
AI & Big Data에 꼭 필요한 최적화 기법 실습캠프

Fundamental Optimization Techniques Essential for Artificial Intelligence and Big Data Analytics

June 29th – July 1st
M T W 1:00 pm – 6:00 pm

We meet at Zoom!

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Acknowledgement



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SW 단기교육과정 개발사업비로 개최되었습니다.

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Optimization and Decision Making

Competitive edge and improved level of service

Better and **faster** data-driven decision-making

Data and algorithms to support complex business & policy decisions

Descriptive Analytics
(Data)

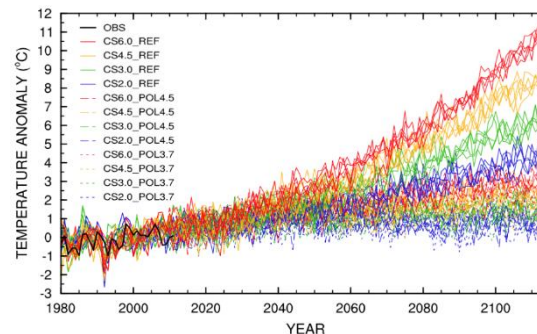
- ☐ Data management
- ☐ Data visualization

Predictive Analytics
(Insight)

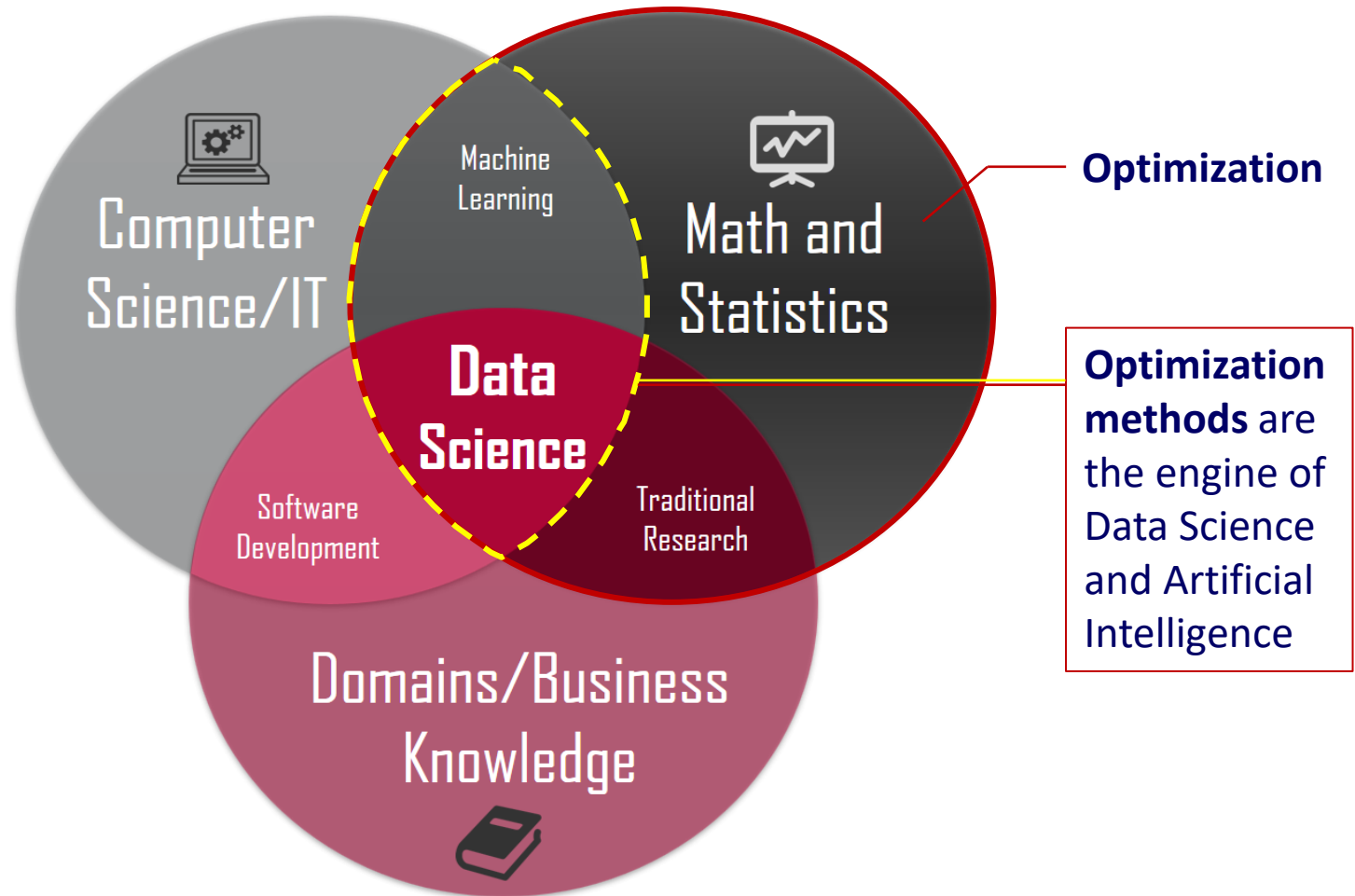
- ☐ Data mining
- ☐ Machine learning
- ☐ Forecasting

Prescriptive Analytics
(Decision)

- ☐ **Operations Research approach**
- ☐ **Optimization**
- ☐ **Simulation**



Role of Optimization in Data Science



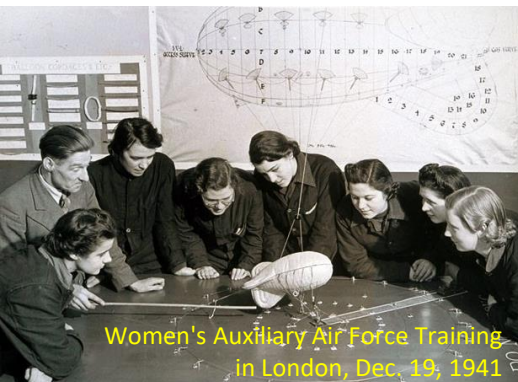
Source: Michael Barber (2018). "Data science concepts you need to know! Part 1". Towards Data Science. Available at <https://towardsdatascience.com/introduction-to-statistics-e9d72d818745>.

What is Operations Research?

- ❑ **Operations Research (OR)** is the scientific approach to execute decision making, which consists of:
 - The art of *mathematical modeling* of complex situations
 - The science of the development of *solution techniques* used to solve these models
 - The ability to effectively *communicate* the results to the decision maker

Origins of Operations Research

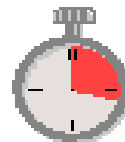
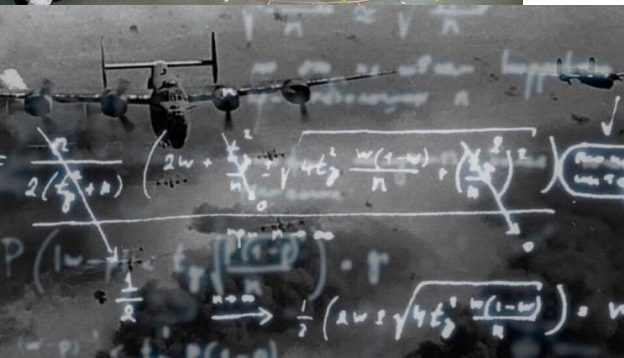
- ❑ Operations Research (OR) is a relatively new discipline.
- ❑ There is no clear history that marks the Birth of OR, but it is generally accepted that this field originated in England during the World War II.
- ❑ The World War II; Its object is to assist the finding of means to improve the war operations in progress or planned for the future.



Bomber armor-adding problem



Anti-U-boat bomber operation



Radar control operation.gif

What does Operations Research do?

1. Operations Research (OR) professionals aim to provide rational bases for **decision making** by seeking to **understand** and structure complex situations and to use this understanding to **predict** system behavior and **improve** system performance.
2. Much of this work is done using **analytical** and **numerical** techniques to develop and manipulate **mathematical and computer** models of organizational systems composed of people, machines, and procedures.

Terminology

- ❑ The British/Europeans refer to "**Operational Research**", the Americans to "**Operations Research**" - but both are often shortened to just "**OR**".
- ❑ Another term used for this field is "**Management Science**" ("**MS**"). In the U.S., **OR** and **MS** are combined together to form "**OR/MS**", "**ORMS**", or "**MSOR**".
- ❑ Yet other terms sometimes used are "**Industrial Engineering**" ("**IE**") and "**Decision Science**" ("**DS**").

Deterministic vs. Stochastic Models in Operations Research

Deterministic models

assume all data are known with certainty

Stochastic models

- assume some data contain uncertainty (=risk)
- explicitly represent uncertain data via random variables or stochastic processes.

Deterministic models involve optimization

Stochastic models

characterize / estimate system performance

Deterministic vs. Stochastic Models in Operations Research

Deterministic models

- Linear Programming
- Integer Programming
- Multi-Criteria Optimization
- Nonlinear Programming
- (Det.) Dynamic Programming
- (Det.) Inventory Models
- Network Optimization

⋮

Stochastic models

- (Sto.) Dynamic Programming
- Discrete-Time Markov Chains
- Continuous-Time Markov Chains
- Queuing Theory
- (Sto.) Inventory Models
- Revenue Management
- Game Theory

⋮

Deterministic vs. Stochastic Models in Operations Research

Deterministic models

- Linear Programming
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⋮

- Metaheuristic

Stochastic models

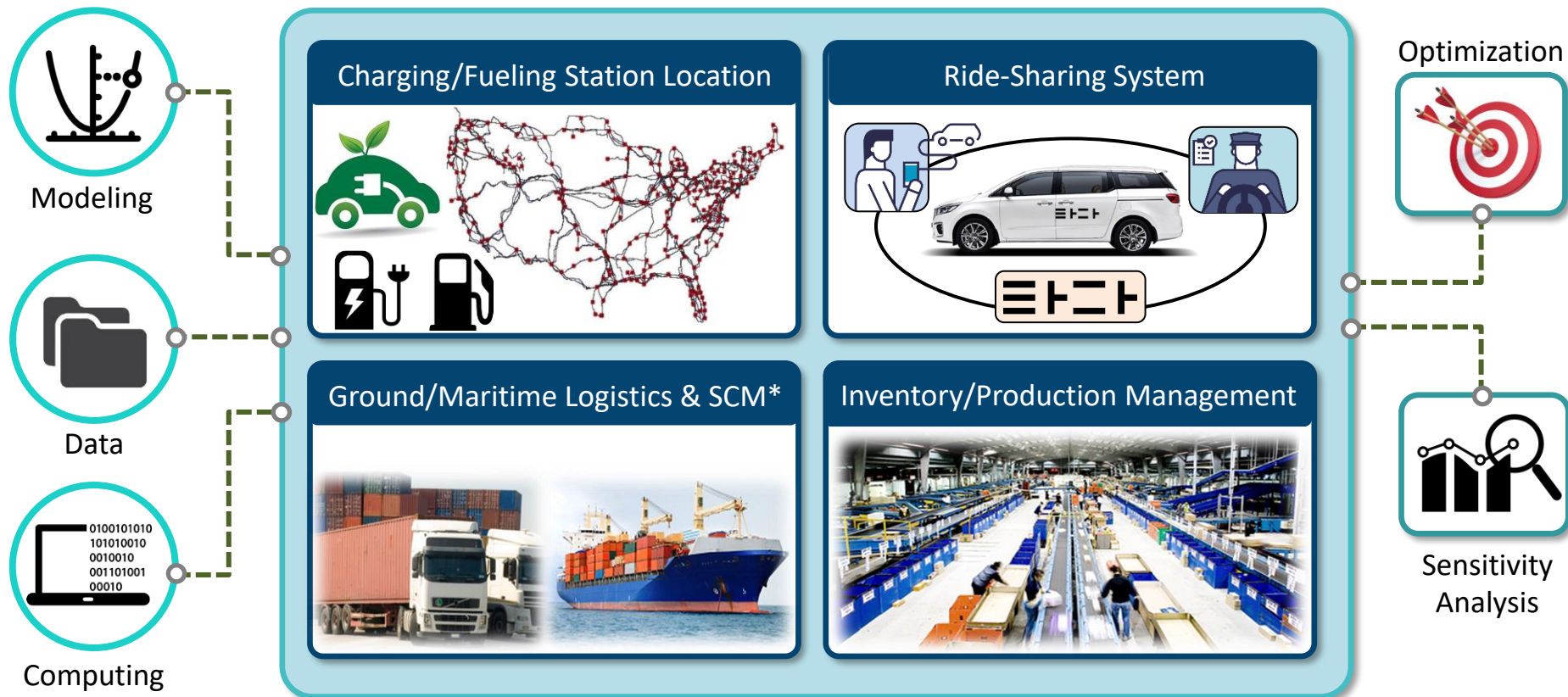
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⋮

Applications of Operations Research

❑ Applied Optimization Lab

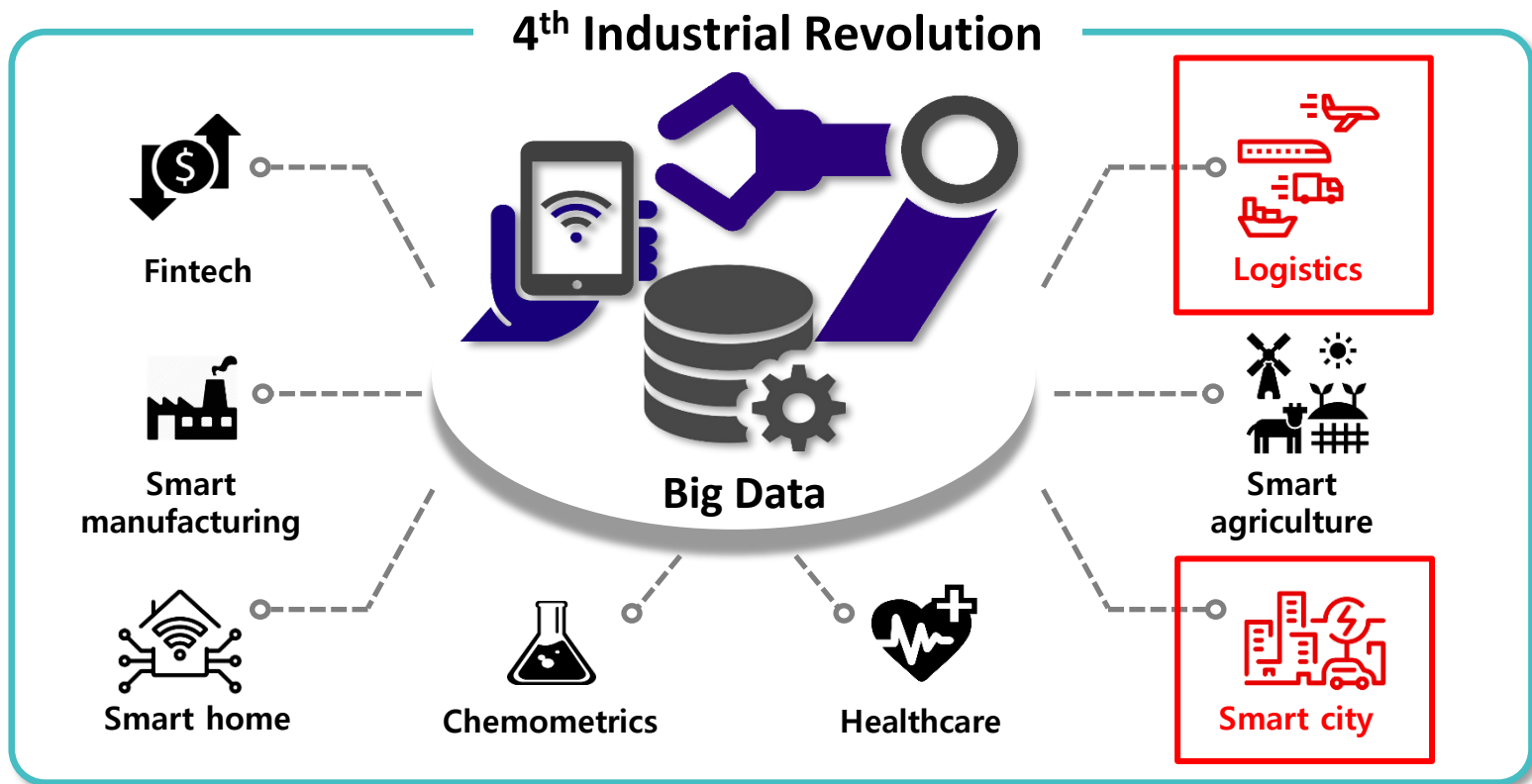
Development of mathematical models for industry & society optimization



*SCM: Supply Chain Management

Applications of Operations Research

- ❑ Data analytics through Optimization is the core enabler of 4th Industrial Revolution



Syllabus

- **Prerequisites**

Courses covering the basic concept of Systems of Linear Equations and Matrix Algebra

- **Course Objectives**

Operations Research (OR) is a quantitative approach to decision making based on the scientific method of problem solving. OR has been extensively used in the military, industrial, governmental, and urban planning fields, among others. This course will introduce students to fundamentals of OR, including linear programming (LP), integer programming (IP), and their applications and heuristic algorithms to efficiently solve these optimization problems. This course will also present a relevant programming language to solve large-size LP and IP problems. Upon completion of this course, students should understand and interpret LP and IP formulations, and furthermore, be able to design their own models and apply various mathematical techniques to solve optimization problems using heuristic algorithms.

Syllabus

• Course Objectives (한글)

계량경영학은 수학과 행동과학적인 기법에 기반을 두고 최적의 해법을 찾는 계량적 의사결정 방법론으로, 군사학, 생산관리, 제조관리, 물류관리, 금융, 고객서비스관리 등의 현실 경영 체계 뿐 아니라 최근에는 기계학습, 인공지능 기법에까지 폭넓게 응용되고 있다. 본 과목은 학생들에게 계량경영학 및 최적화이론의 가장 기본이 되는 선형계획법, 정수계획법 및 효율적 솔루션 도출을 위한 휴리스틱 알고리즘을 기법을 소개한다. 또한 본 문제는 복잡한 선형계획법 및 정수계획법 문제를 프로그래밍 언어를 통해 푸는 방법을 소개하고 코딩 실습 멘토링을 진행한다. 본 과목을 통해서 학생들을 선형계획법과 정수계획법 모델을 이해하고 해석할 수 있으며, 더 나아가 스스로 최적화모델을 개발하고 휴리스틱 알고리즘과 프로그래밍 언어를 적용하여 문제를 정의하고 풀 수 있게 된다.

• Textbooks

- Class materials are the main textbook and will be available before class.

Syllabus

• References

1. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 10th Edition, McGraw Hill, New York, 2014.
2. R.L. Rardin, Optimization in Operations Research, Prentice Hall, Saddle River, NJ, 1998.
3. M.S. Bazaraa, J.J. Jarvis, and H.D. Sherali, Linear Programming and Network Flows, 4th Edition, Wiley, Boston, MA, 2010.

• Acknowledgement

I would like to acknowledge the support of Professor Jose A. Ventura at Pennsylvania State University in sharing the course material for this course.

• Grading & Awards

- Two homework assignments will be provided.
- Students with high grades will be awarded.

Tentative Schedule

Days	Contents
01 (Mon. June 29)	<ul style="list-style-type: none"> • Introduction to Operations Research • Linear Programming Modeling and Applications • Graphical Solution and Graphical Illustration of Special Cases of a Linear Program • Programming Language Mentoring for Optimization Problems (1) • 계량경영학 소개 • 선형계획법 모델링 및 응용 • 그래픽 솔루션 접근법에 의한 선형계획법 풀이 및 선형계획법 특수상황 정리 • 최적화 문제 프로그래밍 언어 코딩 실습 멘토링 (1)
02 (Tue. June 30)	<ul style="list-style-type: none"> • Review of Linear Algebra • Convexity • Simplex Method • Computational Complexity • Programming Languages Mentoring for Optimization Problems (2) • 선형계획법 이론에 필요한 선형대수 응용 복습 • 컨벡스와 최적화 • 심플렉스 기법을 이용한 선형계획법 풀이 • 알고리즘 계산 복잡도 • 최적화 문제 프로그래밍 언어 코딩 실습 멘토링 (2)
03 (Wed. July 1)	<ul style="list-style-type: none"> • Integer Programming • Branch and Bound • Introduction to Genetic Algorithm • Programming Languages Mentoring for Optimization Problems (3) • 정수계획법 • Branch and Bound를 이용한 정수계획법 풀이 • 복잡한 선형계획법 및 정수계획법을 효율적으로 풀기위한 유전알고리즘 소개 • 최적화 문제 프로그래밍 언어 코딩 실습 멘토링 (3)

Acknowledgement



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