

M. Danyal Malik

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EDUCATION

Lahore University of Management Sciences

Bachelor of Science in Computer Science

Lahore, Pakistan

Sept 2021 – May 2025

- Current CGPA: 3.96
- Relevant Coursework: Machine Learning[†], Deep Learning[†], Dynamic Programming and Reinforcement Learning[†], Multi-Agent Systems[†], Intro to Artificial Intelligence, Data Science, Intro to Analysis I, Numerical Analysis, Linear Algebra, Probability, Statistics and Data Analysis, Intro to Differential Equations, Calculus I & II

[†] *Graduate Level Courses*

RESEARCH PROJECTS

Equilibrium Selection in Markov Routing Games

November 2024 – Present

- *Objective:* To leverage equilibrium selection techniques from game theory for the guidance of agents to the potential maximizing equilibrium in a multi-agent markov routing game setting
- Implemented baseline models for comparison: Independent Q-Learning (each agent has its own DQN) and Mean Field Deep-Q Learning (each group of agents has one DQN and the mean action of the other agents is used as input to learn the policy)
- Implemented a Deep Neural Network based approach inspired by the Unified Equilibrium Selection Framework, wherein the reward of each agent is modified to guide it to the global optimum decision
- Utilized concepts from game theory, namely Markov potential games and marginal contribution utility to modify the reward functions
- Simulated each of the algorithms, showcasing specific cases where my approach would converge to the global optimum and the others would fail
- Derived conditions for nodes' edges where the algorithm would show superior performance
- *Status:* Currently working on deriving necessary and sufficient conditions for a Markov routing game to be a Markov potential game and on reducing the computational complexity of our algorithm, aiming to submit my findings to a journal/conference in the coming months
- The preliminary implementation is available on this [repository](#).

Explainable Audio Deepfake Detection Using Multi-Modal LLMs

July 2024 – Present

- *Objective:* To leverage the advanced audio-understanding capabilities of multi-modal Large Language Models (LLMs) to provide interpretable explanations distinguishing bona fide audio from spoofed or deepfake content, thus enhancing the transparency and trustworthiness of deepfake detection systems.
- Utilized diverse datasets, including ASVSpoofer 2021, ADD 2023, and the CSaLT Urdu Deepfake Detection Dataset, to train and evaluate model performance across a wide variety of deepfake audio scenarios, covering different languages and spoofing techniques.
- Explored cutting-edge multi-modal models such as Qwen2-Audio, SALMONN, and GAMA, to assess their ability to detect deepfakes and provide detailed, explainable insights into the distinguishing acoustic and para-linguistic features between genuine and spoofed audio samples.
- Developed and tested various prompt engineering techniques to optimize the evaluation of these AudioLLM models on deepfake detection tasks, tailoring prompts to probe different aspects of audio authenticity and linguistic subtleties.
- Implemented a multi-stage pipeline, wherein the initial textual output from AudioLLMs is further processed by more sophisticated LLMs, including GPT-4 and Llama3.1, to generate comprehensive and human-interpretable explanations for the detected deepfakes. This layered approach enhances the explainability of detection results.
- Leveraged Parameter-Efficient Fine-Tuning (PEFT) methods to fine-tune the models, improving their sensitivity to subtle paralinguistic features—such as intonation, emotion, and speaker idiosyncrasies—crucial for detecting and explaining deepfakes.
- Ongoing efforts to collect additional training data are aimed at enhancing model performance on the downstream task of *explainable deepfake detection*, ensuring that models not only detect deepfakes accurately but also provide robust, interpretable justifications for their decisions.

Survey on Low-Resource Text-to-Speech (TTS) Systems

Mar 2024 – Present

- *Objective:* To investigate and document advanced strategies for developing Text-to-Speech (TTS) systems in low-resource language environments, aiming to address the challenges posed by limited data availability and improve model performance through innovative training techniques.
- Authoring a comprehensive survey paper that critically examines the effectiveness of various approaches in this domain, including the utilization of multilingual pre-trained models, training TTS systems from scratch on limited datasets, and leveraging data synthesis and augmentation techniques to enhance training quality.
- Conducting in-depth evaluations to compare the naturalness, intelligibility, and robustness of TTS systems trained using different strategies, with a focus on how these methods handle phonetic variability and linguistic nuances in low-resource languages.
- Analyzing the impact of cross-lingual transfer learning, where knowledge from high-resource languages is applied to improve performance in under-represented languages. This includes exploring the role of self-supervised learning and fine-tuning on small datasets.
- Exploring the potential of voice cloning and adaptive TTS techniques, which allow for personalized speech synthesis in low-resource languages by requiring minimal voice samples from the target language.
- Evaluating the effectiveness of synthetic data generation and augmentation methods, such as noise injection and phoneme balancing, in increasing the diversity of training data to improve the generalization of TTS models.

Urdu Chatbot for Self-Attachment Therapy (SAT)

Aug 2023 – Dec 2023

- *Objective:* To design and implement a chatbot in Urdu aimed at assisting users in Pakistan with performing Self-Attachment Therapy (SAT), a self-administered psychological technique. This initiative extends a series of similar therapeutic applications across various languages, originally developed by researchers at Imperial College London.
- In response to the sensitive nature of the therapy, the chatbot was engineered with a hybrid approach, incorporating both rule-based and classification-driven modules to enhance user comprehension. The dialogue flow was carefully structured, ensuring that users were directed toward appropriate SAT exercises in a context-aware and supportive manner.
- The chatbot's dialogue pool was built by leveraging existing iterations of the project, previously developed in Farsi, Mandarin, and English. These were translated into Urdu, followed by creative rewriting to expand dialogue variety while maintaining therapeutic integrity.
- To simulate the actual conversation, a retrieval-based system was implemented that fetched responses from the pool of Urdu utterances, based off embedding similarity with messages from the conversation. It was important to fetch fixed responses rather than rely on Language Models for generation for safety and control, owing to the sensitive nature of the task.
- *Status:* The project has been successfully handed over to subsequent students, who are currently advancing the system and preparing for an upcoming publication.

Urdu Deepfake Generation for Political Figures

May 2023 – July 2023

- *Objective:* To develop an advanced Text-to-Speech (TTS) system capable of replicating the voices of prominent Pakistani political figures in Urdu, with the goal of exploring both the potential uses and ethical implications of voice cloning technology.
- Curated a dataset by extracting audio clips from YouTube videos of political speeches. Employed Whisper for automatic transcription, followed by manual verification to ensure transcription accuracy and consistency.
- Trained state-of-the-art single-speaker and multi-speaker models, including YourTTS and VITS, to synthesize high-fidelity voice clones in Urdu for selected public figures, with a focus on capturing the unique vocal characteristics of each individual.
- Performed an in-depth analysis of the dataset, identifying and addressing various inconsistencies and quality issues, followed by comprehensive data cleaning to enhance model training and output quality.
- *Status:* The completed TTS systems were successfully integrated into a broader study aimed at combating misinformation, particularly focusing on the detection of deepfakes and spoofed audio in the sociopolitical landscape of Pakistan.

Generative Models for Synthetic Chest X-Ray Data

Apr 2023 – May 2023

- *Objective:* To employ generative models, including Progressive Growing GANs (PG-GANs) and fine-tuned Stable Diffusion models, for generating synthetic chest X-ray images to address the challenges of limited access to real-world medical imaging data, while mitigating privacy concerns and legal restrictions associated with the collection and use of sensitive patient data in medical research.

- Mitigated the scarcity of labeled medical data by synthesizing high-quality, realistic chest X-ray images, providing a valuable augmentation to existing datasets and contributing to improved performance in medical imaging tasks.
- Leveraged the publicly available Chest X-ray 14 dataset to train, validate, and rigorously evaluate the generative models using both qualitative visual assessments and quantitative performance metrics.
- Demonstrated through experimental results that the incorporation of synthetic images improves the performance of deep learning-based classification models for medical diagnosis, particularly in cases of rare or underrepresented conditions.
- Identified key areas for further refinement, including addressing model overfitting and the necessity for a broader variety of real-world data to enhance the diversity of both training and evaluation sets.
- Highlighted the transformative potential of generative models in medical diagnostics, underscoring their ability to augment data-scarce fields through synthetic image generation and facilitate advancements in deep learning applications for healthcare.
- Conducted a comparative analysis of classifier performance when trained on 100% real images versus a mixed dataset of 50% real and 50% synthetic images. The results indicated only an 8% decrease in accuracy, from 81% to 73%, demonstrating the viability of incorporating synthetic data for medical image classification tasks.
- Further details can be found in the paper [here](#).

Urdu Text-to-Speech (TTS)

Jan 2023 – Apr 2023

- *Objective:* To develop and rigorously assess state-of-the-art Urdu Text-to-Speech models, with a focus on enhancing the naturalness, emotional expressiveness, and overall clarity of synthesized speech.
- Successfully trained multiple advanced TTS architectures, including FastSpeech2, VITS, and yourTTS, leveraging an extensive corpus of Urdu speech data previously curated within the lab. These models were evaluated for their ability to generate high-quality, natural-sounding speech.
- Devised a comprehensive evaluation strategy by meticulously selecting a diverse set of sentences designed to cover a wide range of phonemes. This ensured robust and meaningful human evaluation of model outputs across various speech dimensions.

EXPERIENCE

Senior Lab Lead

Jun 2024 - Present

Center for Speech and Language Technologies (CSaLT) | Led by Dr Agha Ali Raza

Lahore, Pakistan

- Managing 20 students carrying out their SProj and 27 students carrying out Directed Research Projects (DRPs)
- Handling the logistics of the laboratory, such as equipment, website, file management, communication channels etc
- Overseeing all the projects (students' own and externally funded) and tracking every individual's contribution toward their projects
- Details of my own research projects during this time are mentioned in the Research Projects section.

Teaching Assistant - CS535 Machine Learning

Sept 2024 – Present

Lahore University of Management Sciences

Lahore, Pakistan

- Designing and grading course material such as quizzes, assignments, questions for final exam etc.
- Solely responsible for designing the first research assignment for both sections.
- Over 250 students across the two sections.
- Graduate-Level course.

Teaching Assistant - CS5302 Generative AI

Jan 2024 – May 2024

Lahore University of Management Sciences

Lahore, Pakistan

- Designed this course as the first of its kind in LUMS, intended to educate students on the foundations of Generative Artificial Intelligence covering topics including but not limited to: Transformers, Large Language Models, Training and Finetuning mechanisms, Prompt Engineering, RAG and Vector Databases, Quantization and other aspects of Efficient Deep Learning.
- Managed all questions and assignments related to topics in linguistics such as morphology and related them to modern NLP to teach students how these concepts can affect models today.
- Designed and graded course material such as quizzes, assignments, questions for the final exam, etc.
- Over 130 students were enrolled.
- Graduate-Level course.

Junior Lab Lead

Jun 2023 - May 2024

Center for Speech and Language Technologies (CSaLT)

Lahore, Pakistan

- Managed 30+ students involved in research projects, divided into teams for each project
- Handled the complete redesign and maintenance of the lab's website
- Assisted the senior lab leads in handling SProj students, DRPs and more.
- Details of my own research projects during this time are mentioned in the Research Projects section.

Teaching Assistant - CS202 Data Structures

Sept 2023 – Dec 2023

Lahore University of Management Sciences

Lahore, Pakistan

- Designed and graded course material such as quizzes, assignments, questions for the final exam, etc.
- Designed a lecture introducing students to recursion and teaching them how to solve problems recursively.
[Link to slides](#)
- Over 70 students were enrolled.

Junior Machine Learning Engineer

May 2023 – Sept 2023

ISSM.AI

Islamabad, Pakistan (Remote)

- Prepared a survey of the current landscape of Document-Understanding models for the purpose of extracting Invoice Numbers from receipts
- Designed and implemented an annotation pipeline to label a custom dataset consisting of 60,000 datapoints, facilitating the training of an OCR model.
- Designed a pipeline to extract Invoice Numbers from the detection of QR Codes, and written text using OCR, within receipts.
- Helped rewrite the source code for existing tools to train custom Text Detection and Recognition models for the private dataset mentioned above.
- Improved the pipeline by optimizing the final models on Intel CPUs, using ONNX and OpenVINO, dropping the latency per image from 1700ms to 350ms, with 0.83 Recall and 0.8142 Precision.

Research Intern

Jan 2023 - Jun 2023

Center for Speech and Language Technologies (CSaLT)

Lahore, Pakistan

- Details of my research projects during this time are mentioned in the Research Projects section.

Information Technology Intern

Jun 2022 – July 2022

Reckitt

Dubai, UAE (Remote)

- Conducted in-depth analysis of sales data to evaluate the effectiveness of various promotional strategies in driving sales growth, providing actionable insights for marketing and sales teams.
- Applied regression models to forecast sales volumes across different pricing strategies, offering data-driven recommendations to optimize product pricing and maximize revenue.
- Explored deep learning techniques for predicting future sales trends, summarizing findings and proposing new approaches to enhance predictive accuracy in sales forecasting.

PROJECTS

Neural Temporal Difference Learning for 3D Tic-Tac-Toe

Nov 2023 – Dec 2023

- *Objective:* Implemented Neural Networks (NNs) as function approximators to perform temporal difference (TD) learning in a 3D TicTacToe environment (4x4x4 grid), aimed at learning optimal strategies via self-play.
- Developed value iteration algorithms for 3x3 TicTacToe, demonstrating classical dynamic programming techniques for smaller state spaces.
- Implemented Q-learning on a 4x4 TicTacToe grid, leveraging reinforcement learning to optimize decision-making by updating state-action value functions.
- Utilized NNs for approximating value functions in the 4x4x4 TicTacToe environment, handling the larger state space more efficiently compared to traditional algorithms.
- For more details, visit the [repository](#).

Language Models for Content Moderation

Nov 2023 – Dec 2023

- *Objective:* To implement and compare different machine learning models for detecting and classifying toxic content in online comments, sourced from Kaggle's Jigsaw Comment Classification dataset.
- Explored three distinct approaches for toxicity classification: Long Short-Term Memory (LSTM), pre-trained Encoder Transformers (BERT), and Large Language Models (LLaMA-2), each evaluated on multiple performance metrics such as accuracy, F1 score, and ROC AUC.

- Developed an LSTM model with text preprocessing techniques, including tokenization, sequence padding, and text cleaning, achieving notable performance in toxicity detection by capturing long-range dependencies in language data.
- Fine-tuned BERT to capture the semantic meaning of comments through self-attention scores, improving performance by leveraging the pre-trained model's ability to understand the context in text.
- Experimented with LLaMA-2 for fine-tuning on the toxicity classification task, utilizing its efficiency in multi-label classification with reduced data requirements, yielding strong results in comparison to traditional models.
- Compared model outputs and their ability to detect toxic language across different classes, highlighting challenges such as class imbalance and strategies for improving model robustness in future work.

Deep Q Learning vs Snake Game

Jun 2022 – July 2022

- *Objective:* Developed a Snake game clone featuring a self-learning AI mode powered by reinforcement learning, utilizing Deep Q-Learning to enable the agent to autonomously learn and master the game.
- Implemented the DQN using PyTorch, allowing the AI agent to improve its gameplay through iterative training and self-play, learning optimal strategies by balancing exploration and exploitation.
- Designed a single-player mode to challenge human players, providing an opportunity to compare player performance against the AI's evolving skill set.
- Evaluated the AI's performance by comparing its gameplay strategies over multiple training episodes, demonstrating the effectiveness of Deep Q-Learning in mastering a classic game environment.
- For more details, visit the [repository](#).

TECHNICAL SKILLS

Languages: Python, C/C++, JavaScript, TypeScript, HTML/CSS, Haskell

Frameworks: React, Node.js, Flask, Django, WordPress

Developer Tools: Git, Docker, Google Cloud Platform, Google Colab, VS Code, Visual Studio

Libraries: Pandas, NumPy, Matplotlib, PyTorch, TensorFlow, HuggingFace, Sci-kit Learn

VOLUNTEERING

IT Assistant Director

Jun 2022 – Jun 2023

IEEE LUMS Student Chapter

Lahore, Pakistan

- Designed several webpages using HTML, CSS and Javascript
- Led a 10-member team to design and develop websites efficiently
- Converted the pre-existing Wordpress webpages to HTML and CSS
- Conducted workshops teaching HTML and CSS to new inductees

IT Department Member

Sept 2021 – May 2023

SPADES (Society for Promotion And Development of Engineering and Science)

Lahore, Pakistan

- Designed webpages using HTML, CSS and Bootstrap for notable events such as PsiFi, resulting in an increase in web traffic for the event

ACHIEVEMENTS

- Dean's Honour List (LUMS) 2022-24.
- Top 10 in batch ranking: 2022-24 (50% merit scholarship).
- Chevron International Reach Scholarship 2021-25.
- 99th Percentile in SAT.
- KGX (Cybernetics Competition): Glitch n Grind Winner, Turing's Construct Winner, Overall Winner
- Epsilon Science Olympiad: Skeptical Chemist Winner