Topics in Applied Optimization

Applications to Machine Learning, Vision, and Data Analytics

Pawan Kumar

CSTAR, IIIT-H

Course Information

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   4.5 Basic Linux Utilities (assumed)

Weightages

1. Online Randomized Quizzes: 30 % (Most of Boyd's Book)

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4. Assignments: 25 % (Take Home Assignments)

References

- Convex Optimization by Boyd and Vanderberghe (main)
- Convex Optimization by Bertsekas (some part)
- Deep Learning, Bengio, Hinton, Goodfellow (some part)
- Numerical Optimization, Jorge Nocedal, Stephen J. Wright (some part)
- Non-convex Optimization, Jain
- Non-Smooth Optimization, Boyd (Online notes)

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    - Recommender systems (Matrix completition problem)
    - Non-linear optimization in computer vision
    - Plenty more applications during the semester...

Have you seen optimization problem before?

$$\text{maximize } f(x) = -x^2 + 4x - 3$$
$$\text{subject to } x \in [-1, 1].$$

What is the solution?

What is an Optimization Problem?

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A problem of the form

$$\begin{aligned} &\text{minimize } f(x) \\ &\text{subject to } x \in C \end{aligned}$$

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- $f(x)$ is called objective function

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- $f(x)$ is called objective function
- C is called constrained set
- We want to find x such that $f(x)$ is minimized

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  - Find suitable set of constraints
- Learn algorithms to solve the optimization problem (Solver)
  - Identify the problem class: linear/nonlinear, smooth/nonsmooth, convex/nonconvex
  - Propose a suitable solver for the given class

Optimization = Problem Solving

Problem: Of all rectangles of area 100, which has the smallest perimeter?

Modelling:

- Objective function:
- Constraint set:
- Final Model:

Optimization = Problem Solving

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Solution:

Optimization = Problem Solving

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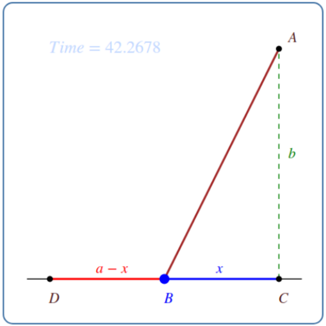
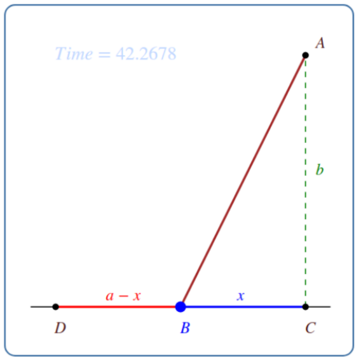
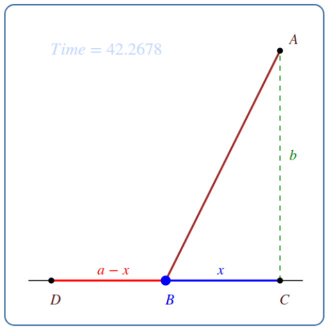
Problem: Suppose you want to reach a point A that is located across the sand from a nearby road. Suppose that the road is straight, and b is the distance from A to the closest point C on the road. Let v be your speed on the road, and let w, which is less than v, be your speed on the sand. Right now you are at the point D, which is a distance a from C. At what point B should you turn off the road and head across the sand in order to minimize your travel time to A?



- How do we model this problem as optimization problem?
- How do we solve the formulated optimization problem?


Time = 42.2678
A
b
a − x
x
D
B
C

Optimization = Problem Solving



- Objective function:
- Constraints:
- Model:

Optimization = Problem Solving

Consider the following temperature data of a city in a day:

Time	Rescaled Time	Temperature
9:00	0:00	15
11:00	2:00	30
14:00	4:00	34
16:00	6:00	33
18:00	8:00	21
22:00	12:00	18

Predict temperature at 14:30.

- Objective function:
- Constraints:
- Model: