Abhijit Mahalunkar

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Overview

Dedicated researcher specializing in machine learning, deep learning, and natural language processing. Proven expertise in advancing the state of the art in natural language processing through innovative research and development. Extensive experience in designing, implementing, and evaluating cutting-edge LLM architectures. Published researcher with a strong track record in peer-reviewed journals and conferences. Skilled in exploring novel applications of deep learning techniques for language understanding and generation. Collaborative team player committed to pushing the boundaries of LLMs and contributing to the broader field of artificial intelligence.

Education

Ph.D. Deep Learning, Technological University Dublin, Ireland. 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.
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 focused on improving foundational models, such as Large Language Models (LLMs), and assessing their proficiency in effectively capturing long-distance dependencies within datasets.

- Investigated the complexity of long-distance dependencies within sequence datasets, leading to the discovery that the dependencies within natural language decay with a broken power-law relationship.
- Confirmed that the occurrence of a broken power-law relationship of the dependency decay is attributed to the distribution of word co-occurrences in natural language.
- Investigated the representational capacity of language models, specifically exploring Recurrent and Transformer-based architectures. Utilized datasets of artificial grammars to analyze their performance.
- Optimized the hyper-parameters of language models through an enhanced grid-search process by refining the hyper-parameter space, leading to improved performance of the language model.
- Explored the scaling properties of natural languages and their intricate relationship with the representational capacity of language models, providing valuable insights for improving language models.
- Conducted training of language models and fine-tuned pre-trained LLMs, exploring their capacity to effectively model Long-Distance Dependencies. Prepared datasets for training and fine-tuning.
- Explored the predictability of sequences and their interconnection with the compression capabilities of language models, contributing valuable insights to the explainability of language models.

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. *ACL: 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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