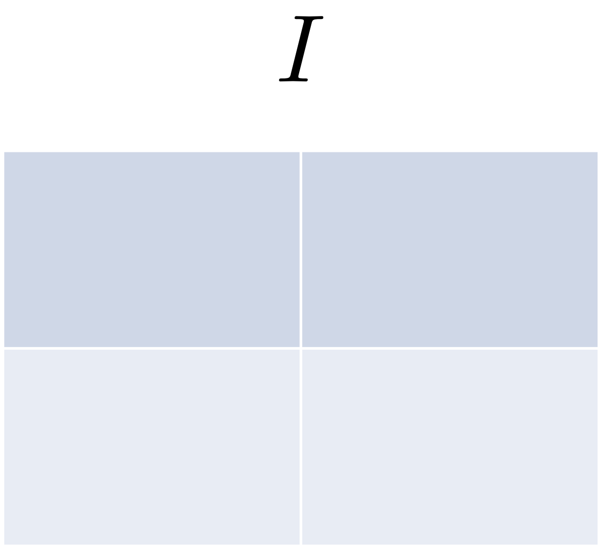
Image Classification



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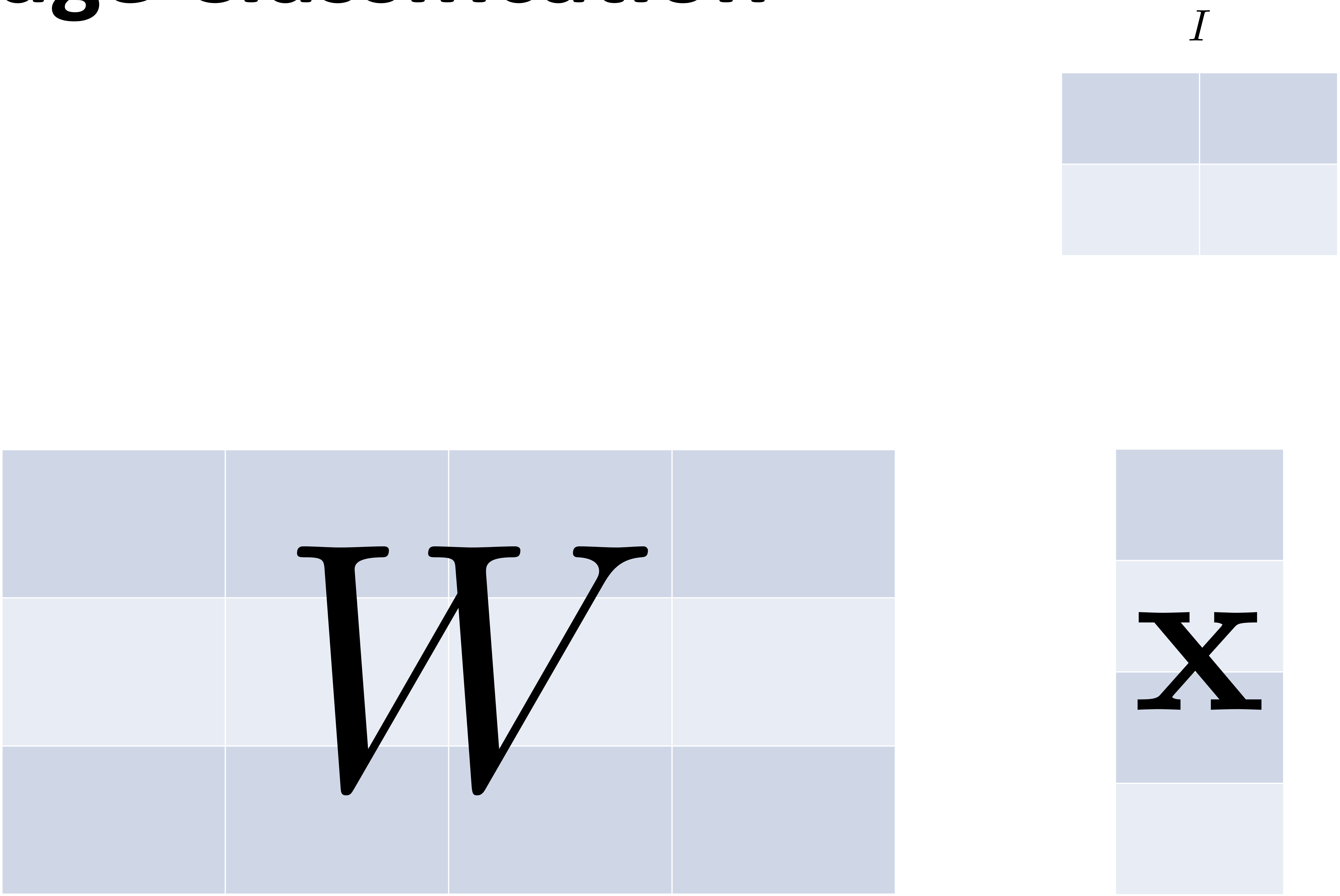

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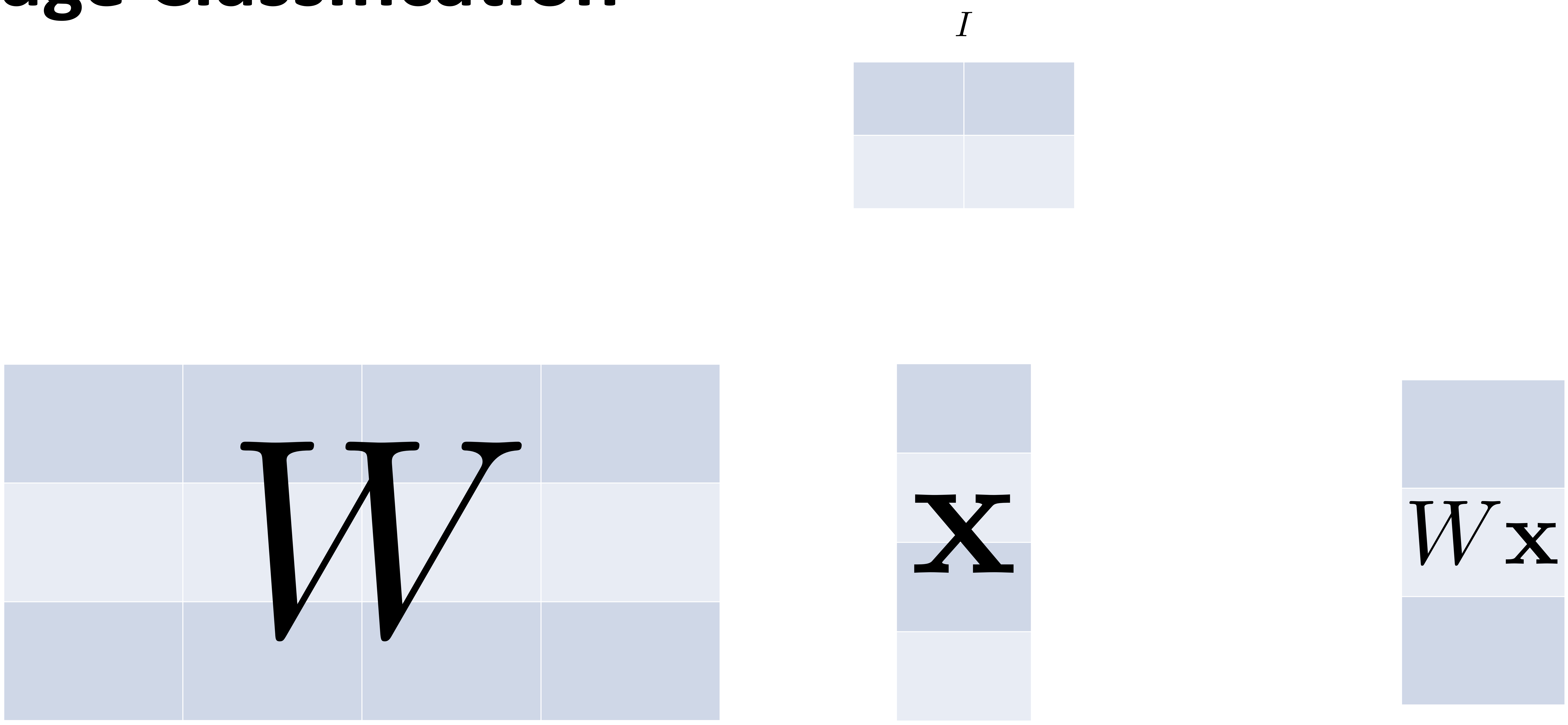

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- Optimization $\mathbf{W}^* := \arg\min L(W) = \arg\min L_i(W)/N$

Linear versus Nonlinear Models

$$s = f(\mathbf{x}_i, W) = W\mathbf{x}_i$$

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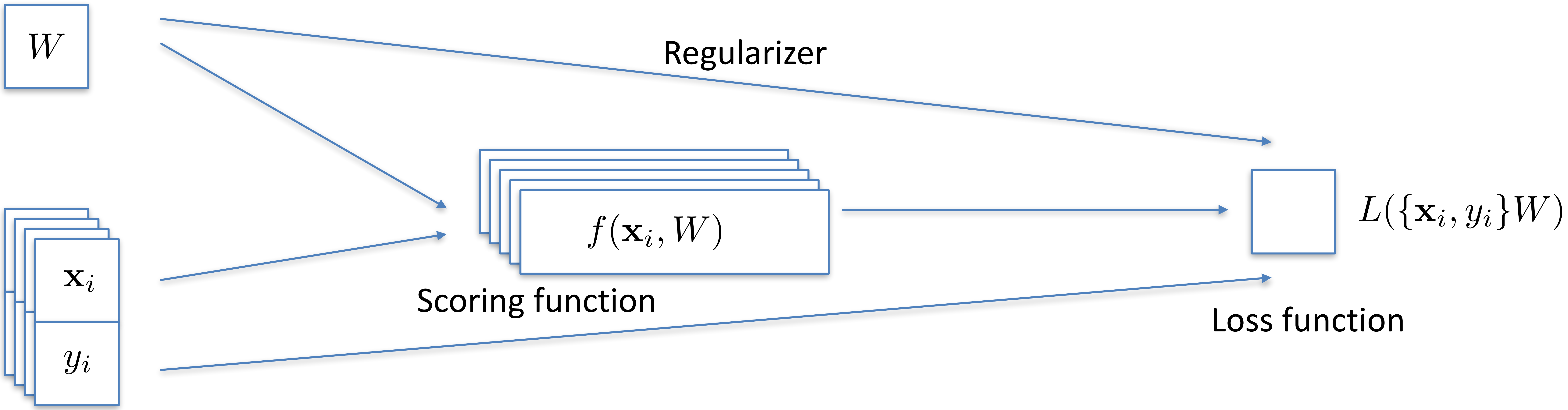
- Objective function #1 $$L_i(W) := (Wx_i - y_i)^2$$
- Objective function #2 $$L_i(W) := -\log\left(\frac{e^{Wx_iy_i}}{\sum_j e^{Wx_jy_j}}\right) = -\log\left(\frac{e^{sy_i}}{\sum_j e^{sy_j}}\right)$$

Image Classifier



Optimize

$$\mathbf{W}^* = \arg\min g(\mathbf{x}_i, W)$$

$$\nabla g(\mathbf{x}_i, W) = \left[\frac{\partial g(\mathbf{x}_i, W)}{w_i} = 0 \right]_{D \times 1}$$

Error Landscape

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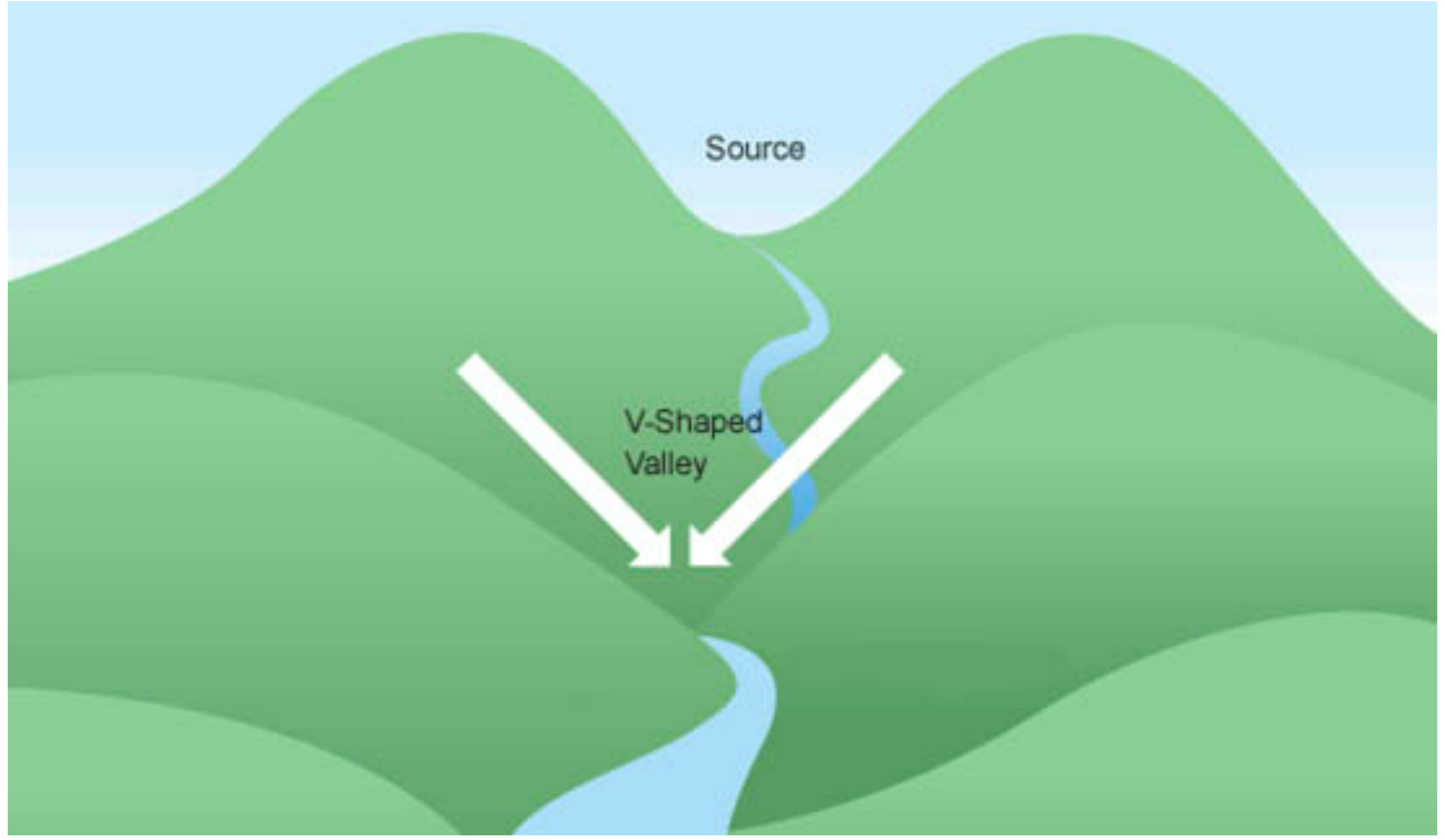

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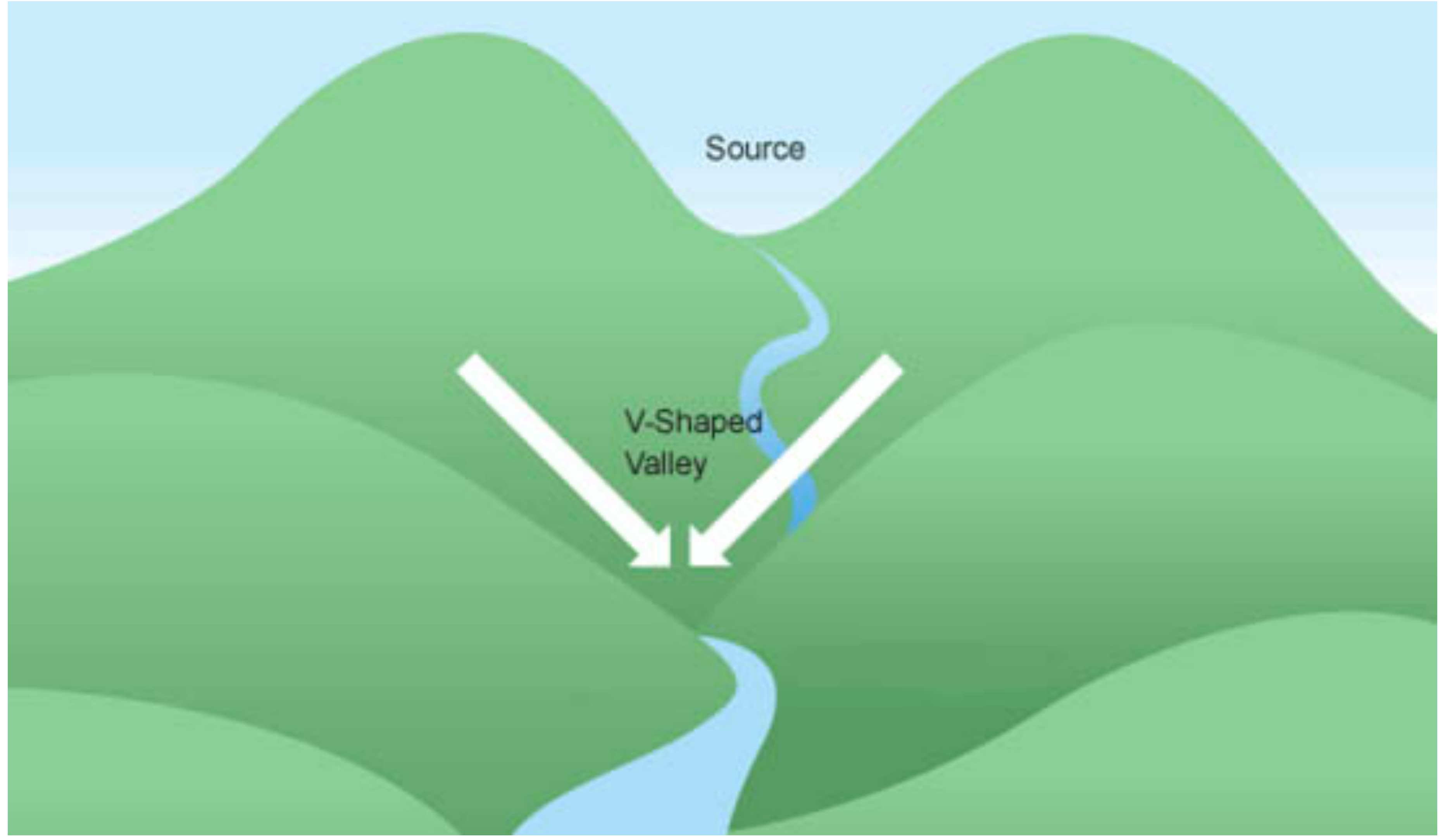
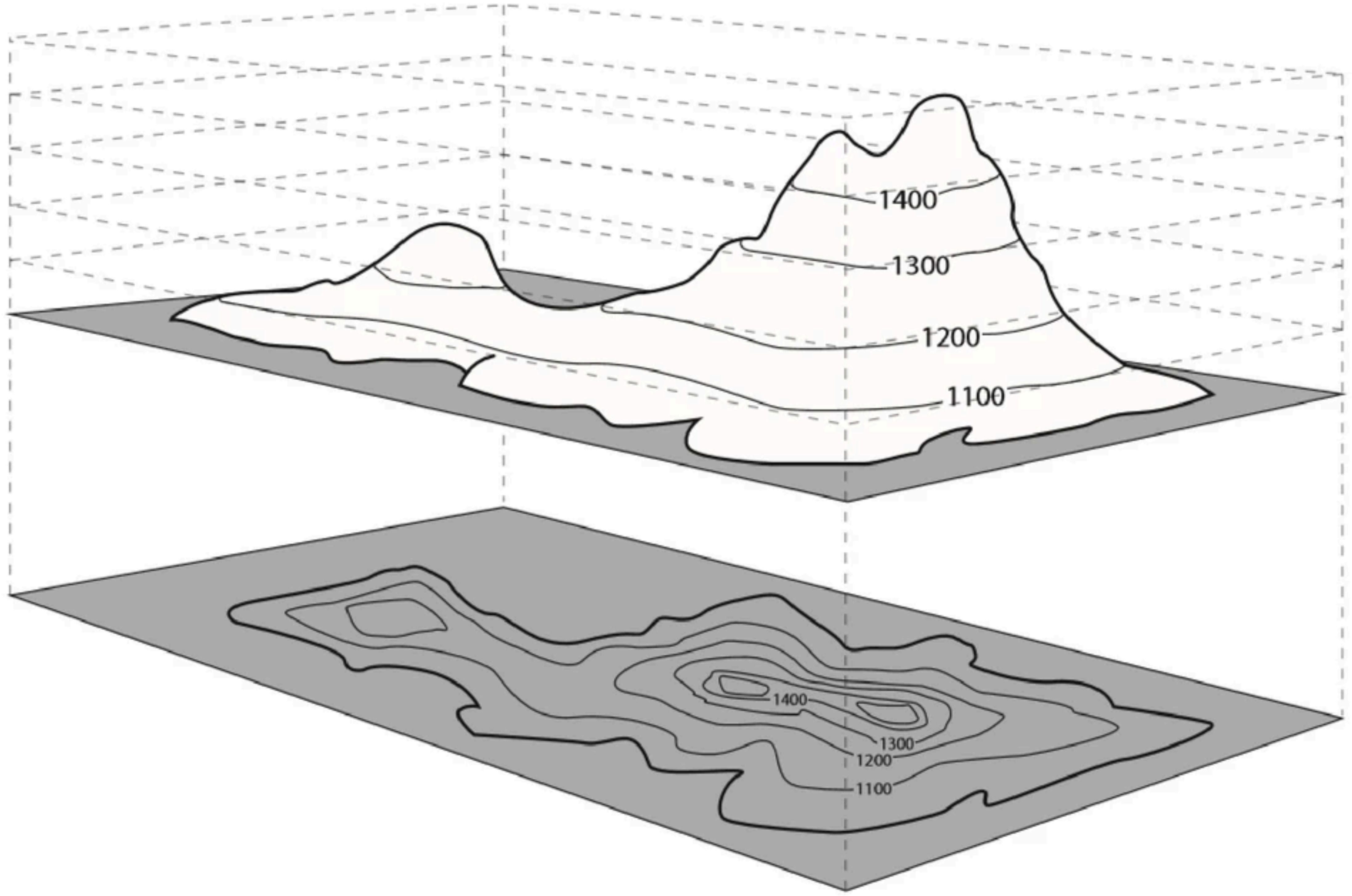
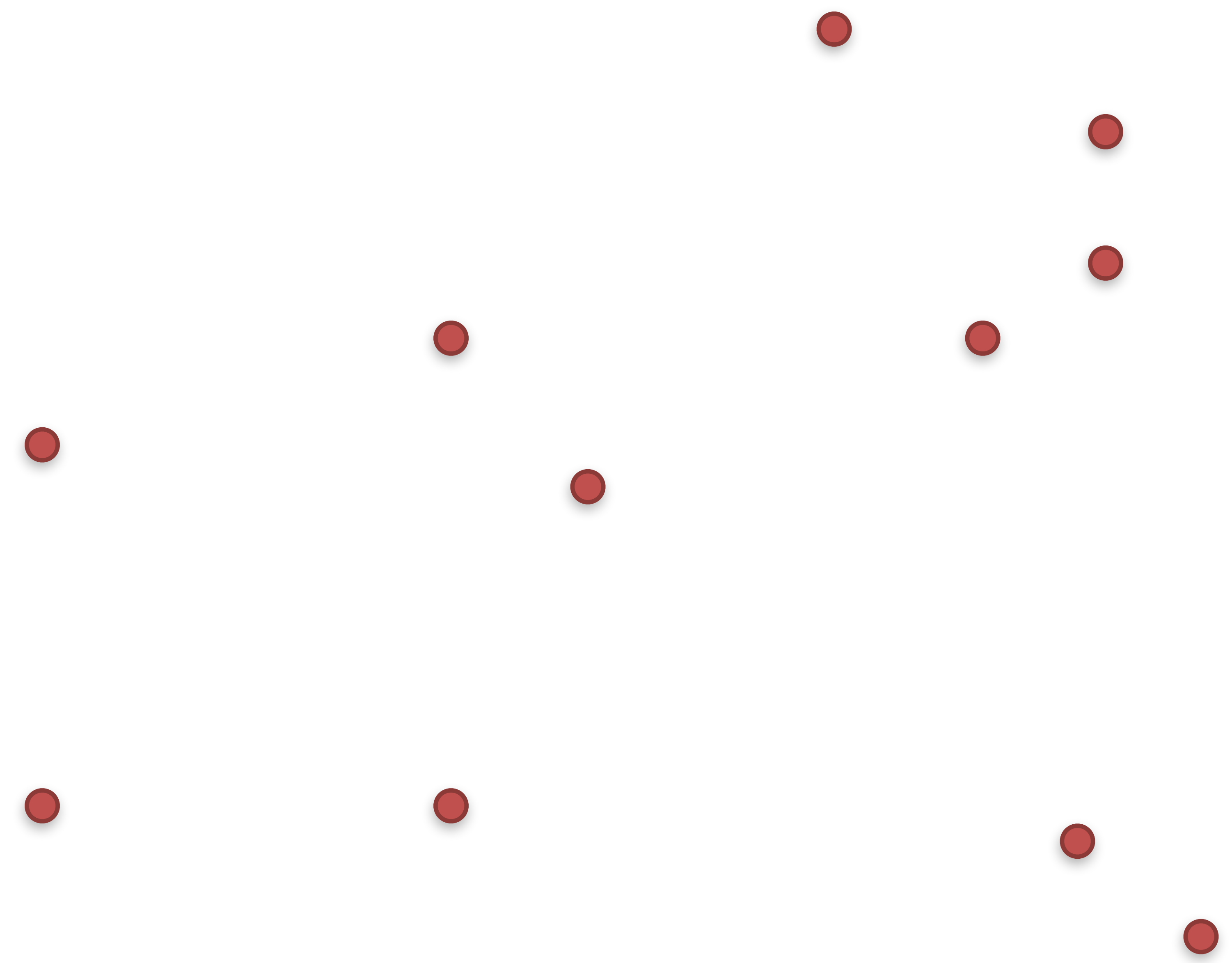




Method 1a: Random search

- bestLoss = inf
- Loop

```
    Pick random W
    Compute loss
    if loss<bestLoss
        bestLoss = loss
        currW = W
     endif
endLoop
```



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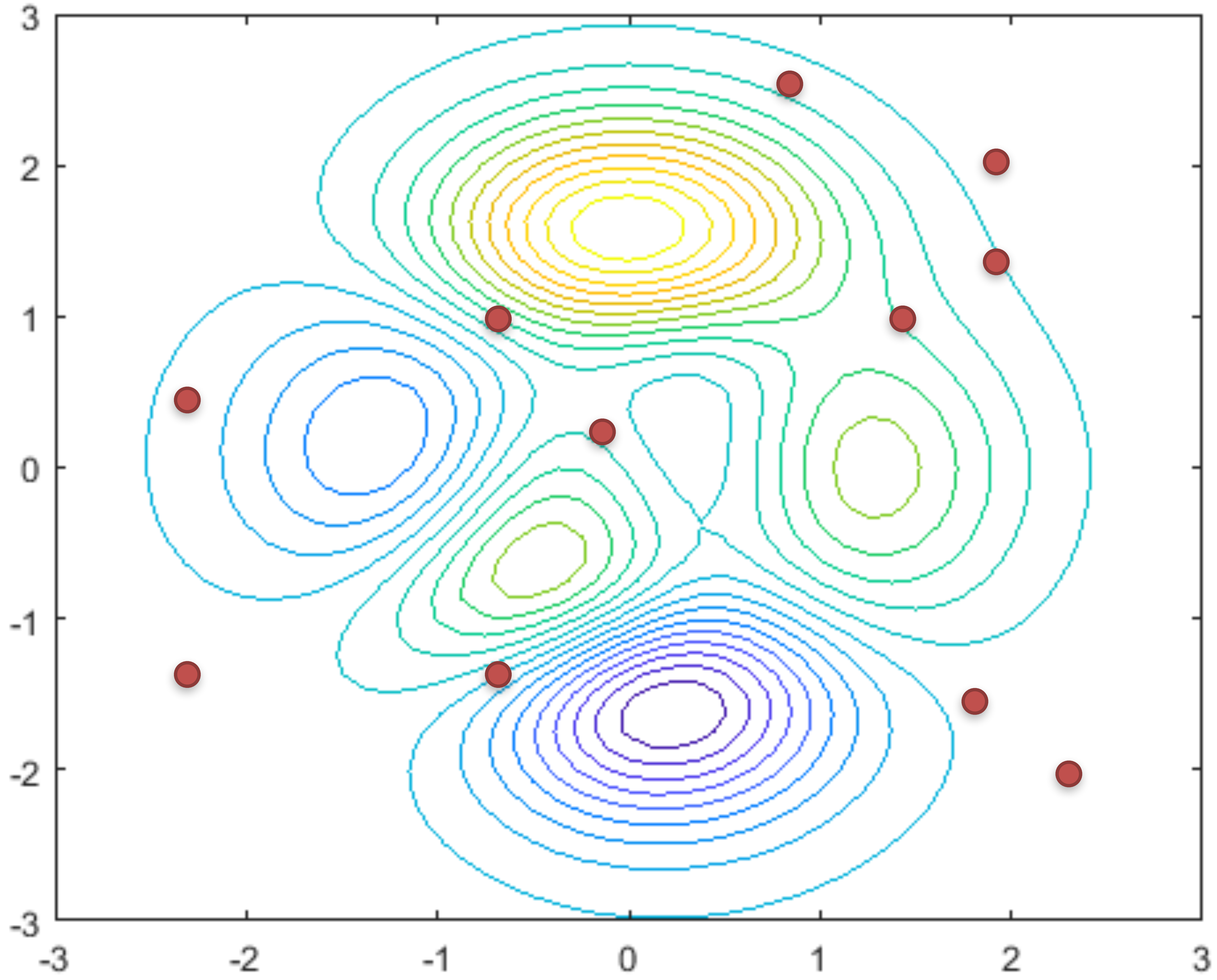
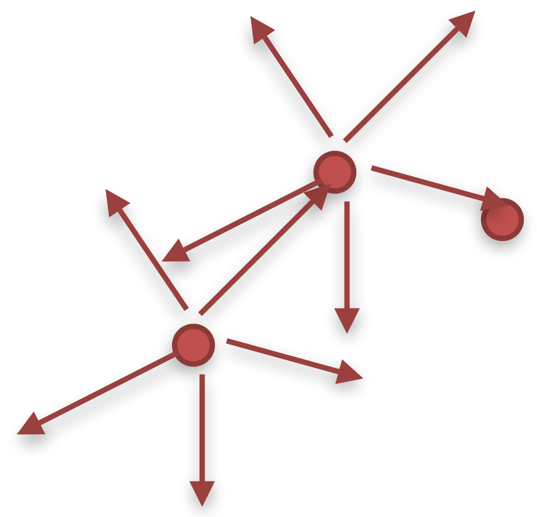


Method 1b: Random search++

- bestLoss = inf
- W = setRand
- stepsize
- Loop

```
    W_local = W + stepsize*W_random
    Compute loss
    if loss<bestLoss
        bestLoss = loss
        W = W_local
    endif
endLoop
```



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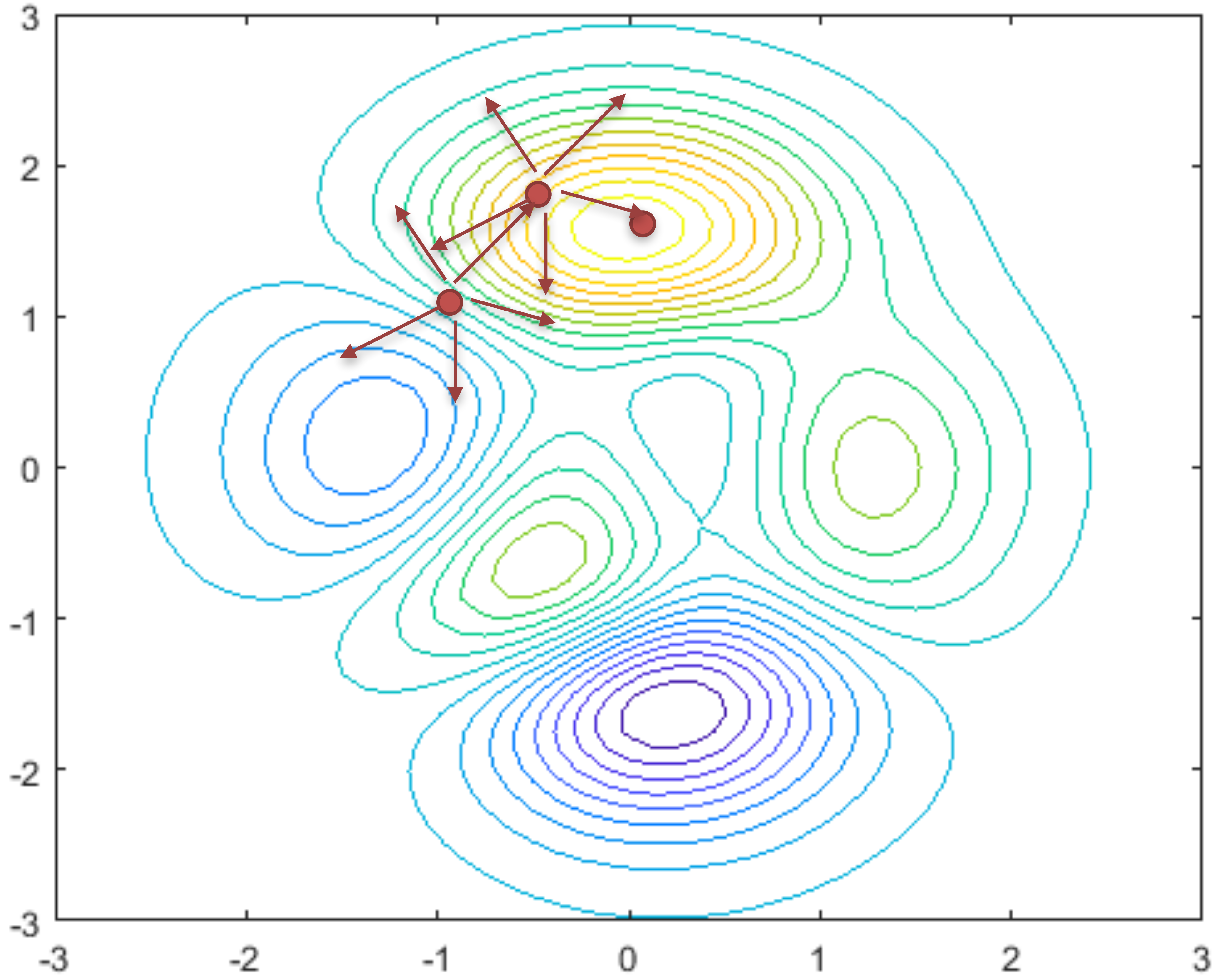

Method 2: Follow Negative of Gradient

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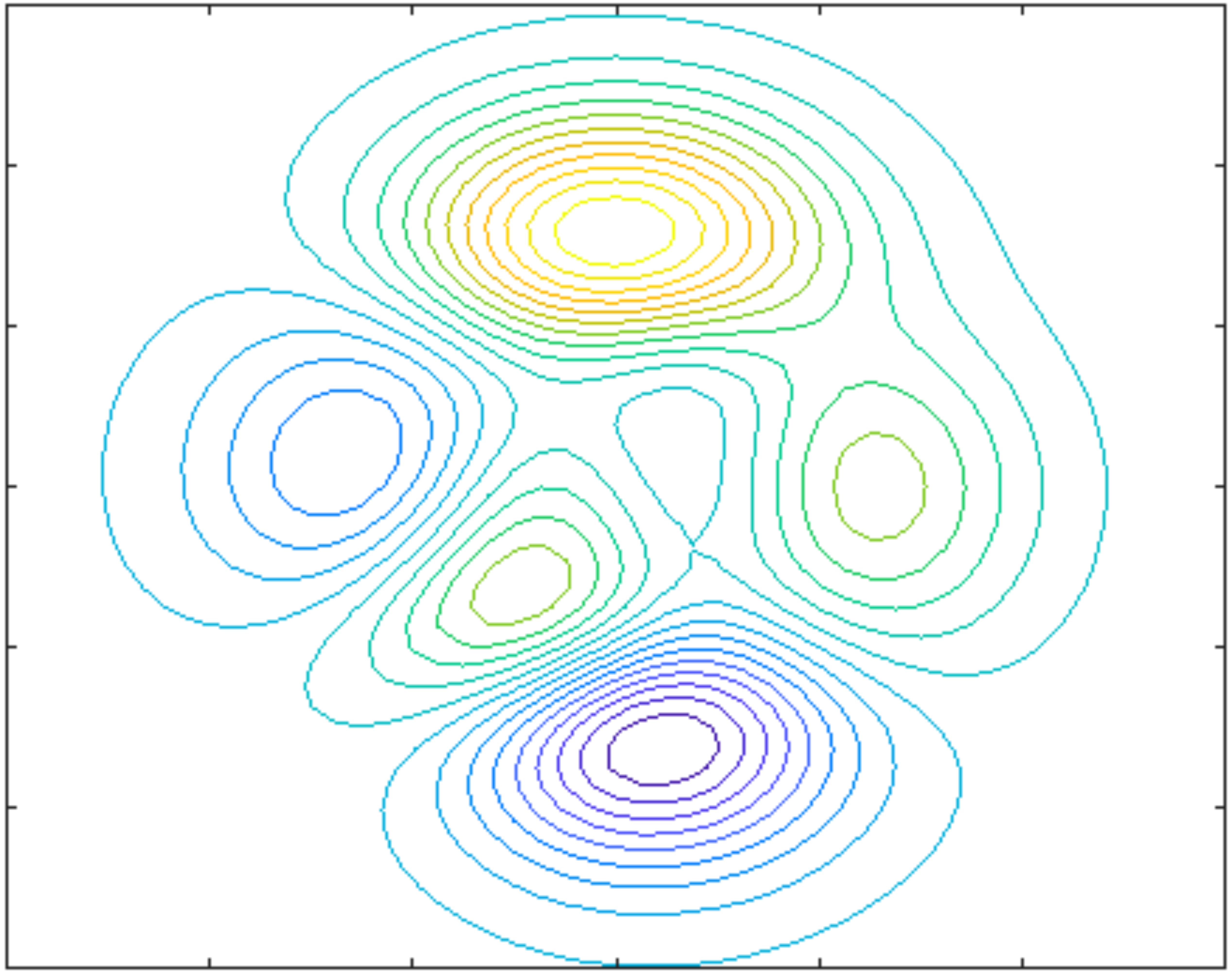

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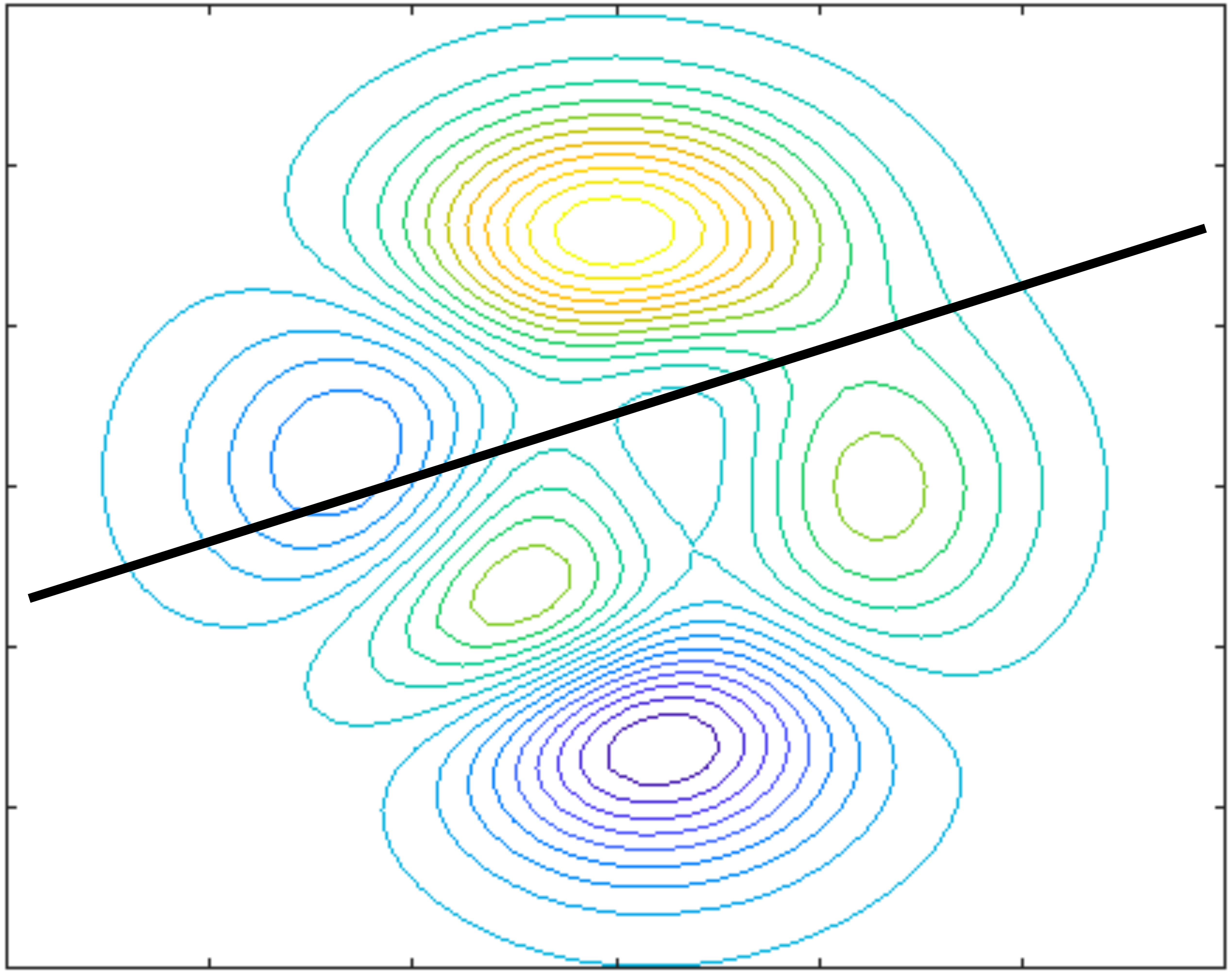

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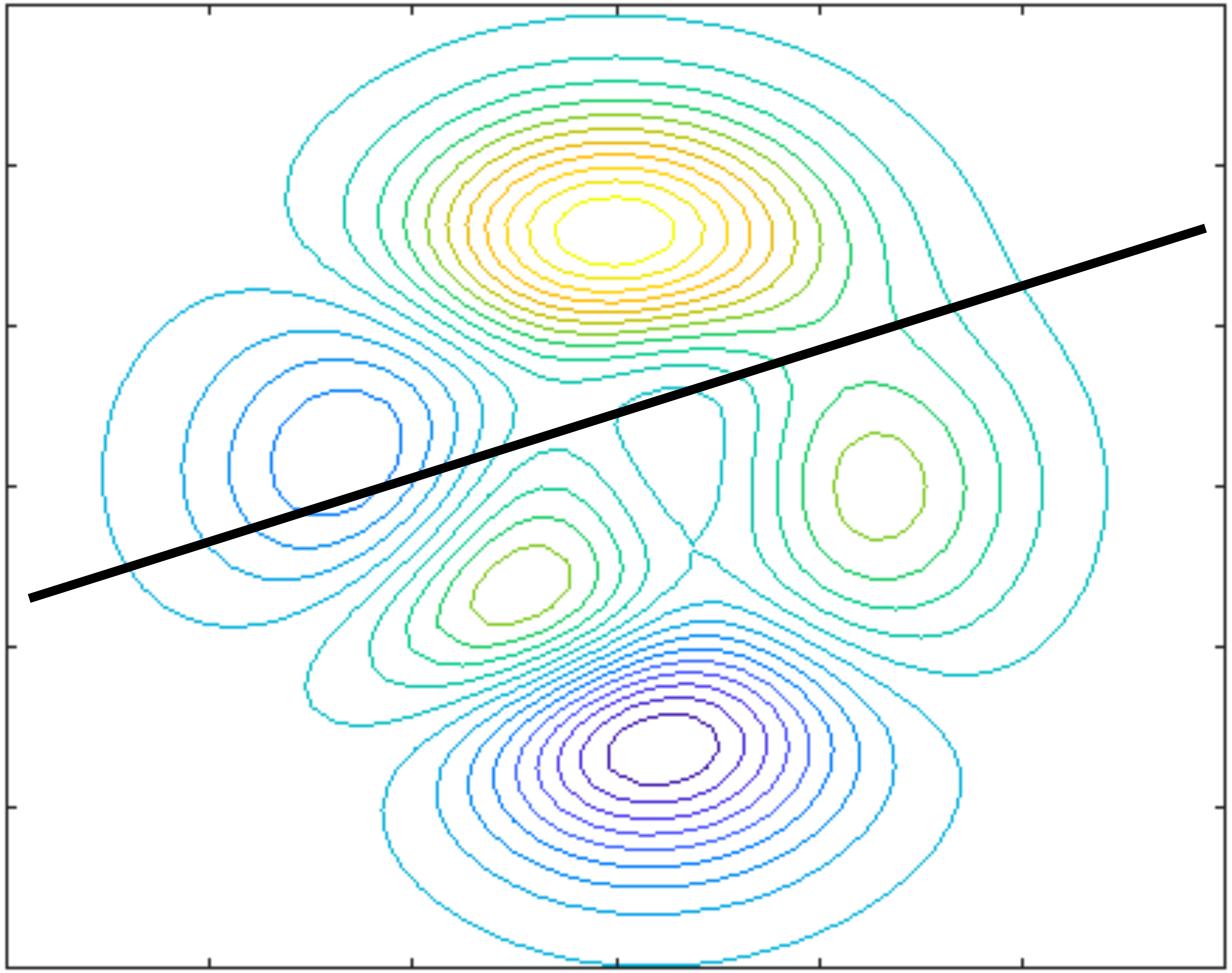

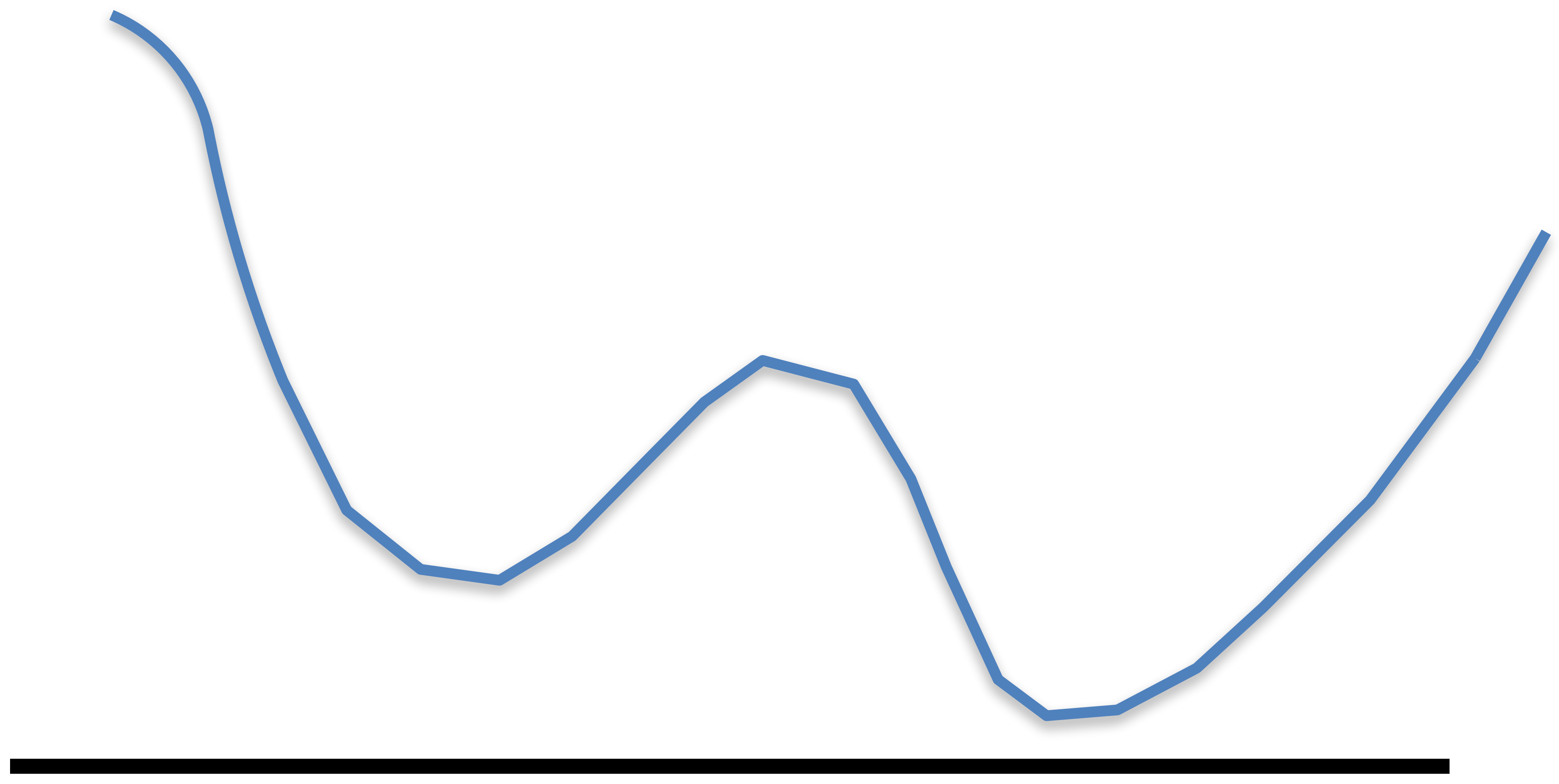

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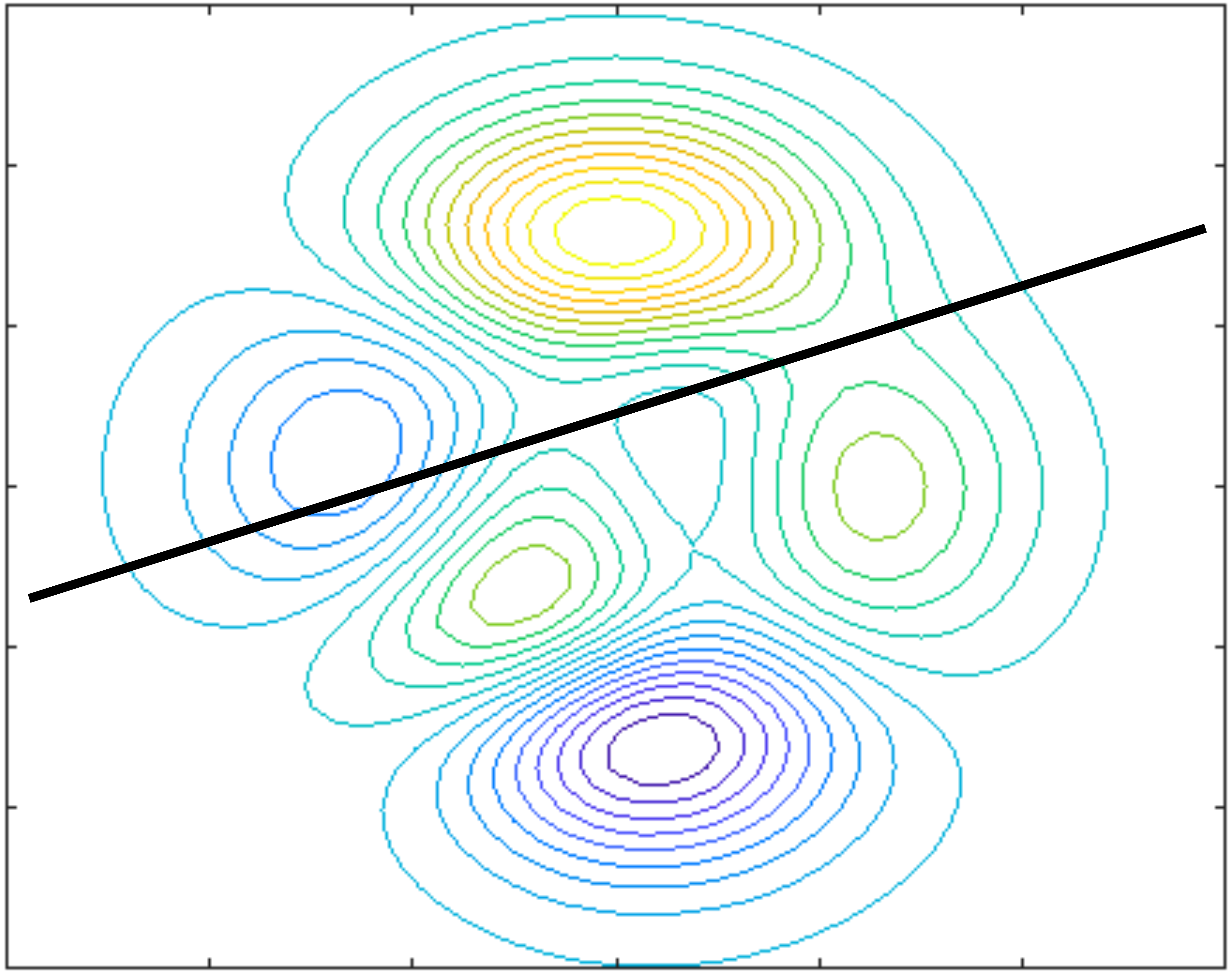

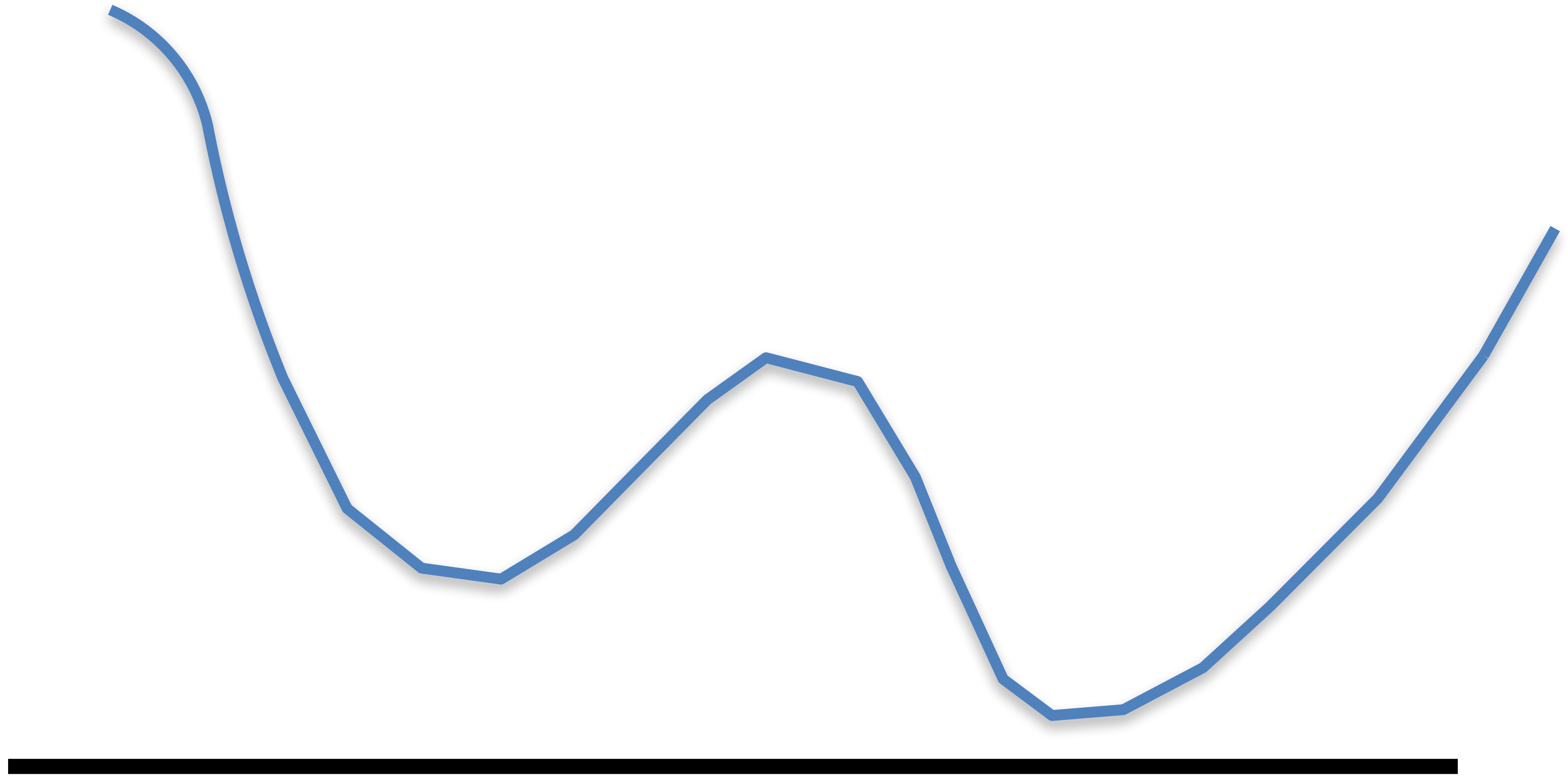

$$\frac{df(x)}{dx}$$