Data Science Internship at Czech Technical University

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University Summary

Department of Computer Science

University Summary

Group: **Intelligent Data Analysis**

Funded projects possible in:

1. Stochastic optimization
2. Causal Inference
3. Probabilistic Graphical Models
4. Quantum System Uncertainty Quantification

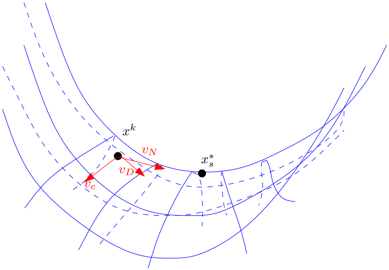
University Summary

1. Remote is possible
2. Otherwise Prague is beautiful

Mathematical Optimization

Generally: solve problems of the form,

$$\begin{aligned} \min_x \quad & f(x), \\ \text{s.t.} \quad & c(x) \geq 0, \\ & d(x) = 0 \end{aligned}$$



Mathematical Optimization

In Machine Learning

- Classical learning (SVM, kernels, regression, etc.)

$$\min_x \quad \mathbb{E}_\xi[f(x,\xi)] + g(x),$$

  f is continuously differentiable and smooth and convex, and g is a nonsmooth convex regularizer.

- Deep learning:

$$\min_x \quad \mathbb{E}_\xi[f(x,\xi)],$$

  f is nonconvex, and generally nonsmooth

- Inverse Problems:

$$\begin{aligned} \min_x \quad & \mathbb{E}_\xi[f(x,\xi)], \\ \text{s.t.} \quad & c(x) = 0,\ d(x) \geq 0 \end{aligned}$$

  f, c and d continuously differentiable

Bayesian Methods, Sampling

Instead of $\min f(x)$ sample from $\pi(x) \sim e^{-f(x)}$

Open Projects

Stochastic Optimization for *Fair Machine Learning (AutoFair)*

$$\begin{array}{rl} \min_x & \mathbb{E}[f(x,\xi)] \\ s.t. & \mathbb{E}[g(x,\xi)] \leq 0 \end{array}$$

where ξ is the data distribution f is the loss and g is some *fairness* measure

Open Projects

Causal Inference and Probabilistic Graphical Models for *CoDiet*

1. Agglomerate background nutritional data into comprehensive models
2. Study causal structure of microbiome interactions in response to food
3. Develop personalized data-driven nutrition system

Open Projects

Quantum System Uncertainty Quantification using Geometric Applied Probability

- Closed system (simpler, the idealized circuit model),

$$\frac{dU}{dt} = A(t)U(t),\ A(t) = \exp(-iH(t))$$

  with uncertainty in the elements of H

- Open System (more realistic, models quantum engineering)

$$\frac{\partial\psi(x,t)}{\partial t} = \left(-ih\frac{\partial^2}{\partial x^2} + V(x,t)\right)\psi(x,t)$$

  with uncertainty of V

find distribution, or properties of distributions of errors associated with quantum operations

Skills

Languages used:

1. MATLAB
2. Python
3. Julia

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