Abhijit Mahalunkar

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OVERVIEW

I am a skilled researcher with expertise in training and fine-tuning Language Models and modeling sequential data. My research work, complemented by hands-on experience in machine learning, positions me as a dynamic professional, bridging the gap between theoretical knowledge and practical applications.

EDUCATION

Ph.D. Deep Learning, Technological University Dublin, Ireland. (exp.) 2024
"The Complexity of Long-Distance Dependencies in Sequence Data and their Impact on the Representational Capacity and Performance of the Language Models", Supervised by Prof. John D. Kelleher

B.E. Electronics & Telecommunications, Goa College of Engineering, Farmagudi, Goa. 2010

SKILLS

Research: Data Collection, Statistical Analysis, and Research Design and Methodology.
Large Language Models: Trained and fine-tuned language models, e.g., Transformer-based, RNN-based, BERT, GPT, and XLNet (using HuggingFace libraries) on downstream tasks.
Data Processing: Examined the scaling properties of large natural language datasets.
Programming Languages: C, C++, Visual C++, Python, Java, R, SQL, LabView, MATLAB, Octave.
Libraries: PyTorch, TensorFlow, Keras, Scikit-Learn, Pandas, Matplotlib, OpenCV, CUDA.
Tools: Anaconda, GIT, Jupyter Notebook, Eclipse, Visual Studio, Android SDK, Nokia Qt Applications.

RESEARCH EXPERIENCE

Doctoral Research, Technological University Dublin, Ireland. 2017–2023
The research is centered on uncovering the limitations of Language Models (both Transformer-based and RNN-based) in effectively capturing Long-Distance Dependencies present in datasets.

- Researched to investigate Long-Distance Dependencies within large sequence datasets, identifying variations in the dependency decay patterns across different sequence datasets. Notably, discovered a broken power-law relationship in the dependency decay of natural language datasets.
- Analyzed the broken power-law dependency decay in natural language datasets, elucidating this phenomenon through an investigation of word co-occurrences within these datasets.
- Compared the representational capacity of RNN-based and Transformer-based Language models using artificial grammars, providing valuable insights into their relative strengths and weaknesses.
- Accelerated the grid-search optimization process for Language Model hyper-parameters by narrowing down the hyper-parameter space, informed by examining how different hyper-parameters are influenced by the dependency decay pattern, resulting in an improved and finely tuned model performance.
- Investigated the nuanced relationship between the scaling properties of natural language datasets and the evaluation of Language Models, offering rich insights for the enhancement of Language Models.
- Trained language models (RNN-based and Transfomer-based) using TensorFlow and PyTorch. Also, fine-tuned pre-trained Large Language Models (transformer-based) and investigated their ability to learn Long-Distance Dependencies.

WORK EXPERIENCE

Technical Consultant, Qubiseed Technologies LLP, Goa, India. Nov 2015–Dec 2017
- Developed a differential diagnosis system for endocrine diseases by consulting medical experts.
- Developed the web application architecture for the doctor's appointment system using Amazon AWS.

Co-founder & Product Architect, Spitiq, Goa, India. April 2015–July 2017
- Led and managed a team that designed wireless sensor nodes using Atmega128RFA1 microcontroller, smart home sensors, and electric switching to be integrated with a home automation system.
- Implemented activity discovery for the home automation system by processing the interleaved sensor data collected via the wireless sensor network to assist in optimal decision-making.

Technical Consultant, SmartKlock Inc., Austin, TX. Oct 2014–Oct 2015
- Led a team that developed a social media device utilizing the BeagleBone Black operating on the Android OS, seamlessly combining social media functionality with that of a table clock.

Project Assistant, National Institute of Oceanography (NIO), Goa, India. Nov 2010–Sept 2014
- A member of the team engaged in the development and deployment of the Autonomous Underwater Vehicle (AUV-MAYA) and Autonomous Vertical Profiler (AVP) for scientific ocean data collection.

- Developed a Hardware-In-Loop Simulator for AUV-MAYA to minimize the need for extensive field trials by providing a controlled laboratory environment for testing the functionality of AUV-MAYA.
- Developed a communication protocol to transmit the data between AVP and NIO server via the Iridium satellite constellation and a web app to display the real-time location of AVP and the collected data. This enabled the AVP to operate as a Lagrangian drifter, gathering ocean column data amidst the demanding conditions of the monsoon season over three months.

MACHINE LEARNING PROJECTS

Fine-Tuned a Transformer-Based LLM on Named Entity Recognition task 2023
- Dataset used: MultiNERD: A Multilingual, Multi-Genre, and Fine-Grained Dataset for Named Entity Recognition (and Disambiguation).
- Fine-tuned pre-trained BERT, DistilBERT, and XLNet LLMs on the MultiNERD dataset for Named Entity Recognition task using HuggingFace libraries.
- Compared the performance of the fine-tuned LLMs on the Named Entity Recognition task.

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

Design and Implementation of an Optimized Speech Recognition System 2010
- Computed speech signal data features, i.e., Cepstral Coefficients, and Mel-Frequency Cepstral Coefficients (MFCC), used Vector Quantization and Dynamic Time Warping (DTW) for matching.

TEACHING

Senior Demonstrator, Technological University Dublin, Ireland — Sept 2017–June 2021
- Conducted labs and tutored students in Deep Learning, Machine Learning, and Databases

Instructor, CTYI - Dublin City University, Ireland — June–July 2019
- Designed and delivered a course on robotics and embedded systems for high school students.

AWARDS & GRANTS

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

ADAPT Auxiliary Fund to enhance computational capabilities for Language Model training. — 2019

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

NVIDIA GPU grant of NVIDIA TITAN Xp GPU to enhance the computational capability. — 2017

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.*

REFERENCES

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