

Ghulam Mustafa

PhD Researcher in Computer Science and Engineering
Gamma-Ray Astrophysics, COSI Data Analysis, and Scientific Machine Learning
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Research Profile

PhD researcher working at the intersection of **gamma-ray astrophysics**, **scientific data analysis**, and **machine learning**. My research contributes to NASA's **Compton Spectrometer and Imager (COSI)** mission, a space-based gamma-ray telescope designed to study the MeV sky. My work focuses on gamma-ray burst detection and localization, Compton event reconstruction, detector simulation, background and light-curve analysis, event selection, and scientific pipeline development. A major part of my research is the calculation and analysis of the **Angular Resolution Measure (ARM)** for evaluating the directional and imaging performance of Compton telescopes.

Research Interests

Gamma-ray astrophysics; gamma-ray bursts; MeV astronomy; Compton telescopes; COSI data analysis; ARM analysis; transient detection and localization; detector simulation; scientific machine learning; deep learning; HEALPix-based sky analysis; uncertainty estimation; continual learning; domain adaptation; and astronomical time-series analysis.

Education

PhD in Computer Science and Engineering *November 2024 – Present*
University of Bologna, Italy
Expected completion: 2027. Supervisor: Prof. Claudio Sartori. Research focus: machine learning and data analysis for gamma-ray astrophysics, COSI GRB localization, event reconstruction, detector simulation, and ARM analysis.

M.S. in Computer and Electronic Convergence Engineering *March 2022 – February 2024*
Sun Moon University, South Korea
GPA: 4.4/4.5. Supervisor: Prof. Youngsup Hwang. Thesis: *Bus Travel Time Prediction in Cheonan City Using Deep Learning with Digital Tachograph Data.*

Exchange Program in Computer Engineering *February 2020 – July 2020*
Karabuk University, Türkiye
International academic and cultural exchange semester.

B.S. in Computer Science *January 2017 – January 2021*
Quaid-e-Awam University of Engineering, Science and Technology, Pakistan
GPA: 3.74/4.0. Thesis: *Application of Drone Surveillance for Advanced Agriculture Monitoring Using Convolutional Neural Networks.*

Research and Academic Experience

PhD Researcher – COSI Gamma-Ray Data Analysis *November 2024 – Present*
University of Bologna, Italy

- Conduct research on GRB detection and localization for NASA's COSI mission using computational astrophysics and machine learning.
- Develop COSI analysis workflows using **COSIpy**, **COSIMA**, **REVAN**, **Mimrec**, **HEALPix**, and **Fermi-GBM TTE data**.
- Compute and analyze ARM distributions to evaluate directional resolution, event selection, and Compton imaging performance.
- Contribute to the development and testing of an **ARMSelector** for the COSIpy event-selection framework.

- Develop pipelines for detector simulation, event reconstruction, light-curve generation, background analysis, and GRB localization.
- Analyze GRB populations using detector selection, peak-rate thresholds, saturation review, and duration-based comparisons.

Lecturer – Artificial Intelligence

August 2024 – Present

Faculty of Emerging Sciences and Technology, Aror University, Pakistan

Currently on study leave. Taught and supported courses in computing, artificial intelligence, machine learning, and deep learning. Supervised student projects and provided research and programming guidance.

Machine Learning Instructor

November 2025 – February 2026

Bologna Business School, University of Bologna, Italy

Conducted practical machine-learning laboratories, Python programming sessions, model evaluation exercises, and applied data-science projects.

Research Mobility and Collaboration

Visiting PhD Researcher

September 2026 – November 2026

Institute of Physics, Johannes Gutenberg University Mainz, Germany

Project: *Advanced Machine Learning for Transient Detection and Localization for the COSI Space Mission.*

Research Visit – COSI Simulation and Analysis

June 2026

Italian Space Agency, Rome, Italy

Participated in activities related to COSI GRB simulation, detector response, event reconstruction, and scientific data-analysis workflows.

Publications

Journal Articles

1. F. H. Dahri, **G. Mustafa**, A. Khowaja, A. K. Jumani, V. V. Estrela, and A. A. Laghari, “Advancing Cervical Cancer Classification Through a Fusion of CNN and Vision Transformer Models,” *International Journal of Imaging Systems and Technology*, vol. 36, no. 3, 2026.
2. N. Parmiggiani et al., including **G. Mustafa**, “COSI Short Gamma-Ray Burst Localization Using BGO Shield Data,” *The Astrophysical Journal*, vol. 997, no. 2, article 135, 2026.
3. **G. Mustafa**, Y. Hwang, and S.-J. Cho, “Predicting Bus Travel Time in Cheonan City through Deep Learning Utilizing Digital Tachograph Data,” *Electronics*, vol. 13, no. 9, article 1771, 2024.
4. **G. Mustafa**, S.-J. Cho, and Y. Hwang, “TrafficNet: A Hybrid CNN-FNN Model for Analysis of Traffic Accidents in Seoul,” *Journal of Computing Science and Engineering*, vol. 17, no. 4, pp. 182–194, 2023.
5. S. A. Shah, **G. Mustafa**, H. A. Keerio, M. N. Sattar, G. Hussain, M. Mehdi, R. B. Vistro, E. A. Mahmoud, and H. O. Elansary, “Application of Drone Surveillance for Advance Agriculture Monitoring by Android Application Using Convolution Neural Network,” *Agronomy*, vol. 13, no. 7, article 1764, 2023.
6. F. H. Dahri, **G. Mustafa**, and U. Dahri, “Automatic Face Mask Detection and Recognition Using Deep Learning,” *International Journal of Scientific & Engineering Research*, vol. 13, no. 11, 2022.

Conference Papers and Proceedings

1. N. Parmiggiani et al., including **G. Mustafa**, “Localization and Confidence Region Estimation of Short GRBs with the COSI BGO Shield Using a HEALPix-Based Deep Learning Approach,” *Proceedings of the ADASS XXXV Conference*, ASP Conference Series, to appear, 2026.
2. **G. Mustafa**, C. Sartori, A. Hyder, A. Anwer, M. Adnan, A. Magsi, and M. Younis, “SmartSafetyNet: A Hybrid Deep Learning Model for Predicting Traffic Accident Severity and Enhancing Road Safety Measures,” *2025 International Conference on Electrical, Communication and Computer Engineering*, 2025.
3. **G. Mustafa**, S.-J. Cho, and Y. Hwang, “Hybrid ConvLSTM with Attention for Precise Driver Behavior Classification,” *2023 IEEE Sixth International Conference on Artificial Intelligence and Knowledge Engineering*, 2023.

Technical Skills

Programming	Python, C, C++, Java, SQL, and JavaScript.
Gamma-Ray Analysis	COSIpy, COSIMA, REVAN, Mimrec, HEALPix, Fermi-GBM TTE analysis, Compton reconstruction, ARM analysis, detector simulation, background analysis, and light curves.
Machine Learning	Deep learning, scientific machine learning, classification, localization, continual learning, domain adaptation, and uncertainty estimation.
Tools	Linux, Git, GitHub, Jupyter Notebook, MySQL, SQLite, NetworkX, and SUMO.

Awards and Honors

- Professor's Research Scholarship, Sun Moon University, supported by the National Research Foundation of Korea.
- Silver Medal and third position in the Faculty of Computer Science at QUEST, Pakistan.
- Second position in the undergraduate final-year project competition.
- Selected for an international exchange semester at Karabuk University.

Languages

English: IELTS overall band 7.0. **Korean:** Basic proficiency.

References

Prof. Claudio Sartori
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Dr. Andrea Bulgarelli
INAF–OAS Bologna, Italy
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Dr. Nicolò Parmiggiani
INAF–OAS Bologna, Italy
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