A Hybrid Approach to Phishing URL Detection using Bidirectional LSTM and Evolutionary–Spider Wasp Optimization

Indu Singh*, Ayush Srivastava*, Arjun Vir Vashisht*, Karan*, Md Anas*

**Department of Computer Science and Engineering, Delhi Technological University, New Delhi, India*

indusingh@dtu.ac.in, srivastavaayush.1611@gmail.com, arjunvirvashisht@gmail.com, karan1611177@gmail.com, md02anas02@gmail.com

***Abstract*—Phishing attacks are a major cybersecurity threat, often relying on misleading URLs to deceive users into sharing confidential information. This research introduces an innovative hybrid approach for detecting phishing URLs, combining deep learning techniques for extracting temporal features with advanced metaheuristic optimization strategies. The proposed method initiates with a robust multi-stage feature selection strategy, which includes mutual information filtering, recursive feature elimination, model-driven importance ranking, and pruning based on feature correlation. This ensures that only the most significant and non-overlapping features are chosen for the subsequent learning process. A Bidirectional Long Short-Term Memory (BiLSTM) network is then applied to extract deep temporal representations from the preprocessed feature vectors. These temporal embeddings are subsequently fed into a Support Vector Machine (SVM) classifier to perform the final prediction. To improve classification accuracy, we introduce a hybrid metaheuristic approach, hEVOSWO, that combines Evolutionary Optimization (EVO) and Spider Wasp Optimization (SWO). This approach simultaneously optimizes feature selection and SVM hyperparameters, enabling efficient exploration and fine-tuning within the search space. Experimental results on the benchmark ISCX-URL2016 dataset demonstrate that our proposed approach achieves an accuracy of 97.31%, a precision of 97.42%, a recall of 97.18%, and an F1-score of 97.30%. The findings confirm the efficiency and robustness of the proposed framework, highlighting its potential for advancing resilient phishing detection systems.**

***Keywords*—Phishing Detection, Bi-LSTM, Metaheuristic Optimization, Evolutionary Algorithm, Spider-Wasp Algorithm**

Dr. Indu Singh is currently working as Assistant Professor in Computer Science Engineering Department at Delhi Technological University, Delhi, India. Singh has received her B.Tech in 2010 in Computer Science Engineering and M.Tech degree in Information Security from Ambedkar Institute of Technology, Govt. of NCT Delhi in 2012. She has done PhD in Computer Science & Engineering (CSE) from Delhi Technological University (DTU, Delhi) with specialization in Data Mining and Information Security in 2023. Her research interests include Database Systems, Data Mining, Information Security, Machine Learning, Fuzzy systems, Biometrics Recognition and Metaheuristic Optimization. She has published 48 research papers in reputed International Journals and conferences of IEEE, Elsevier, Springer and ACM. She has received IEEE Best Paper Award in ICACCI-2016. Singh is also serving as a reviewer for various SCI Indexed Journals including IEEE Transactions on Evolutionary Computation, Journal of Information Security and Applications (Elsevier), Computers in Biology and Medicine (Elsevier), Computers and Electrical Engineering (Elsevier), Biomedical Signal Processing and Control (Elsevier), Soft Computing Journal (Springer), Cluster Computing Journal (Springer) and various International Conferences of Elsevier, Springer and IEEE. She is also a member of IEEE.

Ayush Srivastava received the B.Tech degree in Computer Science and Engineering from Delhi Technological University (Formerly DCE), Delhi, India. He is currently working at Lambdatest company as a Software Developer. His current research interests include Database Security, Machine Learning, Natural Language Processing, and Deep Learning.

Arjun Vir Vashisht is a final-year B.Tech. student in Computer Science and Engineering at Delhi Technological University (formerly DCE), Delhi, India. His primary research interests span Machine Learning, Artificial Intelligence, Deep Learning, Metaheuristic Optimization, and Database Security. His recent work on a novel Database Intrusion Detection System was accepted and presented at the IEEE ICCE–Berlin 2025, Germany conference. In 2025, he also completed a research internship at IIIT Naya Raipur, where he worked on user authentication using keystroke dynamics.

Karan is currently pursuing the B.Tech. degree in Computer Science and Engineering from Delhi Technological University (Formerly DCE), Delhi, India. He is a third-year undergraduate student with a strong academic interest in cyber security, machine learning, and deep learning–based threat detection systems.

Md Anas is a final-year B.Tech student in Computer Science and Engineering at Delhi Technological University (formerly DCE), Delhi, India. His research interests include Cybersecurity, Artificial Intelligence, Deep Learning, and Metaheuristic Optimization. In 2025, he gained industry experience as a Software Engineering Intern at Infosys.