

RUDRAJIT DAS

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EDUCATION

Indian Institute of Technology Bombay

Dual Degree in Electrical Engineering - GPA: 9.43/10
Minor in Computer Science

Mumbai, India

Expected Graduation: May '19

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

- *Sparse Kernel PCA for Outlier Detection* [3]
Rudrajit Das, Aditya Golatkar and Suyash Awate - Oral paper in **IEEE ICMLA 2018**.
<https://arxiv.org/abs/1809.02497>
- *An Efficient Randomized Algorithm to Detect and Escape Saddle Points* [1]
Rudrajit Das and Subhasis Chaudhuri - Submitted to **AAAI 2019**.
(Manuscript available on request)
- *On the Existence of Sparse Bases for Deep Learning Kernels* [2]
Rudrajit Das and Subhasis Chaudhuri - Submitted to **AISTATS 2019**.
(Manuscript available on request)
- *iFood Challenge, FGVC Workshop, CVPR 2018*
Parth Kothari*, Arka Sadhu*, Aditya Golatkar*, **Rudrajit Das*** (* denotes equal contribution). Finished 2nd & 3rd in the public and private leaderboards respectively, with team name "Invincibles". Leaderboard link - <https://www.kaggle.com/c/ifood2018/leaderboard>. Invited to present our method at **CVPR 2018** (slides can be found [here](#)).

INTERNSHIPS

PRAIRIE Artificial Intelligence Summer School (PAISS)

Grenoble, France

Inria, NAVER LABS Europe

July '18

- One of the few **undergraduates** selected 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 Learning, etc.
- 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**, 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

Bengaluru, India

Software Engineering Intern

May '16 - July '16

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

RESEARCH EXPERIENCE

Improving Optimization in Deep Learning [1] - Master's Thesis

July '18 - Nov '18

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

- Proposed a **novel randomized algorithm** to detect and escape **saddle points** without requiring to compute the **Hessian**. Its complexity is **logarithmic** wrt the number of positive eigenvalues of the Hessian at that point and **faster than linearithmic** wrt the inverse of the magnitude of the minimum eigenvalue of the Hessian, which is **better** than that of PGD proposed in "How to escape saddle points efficiently." by Jin et al. (2017) and CNC-GD proposed in "Escaping Saddles with Stochastic Gradients." by Daneshmand et al. (2018).
- In relation to the complexity of the proposed algorithm, approximately obtained 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**. Also computed the **critical loss value** below which all critical points are **guaranteed** to be local minima. This is the **first attempt** at index computation for the cross-entropy loss function.

On the Existence of Sparse Bases for Deep Learning Kernels [2]

Aug '18 - Sep '18

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

- Derived a **probabilistic proof** to suggest the possibility of the **existence of sparse bases** for the **final layer** of binary classification networks before sigmoid (i.e. the transformed input which is linearly separable and the **kernel** being the transformation function) with the cross-entropy loss using only a few (transformed) training points. The number of training points constituting the sparse basis is much lesser than the dimension of the transformed input.
- Hypothesis supported by experimental results on 2 fully connected network and 2 CNN architectures.
- This implies that even though a large number of examples might be required to train deep learning networks, perhaps the **learnt kernel** can **generalize well** using only a **few of the training examples**.

Sparse Kernel PCA (SKPCA) for Outlier Detection [3]

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 **alternating minimization**. Tested it on **5 real world datasets** and showed that it **outperforms** the most recent SKPCA method with **lesser parameter tuning**. [Code]
- 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.

Non-linear blind compressed sensing

June '18 - Present

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

- Working on an algorithm for **non-linear blind compressed sensing** (jointly estimating the sparse basis & sparse codes) under the **Anscombe transform** (square root transform) for **Poisson measurements**.
- Obtained a **novel multiplicative update rule** (like in NMF) to maintain positivity constraints of the sparse basis and sparse codes while minimizing the objective function. Currently working on deriving an **upper bound** on the algorithm's **expected value of the squared norm of the error** (difference between the actual and estimated signal) using a Bernoulli sensing matrix.

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** with different loss functions, to learn good **embeddings** which can be used for **deep attention based MIL**. Additionally, preliminary experiments on 3 medical datasets indicate that self-supervision using the proxy task of colorization with the **MS-SSIM loss** provides a **good initialization for segmentation** which not only leads to **faster convergence** but also **lesser overfitting**. [Code]
- 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. But it did not generalize well. [Report]

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**. [Code] [Report]

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. Implemented it and obtained almost a **linear speed up** over MATLAB's "eigs" function with **negligible error** in the obtained eigenvectors and eigenvalues. [\[Code\]](#) [\[Report\]](#)

KEY ACADEMIC PROJECTS

Using the Kernel Trick in Compressed Sensing

April '18 - May '18

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

- Extended the method proposed in the paper "Using the kernel trick in compressive sensing: Accurate signal recovery from fewer measurements." to the case of directions sampled from a **Bernoulli distribution**, thus making it more **hardware realizable**. Also provided a **theoretical proof** for this extension. [\[Report\]](#) [\[Presentation\]](#)

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 a binary classification problem) in a document (**extractive summarization**) by **ensembling neural networks**. Also designed a **CNN** architecture which further **improved results**. [\[Code\]](#) [\[Report\]](#)

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 it on medical and natural images, obtaining good results. [\[Code\]](#) [\[Report\]](#)

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 and worked successfully in real world videos. [\[Code\]](#) [\[Report\]](#)

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. [\[Code\]](#)

Min-cut based approach to find pathways in 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**.

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** 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.
- Received a bronze medal & cash prize for securing **3rd** rank in **IIT Bombay Maths 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** and **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. Also 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, 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, 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.
- **Mathematics** : Calculus, Linear Algebra, Complex Analysis, Differential Equations.

TECHNICAL SKILLS

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

TEACHING EXPERIENCE

- Teaching Assistant for **Applied Linear Algebra** course taken by about **70 students** which involves providing practice problems, organizing tutorials & help sessions and the invigilation & grading of exams.

EXTRA CURRICULAR ACTIVITIES

- Ranked 1st among all freshmen & 2nd overall in Maths Olympics 2014 conducted by the 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.
- Recently started blogging about my research.
- 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

Subhasis Chaudhuri
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Ajit Rajwade
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