JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Algorithms for Data Science

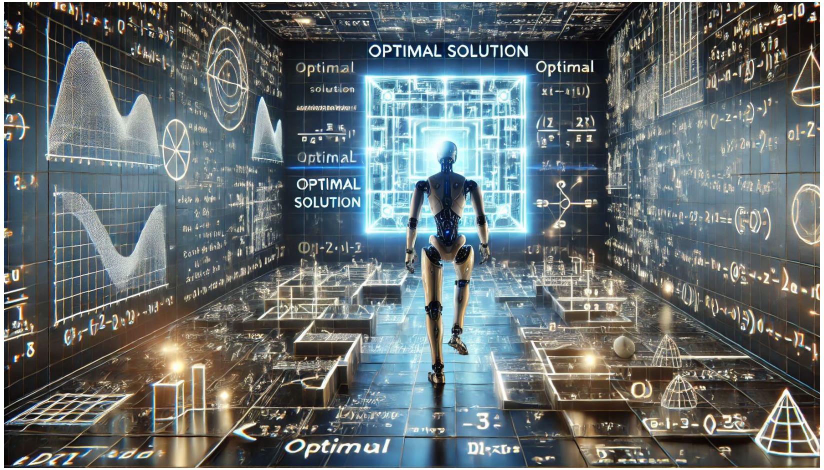
Optimization: Introduction

Module Learning Objectives

1. Apply methods to solve problems where both the objective function and the constraints are linear.
2. Analyze optimization problems where the objective function or constraints are nonlinear, and implement appropriate solution techniques.
3. Implement optimization solutions for problems with quadratic objectives.
4. Design solutions for problems requiring a sequence of decisions over time by optimizing cumulative outcomes and addressing temporal components.
5. Evaluate strategies for finding feasible solutions within a reasonable timeframe, particularly in large-scale or complex problems.
6. Apply advanced algorithms to solve highly complex or large-scale optimization problems where traditional methods are inefficient.
7. Formulate multiple types of optimization problems to address real-world scenarios effectively.

What is Optimization?

Optimization is the process of finding the best solution from a set of feasible solutions.



Selecting the "best" solution often involves maximizing or minimizing an objective function.

Type of Optimization Problems

Continuous vs. Discrete	Constrained vs. Unconstrained	Linear vs. Nonlinear
▪ Continuous variables take any value within a range. ▪ Discrete variables are restricted to discrete values.	▪ Constrained optimization is subject to restrictions. ▪ Unconstrained optimization has no restrictions on solution space.	▪ Linear objective functions and constraints. ▪ Involve at least one nonlinear element.

Components of Optimization Problems

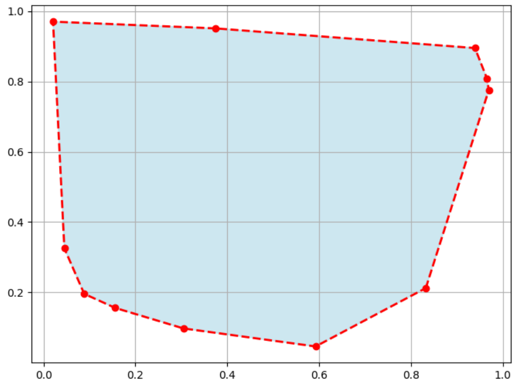
1. **Objective Function:**
   - Then function to maximized/minimized
2. **Constraints:**
   - Conditions that solutions must satisfy
3. **Feasible Region:**
   - The set of all points that satisfy the constraints
4. **Solution Quality:**
   1. Optimality
   2. Feasibility
   3. Robustness

$$\min f(x) = x^2 - 4x + 3$$

$$\text{s.t.}$$

$$x + y \leq 10$$

$$x, y \geq 0$$



Application of Optimization

Logistics

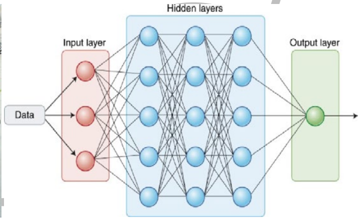
Minimize delivery costs and times.

Finance

Asset allocation to maximize return.

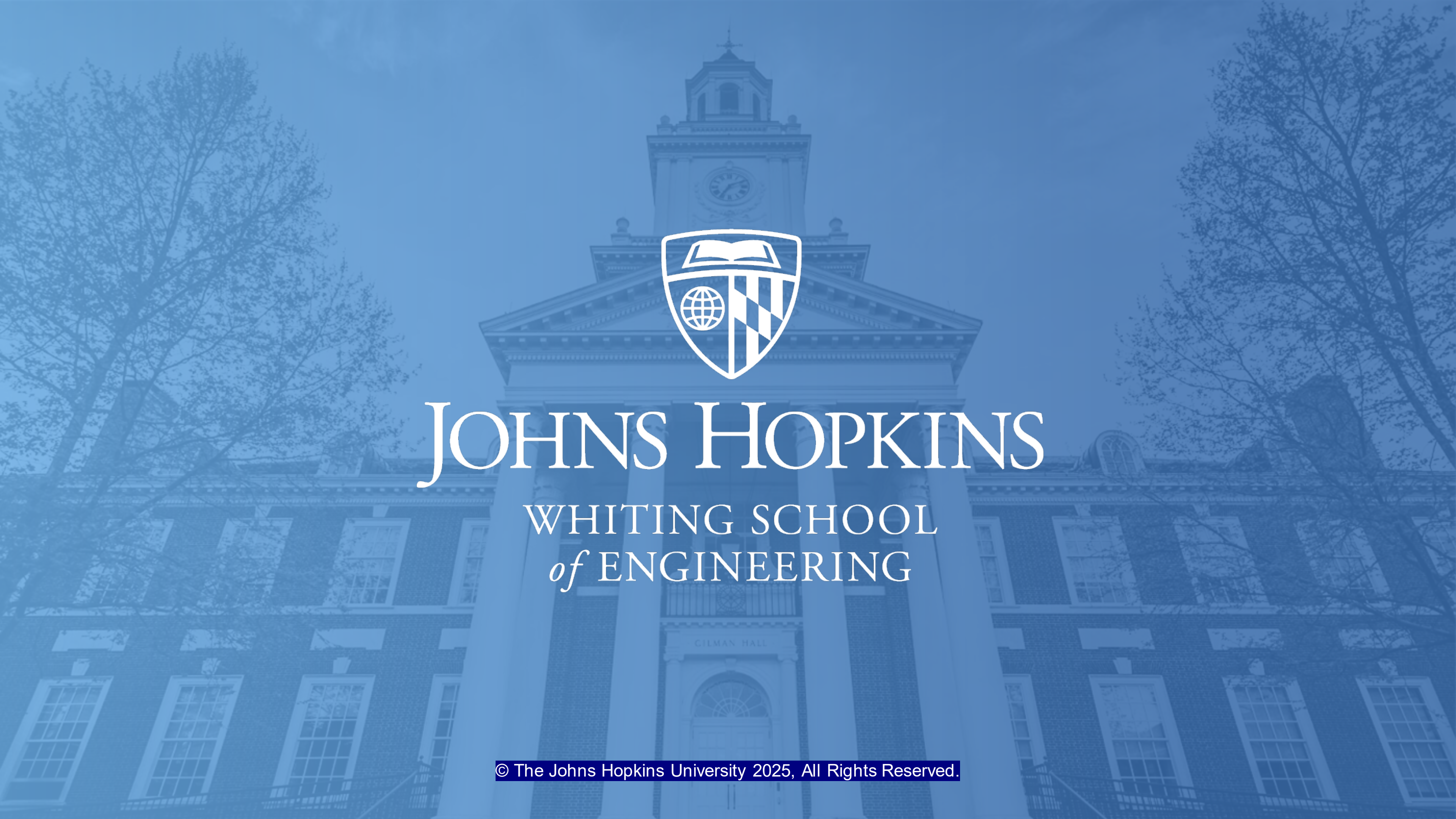
Healthcare

Optimize resource allocation in hospitals.



AI/ML

Minimize error in training models using gradient descent.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