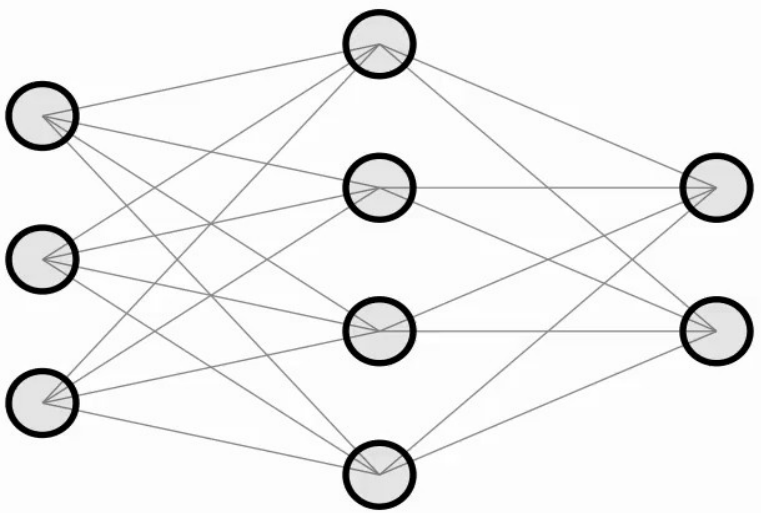
Introduction to Machine Learning

by Filip Pawlicki

What is Machine Learning?

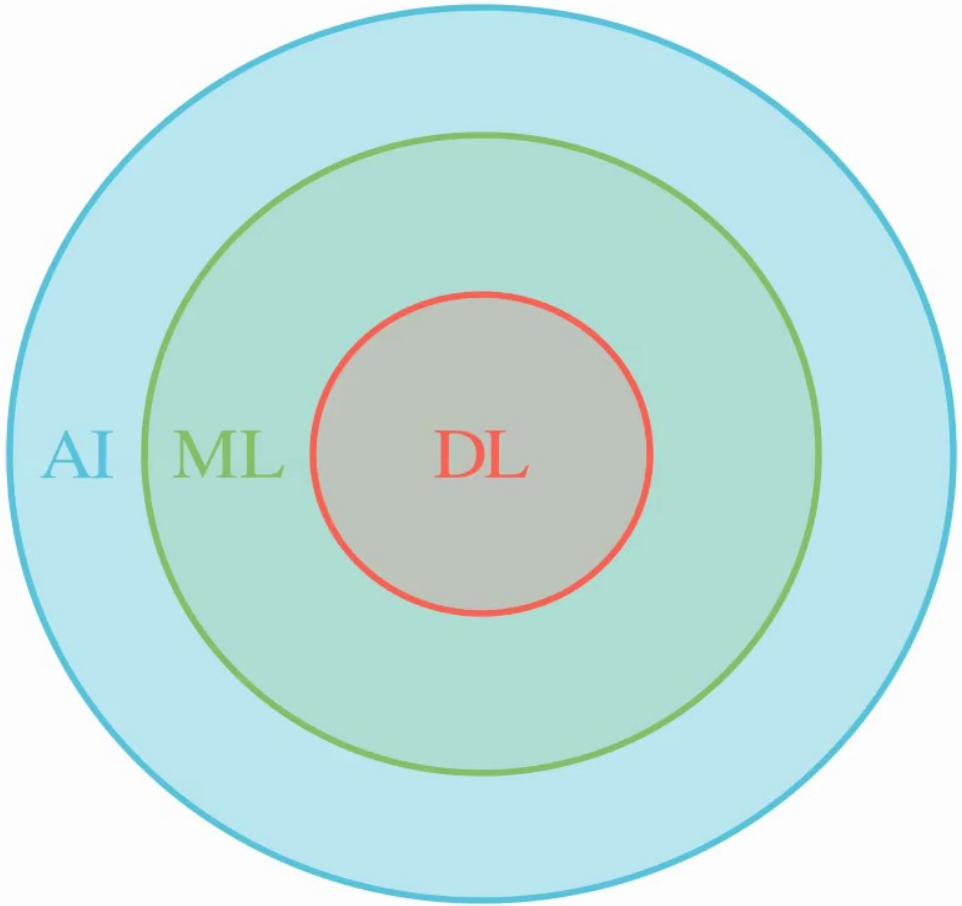
Machine Learning (ML) is a field of AI that allows computers to learn patterns from data and make predictions or decisions.

"Best science club?"

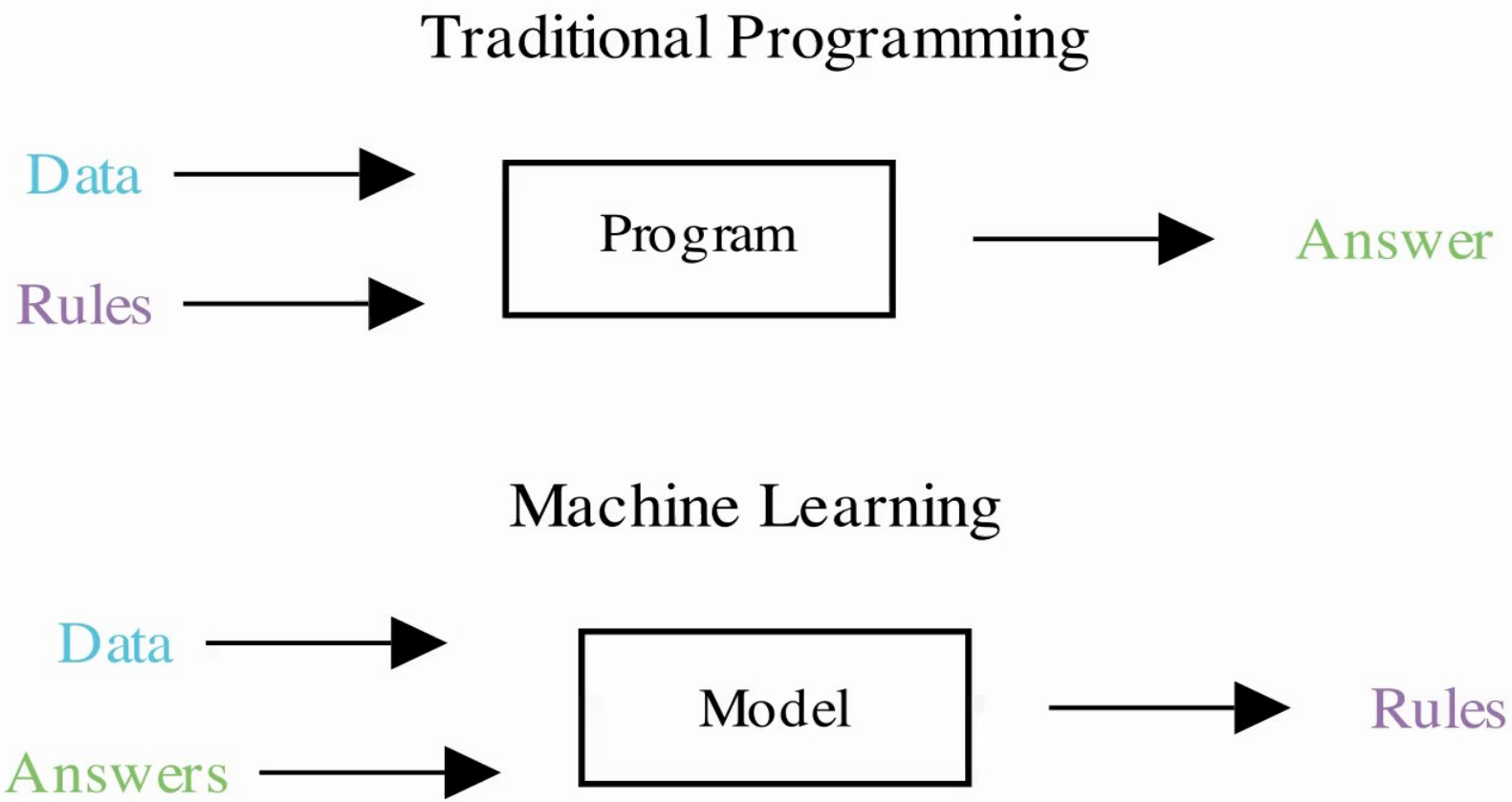


"Gradient"

AI, ML & DL



ML vs Traditional Programming



Main ML Paradigms

Supervised Learning: labeled data → e.g. classification, regression

Unsupervised Learning: unlabeled data → e.g. clustering, PCA

Reinforcement Learning: agent learns via environment interaction

Real Examples

- Supervised: spam detection, house price prediction
- Unsupervised: customer segmentation, anomaly detection
- Reinforcement: self-driving cars, AI in games

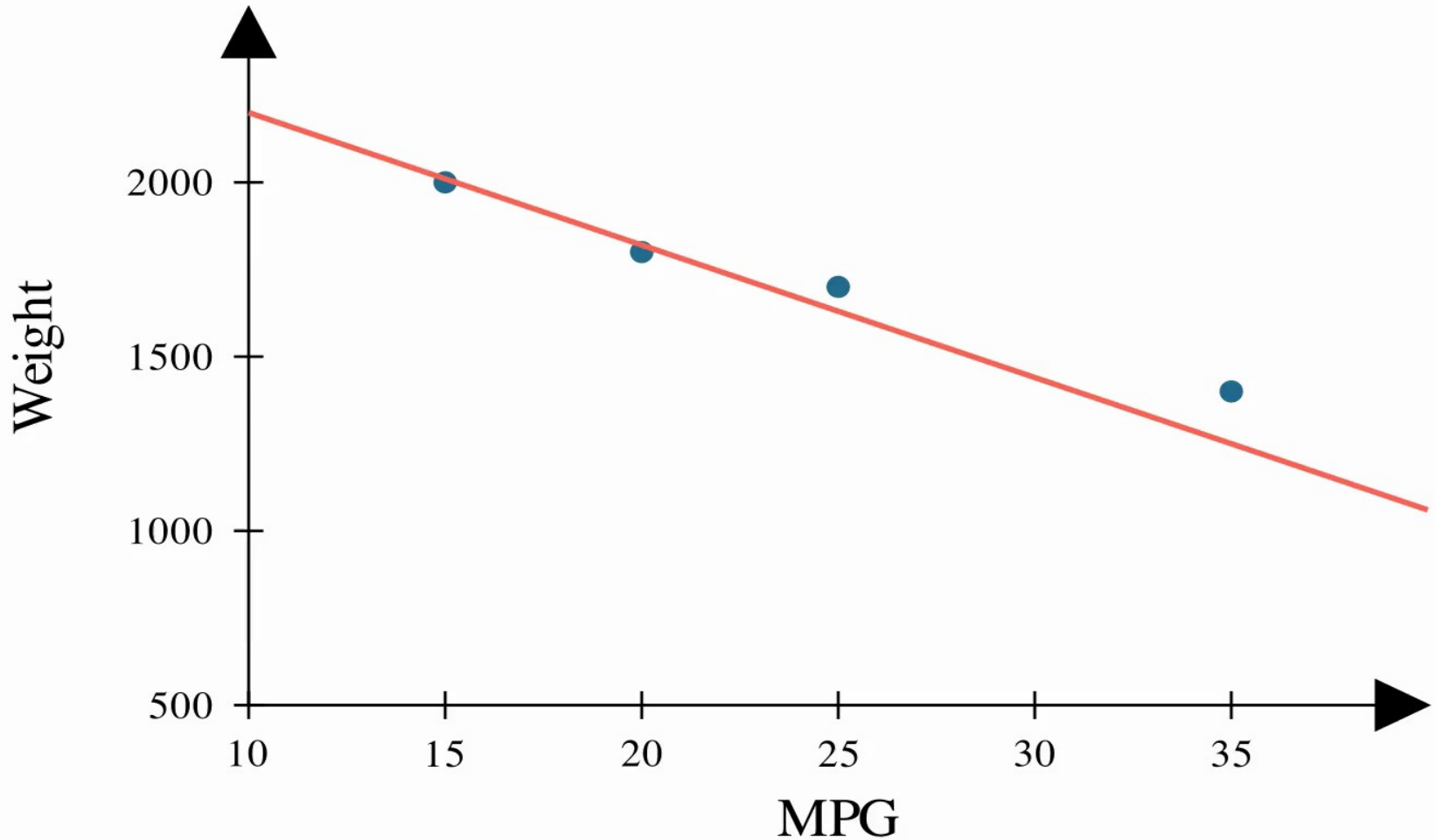
What is Regression?

Regression is a method to predict numerical values from data.

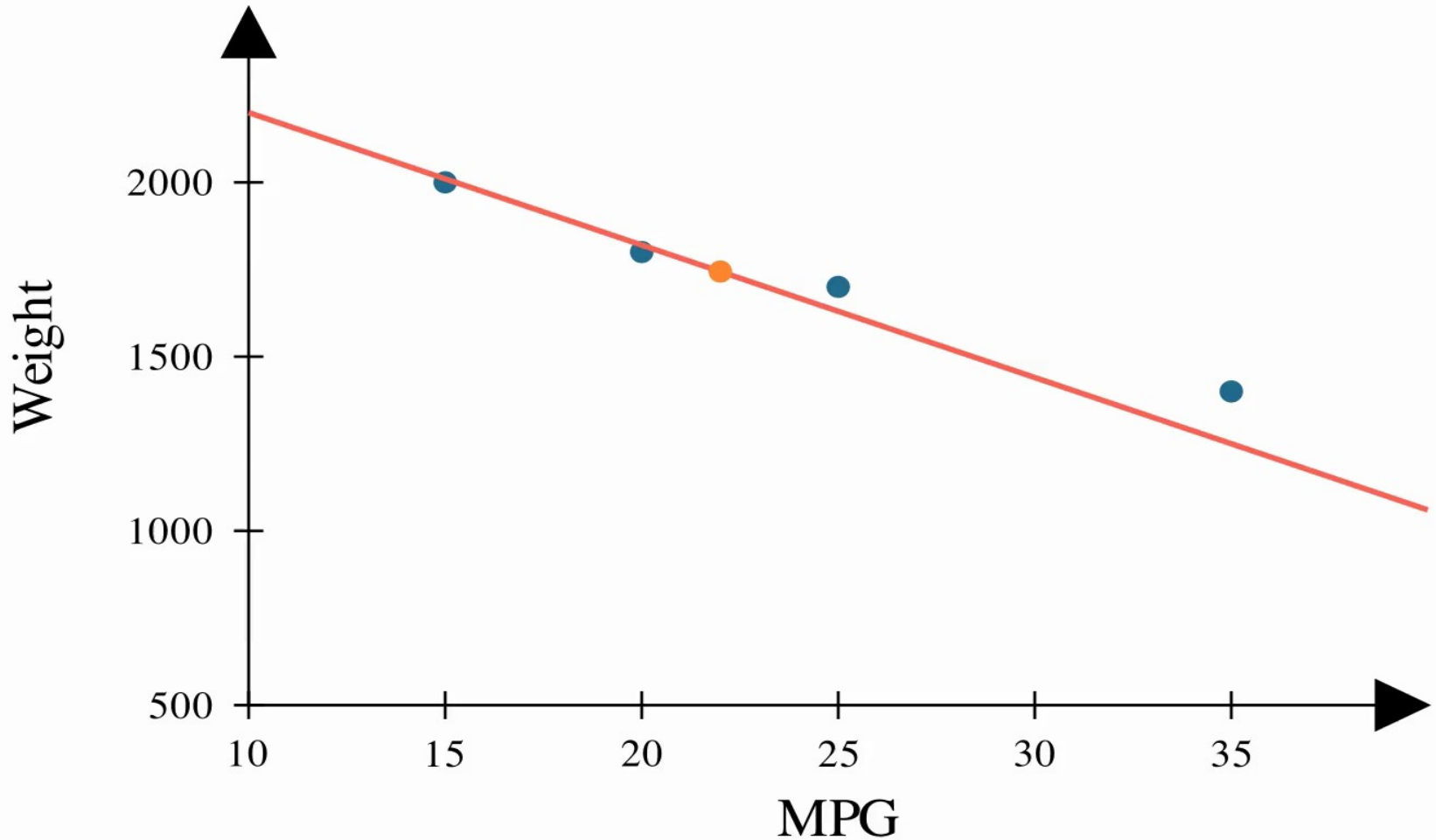
Examples of Regression

- Predicting car MPG
- Weather forecasting
- Trend analysis

Linear Regression Example



Linear Regression Example



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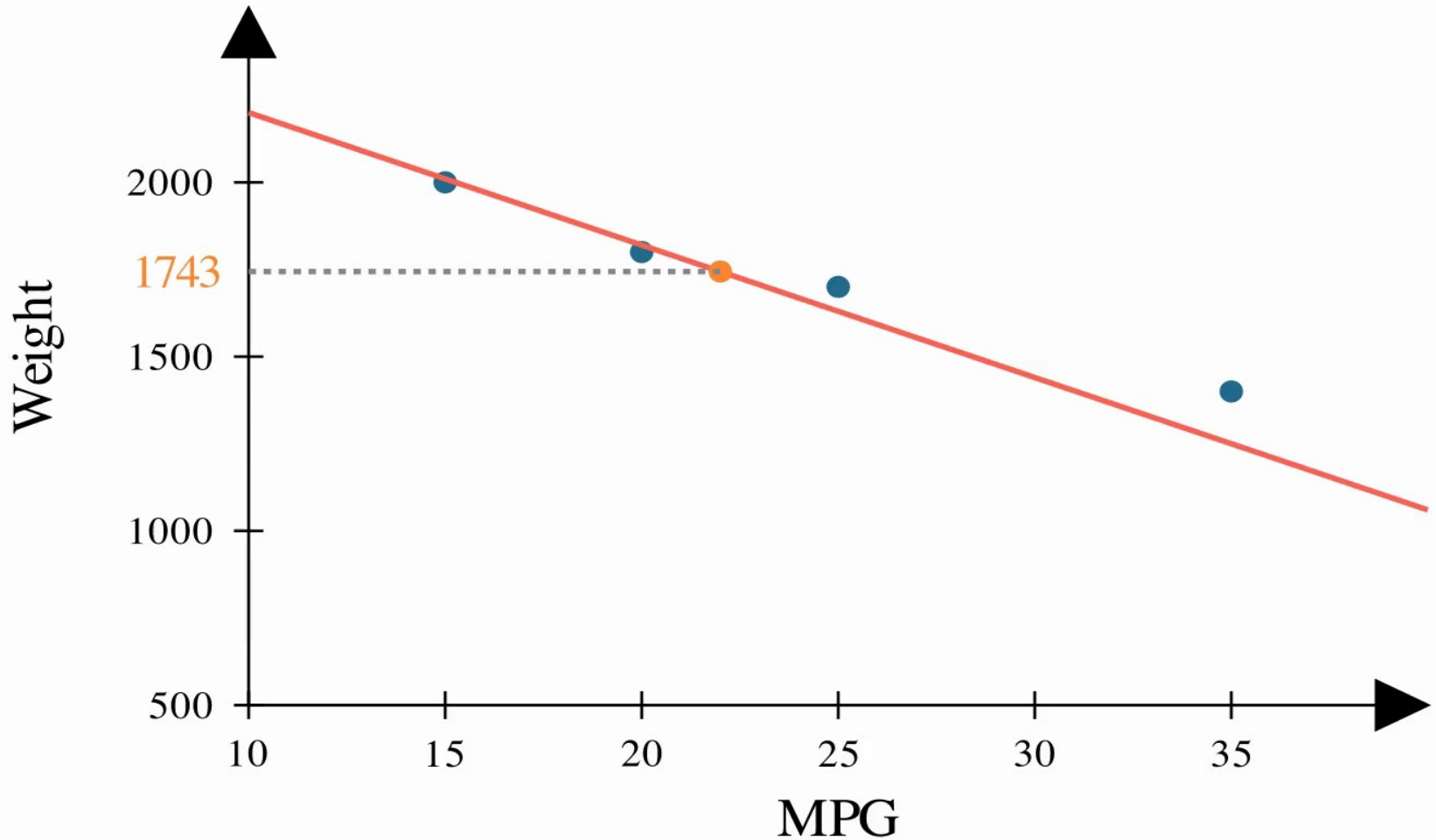
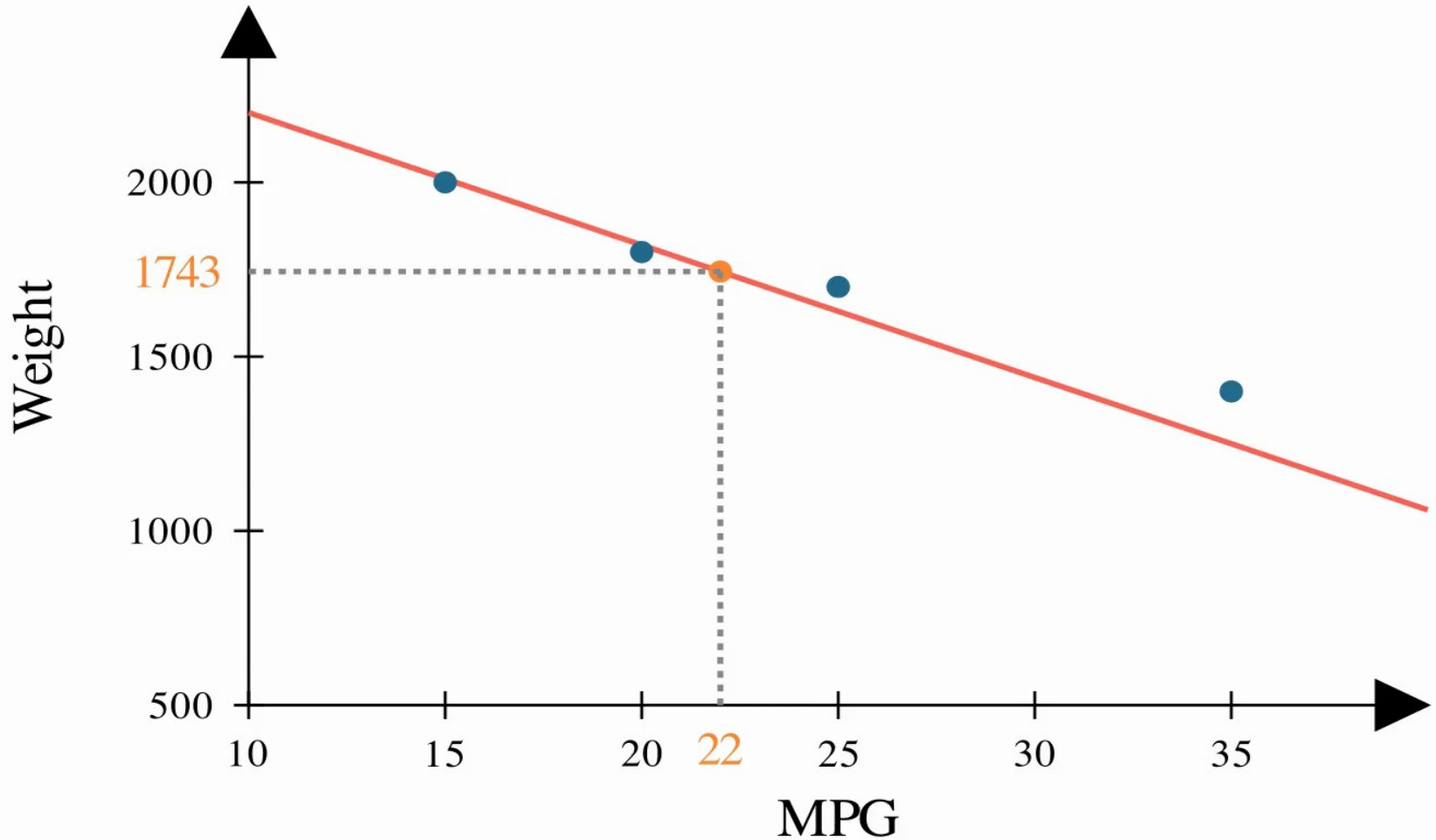


Linear Regression Example



Regression Formula

$$f(x) = a \cdot x + b$$

Regression Formula

$$\hat{y} = w \cdot x + b$$

Training Models

Training Models

Dataset

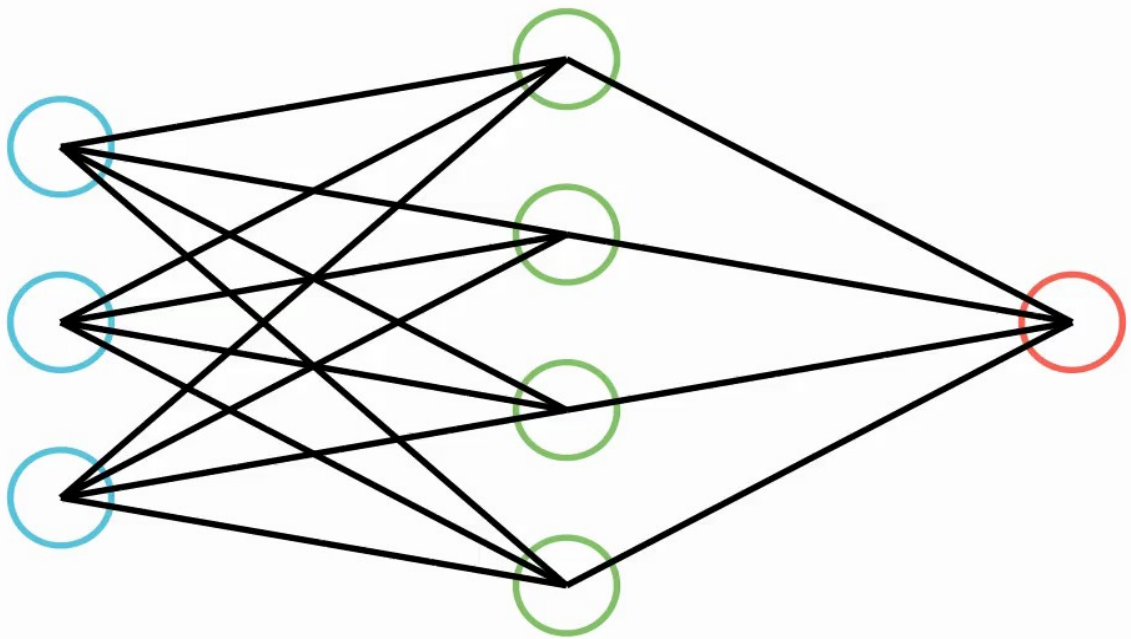
Train set	Validation set	Test set
≈70%	≈20%	≈10%

Training Models

Training Models

Model

$$\hat{y} = w \cdot x + b$$



Training Models

Loss

$$MSE = \frac{1}{n}\sum_{i}(y_i - \hat{y}_i)^2$$

Label: 2 Prediction: 2.1

Label: 3 Prediction: 2.9

Label: 4 Prediction: 4.2

$$MSE = \frac{1}{3}\left((2-2.1)^2 + (3-2.9)^2 + (4-4.2)^2 \right) = 0.0267$$

Training Models

Optimizer

Gradient Descent

$$\nabla_w L = \frac{1}{n}\sum_i 2((wx_i + b) - y_i)x_i, \quad \nabla_b L = \frac{1}{n}\sum_i 2((wx_i + b) - y_i)$$

$$g_{w,1} = 2 * (2.5 - 2) * 1 = 1.00$$

$$g_{b,1} = 2 * (2.5 - 2) = 1.00$$

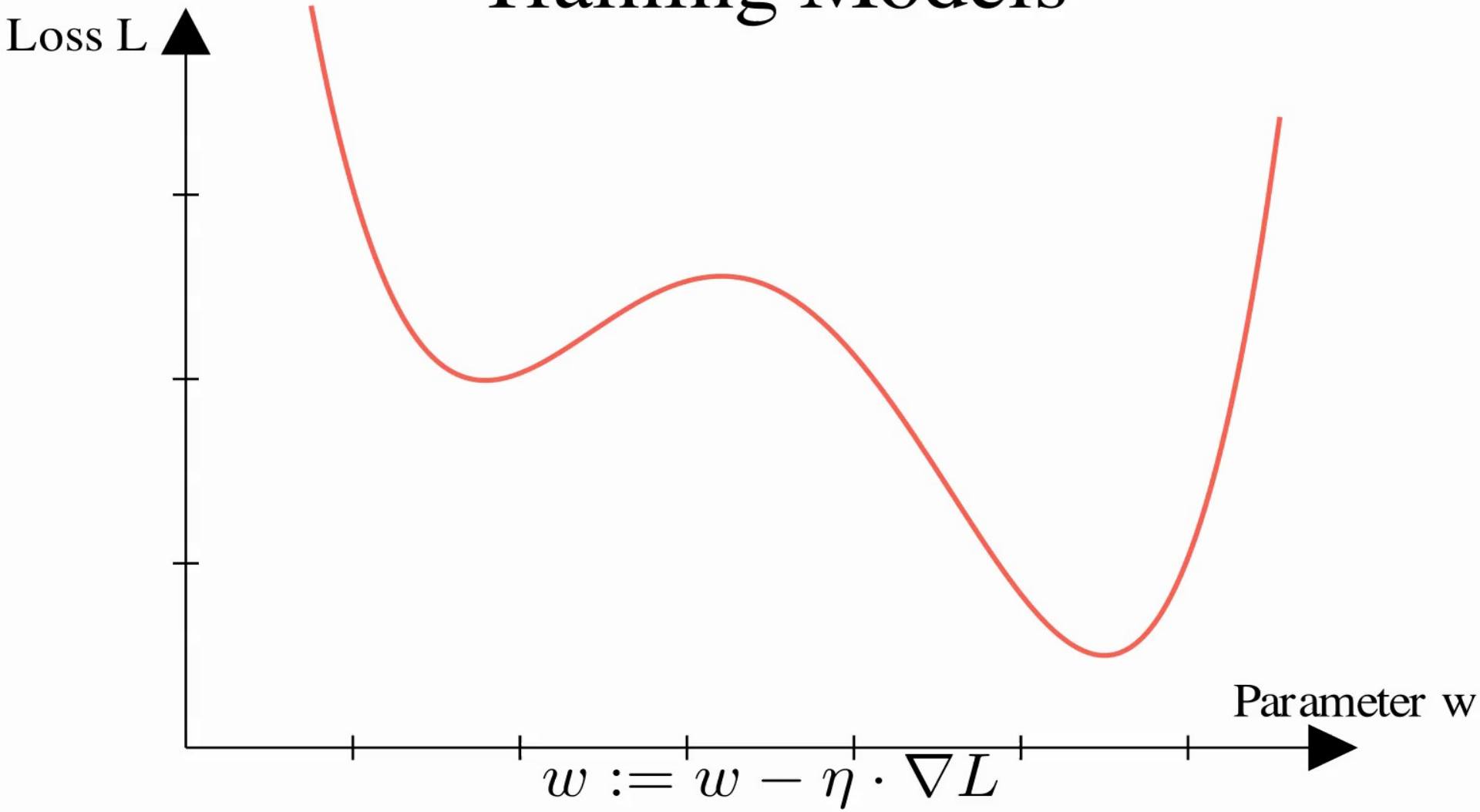
$$g_{w,2} = 2 * (2.8 - 3) * 2 = -0.80$$

$$g_{b,2} = 2 * (2.8 - 3) = -0.40$$

$$g_{w,avg} = \frac{1.00 + -0.80}{2} = 0.100$$

$$g_{b,avg} = \frac{1.00 + -0.40}{2} = 0.300$$

Training Models



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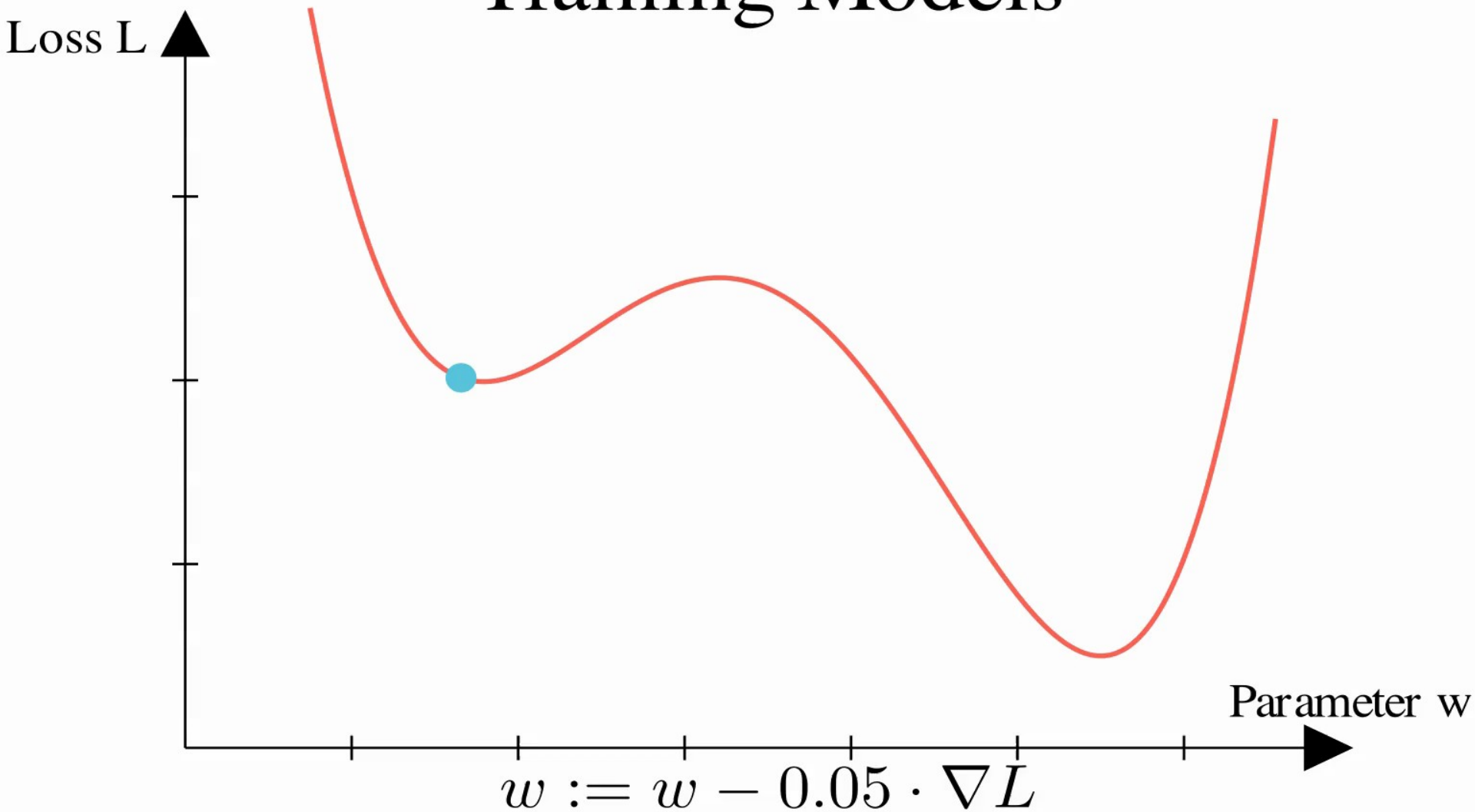

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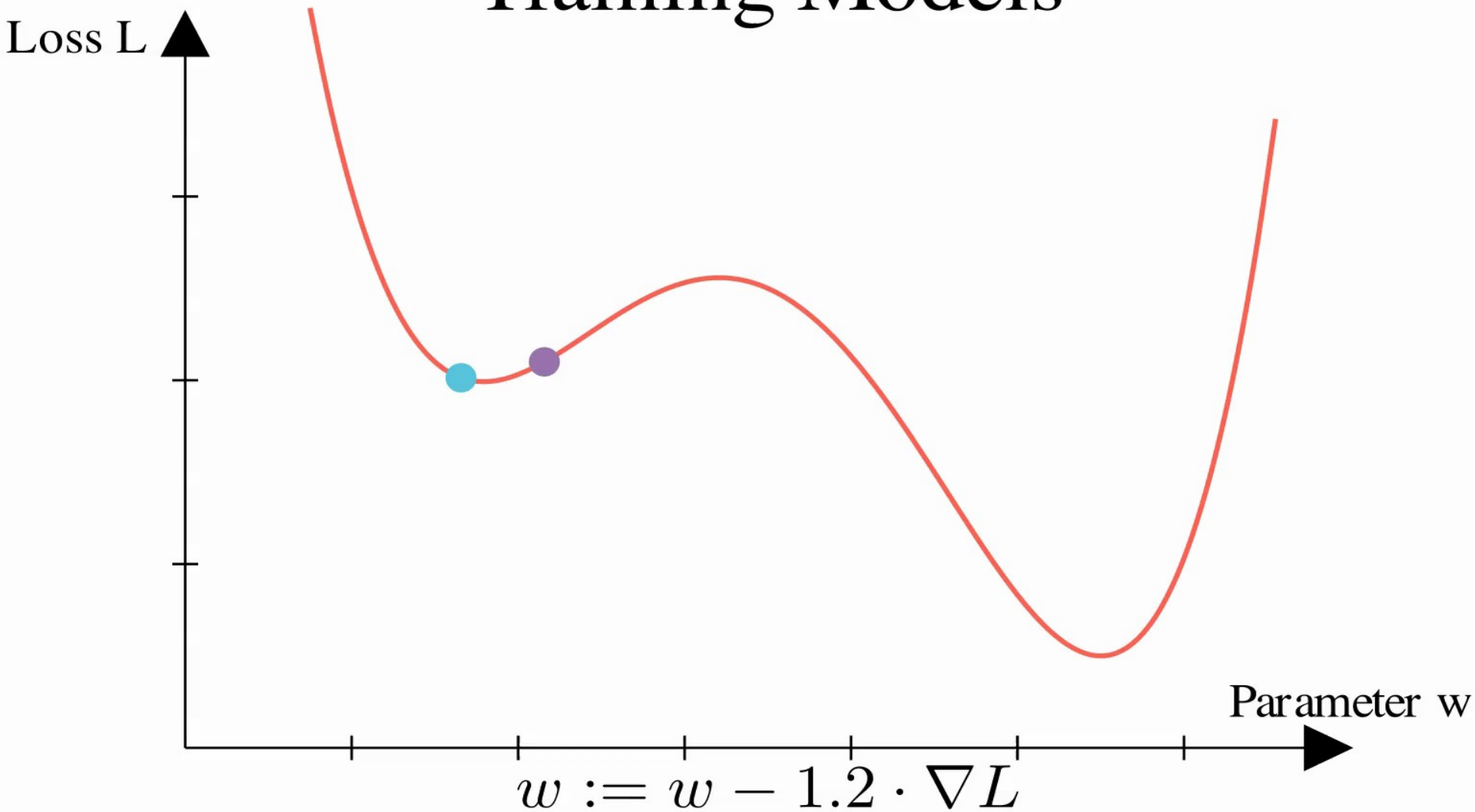
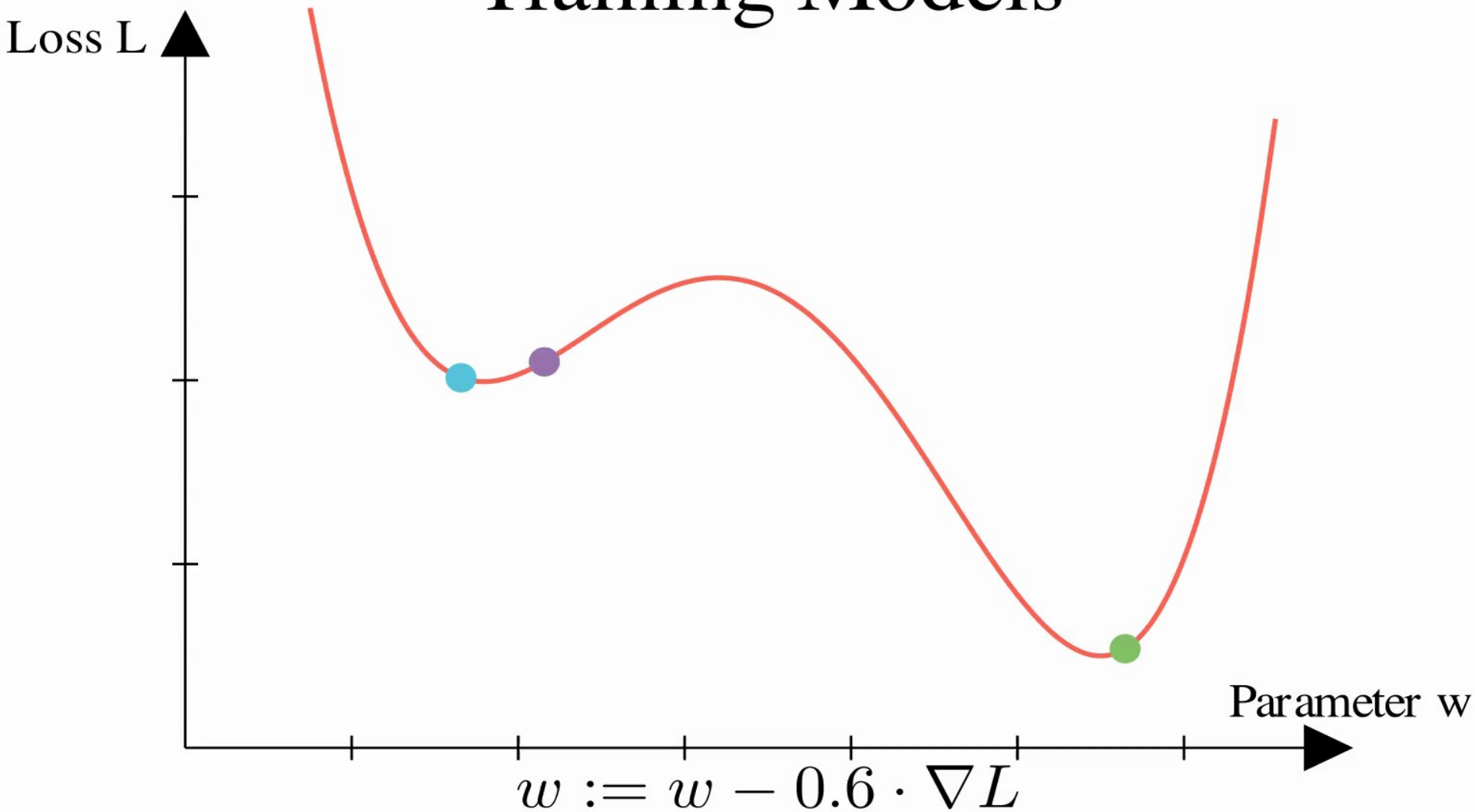
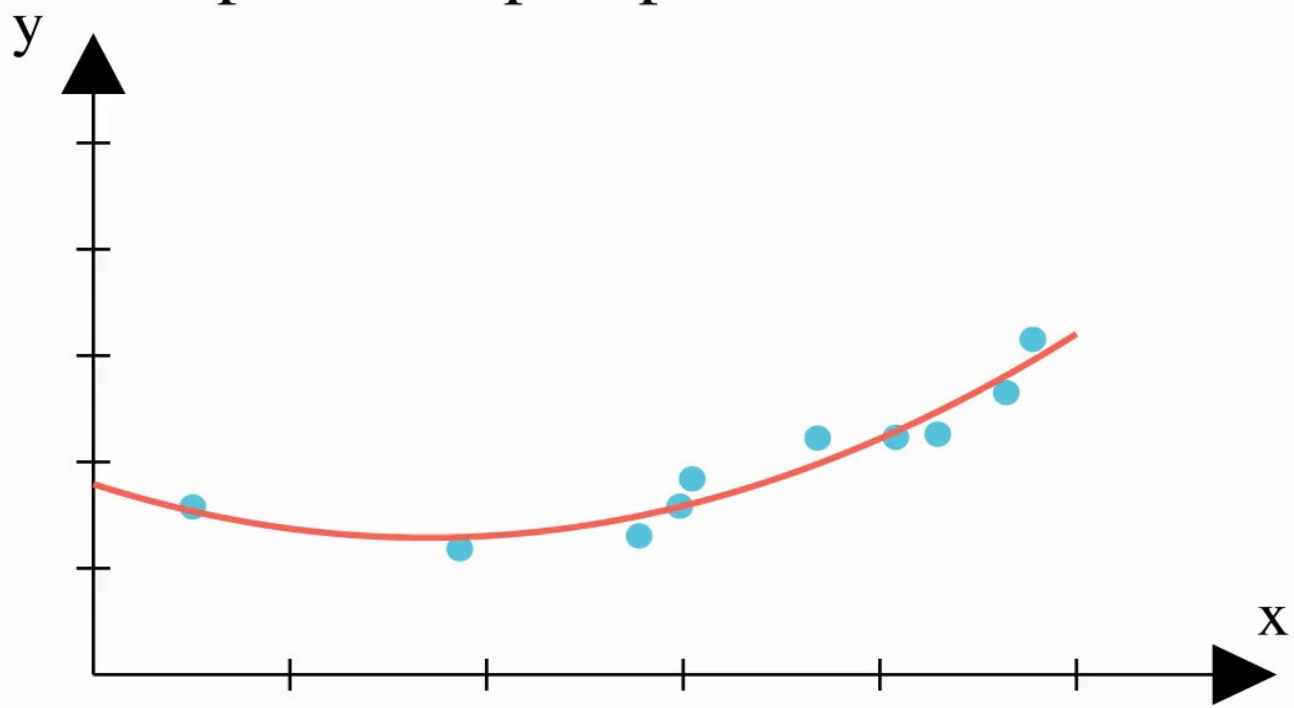


Training Models



Non-linear Regression

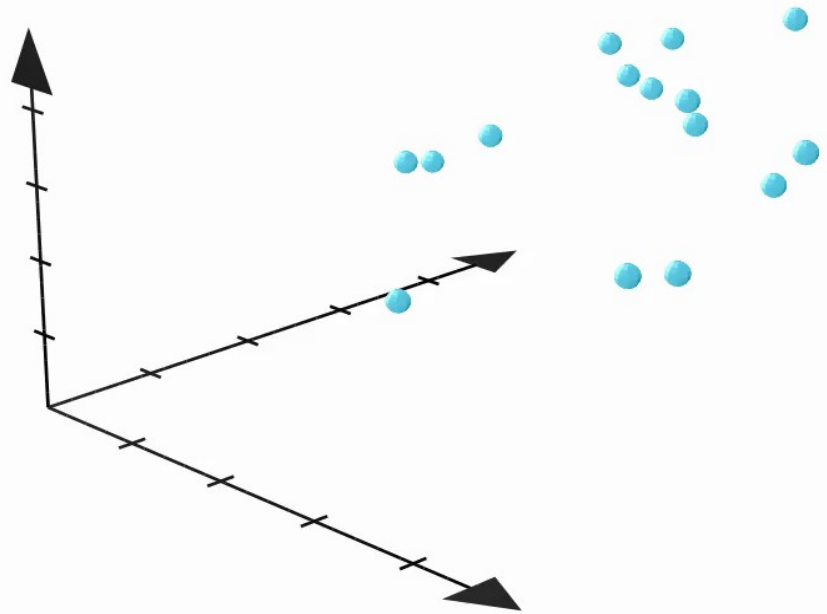
Used when the relationship between input and output is not linear.
Fits curves to capture complex patterns.



$$\hat{y} = \theta_0 + \theta_1 x + \theta_2 x^2$$

Multidimensional Regression

Used when the output depends on multiple input features.
Fits surfaces to capture complex patterns in higher dimensions.



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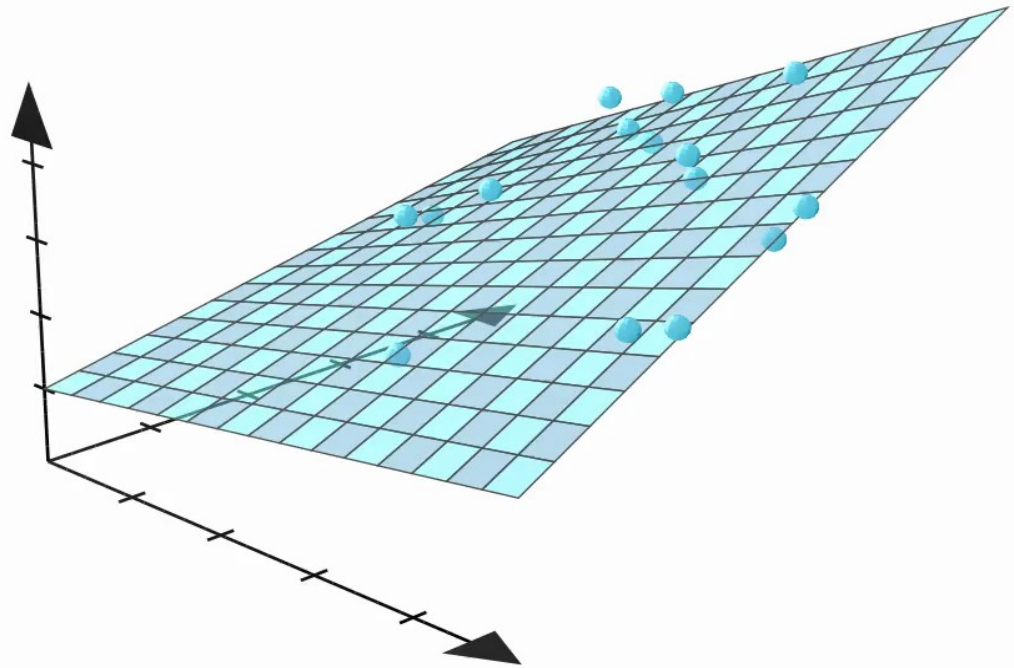

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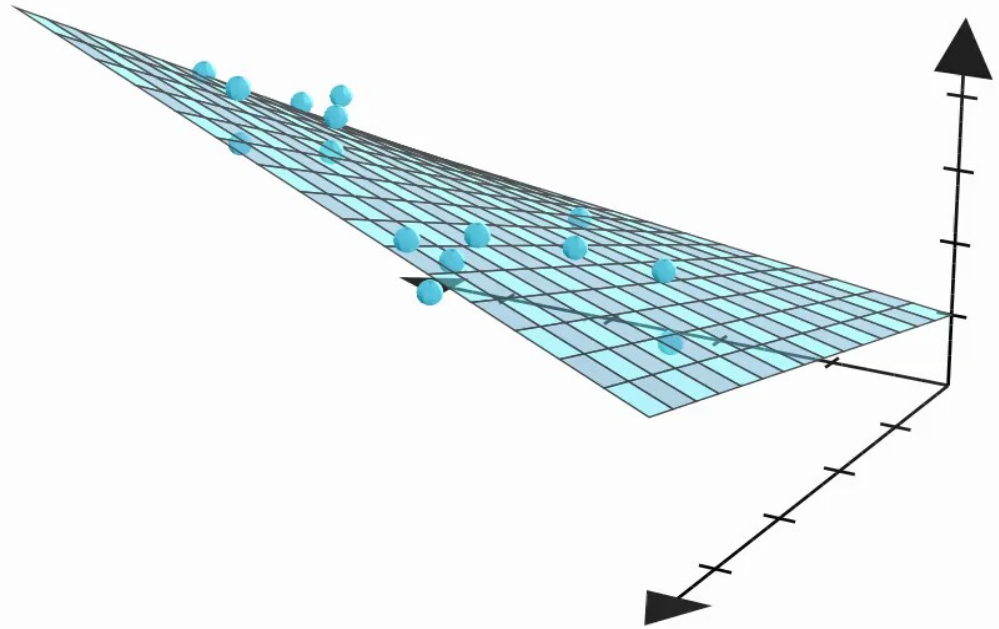

$$\hat{y} = \theta_0 + \theta_1 x + \theta_2 z + \theta_3 xz$$

Questions & Discussion

Thank you!