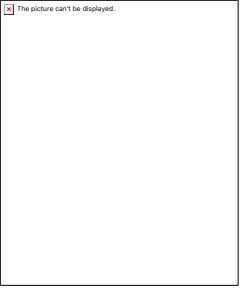

Optimisation
Lecture 1 Introduction

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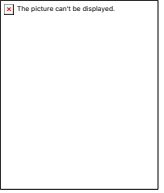
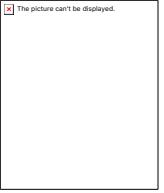


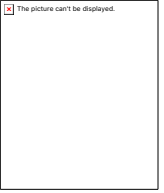
Outline

- What is optimisation?
- Why to study optimisation?
- What to study?
- How to study this module?
- Assessment
- Reading list



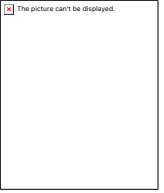
What is optimisation (UK)/optimization (US)?

- Meaning of Optimise on Cambridge Dictionary
  - To make something as good as possible.
- Mathematical Optimisation (Wikipedia)
  - is the selection of a best element (with regard to some criteria) from some set of available alternatives.
  - In the simplest case, an optimization problem consists of maximizing or minimizing a real function by systematically choosing input values from within an allowed set and computing the value of the function.



What is optimisation (UK)/optimization (US)?

- Four key elements
  - One function
  - Best input, from
  - Allowed set (conditions)
  - Maximum or minimum of the value of the function



What is optimisation (UK)/optimization (US)?

- Optimisation vocabularies
  - Function, which is normally called objective function, $f(x)$, is the output you are trying to maximise or minimise
  - Variables, x_1, x_2, x_3 and so on, which are the inputs – things you can control.
  - Constraints, which are equations that place limits on how big or small some variables can get.

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Min $f(x)$
subject to $g(x)$

minimise $f(x)$ subject to constraint $g(x)$

Max $f(x)$
subject to $g(x)$

maximise $f(x)$ subject to constraint $g(x)$

Optimisation Examples

- Optimisation for business and economics

(1) The revenue for a certain product is given by the equation

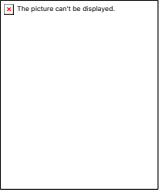
$$R(x) = 100 - \frac{400}{x+5} - x,$$

where *x* is the number of produced items. Find the value of *x* that results in maximum revenue.

(2) When a ship is sailing, the fuel cost is proportional to the square of its speed relative to water. Besides that, there are fixed costs, which do not depend on the speed and are equal to *p* ($/*hour*). At what speed the total cost per 1 mile will be the lowest?

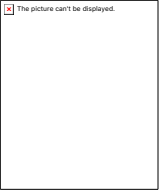
Optimisation Examples

- Investment
  - Portfolio Optimization - Allocate funds to stocks to minimize risk for a target rate of return
- Production
  - Process Selection - Decide which of several processes (with different speeds, costs, etc.) should be used to make a desired quantity of product in a certain amount of time, at minimum cost.
- Distribution
  - Transportation Model - Determine how many products to ship from each factory to each warehouse, or from each factory to each warehouse and direct to each end customer, to minimize shipping cost while meeting warehouse demands and not exceeding factory supplies



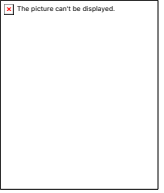
Optimisation Examples

- Purchasing
  - Media Planning - Decide how much advertising to purchase in different media to minimize total cost while achieving a target level of reach or frequency
- Human Resources
  - Workforce Composition: Decide how many employees to retrain, hire and fire to meet changing workforce composition requirements while minimizing costs or employee turnover
  - Workforce Movement: Decide how many troops to move from several camps to several other bases, to minimize movement time or total cost



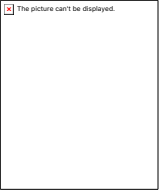
Optimisation Examples

- Airlines
  - Crew Scheduling: Given a flight schedule, aircraft assignments, and restrictions on duty periods, allocate crews most effectively to flights
  - Revenue Management: For different classes of tickets, determine how many seats to sell or hold back as flight date approaches
- Agriculture
  - Crop Planning: Given forecasted crop prices and growing conditions, determine how much of each crop to plant
- Electric Power
  - Generator Commitment: Given forecasted demand by period and operating cost for each generator, determine which generators should be run in each time interval
  - Electricity Trading: Maximize the value of electricity sales in an ongoing auction environment



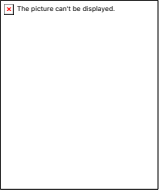
Optimisation Examples

- Networks
  - Travelling salesman problem: Given a list of cities and the distances between each pair of cities, what is the shortest possible route that visits each city and returns to the origin city?
  - Vehicle routing problem: What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?



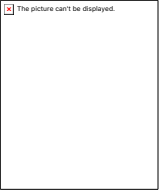
What to learn?

- Optimisation methods
  - Gradient method
  - Steepest descent method
  - Newton method
  - Conjugate direction method
  - Graphical optimisation
- Single variable and multi-variable optimisation



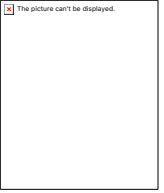
How to learn?

- Lecture
- Lab – Matlab and Simulink



How to assess the learning?

- Exam: 85%
- Lab: 15%



Reading list

- Edwin K.P. Chong and Stanislaw H. Zak, “An Introduction to Optimisation”, Wiley,
- Osmar Guler, “Foundations of Optimisation”, Springer,
- Singiresu S. Rao, “Engineering Optimisation”, fourth edition, Wiley, 2009

THANK YOU

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