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Week 1. Artificial Intelligence Module Introduction

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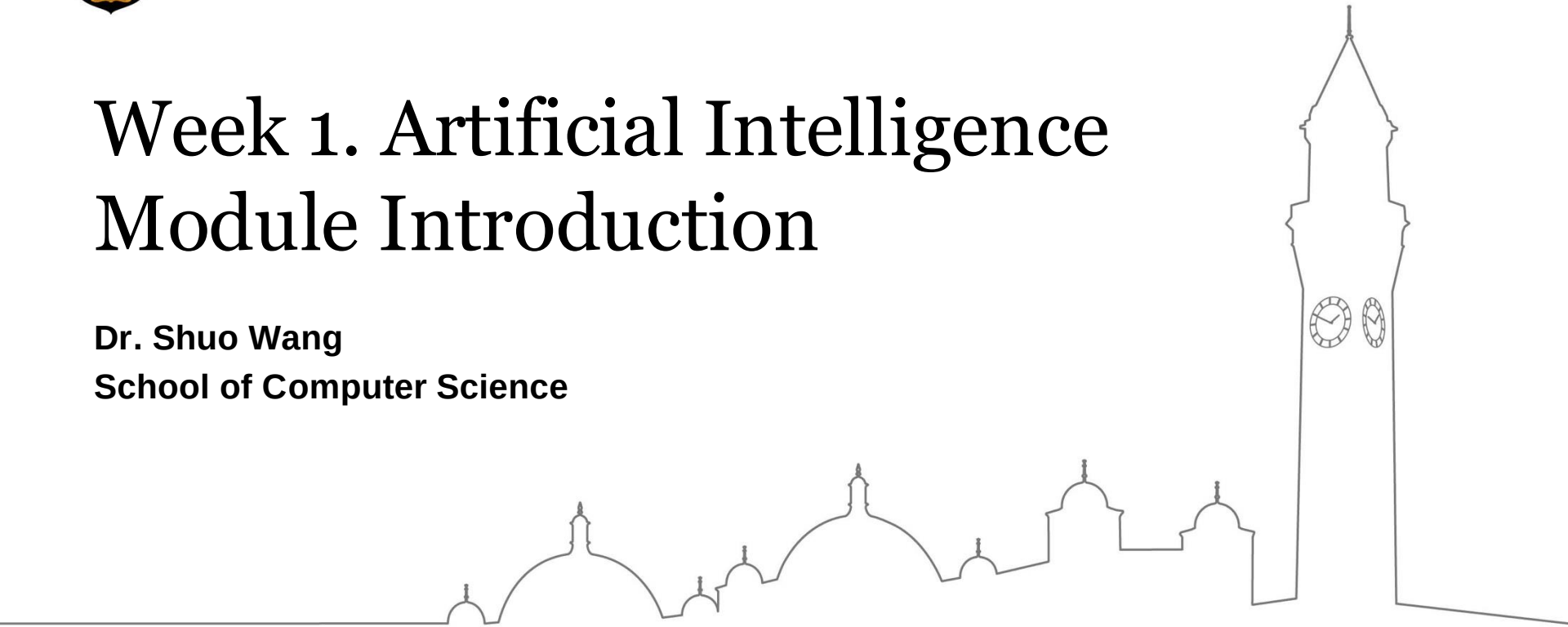
School of Computer Science

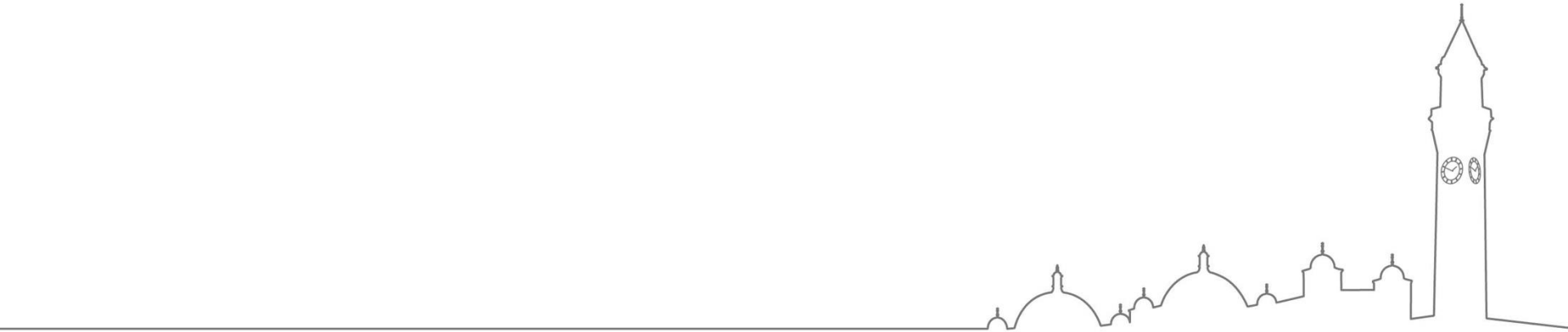


Module Objectives

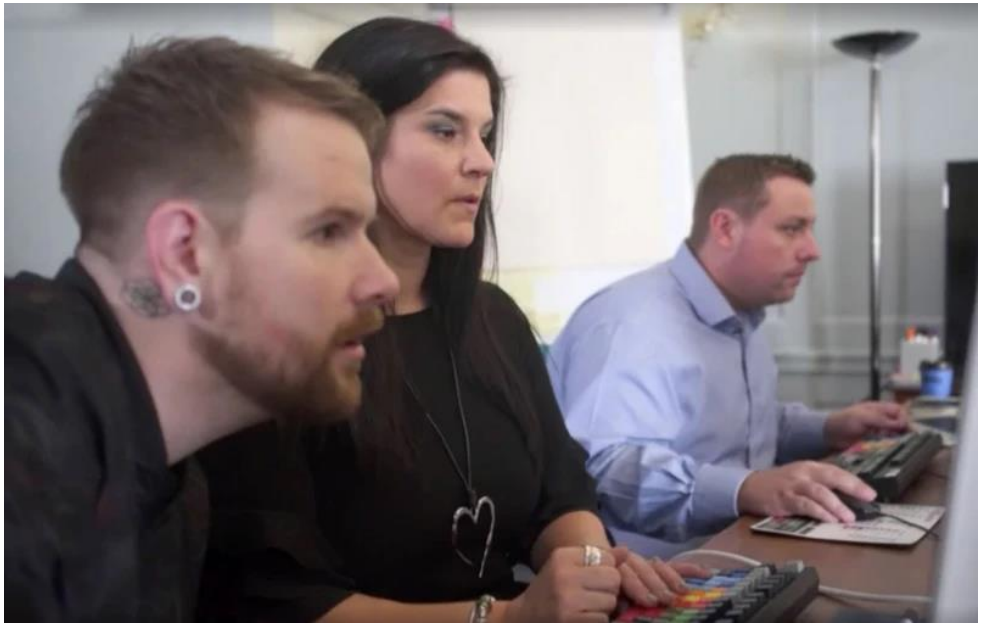
- Demonstrate an understanding of traditional AI approaches
- Demonstrate an understanding of the core principles of Optimisation and Machine Learning
- Demonstrate an understanding of the relationship between basic concepts of differentiation and techniques of AI
- Apply core principles of artificial intelligence to solve problems

Lecture Overview

- Why AI?
- What exactly is AI?
- Module overview



Super Recognizers



- Recognise faces and link to memories of who they are and how they met them.
- To track criminals

- Hard to recruit a team of these people.
- Very labour intensive, considering the size of the database.

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Underground pipe leak detection

- Need very specialised people
- Very costly if the wrong place is found.
- Hard for human to reach inside the pipes.

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So, why AI?

- Many real-world problems are:
  - time consuming and/or
  - challenging

  for humans to solve.
- Takes too much time and thus a lot of money.
- Solutions found manually may still not good enough.

Benefits of AI

- Reduce labor and human error
  e.g. automated production line in manufacturing that may cause injury.
- Always available, perform faster, don’t mind tedious/repetitive jobs
  e.g. chatbot to provide instant assistance.
- Make our life easier
  e.g. keyboard word prediction, product recommendation
- and more…

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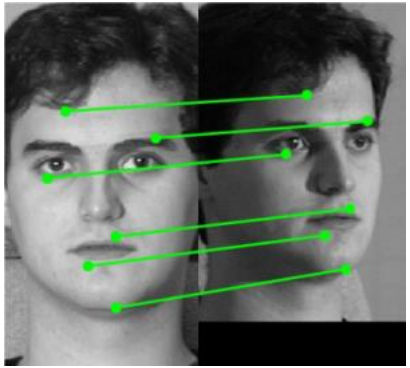
What Problems Can AI Solve?

- Face Recognition

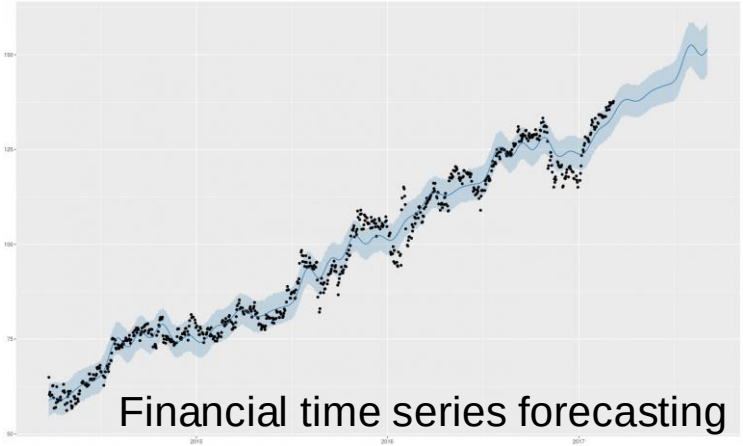


AI could automatically learn a model able to recognize whether faces match faces that are in a database.

To learn this model, AI uses examples of faces that are known to match/not match faces that are in the database.

Machine Learning Problems

Machine learning problems are those that require a model to be built automatically from data, e.g. to make classifications, estimations or predictions.



AI for Solving Machine Learning Problems

- AI can be used to automatically create models from data to perform certain tasks through machine learning.
- Typically not guaranteed to find perfect models, but may be able to find good models, depending on the difficulty of the problem and on the data available.
- Good for problems where models are necessary and it is difficult to create good models manually.
- Good for problems where there is no need for a perfect answer.

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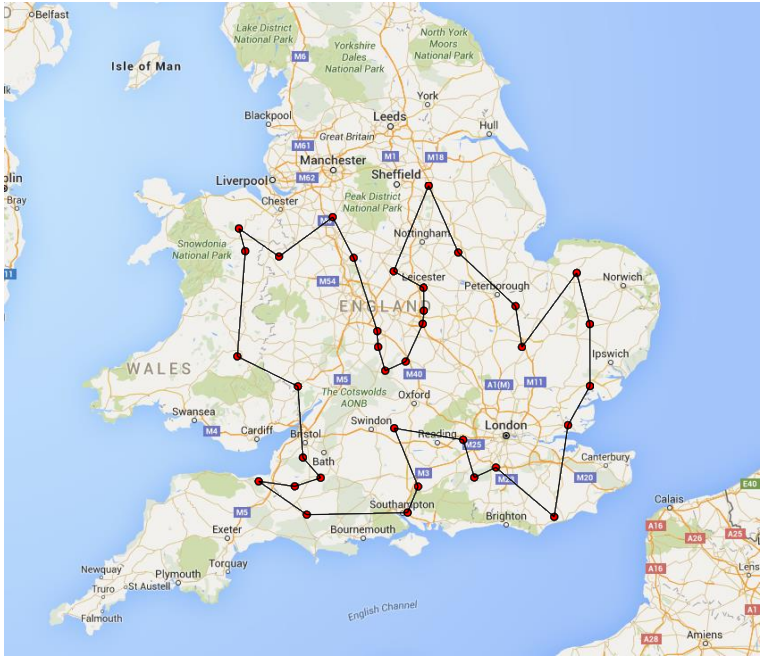
What Problems Can AI Solve?

Traveling Salesman Problem (TSP):

- Given N cities and the distances between each pair of cities, a salesman must travel passing through all the cities once and only once.
- Depending on the route the salesman takes, the travel distance can be longer or shorter.
- Problem: find a route that minimizes the travelling distance.



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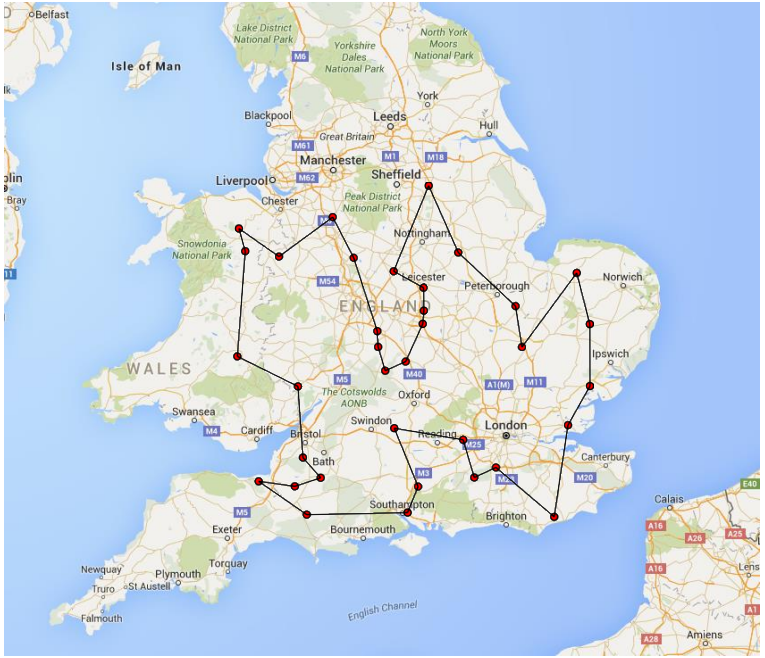
What Problems Can AI Solve?

Traveling Salesman Problem (TSP):

- Why is it difficult to solve manually?
- Is it time-consuming for computer to solve using brute-force strategy?



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Brute-Force for TSP

A solution is a sequence of cities, where each city appears only once.

- Number of cities N = 2

A	B
B	A

- Number of cities N = 3

A	B	C
A	C	B
B	A	C
B	C	A
C	A	B
C	B	A

Brute-Force for TSP

Computing N!

- 2! = 2 x 1 = 2
- 3! = 3 x 2 x 1 = 6
- …
- 10! = 10 x 9 x 8 x … x 1 = 3,628,800
- 20! = 20 x 19 x 18 x … x 1 = 2,432,902,008,176,640,000 ≈ 2.43 x 10^{18}
- …
- 50! ≈ 50 x 49 x 48 x … x 1 ≈ 3.04 x 10^{64}

Assume that 10^{10} possible sequences (10 billion) take one second (CPU):

$2!/10^{10}$ = 0.0000000002s

$3!/10^{10}$ = 0.0000000006s

…

$10!/10^{10}$ = 0.00036288s

$20!/10^{10}$ ≈ 243,290,200s ≈ 7.7years

…

$50!/10^{10}$ ≈ 3.04 x 10^{54}s ≈ 9.64 x 10^{46}years

Brute-force works only for very small problems, or problems for which the number of possible solutions is small.

Real-world problems are often quite large.

AI can be used to find a route that minimizes travelling distance in a reasonable amount of time. (optimization problem)

Optimization Problems

Optimization: find a solution that minimizes/maximizes one or more objective functions, possibly subject to certain constraints.

Bin Packing Problems

AI for Solving Optimisation Problems

- AI can help us to solve optimisation problems in a reasonable amount of time through optimisation techniques
- Typically not guaranteed to find optimal solutions in a reasonable amount of time, but able to find good (near-optimal) solutions in a reasonable amount of time.
- Good for optimisation problems where it is not a requirement to guarantee that the optimal solutions are found.
- Good for optimisation problems where we cannot afford enumerating all possible solutions to guarantee that a perfect solution is found.
- Good for optimisation problems where no specific technique exists that guarantees that an optimal solution can be found quickly.

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Search Problems

Search: find a solution that satisfies certain constraints.

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What is AI?

- Many different definitions
  - Think humanly
  - Act humanly
  - Think rationally
  - Act rationally

What is AI?

- Russell and Norvig's definition, based on "act rationally":
  - AI is the area of Computer Science which studies "rational agents".
  - Rational agents are computer programs that perceive their environment and take actions that maximise their chances of achieving the best [expected] outcome.

AI in Real Life

- **Meta** uses neural nets for their automatic tagging algorithms, **Google** for their photo search, **Amazon** for their product recommendations, **Pinterest** for their home feed personalization, and **Instagram** for their search infrastructure.




In this Module:

- You will get an introduction to different areas of Artificial Intelligence, including search / optimisation, and machine learning.
  - Artificial intelligence algorithms / approaches that can be used to create rational agents.
  - Examples of real world problems that can be solved using such algorithms.
  - Learn to solve real-world problems using Java-based AI tool – Weka.
- This will give you a general idea of the area.
- It will help you to decide whether you wish to investigate any topic further.

Module Lecturers - Edgbaston

Shuo Wang
Weeks 1 - 3 + revision
Topics: Introduction, ML (supervised learning)

Sharu Jose
Weeks 4 - 7
Topics: ML(clustering), Weka

Batu Buyukates
Weeks 8 – 11
Topics: search and optimisation

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Module Organisation

Teaching plan available in the “modules” tab on Canvas.

Teaching on campus:

- 2h lecture (attendance strictly taken) + 1 tutorial (attendance not taken)
- Lecture slides and tutorial questions available 1 or 2 days before the lectures.
- Recording of on campus lecture available after the lectures.
- Reading materials and quizzes on the fundamentals covered during the lectures to try after the lecture on Canvas.
- Tutorials for smaller groups are exercise classes with the TAs.

  Content of Week ***x*** will be covered in Tutorial of Week ***x+1***. So, we recommend you to study Week ***x***’s materials before the Week ***x+1***’s tutorials.

How this module is supported

- Tutorial: important to attend
- Lecturer office hours (f2f or both)
  Attend the office hours of the lecturer who led the content that you have questions about
- TA drop-in sessions (f2f)
  Canvas ”welcome” page for time and locations
  Attend any.
- Microsoft teams (online support)
  Encourage peer support
- Please do not send questions by email unless you wish them to be confidential.

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Assessment

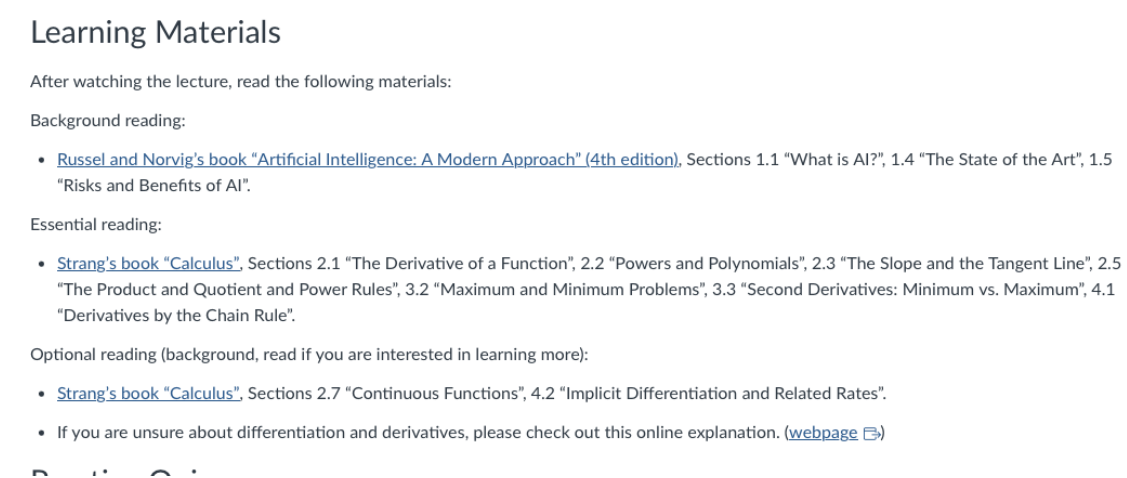
- Continuous Assessment (20% of marks)
  - 1 summative Canvas quiz, worth 10%
    It will be timed, but can be taken at any time between the release and due dates.
    Release around week 4, due week 5.

    Open problem solving quiz (using Weka), worth 10%.
    Release around week 7, due week 8.
- Exam (80% of marks).

Learning Resources

Canvas module => Modules => Resource Lists
For textbooks and supporting books

Brua platform: generative AI tool
For online material sharing



Learning Materials

After watching the lecture, read the following materials:

Background reading:

- Russel and Norvig's book "Artificial Intelligence: A Modern Approach" (4th edition), Sections 1.1 "What is AI?", 1.4 "The State of the Art", 1.5 "Risks and Benefits of AI".

Essential reading:

- Strang's book "Calculus", Sections 2.1 "The Derivative of a Function", 2.2 "Powers and Polynomials", 2.3 "The Slope and the Tangent Line", 2.5 "The Product and Quotient and Power Rules", 3.2 "Maximum and Minimum Problems", 3.3 "Second Derivatives: Minimum vs. Maximum", 4.1 "Derivatives by the Chain Rule".

Optional reading (background, read if you are interested in learning more):

- Strang's book "Calculus", Sections 2.7 "Continuous Functions", 4.2 "Implicit Differentiation and Related Rates".
- If you are unsure about differentiation and derivatives, please check out this online explanation. (webpage)

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