Abhijit Mahalunkar

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Research Experience

Doctoral Candidate, Technological University Dublin, Ireland. 2017–2022
Supervised by Prof. John D. Kelleher
Deep Learning, Natural Language Processing, and Language Modeling

- Developed an information theoretic approach to compute the decay of dependencies (or long distance dependencies) within the elements of the sequence datasets. Five unique decay patterns were observed across varying domains indicating varying spans and gradients of the decay.
- Developed a framework to analyze the decay of dependencies in natural language datasets and demonstrated the impact of word co-occurrences on the decay of dependence in natural language datasets.
- Developed a rigorous evaluation task to study the representational capacity of language models (LMs) by using datasets generated using artificial grammars of Strictly k-Piecewise languages.
- Compared the representational capacity of (i) Recurrent Neural Architectures (Long Short Term Memory, ASGD Weight-Dropped LSTM, and Recurrent Highway Networks) and (ii) Transformer-based Architectures (Transformer-XL) using artificially generated and natural language datasets.
- Developed a framework for interpreting the decay of dependencies within sequence datasets to inform the optimal hyper-parameter selection for language models (Dilated Recurrent Neural Networks).
- Proposed a novel neural architecture for a Large Language Model (LLM) to effectively learn the natural language. The novel neural architecture effectively learns long distance dependencies.
- Examined the relationship between the complex system properties (Zipf's, Heaps, and Taylor's Law) of natural language datasets used to evaluate language models and the language model perplexity.
- Examined the current computation methodology of the upper bound of predictability of human-mobility sequence datasets based on Fano's inequality that is widely used to corroborate the accuracy of mobility prediction models. The current method tends to overlook the presence of long distance dependencies exhibited by mobility behaviors.

Work Experience

Technical Advisor, Cyanodoc Healthcare, Goa, India Nov 2015–Dec 2017

- Designed the web application architecture of the doctor's appointment system and deployed it on Amazon AWS. Advised on developing the Android and iOS apps of patient and doctor's user interface.
- Consulted with medical experts in designing the differential diagnosis system for endocrine diseases and optimizing the probabilities of the symptoms manifesting due to the presence of a disease.

Product Architect, SpitiQ, Goa, India April 2015–July 2017

- Designed a wireless sensor node (mote) for home automation using Atmega128RFA1 microcontroller that is compliant with IEEE 802.15.4 stack and 6LoWPAN protocol. Integrated smart home sensors, i.e., temperature, humidity, light, smoke, and CO sensors, and electrical switching with the motes.
- Ported Contiki OS on the mote and set up a communication protocol via MQTT on the mote to enable communication between motes and the broker on AWS IoT Core.

Freelance Developer, Freelance Development, India Sept 2010–July 2017

- Designed a social media device using BeagleBone Black Single Board Computer (SBC) running Android OS that integrated social media with a table clock.
- Developed a control program for the Raspberry Pi to abstract the developer from the Raspberry Pi hardware while designing tasks using a programming language based on ladder logic.

Project Assistant, National Institute of Oceanography (NIO), Goa, India Nov 2010–Sept 2014

- Developed and maintained an Autonomous Underwater Vehicle (AUV-MAYA) by updating its control, navigation, and communication programs running on a Linux Single Board Computer.
- Developed a Hardware-In-Loop (HIL) Simulator for AUV-MAYA. Designed a mathematical representation of the dynamics of the AUV-MAYA and simulated navigation sensor data of the AUV-MAYA.
- Developed a communication protocol between the Autonomous Vertical Profiler (AVP) deployed in

remote locations connected via the Iridium satellite constellation and a server located in the NIO lab to transmit the status and scientific data of the AVPs. Designed a web application to display the real-time status and graphical plots of the data from the AVP.
- Developed a mission planner for AUV-MAYA that allowed the operator to plan mission paths for AUV-MAYA on Google Earth and converted them into mission files to be uploaded on AUV-MAYA.

PROJECTS

Speech Recognition System Using Spectral Maps 2015
- Speech (time-domain) represented as spectral maps (frequency-domain) using fast Fourier transform.
- Convolutional neural network classified speech signals using the generated spectral maps.

Design of Speech Synthesis System 2011
- Extracted speech parameters i.e., Mel-Frequency Cepstral Coefficients (MFCC) from phonemes.
- Constructed a database of text to phoneme lookup.
- Synthesized speech using TD-PSOLA.

Design and Implementation of an Optimized Speech Recognition System 2010
- Speech signal data features i.e., Linear Predictive Coding (LPC), Cepstral Coefficients, and Mel-Frequency Cepstral Coefficients (MFCC) were computed for the recorded speech.
- Vector Quantization (VQ) was used to create templates for matching.
- Pattern similarity of speech features was measured using Dynamic Time Warping (DTW).

TEACHING

Senior Demonstrator, Technological University Dublin, Ireland Sept 2017–June 2021
Conducted labs and tutored students in the School of Computer Science and the School of Engineering.
- Subjects: Machine Learning, Computer Networks, Operating Systems, Databases, Mobile Robotics.

Instructor, CTYI - Dublin City University, Ireland June–July 2019
Instructor of Robotics at Centre for Talented Youth Ireland (CTYI).
- Designed and delivered a course on robotics and embedded systems for high school students.

EDUCATION

Ph.D. Deep Learning, Technological University Dublin, Ireland. (exp.) 2023
Relevant Courses: Machine Learning, Deep Learning, and Algorithms & Approximation.

B.E. Electronics & Telecommunications, Goa College of Engineering, Farmagudi, Goa. 2010
Relevant Courses: Probability Theory and Random Processes, Statistics, Artificial Neural Networks, Robotics, Digital Signal Processing, Data Communication, and Control System Engineering.

SKILLS

Research: Data Collection, Statistical Analysis, and Research Design and Methodology.

Languages: C, C++, Visual C++, Python, Java, R, SQL, LabView, MATLAB, Octave, Scilab, Assembly.

Libraries: PyTorch, TensorFlow, Keras, Scikit-Learn, Pandas, Matplotlib, OpenCV, CUDA.

Tools: Anaconda, GIT, Jupyter Notebook, Eclipse, Visual Studio, Android SDK, Nokia Qt Applications.

Web Development: HTML/CSS, Django, Ruby on Rails, Node.JS, JavaScript, PHP, Go.

AWARDS

TU Dublin Scholarship to pursue a Ph.D. at Technological University Dublin, Ireland. 2019

ADAPT Auxiliary Fund to pursue a Ph.D. at Technological University Dublin, Ireland. 2019

DIT Fiosraigh Award, to pursue an MPhil at Dublin Institute of Technology, Ireland. 2017

NVIDIA GPU grant, donation of one NVIDIA TITAN Xp GPU. 2017

Travel Grant by Naver Labs August 2019
To attend the ACL 2019 workshop on Deep Learning and Formal Languages: Building Bridges.

ENNS Student Travel Grant Oct 2018
To attend the International Conference on Artificial Neural Networks (ICANN), Rhodes, Greece.

PUBLICATIONS

[1] A. Mahalunkar, J. D. Kelleher (2020). Mutual Information Decay Curves and Hyper-parameter Grid Search Design for Recurrent Neural Architectures. *The 27th International Conference on Neural Information Processing, ICONIP 2020.* doi: https://doi.org/10.1007/978-3-030-63823-8_70

[2] A. Mahalunkar, J. D. Kelleher (2019). Multi-Element Long Distance Dependencies: Using SPk Languages to Explore the Characteristics of Long-Distance Dependencies. *The Workshop on Deep Learning and Formal Languages: Building Bridges.* doi: https://aclanthology.org/W19-3904/

[3] V. Kulkarni, A. Mahalunkar, B. Garbinato, J. D. Kelleher (2019). Examining the Limits of Predictability of Human Mobility. *Entropy.* doi: https://www.mdpi.com/1099-4300/21/4/432

[4] V. Kulkarni, A. Mahalunkar, B. Garbinato, J. D. Kelleher (2019). On the Inability of Markov Models to Capture Criticality in Human Mobility. *Artificial Neural Networks and Machine Learning - ICANN 2019: Image Processing.* doi: https://doi.org/10.1007/978-3-030-30508-6_39

[5] A. Mahalunkar, J. D. Kelleher (2018). Using Regular Languages to Explore the Representational Capacity of Recurrent Neural Architectures. *Artificial Neural Networks and Machine Learning - ICANN 2018.* doi: https://doi.org/10.1007/978-3-030-01424-7_19

[6] A. Mahalunkar, J. D. Kelleher (2018). Understanding Recurrent Neural Architectures by Analyzing and Synthesizing Long Distance Dependencies in Benchmark Sequential Datasets. *arXiv e-prints.*