Jacob Rafati

Electrical Engineering and Computer Science
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Research Interests

- ◇ Machine Learning
- ◇ Large-scale Numerical Optimization
- ◇ Deep Learning
- ◇ Computer Vision
- ◇ Reinforcement Learning
- ◇ Approximation Algorithms Design and Analysis
- ◇ Dynamical Systems and Control
- ◇ Applied Mathematics
- ◇ Optimization and Matrix Analysis

Education

- ◇ **University of California, Merced**, Merced, CA (Fall 2013 – Present)
  PhD Candidate in Electrical Engineering and Computer Sciences
- ◇ **Sharif University of Technology**,
  Tehran, Iran, (2008 - 2010)
  M.Sc. in Mechanical Engineering.
- ◇ **Sharif University of Technology**,
  Tehran, Iran, (2003 - 2007)
  B.Sc. in Mechanical Engineering.
- ◇ **National Organization for Development of Exceptional Talents**,
  Tabriz, Iran, (1999 - 2003)
  High School and Pre-University Certificate in Mathematics and Physics.

Honors and Awards

- ◇ University of California, Merced EECS Bobcat Summer Fellowship (2014 – 2018)
- ◇ Admission to **University of California, Merced** (2013)
- ◇ Chosen ISI Publications in Nano-Mechanics, Funded by Iran Nanotechnology Council (2011, 2013)
- ◇ Best M.Sc. Thesis in Nano-Mechanics, Funded by Iran Nanotechnology Council (2010)
- ◇ **Ranked 131st** in the Iranian National Entrance Exam for Graduate Admission for Mechanical Engineering (2007)
- ◇ **Ranked 141st** in the Iranian National University Entrance Exam among 350,000 Participants (2003)

Current & Recent Projects

- ◇ **Ph.D. Thesis** (2014-now)
  "**Learning Representations in Reinforcement Learning**" (Supervised by Dr. David C. Noelle)
  Reinforcement Learning is a framework for an *agent* that learns to solve a task thru interaction with *environment* to reach to a *goal* or accomplish a *task*. This dissertation investigates biologically inspired techniques for learning useful state representations for reinforcement learning, as well as optimization methods for improving learning.

Recent Projects

- ◇ **Learning Sparse Representations of state in Reinforcement Learning** (2014 – present)
  Inspired by the lateral inhibition in the cortex, we used k-Winner-Take-All mechanism in *Temporal Difference* Learning to produce sparse distributed internal representations of agent's state which leads to the better convergence of value function and policy mapping in problematic control tasks such as puddle world, mountain car and acrobat. he codes is implemented in `Matlab` and also `Python` using `TensorFlow` and is available in `https://github.com/root-master/deeptd`.

- **Quasi-Newton optimization methods in deep learning** (2017 – present)
  Methods for solving the nonconvex nonlinear optimization problems in deep learning are restricted to the class of first-order algorithms, like stochastic gradient descent (SGD). SGD methods has several undesirable properties: they often stuck in saddle-points and they require finetuning so many hyperparameters. Using second derivative information can be useful but computing true Hessian is not practical. Alternatively, quasi-Newton methods, like SGD, attemp to approximate Hessian with low-rank matricies and they can result in superlinear convergence. In this project, we study and implement quasi-Newton optimization methods such as limited-memory BFGS in trust-region framework and in line-search framework that are efficient for deep learning problems such as classification and regression of big data. The codes for this ongoing project is implemented in `Python` using `TensorFlow` and is available in `https://github.com/root-master/lbfgs-tr`.
- **Model Compression in Deep Neural Netwroks with Application in Mobile Devices** (2017)
  Implementation of `model-compression` algorithm from https://arxiv.org/abs/1707.04319. I am using model compression as constrained optimization to quantize the weights of Deep Neural Netowrks from a adaptive codebook (weights are chosen from a trainable codebook). This guarantees to converge to local optimum of the loss. The compressed CNN models will be tested on mobile devices. The codes for this ongoing project is implemented in `Python` using `TensorFlow` and is available in `https://github.com/root-master/deep-compress`.

Past Projects

- **M.Sc. Thesis** (2008-2010)
  "Stability Analysis of hybrid nanotubes based on the nonlocal continuum theories", supervised by: Dr. M. Asghari (20/20)
- **B.Sc. Thesis** (2005-2006)
  "Dynamical simulation of a wagon passing upon a symmetrical non-smooth rail and obtaining the wearing stresses", supervised by: Dr. M. Durali

Publications

- Jacob Rafati, Omar DeGuchy, Roummel F. Marcia "Trust-Region Minimization Algorithms for Training Responses (TRMinATR): The Rise of Machine Learning Techniques", Submitted to review for 26th European Signal Processing Conference (EUSIPCO 2018), Rome, Italy.
- Rafati J, Noelle D.C., "Sparse Coding of Learned State Representations in Reinforcement Learning", *2017*, Cognitive Computational Neuroscience Conference, Newyork City, NY.
- Rafati J, Noelle D.C., "Lateral Inhibition Overcomes Limits of Temporal Difference Learning", *Accepted for poster presentation at CogSci 2015*, 37$^{\text{th}}$ Annual Cognitive Science Society Meeting, Pasadena, CA, 2015.
- Rafati J., Asghari M., Goyal S., "Effects of DNA Encapsulation On Buckling Instability of Carbon Nanotube based on Nonlocal Elasticity Theory", Proceedings of the ASME 2014 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, IDETC/CIE 2014. August 17-20, 2014, Buffalo, New York, USA.
- Asghari M, Rafati J, and Naghdabadi R., "Torsional instability of carbon nano-peapods based on the nonlocal elastic shell theory", Physica E: Low-dimensional Systems and Nanostructures, 2013. 47: p. 316-323.
- Asghari M, Naghdabadi R, and Rafati J., "Small scale effects on the stability of carbon nano-peapods under radial pressure", Physica E: Low-dimensional Systems and Nanostructures, 2011. 43(5): p. 1050- 1055.
- Asghari M, Rafati J., "Variational Principles for the Stability Analysis of Multi-Walled Carbon Nanotubes Based on a Nonlocal Elastic Shell Model", ASME 2010 10th Biennial Conference on Engineering Systems Design and Analysis (ESDA2010), Paper no: ESDA2010-24473 pp. 591-598.

Teaching Experience

- **Teaching Assistant**
  - Artificial Intelligence (Java), Fall 2017, Fall 2018; Instructor: Dr David C. Noelle
  - Computational Cognitive Neuroscience (Emergent software), Spring 2017; Spring 2018; Instructor: Dr David C. Noelle.

- Computer organizations (C, MIPS), Spring 2016, Summer 2018, Instructor: Dr Daniel Leung.
- Introduction to Computing (Java), Spring 2015, Fall 2016, Instructor: Dr Daniel Leung.
- Engineering Computing, (MatLab and Fortran) Fall 2013; Instructor: Dr Jian-Qiao Sun.

Technical Skills

- Programming Languages: `Python`, `MatLab`, `Java`, `C++`, `Bash`.
- Machine Learning Libraries: `TensorFlow`, `Keras`, `scikit-learn`, `Torch`.
- Web Development: Front-end and Back-end, `NodeJS`, `HTML`, `CSS`, `JavaScript`, `expressjs` and `expressjs`.
- Database Systems: NoSQL `MongoDB`.
- Designing Deep Neural Network, architecture, algorithm design, parallel computations on clusters and GPU and Data Analysis.
- Designing and analysis of recent methods in machine learning and deep learning.
- High understanding of algorithms
- High understanding of Linear Algebra, Numerical Analysis, Optimization, Topology, Graph, Statistics, Probability, Dynamical Systems.
- Probabilistic Robotics.
- Web Application Automatic Testing: with `Selenium` API for `Python`.
- Approximation Algorithm design and analysis.
- Search Algorithms in Artificial Intelligence.

Social Skills

- Great passion and skills to manage reserach projects.
- High communication and organization skills.
- Problem Solving and collaborative mindset and high skills in teamwork.
- Innovation and creativity.
- Passion for managing projects and finding interetsing problems.

Language Proficiency

- Persian (Native)
- English (Fluent)
- Azeri (Native)
- Turkish (Fluent)