

RUDRAJIT DAS

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EDUCATION

Indian Institute of Technology Bombay

Mumbai, India

Dual Degree in Electrical Engineering - GPA: 9.37/10.0

Expected Graduation: May '19

Minor in Computer Science

FIELDS OF INTEREST

Deep Learning, Machine Learning and Statistical Learning, Probabilistic Analysis, Optimization, Computer Vision and Image Processing, Natural Language Processing, Signal Processing.

PUBLICATIONS & COMPETITIONS

- *An Efficient Randomized Algorithm to Detect and Escape Saddle Points*
Rudrajit Das and Subhasis Chaudhuri
Submitted for publication to **AAAI-19**.
(Manuscript available on request)
- *Sparse Kernel PCA for Outlier Detection*
Rudrajit Das, Aditya Golatkar and Suyash Awate
Selected for **oral presentation** in **IEEE ICMLA 2018**.
<https://arxiv.org/abs/1809.02497>
- *iFood Challenge, FGVC Workshop, CVPR 2018*
Parth Kothari*, Arka Sadhu*, Aditya Golatkar*, **Rudrajit Das*** (* denotes equal contribution)
Finished 2nd in the public leaderboard and 3rd in the private leaderboard (Team name : Invincibles).
Invited to present our method at **CVPR 2018** (slides can be found [here](#)).
<https://www.kaggle.com/c/ifood2018/leaderboard>

INTERNSHIPS

PRAIRIE Artificial Intelligence Summer School (PAISS)

Grenoble, France

Inria, NAVER LABS Europe

July '18

- Among the top **200** selected applicants **world-wide** for this AI summer school, co-organized by **Inria** and **NAVER LABS Europe**. Attended **lectures & practical sessions** conducted by **leading experts** in Computer Vision, NLP, Robotics, Reinforcement Learning, Meta Learning, Unsupervised & Self-supervised Learning.
- Presented a **poster** (can be found [here](#)) titled “**Existence of Sparse Basis for Deep Learning Kernels?**”.

Institute for Biomechanics, ETH Zürich

Zürich, Switzerland

Research Intern under Dr. Patrik Christen, D-HEST

May '17 - July '17

- Constructed a **linear model** for **bone re-modelling** with some dependence on initial conditions, obtained a **closed form solution** for it and analyzed its stability using **eigenvalue analysis**, which was **not done earlier**.
- Also built a **directed graphical model** to capture the random nature of the process and simulated it.
- Developed an **automated 2D-3D image registration framework** for histology images from scratch, which included **devising an efficient sampling strategy** to obtain the 2D image across an arbitrary plane of the given 3D image, **formulating a good cost function** (for measuring similarity) in order to mitigate the effect of the existence of **several local minima**, choosing a **suitable optimization algorithm** (tried Levenberg–Marquardt, Powell’s method, PSO, Genetic algorithms) and finally coding it all up.

Altisource Business Solutions Private Limited

Software Engineering Intern

Bengaluru, India

May '16 – July '16

- Developed a **notification system** using **Pagerduty**, a popular incident management software and worked on the user interface(UI) of the company's monitoring dashboard built using JBoss Dashbuilder.
- Used Spring Framework(Java) for backend coding and Hibernate for database handling(MySQL).

RESEARCH EXPERIENCE

Improving Optimization in Deep Learning - Master's Thesis

June '18 - Present

Guide : Prof. Subhasis Chaudhuri, EE Department, IIT Bombay

- Proposed a **novel randomized iterative algorithm** to detect whether a critical point (i.e. a point where the derivatives of the loss function with respect to the parameters are zero) is a local minima or a **saddle point** and to escape that point if it is a **saddle point**, without requiring to compute the **Hessian**.
- Derived an **upper bound** on the **expected number of iterations**, which is **logarithmic** with respect to the number of positive eigenvalues of the Hessian at that point and **faster than linearithmic** with respect to the inverse of the magnitude of the minimum eigenvalue of the Hessian. The **complexity wrt the minimum eigenvalue** of the Hessian is **better** than that of existing algorithms.
- Also in relation to the complexity of the proposed algorithm, obtained approximate **upper and lower bounds** for the **expected number of negative eigenvalues** of the Hessian (known as the **index**) at a point, as a function of the loss value at that point, for a single hidden layer neural network with the **cross-entropy loss function**. This is the **first attempt** at index computation for the cross-entropy loss function.
- Paper submitted to **AAAI-19**.

Sparse Kernel PCA (SKPCA) for Outlier Detection

Nov '17 - May '18

Guide : Prof. Suyash Awate, CSE Department, IIT Bombay

- Proposed a **novel SKPCA algorithm** by formulating it as a **constrained optimization problem** with **elastic net regularization** in the kernel space, solving it using **alternate minimization**. Tested it on **5 real world datasets** and showed that it **outperforms** the most recent SKPCA method with **lesser parameter tuning**.
- Also presented a **new probabilistic proof** to justify the **existence of sparse solutions** in KPCA using the RBF kernel, which is the **first attempt** in this direction.
- **Paper accepted** for **oral presentation** in **IEEE ICMLA 2018**.

Non-linear blind compressed sensing

June '18 - Present

Guide : Prof. Ajit Rajwade, CSE Department, IIT Bombay

- Working on **blind compressed sensing** (jointly estimating the sparse basis & sparse codes) under **non-linear transformations** of data to make the noise model **Gaussian**, such as the **Anscombe transform** for **Poisson measurements**. This has not been done before and is **challenging** due to the **non-linearity** and the highly **non-convex** nature of the problem.
- Using Stochastic Gradient Descent (SGD) to solve the **non-linear least squares** problem with **L1** penalty (**Lasso**) imposed for **sparsity**.
- Obtained an **upper bound** on the **expected value of the squared norm of the error** (difference between the actual signal and estimated signal) as a function of the ratio of the number of measurements to signal dimension, number of training examples and value of the squared loss part of the objective function.

Multiple Instance Learning (MIL) in Breast Cancer Histology Images

Feb '18 - Present

Guide : Prof. Amit Sethi, EE Department, IIT Bombay

- MIL is an **unsupervised learning problem** where the label of the entire image ("bag") is given and the labels of the patches ("instances") in the image are to be determined from this.
- Working on **self-supervised learning** using the proxy tasks of **colorization** and **novel gradient based segmentation** (work in progress!) to learn good **embeddings** which can be used for **deep attention based MIL**.

- Tried **Bayesian Learning** for MIL using features extracted from **auto-encoders** and obtained **results comparable to state of the art** for the **Bisque** data set. However, this method did not generalize well.

Sentence Compression Using Deep Learning

Mar '18 - May '18

Guide : Prof. Sunita Sarawagi, CSE Department, IIT Bombay

- Designed a **bi-directional 3-layer LSTM** model for **sentence compression** by modelling it as a binary classification problem (which words to retain/delete). Compared it with the method proposed in "**Sentence Compression by Deletion with LSTMs**" by **Google NLP Research** and got **marginally better results**.

Speeding up Kernel PCA (KPCA)

July '17 - Oct '17

Guide : Prof. Suyash Awate, CSE Department, IIT Bombay

- Used the **improved Nyström** method to obtain a **low rank** approximation to the Gram matrix. Using this, developed a **fast algorithm for eigenvector computation** in KPCA, **improving time complexity** from $O(n^2p)$ to $O(np^2)$, where n is the number of data points and $p \ll n$ is the rank of the approximated Gram matrix.
- Simulated the above algorithm and obtained almost a **linear speed up** over MATLAB's "eigs" function with **negligible error** in the obtained eigenvectors and eigenvalues.

KEY ACADEMIC PROJECTS

Using the Kernel Trick in Compressed Sensing

April '18 - May '18

Guide : Prof. Animesh Kumar, EE Department, IIT Bombay

- Implemented the paper "**Using the kernel trick in compressive sensing: Accurate signal recovery from fewer measurements.**" which performs **compressed sensing** in higher dimensional feature space by utilizing the **kernel trick**. The proposed method in the paper projects the data along **random Gaussian directions** and a probabilistic error bound is provided.
- Extended the method to the case of directions sampled from a **Bernoulli distribution**, thus making it more **hardware realizable**. Also provided a **theoretical proof** for this extension.

Extractive Text Summarization using Neural Networks

Sep '17 - Nov '17

Guide : Prof. Ganesh Ramakrishnan, CSE Department, IIT Bombay

- Implemented the paper "**A Simple but Tough-to-Beat Baseline for Sentence Embeddings**" and used the embeddings to select key sentences (modelled it as binary classification problem) in a document (**extractive summarization**) by **ensembling neural networks**.
- Also designed a **CNN** architecture based on the EMNLP paper "**Convolutional Neural Networks for Sentence Classification**" which further **improved results**.

Image segmentation using Grab Cut Algorithm

Feb '17 - April '17

Guide : Prof. Suyash Awate, CSE Department, IIT Bombay

- Implemented **Grab Cut** which employs Gaussian Mixture Models (**GMMs**) along with the **Graph Cut** algorithm, for interactive extraction of foreground in a complex environment with reduced user interactions.
- Simulated the algorithm on medical images in microscopy and natural images, obtaining good results.

Real Time Tracking of Non-Rigid Objects

Feb '17 - April '17

Guide : Prof. Ajit Rajwade, CSE Department, IIT Bombay

- Built a **real time object tracking model** for videos using **mean shift algorithm** with **Bhattacharya coefficient** to determine the object trajectory. It was **robust** to partial occlusion, clutter, rotation & camera position.
- The algorithm was successfully able to track humans, objects, vehicles etc. in real world videos.

Visible Light Communication(Li-Fi)

Jan '17 - April '17

Guide : Prof. Kumar Appaiah, EE Department, IIT Bombay

- Built an optical channel to transfer a **Manchester encoded** data stream synchronously.

- Used Tiva-C micro-controller to transmit encoded data, which was received by a Clock Recovery Circuit; successfully decoded and displayed on an LCD at the receiving micro-controller.
- **Synchronously** transferred encoded data at speed of **100 kbps** over a distance of **3 meters**. Also built an **asynchronous system** with a data rate of **30 kbps** over **0.5 meters** distance.

Flow Based Image Extraction

Sep '16 - Nov '16

Guide : Prof. Suyash Awate & Prof. Ajit Rajwade, CSE Department, IIT Bombay

- Implemented a non-photorealistic rendering method to give stylized effect to images.
- Applied a flow based difference of Gaussian filter for line extraction and then a flow based bilateral filter for region smoothing to produce a stylized version of natural images.

Min-cut based approach to find pathways in biological regulatory networks

Dec '15 - Jan '16

Guide : Prof. Supratik Chakraborty, CSE Department, IIT Bombay

- Worked on implementing an **efficient semi-automated approach** for finding pathways in systems biological regulatory networks using min-cuts.
- Implemented the **Gusfield algorithm** in C++ to construct the **Gomory Hu tree** of the equivalent undirected graph which was used to obtain the min-cut edges between all pairs of nodes of the graph in $O(n)$ time, instead of the naive algorithm which takes $O(n^2)$ time, thereby providing a **linear speed up**.
- Also optimized the code in terms of memory by utilizing the sparsity of the adjacency matrix.

ACADEMIC ACHIEVEMENTS

- Awarded the only **AP (Advanced Performer)** grade in **Applied Linear Algebra** for securing the highest marks and for outstanding performance in the course.
- Stood **first** overall in **Foundations of Machine Learning Course** in a batch of **170** students and was one of the **10** students in a batch of **166** students to receive an **AA** grade in Advanced Machine Learning course.
- Secured **3rd** rank overall in **IIT Bombay Mathematics Olympiad 2015**.
- Awarded **Merit Certificates** in National Standard Examination in Physics - 2014 and National Standard Examination in Chemistry - 2014 for being within **top 300** students across the country.
- Selected for **Indian National Physics Olympiad 2014** & **Indian National Chemistry Olympiad 2014**.
- Secured **All India Rank 6** in ICSE Examination 2012 amongst 0.1 million candidates.
- Received a Letter of Appreciation from the Education Minister of Maharashtra for being **top 1%** of the state in the Higher Secondary Examination 2014.
- Awarded a scholarship of **Rs 80,000 per year for five years**, for higher education under the INSPIRE scheme by the Government of Maharashtra.

RELEVANT COURSES

- **Computer Science** : Advanced Machine Learning, Advanced Image Processing, Discrete Structures, Foundations of Machine Learning, R&D Project, Computer Vision (both traditional & using Deep Learning), Algorithms for Medical Image Processing, Fundamentals of Digital Image Processing, Design & Analysis of Algorithms, Data Structures & Algorithms, Computer Networks, Computer Programming.
 - **Electrical Engineering** : Optimization*, Supervised Research Exposition, Recent Topics in Analytical Signal Processing, Wavelets, Markov Chains & Queuing Systems, Advanced Topics in Signal Processing, Estimation & Identification, Speech Processing, Applied Linear Algebra, Advanced Concentrations Inequalities, Digital Signal Processing, Probability & Random Processes, Control Systems, Microprocessors, Digital Communications, Digital Systems, Data Analysis & Interpretation, Network Theory.
 - **Mathematics** : Calculus, Linear Algebra, Complex Analysis, Differential Equations.
- * : To be finished by November 2018.

TECHNICAL SKILLS

- **Languages** : Python, MATLAB, C++/C, Java, Octave, VHDL, Arduino.
- **Deep Learning** : Keras, PyTorch, Tensorflow.
- **Others** : HTML, CSS, Javascript, L^AT_EX.

TEACHING EXPERIENCE

- Appointed as a **Teaching Assistant** (TA) for **Applied Linear Algebra** (Jun'18 - Nov'18) course taken by about **70 students** which involves **providing practice problems** and **logistical matters** like **preparation**, **invigilation** and **grading** of exams.

EXTRA CURRICULAR ACTIVITIES

- Ranked 1st among all freshmen and 2nd overall in the Maths Olympics (2014) conducted by the Maths and Physics (MnP) Club, IIT Bombay.
- Presented a poster on the mathematics of X-Ray CT images in MHRD-TEQIP-KITE workshop under the initiative of the Government of India.
- Represented my hostel at various inter hostel competitions at IIT Bombay.
- Keen interest in watching and playing cricket & football, was part of my school cricket team.
- Passionate foodie and interested in learning about new cultures.

REFERENCES

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