Mathematical Methods for Machine Learning
Phương Pháp Toán Cho Học Máy

Nguyễn Quản Bá Hồng

UMT, HCMC – University of Management & Technology, Ho Chi Minh City

Ngày 5 tháng 2 năm 2025

Table of Contents

Resources

[Tie20] Vũ Hữu Tiệp. *Machine Learning Cơ Bản*.

[DFO23] Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong. *Mathematics for Machine Learning*. 2023.

Audiences & Goals

Target Audience. Mainly: Engineering- & CS undergraduate students. Note: Mathematics undergraduate students, especially academic-oriented (researchers), need much more rigorously theoretical mathematical foundations for ML.

Goal/Objective

Learn enough mathematics to be able to balance our comprehension in both mathematical- & technical (engineering) aspects of Machine Learning: Adjust "suitable" coefficients $\alpha, \beta, \gamma \in (0, 1)$ s.t. $\alpha + \beta + \gamma = 1$ &

$$\boxed{\text{Maximize } \mathrm{Goal}(\mathrm{What}, \mathrm{How}, \mathrm{Why}) := \alpha\mathrm{What} + \beta\mathrm{How} + \gamma\mathrm{Why}.} \quad (1)$$

where the functional $\mathrm{Goal}(\mathrm{What}, \mathrm{How}, \mathrm{Why})$ depends on your target job(s) & purpose(s).

Audiences & Goals

Distinguish 2 different perspectives/orientations for a CS student: Engineering-oriented & Mathematics-oriented.

Engineering perspective

Engineers need to learn various What (definitions, tools) & mainly focus on How (technicalities, tools), "practical Why" & a little bit on "theoretical Why".

E.g.: *Why/How does this algorithm/model work? Why/How does(n't) my code work?*

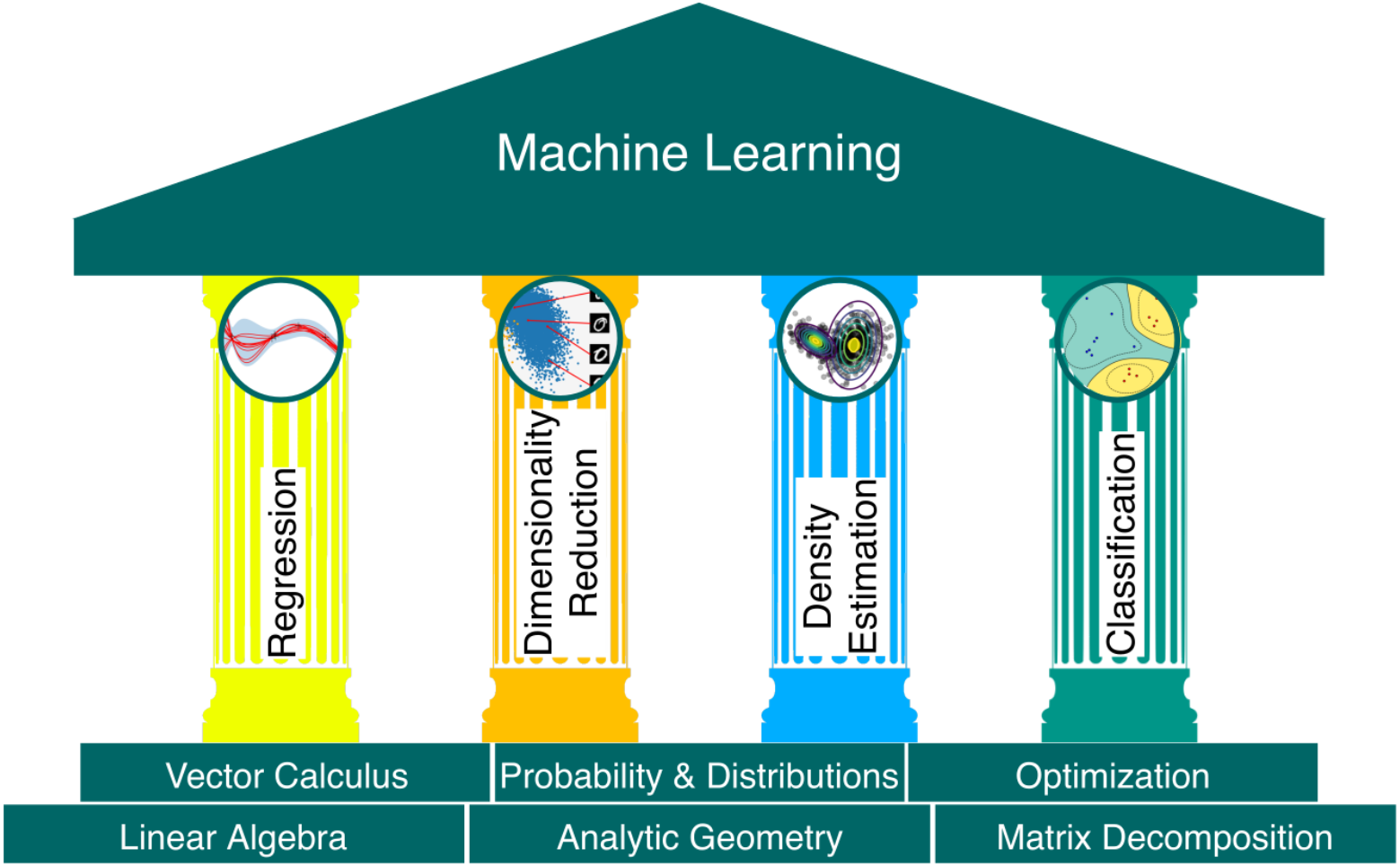
Mathematics perspective

Mathematicians have to learn & build various What (definitions, concepts), mainly focus on "theoretical Why" (logic, rigorous proof), then on How (mathematical tools)

E.g.: *Why/How is this model "optimal" in mathematical sense?*

UMT

Prerequisites



Hình: Foundations & 4 pillars of ML. Source: [DFO23, Fig. 1.1, p. 14].

Prerequisites

Linear Algebra

Probability

Statistics

Linear Regression – Hồi Quy Tuyến Tính

[Tie20] Vũ Hữu Tiệp. *Machine Learning Cơ Bản*. Chap. 7: *Hồi Quy Tuyến Tính*.

Intuition.

- Hồi quy tuyến tính là 1 thuật toán hồi quy mà đầu ra là 1 hàm số tuyến tính của đầu vào:

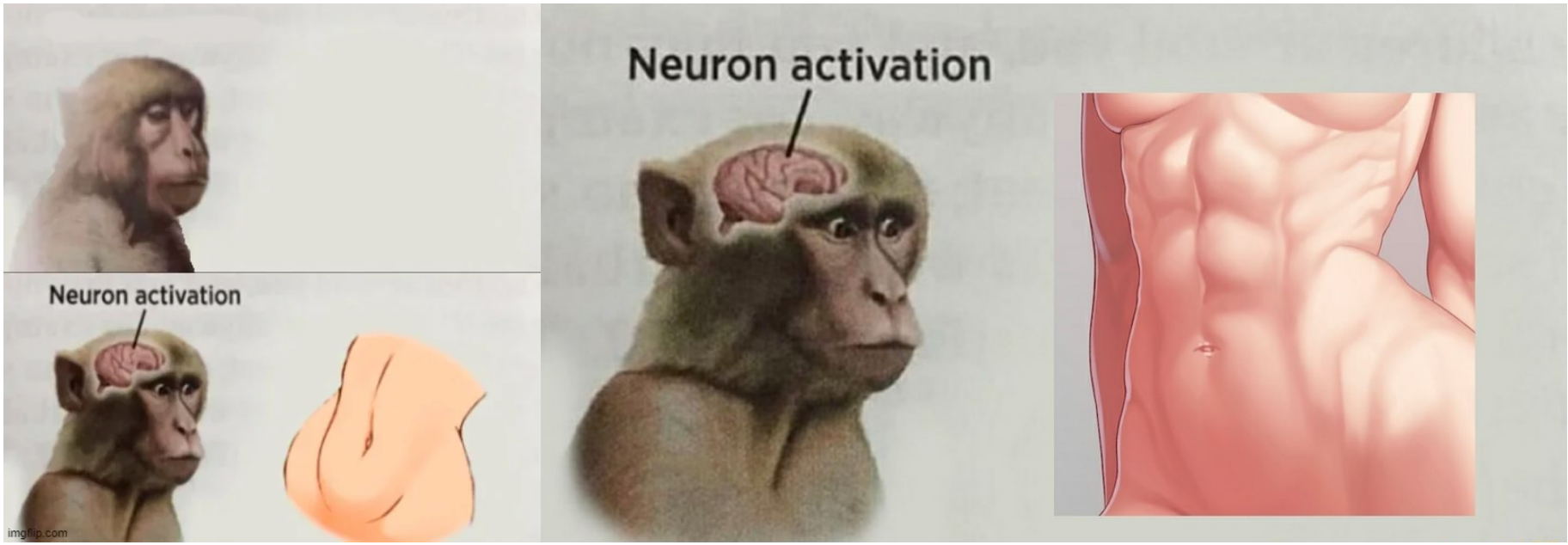
$$\text{Outputs} = \texttt{linear\_function}(\text{Inputs}).$$

$$y \approx \hat{y} = f(\mathrm{x}) = \sum_{i=1}^{N} w_i x_i = \mathrm{x}^\top \mathrm{w}.$$

- Thuật toán đơn giản nhất trong nhóm các thuật toán học có giám sát (simplest algorithm in supervised learning ones).

Artificial Neural Networks (ANNs)

Distinguish: ANN vs. BNN.
Activation function $\sigma(\cdot)$



Hình: A typical monkey's (maybe man also) biological neural networks (BNN) gets activated by 2D/anime girl's strong abs.