# Mathematical Machine Learning

Yahya Saleh, Tizian Wenzel, Kamal Sharma

March 7, 2024

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# Introduction

Underlying the success of artificial intelligence are learning algorithms, i.e., algorithms that learn from data to perform a certain task. We start this book by two concrete examples of supervised learning algorithms. In the first example we consider the problem of approximating functions from pointwise evaluations using linear regression. In the second example we look at the task of classifying hand-written digits. In these two examples we identify and familiarize ourselves with the main components of learning algorithms; *datasets*, *a hypothesis class*, and *optimization algorithms*. We further identify important aspects of supervised learning algorithms, such as overfitting, and underfitting. Finally, we motivate in these two examples problems at the forefront of research in mathematical machine learning, namely *the curse of dimensionality (CoD)* and double/multiple descent phenomenon.

## I.1  Examples of supervised learning

[1] Approximating smooth functions from point evaluations
   Classifying hand-written digits.

### I.1.1  Curse of Dimensionality

### I.1.2  Underfitting, overfitting, or just right?

## I.2  A formal definition of learning

## Wait! What is what?

Here is a list of questions that help you check your understanding of key concepts inside this chapter?

# Empirical Risk Minimization Principles

# Machine Learning Models

**III.1  Neural Networks**

**III.2  Kernel Methods**

# Modern Machine Learning

# Modern Mathematical Machine Learning

# Bibliography

[1]  Y. Saleh, V. Sanjay, A. Iske, A. Yachmenev, and J. Küpper, "Active learning of potential-energy surfaces of weakly bound complexes with regression-tree ensembles", **155** (2021), 144109, arXiv: 2104.00708 [physics].