Jacob Rafati

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Research Interests

- ◇ Machine Learning and Real-world Applications (learning from video, image recognition)
- ◇ Reinforcement Learning and Real-world Applications (games, advertising, ranking)
- ◇ Unsupervised Learning and Applications (anomaly detection, fraud detection, time series analysis)
- ◇ Convex and Non-convex Numerical Optimization in Large-scale Machine Learning
- ◇ Computational Methods for Large-scale Physical and Mechanical Systems
- ◇ Dynamical Systems and Adaptive Control

Education

- ◇ **University of California, Merced**, Merced, CA (2013 – 2019)
  Ph.D. 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.

Work Experiences

- ◇ **Data Scientist intern, Deep RL.** Unity Technologies. San Francisco. (Summer 2019)
  - ◦ Common approach in advertising is to choose an ad with the highest bid from an auction to display to user, however this doesn't guarantee maximizing the life time value (LTV). I want to design and implement RL algorithms for choosing an ad to take into consideration LTV, users and the dynamical environment by maximizing the future rewards rather the immediate ones. I consider policy gradients, soft-actor policy method for entropy maximization, multi-agent approach, as well as unsupervised and hierarchical methods.
- ◇ **Graduate Teaching Assistant** for computer science courses (2013 - 2018). UC Merced.
- ◇ **Mechanical Engineer**. Iran Powerplant Development Company. (2009 - 2012).
  - ◦ Engineering, design, supervision for Construction of 5200MW steam/gas power plants.
- ◇ **M.Sc. Researcher**. Sharif University of Technology. (2008 - 2010)

Recent Projects

- ◇ **Ph.D. Dissertation "Learning Representations in Reinforcement Learning"**
  - ◦ **Summary.** By asserting certain assumptions to the structure of the value function, I worked on methods for learning representations in model-free RL. I also implemented novel quasi-Newton optimization methods for solving empirical risk minimization problems in large-scale machine learning, such as image recognition and deep RL. See my website for more information.
  - ◦ **Learning Hierarchical Representations.** I introduced a novel and scalable approach based on unsupervised learning, over the agent's trajectories, for the subgoal discovery problem. By combining unsupervised subgoal discovery, temporal abstraction and intrinsic motivation learning, I introduced a unified approach for model-free hierarchical reinforcement learning for solving long horizon tasks. The simulation code is implemented in Python using Pytorch, Numpy and SciPy and is available at https://github.com/root-master/unified-hrl.
  - ◦ **Learning Sparse Representations.** Inspired by the lateral inhibition in the cortex, I introduced a fast algorithm to produce sparse conjunctive representations in the hidden layers of the neural nets in order to avoid the catastrophic interference while supporting the generalization. This helps learning highly nonlinear policies. The Matlab code for the simulations is available at http://rafati.net/td-sparse/.

◇ **Optimization Methods for Large-scale Machine Learning**.

- **Quasi-Newton Optimization in Deep Reinforcement Learning.** I introduced a first-order method based on the BFGS line-search to solve the empirical risk minimization problem in deep RL. In comparison to the SGD-based methods, this algorithm converges faster and is more memory efficient. The simulation code is implemented in Python using Pytorch, NumPy, and SciPy and is available at `http://rafati.net/quasi-newton-rl`.
- **Trust-Region Methods in Deep Learning.** I introduced a scalable algorithm based on the BFGS trust-region to solve the empirical risk minimization problem in deep learning. When compared with the line-search approach, the trust-region algorithm runs much faster and can escape ill-conditioned points. The simulation code is implemented in Python using TensorFlow and is available at `https://rafat.net/lbfgs-tr`.
- **Improving Initialization of BFGS Matrices.** I introduced and implemented initialization methods to avoid false negative curvature conditions by asserting constraints in the form of the general eigenvalue problem. The simulation code is implemented in Python using TensorFlow and NumPy and is available at `http://rafati.net/l-bfgs-tr-init-methods`.

◇ **Predicting Crimes from Surveillance Videos.** I design and implement algorithms for detecting criminal behaviors, such as assault, road accidents, shootings, and shoplifting in real-time surveillance. I consider unsupervised learning methods, such as anomaly detection algorithms, over features extracted from the human pose estimation and pose tracking in surveillance camera videos. This is an on-going project. The simulation code is implemented in Python using PyTorch and is partially available at `https://github.com/root-master/pose-anomaly-detection`.

Learning Representations in Reinforcement Learning

PUBLICATIONS

◇ **Jacob Rafati**. (2019). Learning Representations in Reinforcement Learning. Ph.D. dissertation. University of California, Merced. USA.

◇ **Jacob Rafati**, David C. Noelle. (2019). Unsupervised Subgoal Discovery Method for Learning Hierarchical Representations. *7th International Conference on Learning Representations, ICLR 2019 Workshop on "Structure & Priors in Reinforcement Learning", New Orleans, LA, USA.*

◇ **Jacob Rafati**, David C. Noelle. (2019). Learning Representations in Model-Free Hierarchical Reinforcement Learning. *33rd AAAI Conference on Artificial Intelligence, Honolulu, HI.*

◇ **Jacob Rafati**, David C. Noelle. (2019). Unsupervised Methods For Subgoal Discovery During Intrinsic Motivation in Model-Free Hierarchical Reinforcement Learning. *AAAI (2019) workshop on Knowledge Extraction From Games.*

◇ **Jacob Rafati**, and David C. Noelle (2019). Learning Representations in Model-Free Hierarchical Reinforcement Learning. Preprint at `https://arxiv.org/abs/1810.10096`.

◇ **Jacob Rafati**, David C. Noelle. (2017). Sparse Coding of Learned State Representations in Reinforcement Learning, *1st Cognitive Computational Neuroscience Conference, New York City, NY.*

◇ **Jacob Rafati**, David C. Noelle. (2015). Lateral Inhibition Overcomes Limits of Temporal Difference Learning, *37th Annual Meeting of Cognitive Science Society, Pasadena, CA*.

Quasi-Newton Optimization for Large-scale Machine Learning

◇ **Jacob Rafati**, Roummel F. Marcia. (2019). Deep Reinforcement Learning via L-BFGS Optimization. Preprint at `https://arxiv.org/abs/1811.02693`.

◇ **Jacob Rafati**, Roummel F. Marcia. (2018). Improving L-BFGS Initialization For Trust-Region Methods In Deep Learning. *17th IEEE International Conference on Machine Learning and Applications, Orlando, FL.*

◇ **Jacob Rafati**, Omar DeGuchy, and Roummel F. Marcia (2018). Trust-Region Minimization Algorithms for Training Responses (TRMinATR): The Rise of Machine Learning Techniques. *26th European Signal Processing Conference (EUSIPCO 2018), Rome, Italy.*

Computational Methods for Large-scale Physics and Mechanics

- **Jacob Rafati**, Mohsen Asghari and Sachin Goyal. (2014) Effects of DNA Encapsulation on Buckling Instability of Carbon Nanotube based on Nonlocal Elasticity Theory. *Proceedings of the ASME 2014 14th International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Buffalo, New York, USA*.
- Mohsen Asghari, **Jacob Rafati**, and Reza Naghdabadi. (2013). Torsional Instability of Carbon Nano-Peapods based on the Nonlocal Elastic Shell Theory. *Physica E: Low-dimensional Systems and Nanostructures*, 47: p. 316-323.
- Mohsen Asghari, Reza Naghdabadi, and **Jacob Rafati**. (2011). Small Scale Effects on the Stability of Carbon Nano-Peapods under Radial Pressure, *Physica E: Low-dimensional Systems and Nanostructures*, 43(5): p. 1050-1055.
- Mohsen Asghari, **Jacob Rafati**. (2010). 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)*.
- **Jacob Rafati**. (2010). Stability Analysis of Hybrid Nanotubes based on the Nonlocal Continuum Theories. M.Sc. Thesis. Sharif University of Technology. Tehran, Iran.
- **Jacob Rafati**. (2006). Dynamical Analysis of the Train Derailment on Non-smooth Rails: A Computational Approach. B.Sc. Thesis. Sharif University of Technology. Tehran, Iran.

Talks

- "Quasi-Newton Optimization in Large-scale Machine Learning". (April 2019), CalTech.
- "Learning Representations in Reinforcement Learning". (April 2019). Ph.D. dissertation defense.
- "Unsupervised Methods for Subgoal Discovery". (January 2019). AAAI KEG workshop. Honolulu.
- "Trust-Region Methods In Deep Learning". (2018). ICMLA Conference, Orlando.
- "Optimization Methods in Deep Reinforcement Learning". (2018). EECS Technical Seminar Series.
- "Hierarchical Reinforcement Learning". (2018). SIAM Graduate Student Chapter Seminar.
- "State Representations in Reinforcement Learning". (2017). EECS Technical Seminar Series.
- "Dynamics of an encapsulated DNA". (2014). ASME. Buffalo, NY.

Honors & Awards

- University of California, Merced Graduate Dean's Dissertation Fellowship (Fall 2018)
- ICML Travel Award (2019)
- ICLR Travel Award (2019)
- AAAI Travel Award (2019)
- University of California, Merced Graduate Excel Peer Mentorship Program Fellowship (Fall 2018)
- UC Merced EECS Bobcat Fellowships (2014 – 2019)
- M.Sc. Thesis Fellowship (2011 - 2013)

Teaching Experience

- **Teaching Assistance for Undergraduate and Graduate Courses** (2013 - 2018)
  - Introduction to Artificial Intelligence. Fall 2017, Fall 2018.
  - Computational Cognitive Neuroscience. Spring 2017, Spring 2018.
  - Computer organizations. Spring 2016. Summer 2018.
  - Introduction to Computing. Spring 2015, Fall 2016.
  - Engineering Computing. Fall 2013.