Shubhang Bhatnagar

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Research Interests

Machine Learning, Computer Vision, Signal Processing, Robust Explainable Algorithms

Education

Indian Institute of Technology, Bombay July '16-Present
Dual Degree (B.Tech + M.Tech) Electrical Engineering, Specializing in Signal Processing
GPA 9.77/10, Currently **Ranked 1^{st} in the batch (1/72)**
Minor in Computer Science and Engineering

Nanyang Technological University, Singapore July '19-Dec '19
GPA 4.82/5, TFLearn Funded Semester Exchange Program in Electrical Engineering

Publications

- **PAL - Pretext Based Active Learning** [paper]
  Shubhang Bhatnagar, Sachin Goyal *, Darshan Tank *, Amit Sethi
  Submitted to **The Conference on Computer Vision and Pattern Recognition(CVPR) 2021**
- **Analyzing Cross Validation in Compressed Sensing with Mixed Gaussian and Impulse Measurement Noise with L1 Errors**[paper] [supplementary]
  Shubhang Bhatnagar*, Chinmay Gurjarpadhye*, Ajit Rajwade
  Submitted to **International Conference on Acoustics, Speech, and Signal Processing (ICASSP) 2021**
- **QR Code Denoising Using Parallel Hopfield Networks** [pre-print]
  Shubhang Bhatnagar *, Ishan Bhatnagar *, Arxiv Pre print, 2018

* denotes that these authors contributed equally

Research Experience

PAL - Pretext Based Active Learning [paper] Submitted, CVPR '21

Master's Thesis, Advisor - Prof. Amit Sethi, IIT Bombay *Mar '20 – Present*

Introduction- Labelling data for deep learning is expensive, and active learning helps minimise that cost by choosing a subset of most informative unlabelled images for labelling. Most current active learning approaches rely overly on task based uncertainty, which is error prone or use diversity as a metric which is susceptible to dimensionality. We propose using self supervision to address these issues.

- Proposed a **novel technique** to predict informativeness of a sample combining supervision and self supervision using a novel function for better **reliability** and **robustness**, using the difficulty of solving the pretext task as an input
- Introduced **diversity** using a self supervised sub-querying strategy, mitigating dimensionality related disadvantages
- Outperformed current **State of the Art Active learning** techniques in a variety of experiments including noisy labeling scenarios on multiple datasets including CIFAR10, CIFAR100, SVHN and Caltech-101, setting new benchmarks

Robust Cross Validation in Compressed Sensing [paper] [supplement] Submitted, ICASSP '21

Advisor - Prof. Ajit Rajwade, IIT Bombay *March '20 – Oct '20*

Introduction- Compressive reconstruction algorithms require careful selection of parameters for optimal performance. We study the use of cross validation for tuning these parameters and providing probabilistic quality assurance for the recovered signal in absence of information about noise level and signal sparsity.

- **Proposed a novel technique** for selecting parameters using the L1 CV error and **theoretically proved** that it's use yields optimal reconstruction with high probability in presence of mixed gaussian and impulsive noise
- Derived **novel bound** on the Compressed Sensing(CS) recovery error estimate in terms of the L1 Cross Validation(CV) error which is **robust to impulsive and gaussian noise**
- Conducted extensive simulations, demonstrating that the L1 CV based strategy yields a more than **order of magnitude gain** in PSNR over traditional L2 CV based methods in presence of mixed gaussian and impulsive noise

Real Time Wireless Video Transmission Through Obstacles [report] Research Project

Advisor- Prof. Shalabh Gupta, IIT Bombay *Jan'19-May'19*

Introduction- Transmitting video in real time through obstacles like buildings using portable transmitters and receivers is a difficult, but important task. We try to develop a small, efficient system for solving this problem.

- Designed, simulated, soldered and tested PAL video transmitter and receiver modules at 400 MHz for real time exchange of video achieving a range of more than **100 m out of line of sight**
- Designed **upconverter, downcoverter, noise rejection filter and amplifiers** for increasing range of the system
- Submitted system capable of **robustly** sending and receiving video for use by **Indian Armed Forces**

Noise Tolerant QR Code Recognizer using Hopfield Network — Research Project

Advisor - Prof. Suyash Awate, IIT Bombay — *May'18-Jul'18*

Introduction- Hopfield networks are a type of recurrent neural networks used for noise tolerant associative memory, but are limited by their low memory capacity. We study their use for Robust QR code recognition.

- Implemented a **Hopfield network** in MATLAB and trained it using the Pseudo-Inverse rule for QR code denoising
- Proposed a **novel technique** to use Hopfield networks in **parallel** using the energy gradient difference around trained and false energy minima, providing a method to deal with applications requiring large storage capacity
- **Expanded capacity** of Hopfield network QR code recognition by an **order of magnitude** using proposed technique

Self Supervision for COVID-19 Detection — Research Project

Advisor - Prof. Amit Sethi, IIT Bombay — *Feb'20-June'20*

Introduction- X-Rays were a promising and more accessible alternative for detecting COVID-19. There was a shortage of annotated images for its diagnosis. We explore using Self supervision to mitigate this problem.

- Explored literature on use of Self supervision for deep learning on medical images and in computer vision
- Achieved over 90% accuracy on the COVID-Net dataset using a state of the art **contrastive self supervision** method on the CheXpert dataset with **200,000+** chest X rays, comparing favourably to ImageNet based initialization for our task.

Designing Efficient Network Caching Algorithms — Research Project

Advisor - Prof. Prasanna Chaporkar, IIT Bombay — *Jan'20-June'20*

Introduction- Most network caching algorithms are built on the premise that file popularity distributions remain static. Recent studies indicate this assumption is not accurate in the real world. We study caching algorithms considering a more realistic changing distribution model.

- Reviewed literature on performance of caching techniques including LRU, m-LRU, LRU(m) in real world scenarios
- Proposed a new **adaptive algorithm** based on LRU(m) to maximize cache hit probability by exploiting trade off between **rate of learning** current file distribution and **accuracy of learning** current file distribution

Scholastic Achievements

- Received the **Institute Award** for **academic excellence twice** for outstanding performance ('18,'20)
- Awarded the **Temasek Foundation TFLearn** fellowship for **semester exchange** (1/60 students in World) ('19)
- Awarded **AP** grade for **excellence** in computer programming (**4 /470**), **Network analysis** (10/143) ('18)
- Secured **99.66 percentile** in JEE Mains (out of **1.5 million** students) and All India Rank 1082 in JEE Advanced ('16)
- Received the **INSPIRE scholarship** by Govt of India for being in **top 1 % of class 12** board exams ('15)
- Recipient of prestigious **KVPY fellowship** awarded by Govt of India with **All India Rank 93** ('13)

Key Projects

End to End Number Plate Recognition | *Prof. Arjun Jain* (Mar'19-May'19)

- Implemented system for **detecting bounding box** and **recognising characters** of a plate, with over 92% accuracy.
- Trained the system **End to End**, backpropagating on a **single combined loss** from both the box detector and digit recognizer, over more than **250,000 images** in the **CCPD dataset**

Face Image De-Specularization | *Prof. Cham Tat Jen* (Sep'19-Dec'19)

- Reviewed and analysed issues with accurate face recognition in images with specular reflection
- Applied **transfer learning** from reflection removal domain to deal with specular reflection in face images

Music Genre Detection | *Prof. Sunita Sarawagi* (July'18-Dec'18)

- Classified music into **4 distinct genres** using their **MFC coefficients** with over 85% accuracy on GTZAN dataset
- Used **CNN** based classifier and SVM's, using bagging, boosting and other techniques performing a detailed comparison

Iris Recognition | *Prof. Suyash Awate* (July'18-Dec'18)

- Pre-processed the images using **Adaptive histogram equalization** and removed the pupil using **segmentation**
- Used **PCA** to reduce dimensionality of the data and applied **Fisher's LDA** achieving more than 97% accuracy

Designing of pipelined RISC processors | *Prof. Virendra Singh* (Oct'18-Dec'18)

- Designed and implemented **datapath and control unit** of a multicycle and a pipelined processor on an FPGA
- Implemented Turing complete **IITB-RISC** instruction set with instructions like conditional jump and store multiple
- Designed and included logic for hazard detection, data forwarding, stalling etc in the **6-stage** pipeline design

Professional Experience

Qualcomm | Modems Intern (May'19-July'19)

- Developed an automated **tool to optimise** and improve the testing process for Qualcomm chipsets, by **analysing existing data** and automating multiple tasks
- Deployed the tool on **50+ workstations** for the **modem team**, with plans to deploy in other departments too

Decimal Point Analytics Limited | Image Pulse (June'18-July'18)

- Worked on **estimating the income** of a household from pictures of the **house and furnishing** in it
- Scraped and pre processed using **BS4** and **Selenium** a dataset of household images and incomes from the web
- Designed a **convolutional neural network** for classifying the image in 16 defined income categories

Positions of Responsibility

Graduate Teaching Assistant | Complex Analysis | Communication Systems

Prof. B.K. Das and Prof. Gaurav Kasbekar, IIT Bombay (July'18- Oct'18, July'20-Present)

- Part of a **student expert team** selected for excellent communication skills and knowledge to assist the Professor
- Responsible for **taking tutorials, guiding and evaluating** the performance of a class of 40 (or 140) students

Institute Student Mentor (July'20- Present)

- Selected from a pool of 300+ applicants on basis of peer reviews and excellent **all round performance**
- Responsible for **mentoring** and **guiding** incoming batch of freshmen in academic and co-curricular endeavors

Technical Skills

- **Programming Languages**: Python, Pytorch, TensorFlow, Java, MATLAB, C, C++, HTML, CSS, LaTeX, VHDL
- **Software Packages**: NGSPICE, Quartus, AutoCad, Git, GNURadio, Selenium, Pandas

Key Courses Undertaken

Image Processing	Computer Vision, Digital Image Processing, Advanced Image Processing
Machine learning	Intro to Machine Learning, Stochastic Optimization, Advanced Signal Processing
Math and statistics	Markov chains, Calculus, Probability and Random Processes, Linear Algebra
Electrical Engineering	Microprocessors, Audio signal processing, Information security, Digital Signal Processing, Digital Communication
Computer Science	Computer Networks, Operating Systems, Data Structures and Algorithms

Extracurricular Activities

- Underwent training in swimming under **NSO** IITB, including swimming 12 km as a part of IITB swimmathon ('16)
- Served as a **Reviewer** for **Computational Aspects of Deep Learning(CADL), ICPR** ('20)
- Presented a poster on Steganography at the **MHRD-TEQIP-KITE** workshop for knowledge incubation ('19)
- Learned **Ethical Hacking** at a workshop organized by **APOGEE** BITS Pilani,Pilani ('15)
- **Represented India** in the **Young Asian Leaders** Forum for development held at NUS,Singapore ('19)
- Conceptualized and organized **cognitive** and **interactive games** for Elderly at St Luke Elder Care, Singapore ('19)

References

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