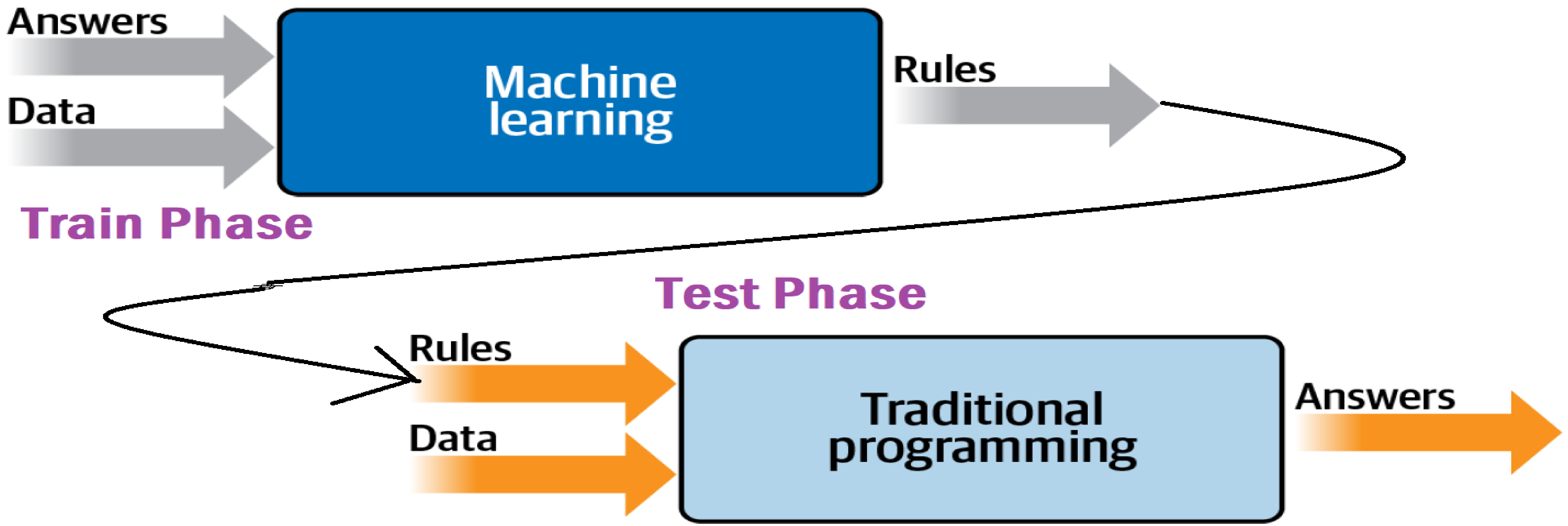
Recap

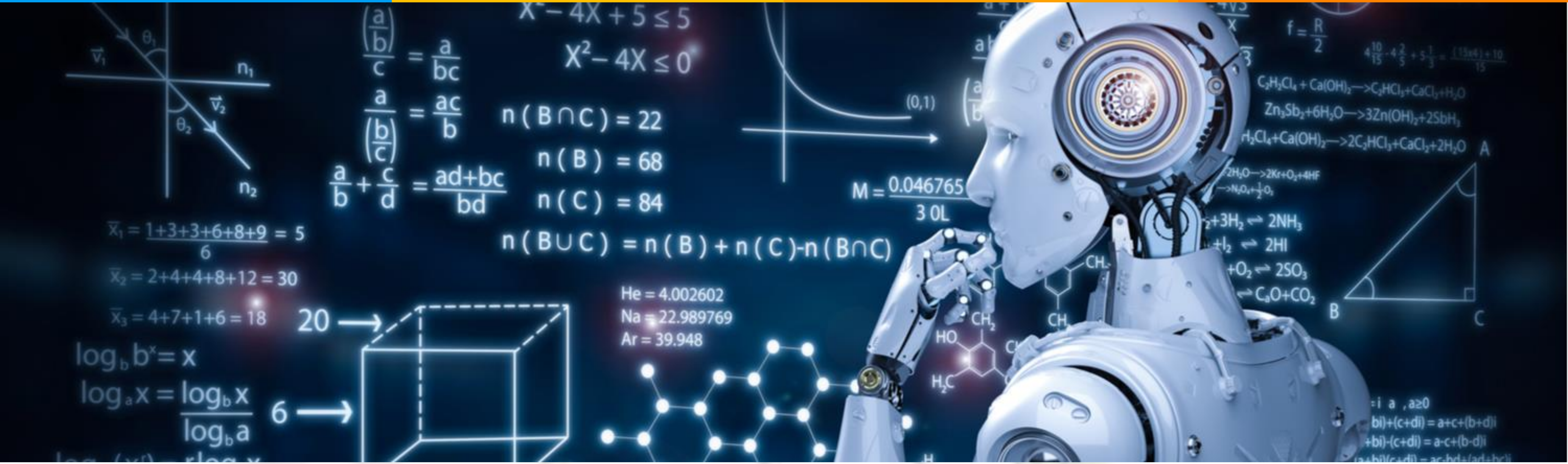
- Compare & Contrast
  - Traditional programming with machine learning
  - How ML scales by learning the pattern
- Brief history of AI from ML perspective
- Compare & Contrast AI and ML
- Different types of Machine Learning

Machine Learning is like exam



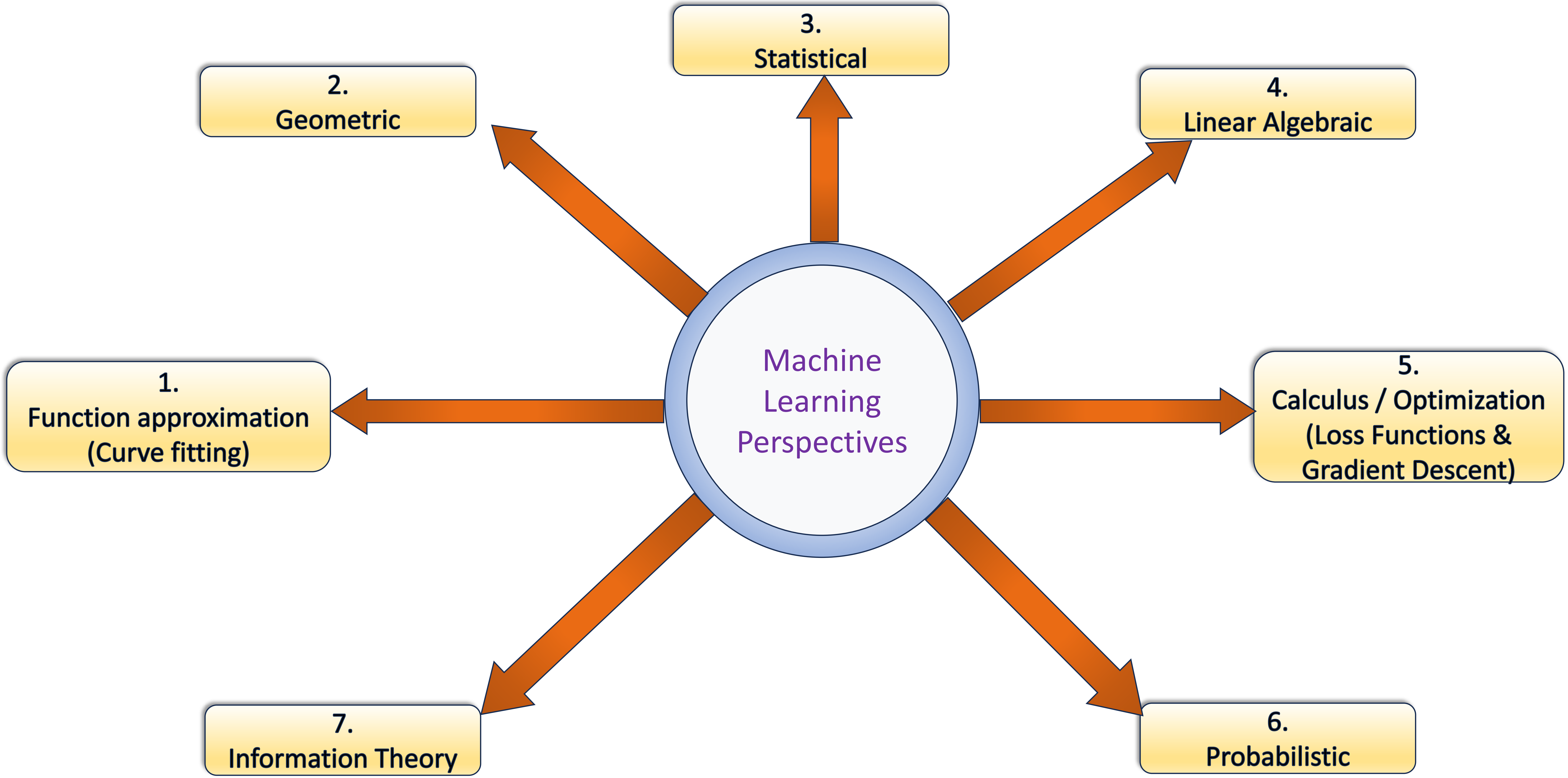
- Success is measured on
  - How one performs in test
  - Not how one practices

Duration: 60 min | Srikanth Shenoy | AML 5102 | M.E. AI & ML



Machine Learning Perspectives

ML perspectives



Purpose

- This overview lecture is mile wide and inch deep
- To provide a holistic perspective of ML landscape
- Reflect on this lecture & revisit at semester end
- To enable reading the menu but not to cook
- Understand intuitively WHAT, WHY, WHEN. Not HOW
- Certain ML problems are better envisioned in one way rather than another
- To understand and to convince others

1. Function Approximation (Curve Fitting) Perspective for regression

Analytical function

- Straight Line $y = 2x + 3$

Geogebra link: https://www.geogebra.org/calculator/bbauvftd

- What is independent & dependent variables here?
- What is the domain and co-domain?
- Mathematical Notation - $f : \mathbb{R} \to \mathbb{R}$
- Plane $z = 2x + y + 3$ $f : \mathbb{R}^2 \to \mathbb{R}$
- In ML, y is reserved for target variable
- Therefore we write $y = 2x_1 + x_2 + 3$

Geogebra link: https://www.geogebra.org/calculator/nsvgpmgz

- Line, Plane, Hyperplane – How do we generalize

Going in the reverse direction is Machine learning

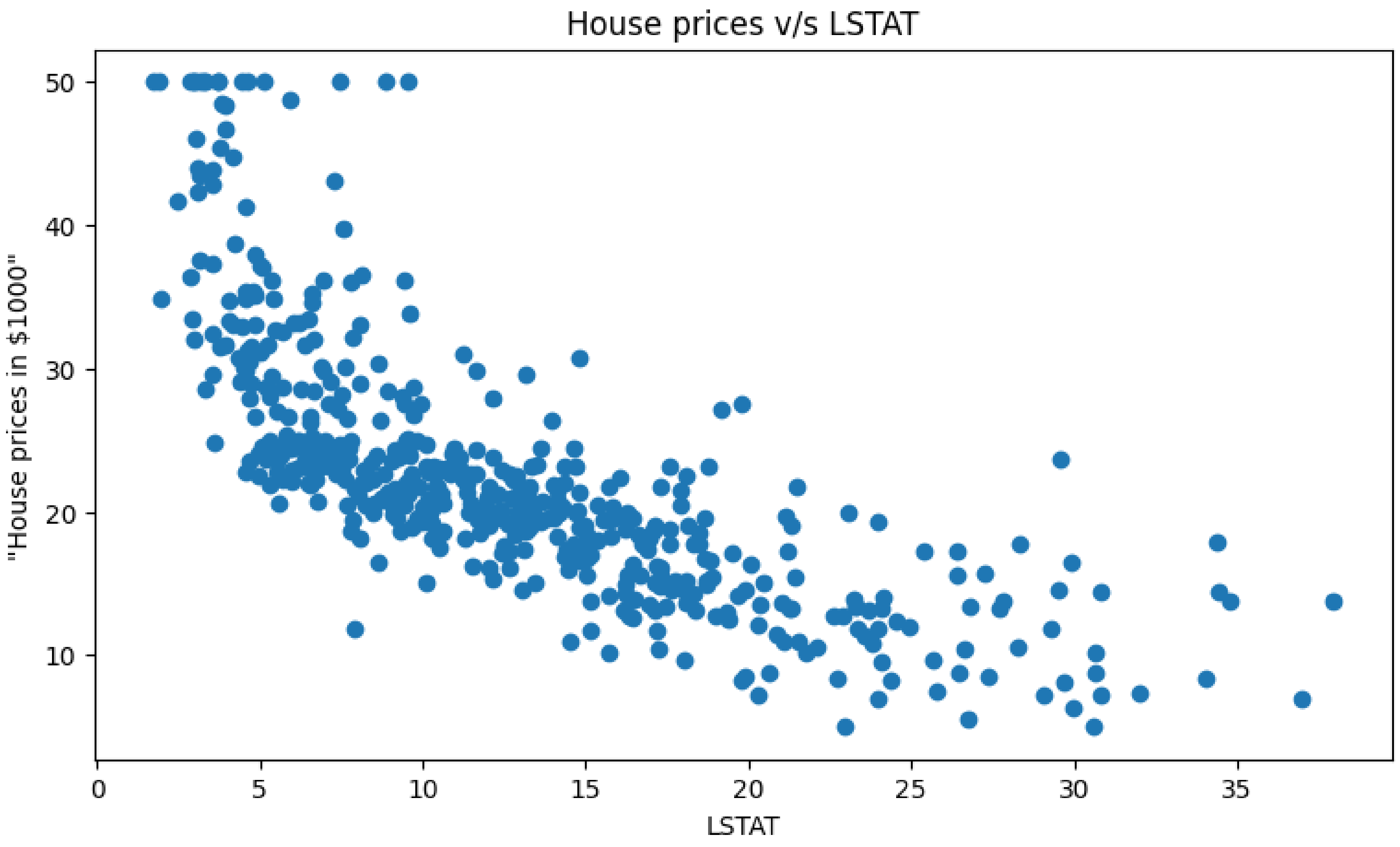
- Given data, deduce the function
- Boston dataset – Record as row, Feature as column

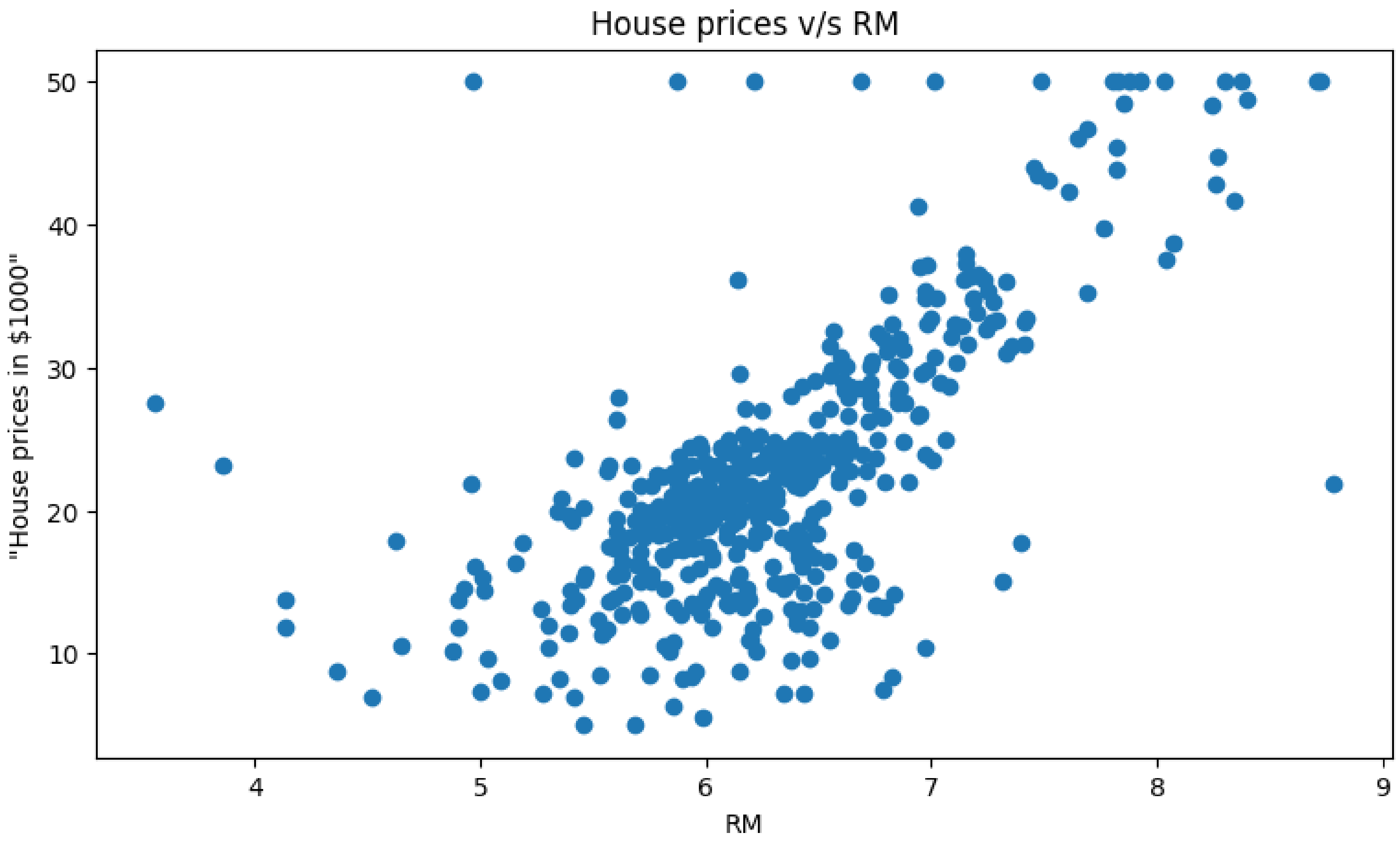
	CRIM	AGE	RM	LSTAT	PRICE
0	0.00632	65.2	6.575	4.98	24.0
1	0.02731	78.9	6.421	9.14	21.6
2	0.02729	61.1	7.185	4.03	34.7
3	0.03237	45.8	6.998	2.94	33.4
4	0.06905	54.2	7.147	5.33	36.2

- What is x and y here? (or rather X and y)
- What are alternate names for X and y?

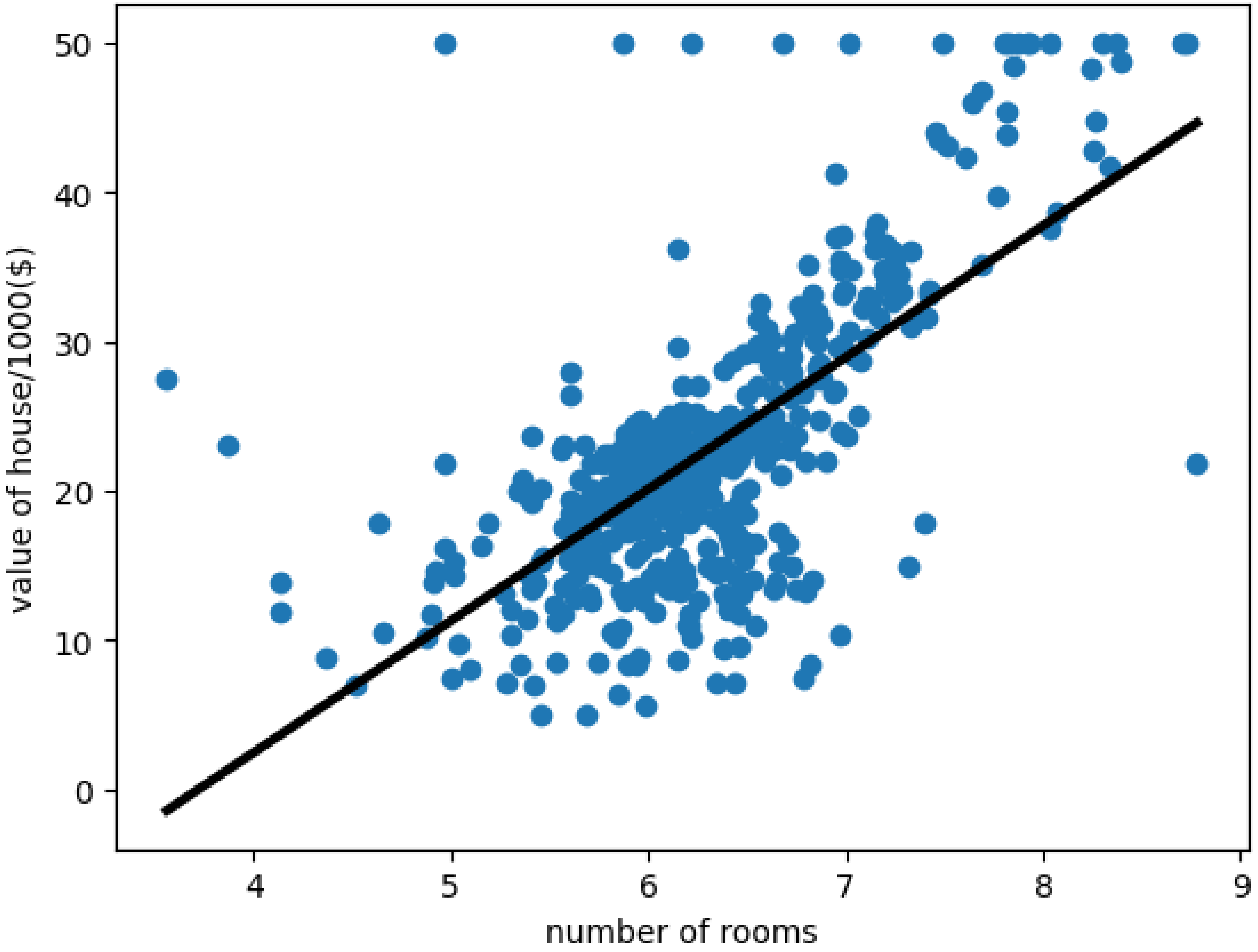
Plotting x and y

- Let us take one variable at a time





Fitting a line



- How is the line chosen?

Analytical function

- 2D - Line $y = 2x + 3$ $f : \mathbb{R} \to \mathbb{R}$
- 3D - Plane $y = 2x_1 + x_2 + 3$ $f : \mathbb{R}^2 \to \mathbb{R}$
- >= 4D Hyperplane
- How do we generalize?

Predicted function (hypothesis function)

$$y = 2x_1 + x_2 + 3 \qquad f : \mathbb{R}^2 \to \mathbb{R}$$

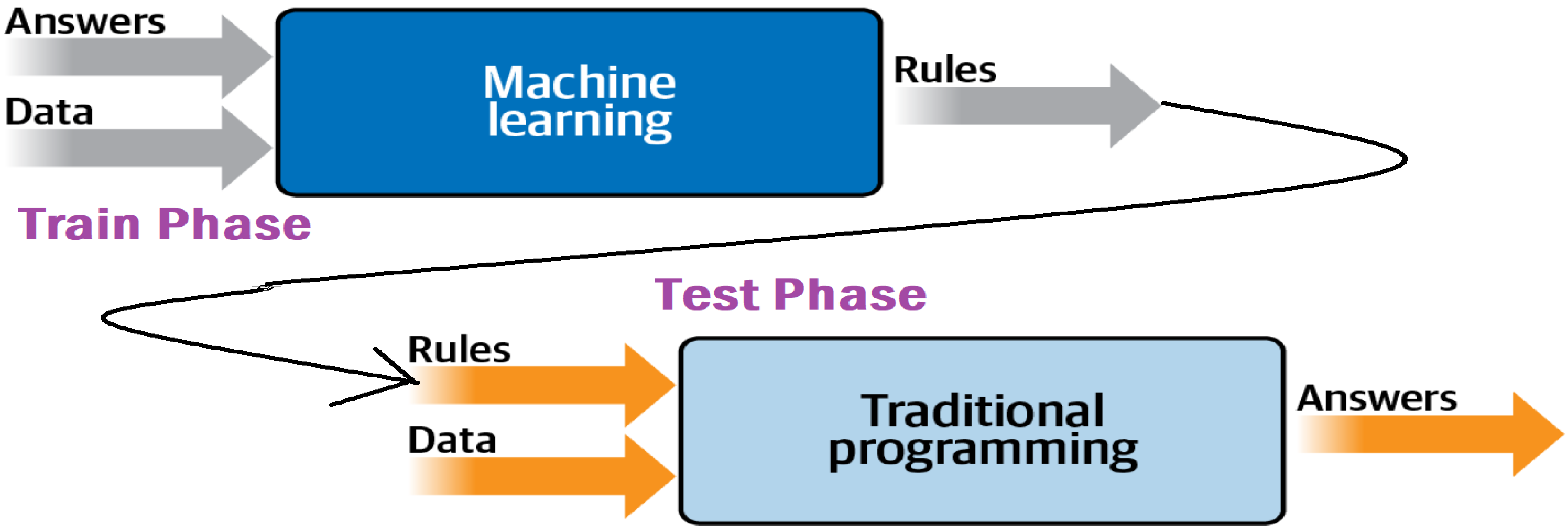
$$w = \underbrace{\begin{bmatrix} 2 \\ 1 \end{bmatrix}}_{Coefficients/Weights\ vector}$$

$$x = \underbrace{\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}}_{Features\ vector}$$

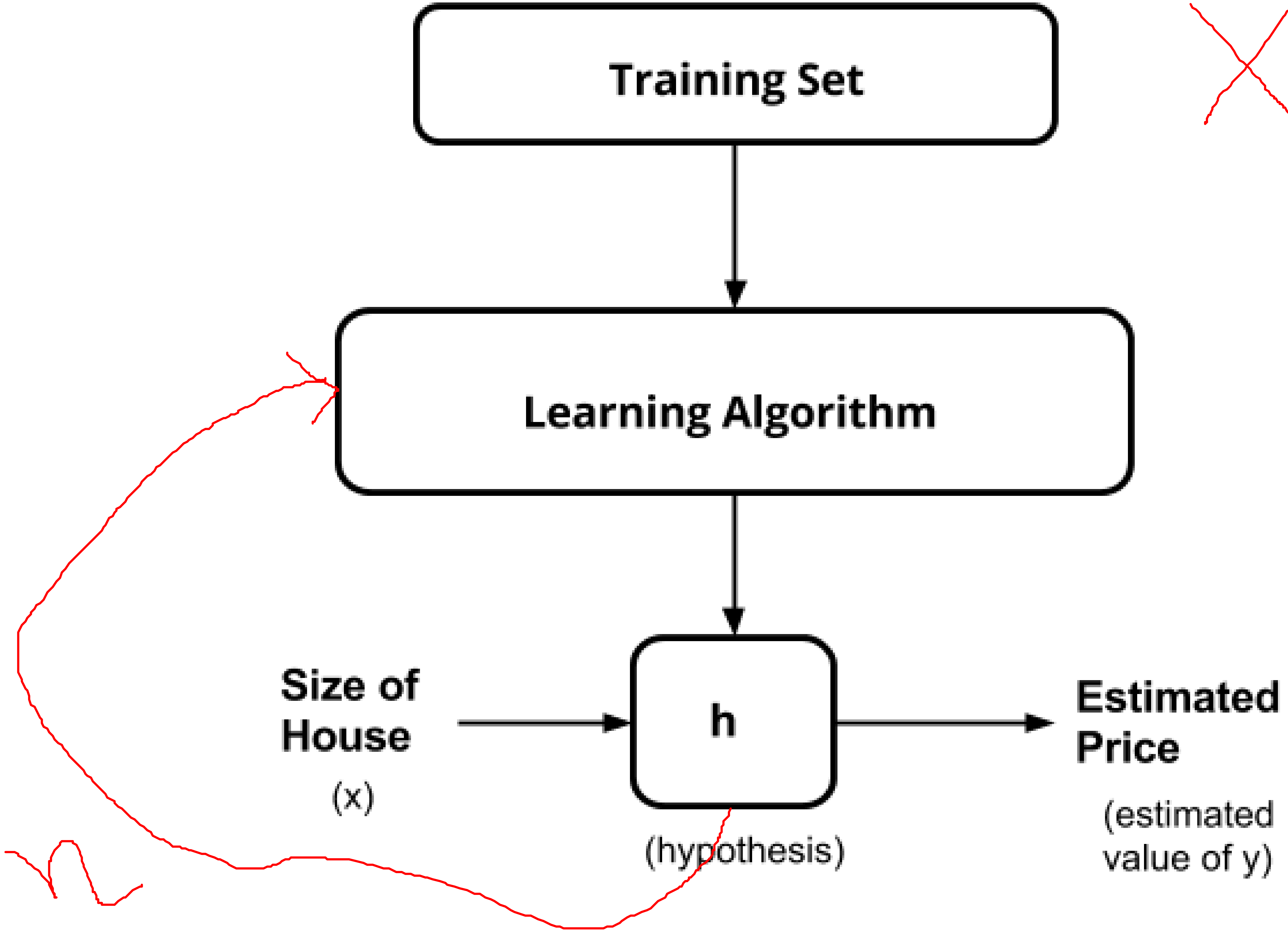
$$w^T x = \begin{bmatrix} 2 \\ 1 \end{bmatrix}^T \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$y = w^T x + b$$

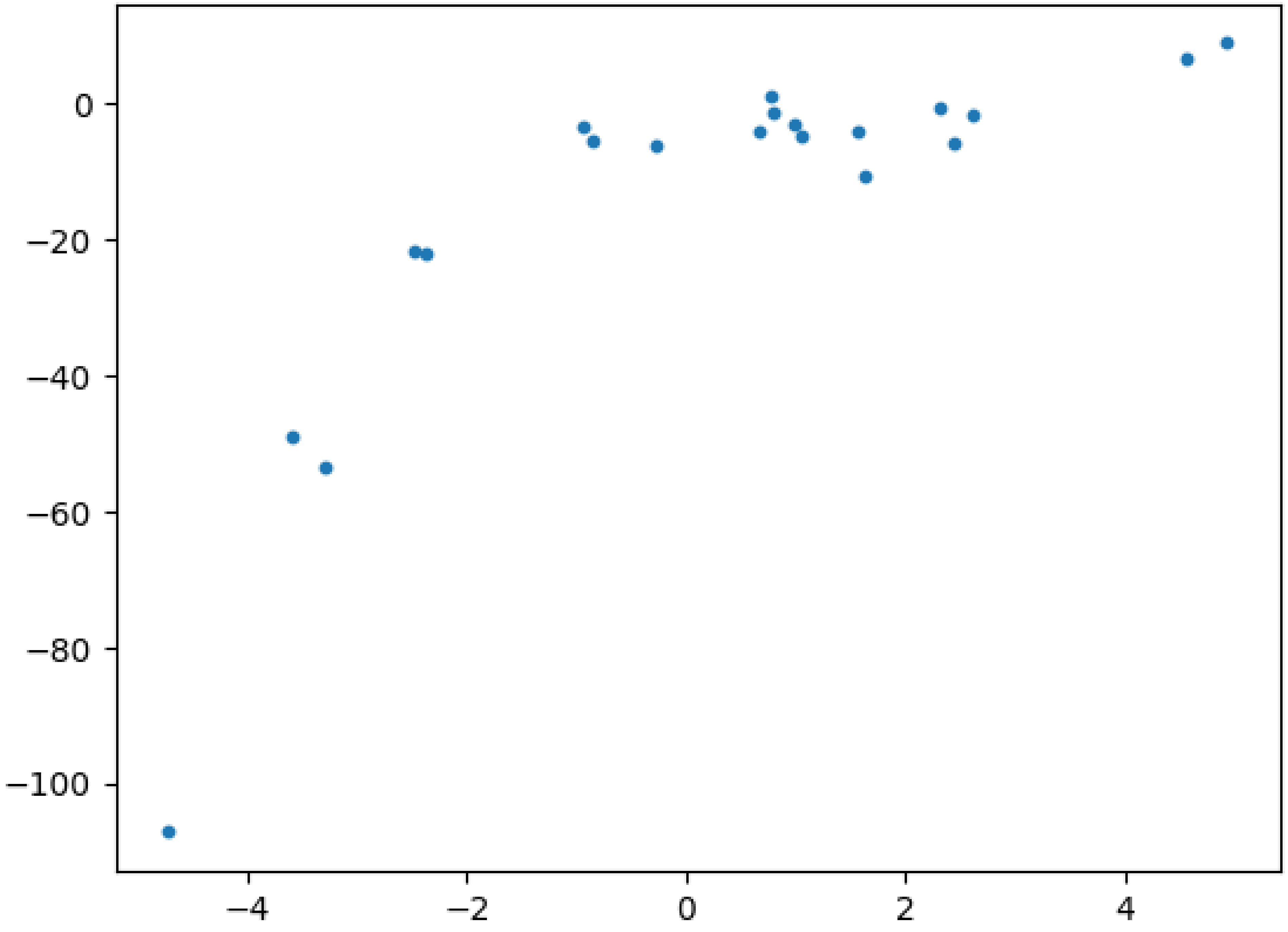
One last look

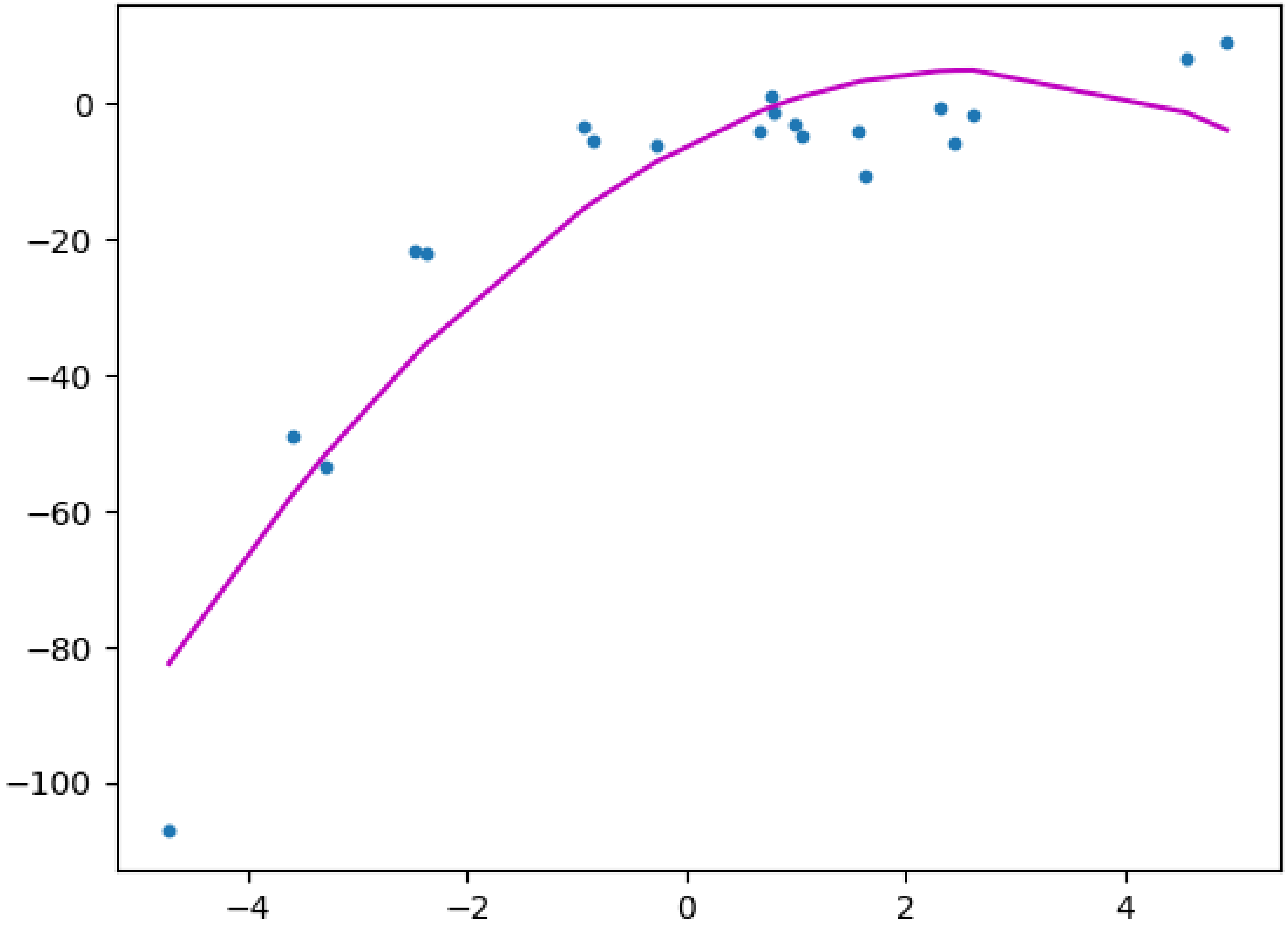


Learning algorithm & hypothesis function

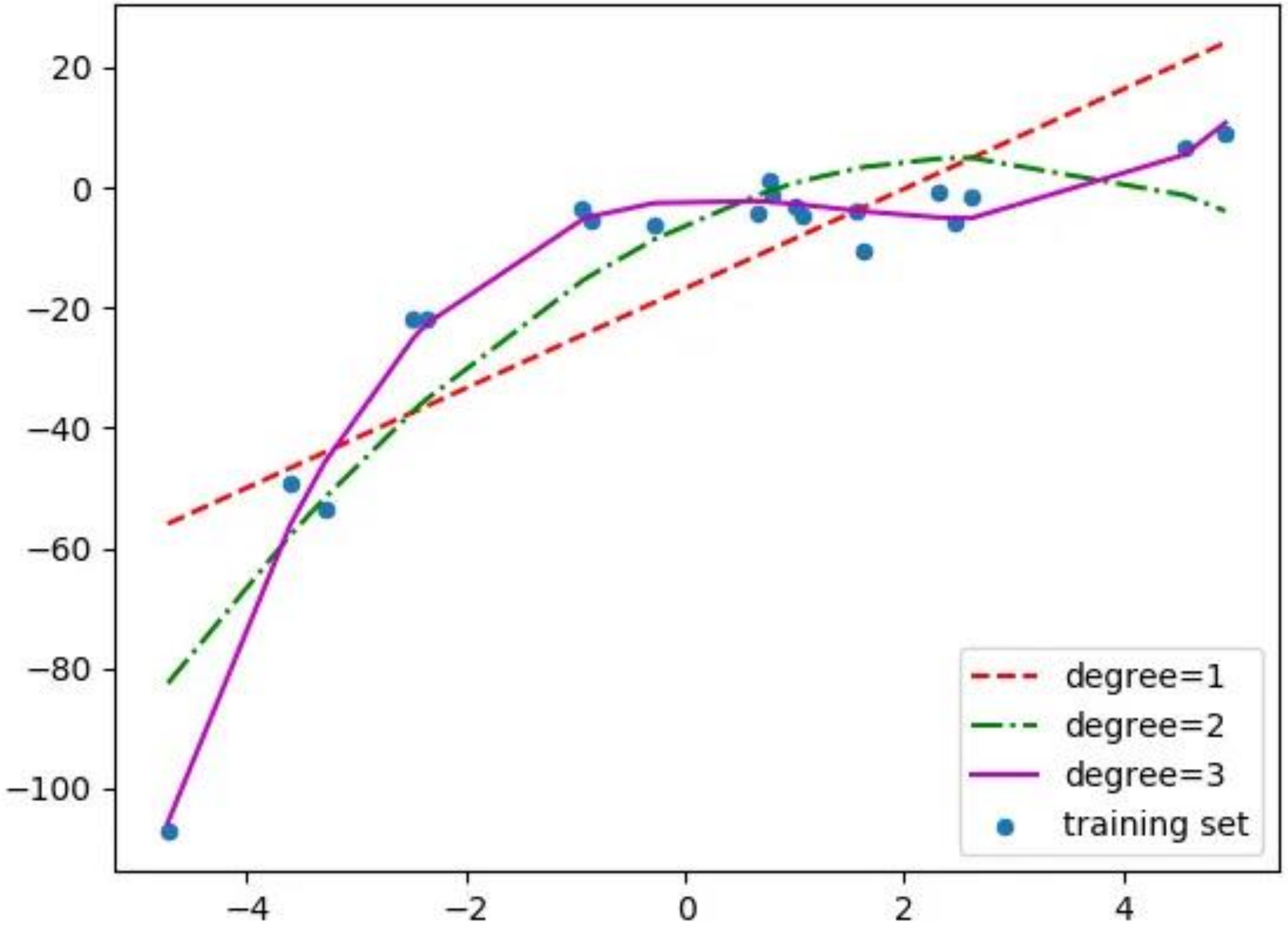


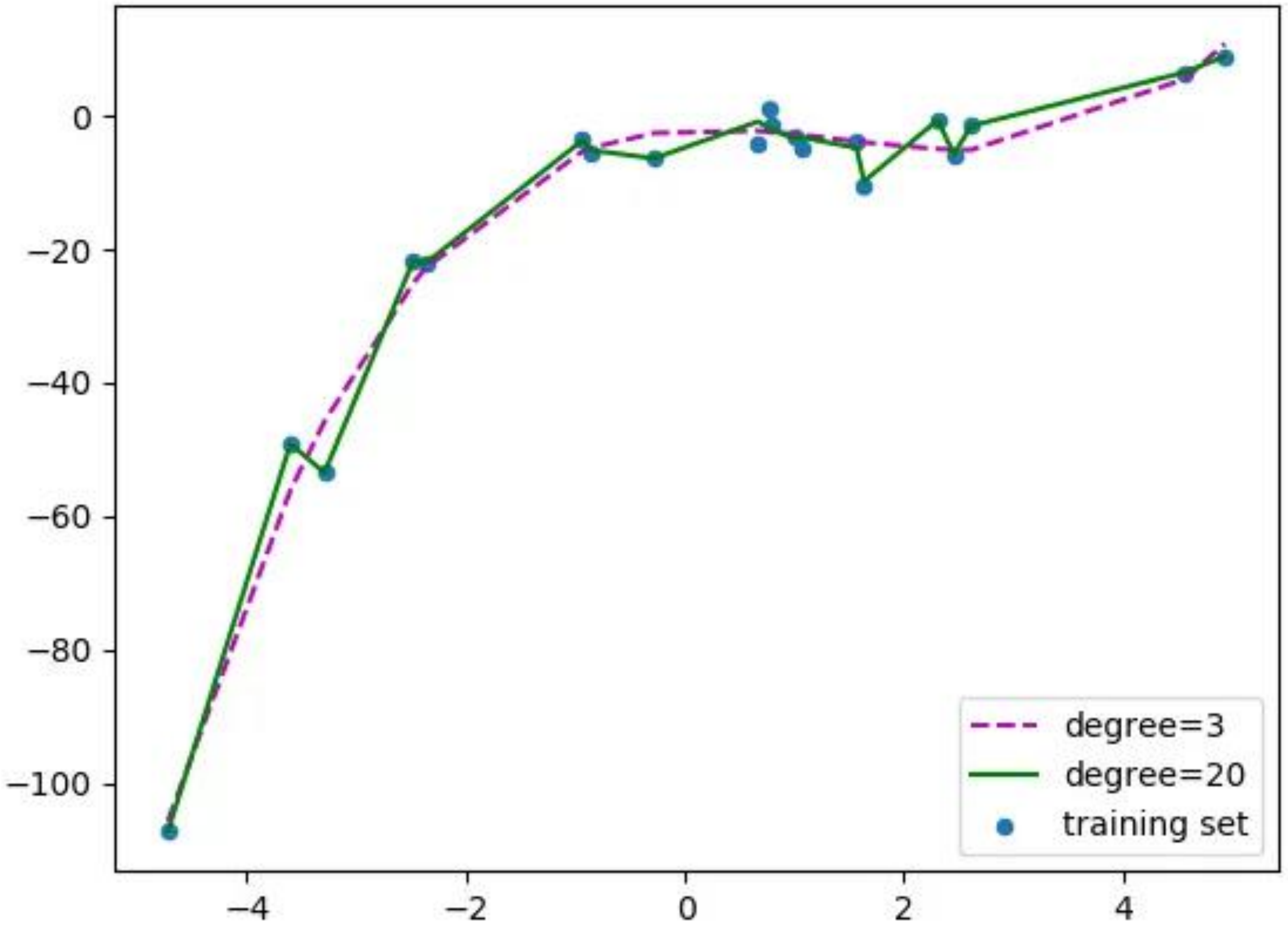
Fitting a curve



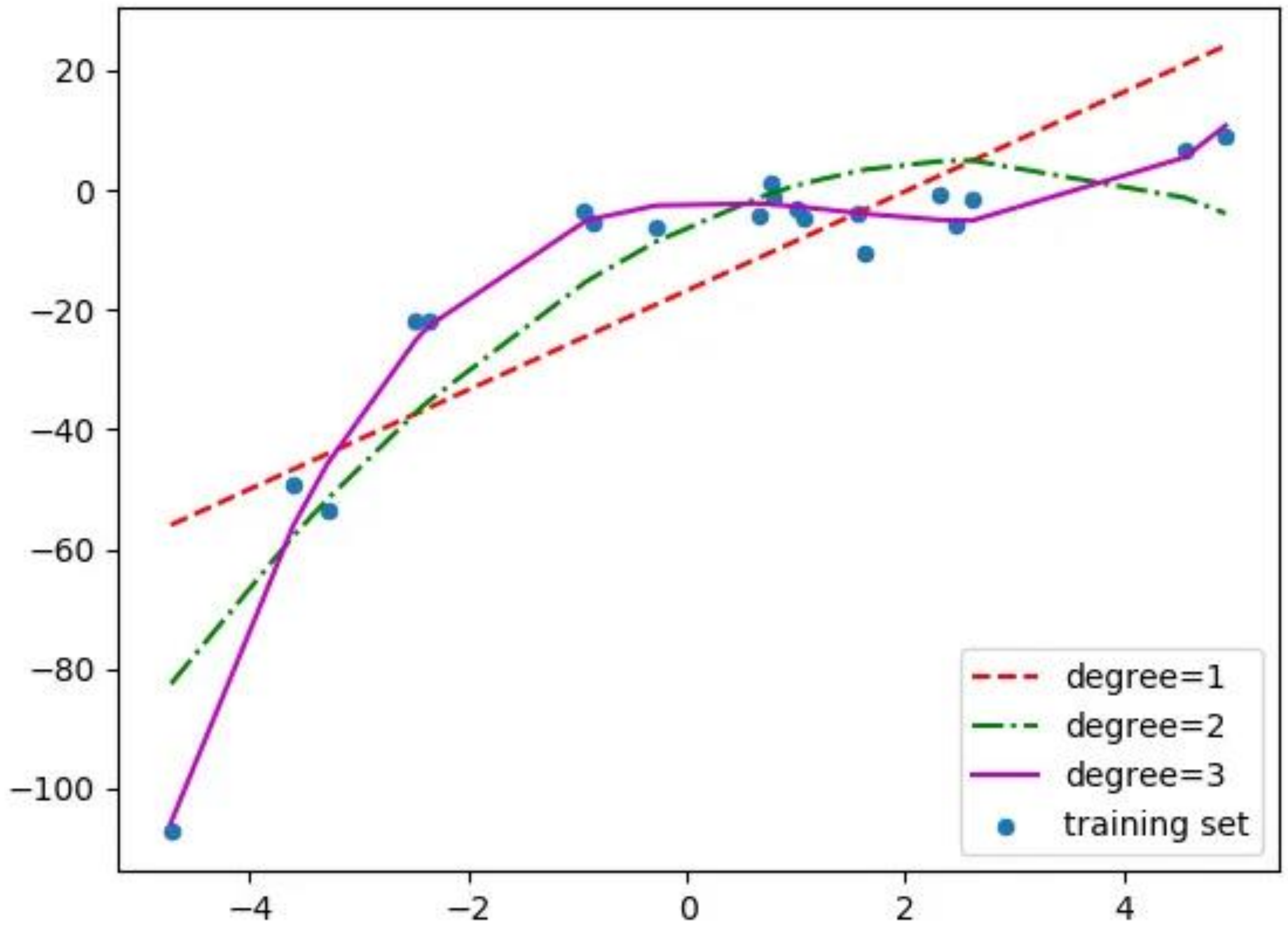


How many degrees is good?





Polynomial Regression

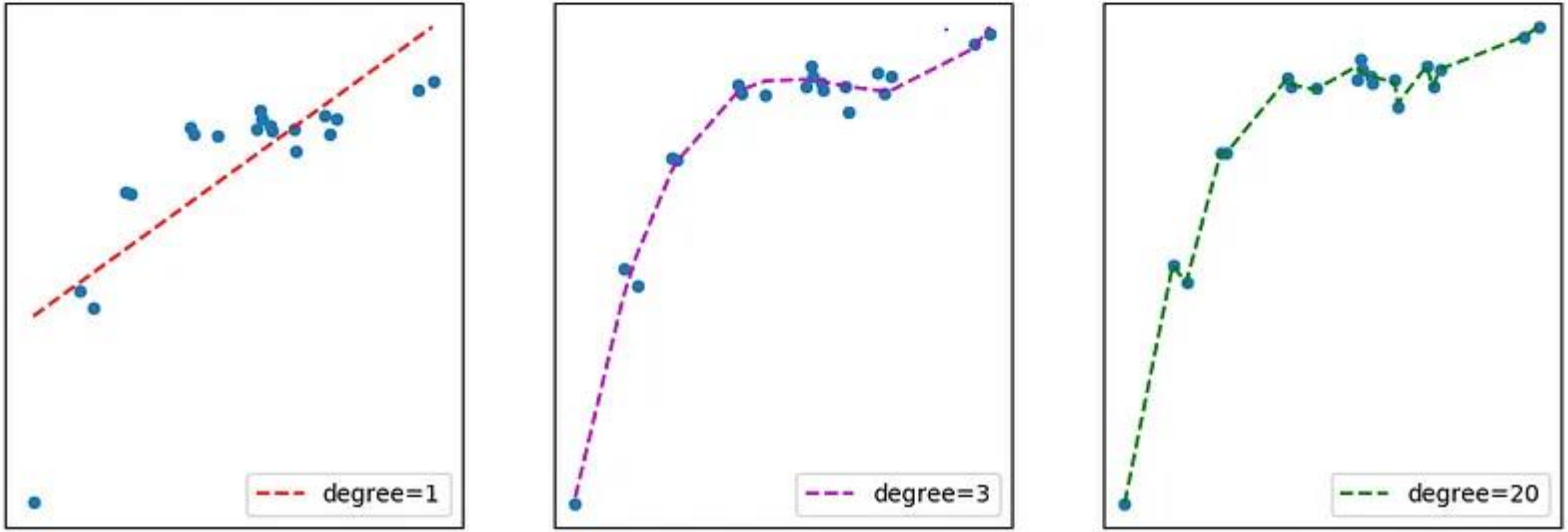


$$y = \mathbf{w}^T \mathbf{x} + b$$

$$y = w_1 x + w_2 x^2 + w_3 x^3 + b$$

$$y = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}^T \underbrace{\begin{bmatrix} x \\ x^2 \\ x^3 \end{bmatrix}}_{Features} + b$$

Underfitting & overfitting



Underfit
High Bias
Low Variance

Correct Fit
Low Bias
Low Variance

Overfit
Low Bias
High Variance

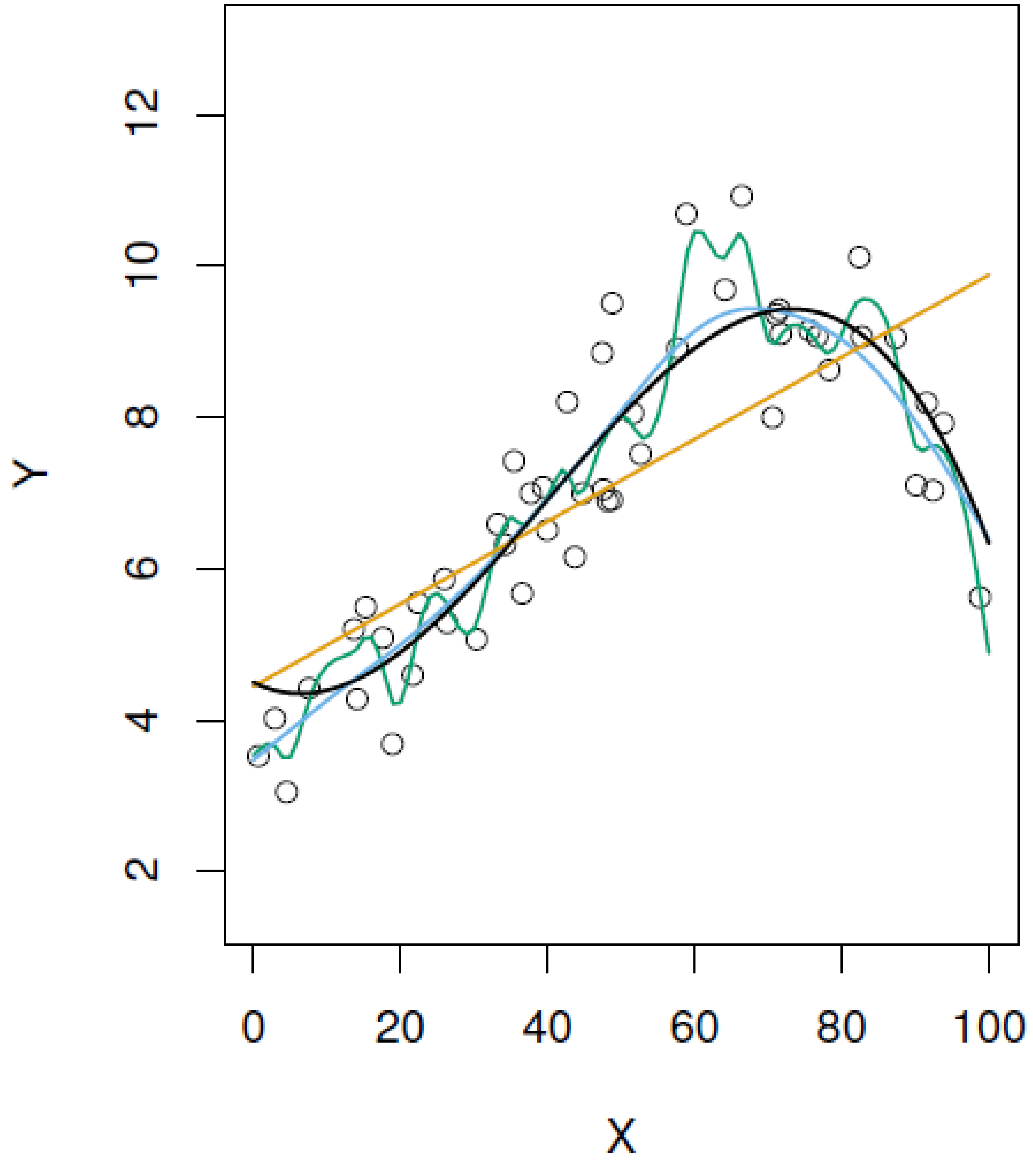
Learning pattern v/s noise

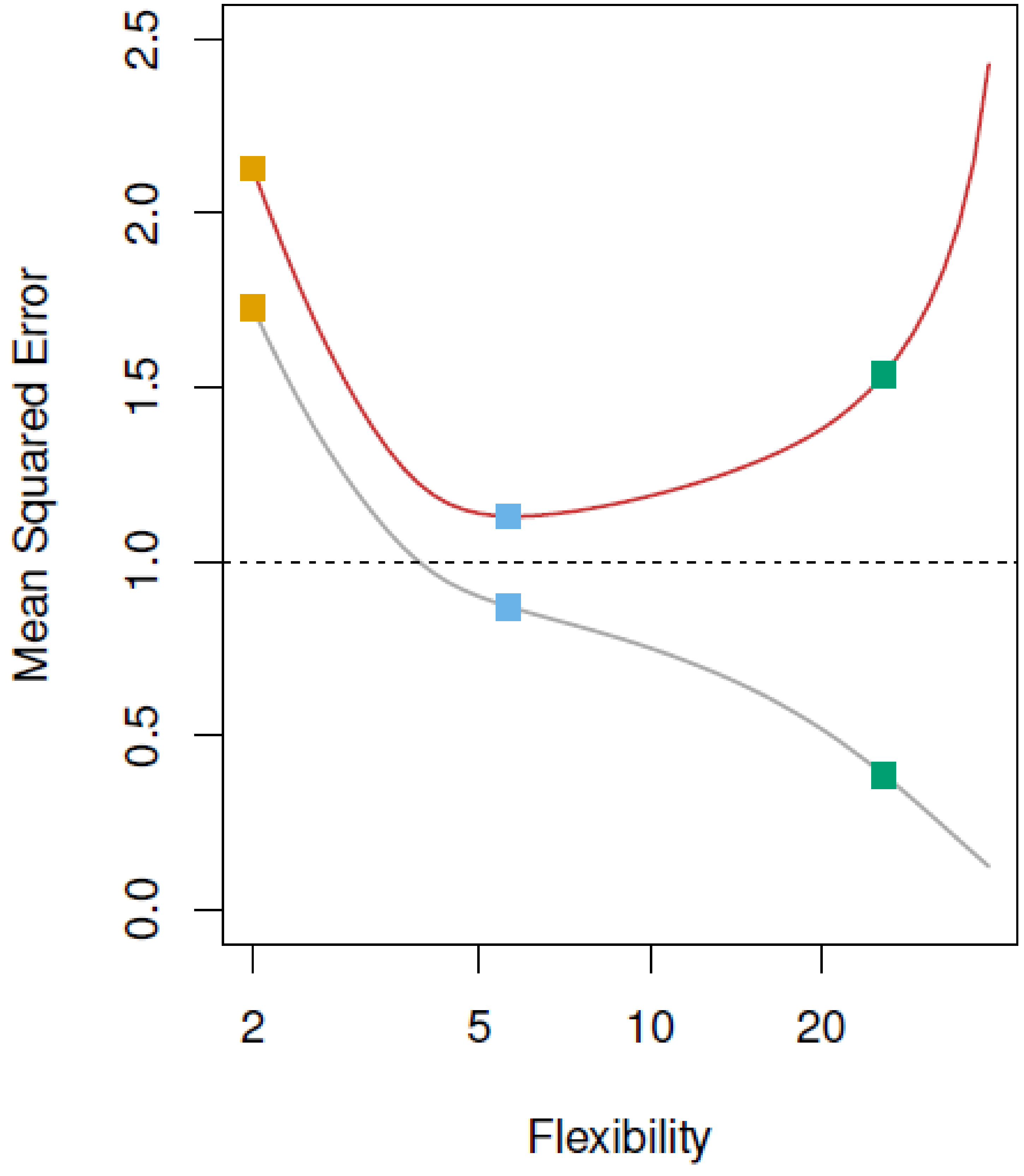
- Overfitting likely tends to learn from noise
- Happiness Index

Country	Per Capita Income	Happiness Index
Finland	25.0	7.82
Denmark	25.0	7.64
Iceland	24.0	7.56
Switzerland	27.0	7.51
Netherlands	22.0	7.42
Luxembourg	22.0	7.40
Sweden	21.0	7.38
Norway	21.0	7.37
Israel	20.0	7.36
Newzealand	20.0	7.20

Country	Per Capita Income	Happiness Index
Somaliland	5.1	3.75
Tanzania	5.0	3.70
Zimbabwwe	4.0	3.00

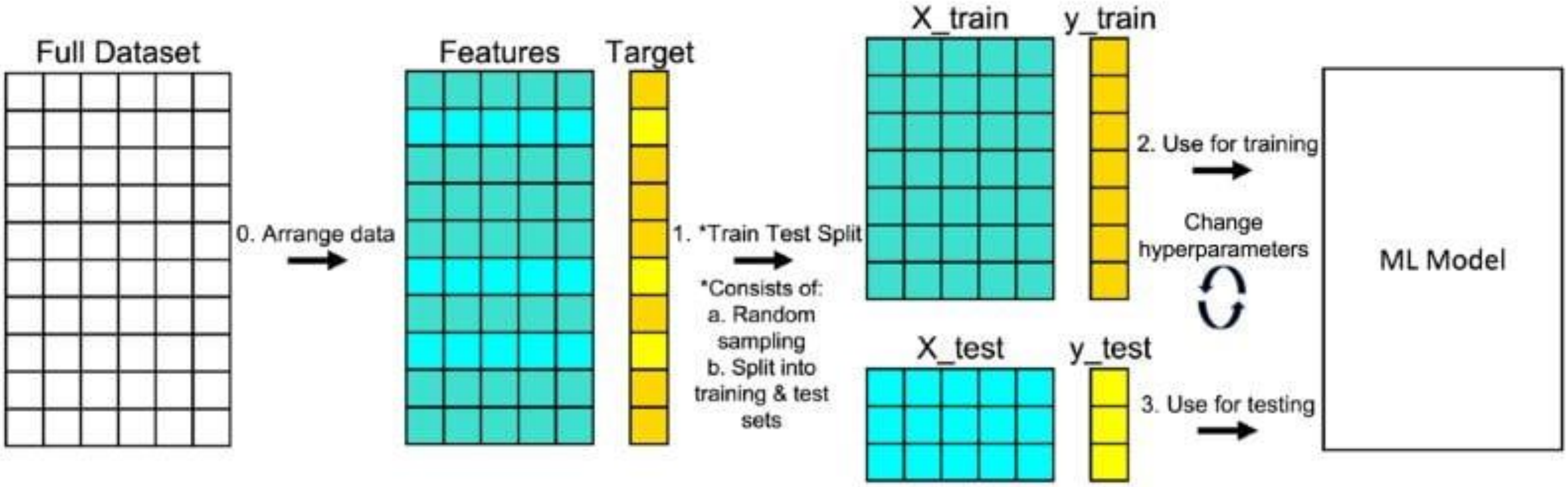
Bias Variance Trade-off





Train Test Split

- Recall: ML is like exam performance



Recap

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- How many dimensional data here?
- Is this a regression or classification problem?

Takeaways

- Curve fitting is logical way of looking at regression problems
- Line, plane & hyperplane - one form $y = w^T x + b$
- Learning algorithm & hypothesis function
- How many degrees is just right
- Underfitting, Overfitting and just right fit
- Bias Variance Tradeoff
- Overfitting discovered by Cross validation and error increasing beyond a point
- Overfitting learns noise


QUESTIONS

Literature Survey