Faculty of Computing
Sabaragamuwa University of Sri Lanka

# ComURS2026

## COMPUTING UNDERGRADUATE RESEARCH SYMPOSIUM

"Next-Gen Solutions for a Digitally Connected World"

# ABSTRACTS

**28th of January 2026**

Faculty of Computing,
Sabaragamuwa University of Sri Lanka

# ComURS2026

Computing Undergraduate Research Symposium 2026

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The Computing Undergraduate Research Symposium 2026 (ComURS2026), organized by the Faculty of Computing, Sabaragamuwa University of Sri Lanka, aims to provide a platform for university undergraduates to showcase their research findings and foster a culture of scholarly engagement among talented students. Building on the success of the inaugural event, ComURS2026 will mark the Third Computing Undergraduate Research Symposium of the Faculty. The symposium is scheduled to be held as a one-day physical event on the 28th of January 2026, under the theme, ***"Next-Gen Solutions for a Digitally Connected World."***



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## Message From Director, Center For Research And Knowledge Dissemination (CRKD)

It is with great pleasure that I extend my warmest greetings to all participants of the Computing Undergraduate Research Symposium (ComURS2026), organized by the Faculty of Computing, Sabaragamuwa University of Sri Lanka, under the theme “Next-Gen Solutions for a Digitally Connected World".

As the Director of the Centre for Research and Knowledge Dissemination (CRKD-SUSL), I am deeply committed to fostering a vibrant research culture within our university and creating platforms for knowledge sharing that benefit both the academic community and society at large. ComURS2026 exemplifies this mission, providing our undergraduate students with an exceptional opportunity to present their innovative research and engage with peers, academics, and industry experts. The theme of this year’s symposium resonates strongly with the evolving technological landscape. In an era where digital connectivity shapes every aspect of our lives, the role of computing research in developing solutions that address real-world challenges has never been more critical. The research presented across the four tracks; Information Systems, Software Engineering, Data Science, and Open Computing will showcase the creativity, technical competence, and problem-solving abilities of our young researchers. Undergraduate research is fundamental to developing critical thinking and a spirit of inquiry among students. It bridges the gap between theoretical knowledge and practical application, preparing students to become future leaders and innovators. Events like ComURS celebrate student achievements and contribute to building a strong foundation for advanced research and national development.

I commend the Faculty of Computing for its unwavering commitment to nurturing research excellence. My sincere appreciation goes to the Dean of the Faculty of Computing, the organizing committee, supervisors, reviewers, evaluators, and all contributors whose support has been invaluable in ensuring the success of this event. To all presenters, embrace this opportunity to share your findings and learn from your peers. Your research contributions today are the building blocks for tomorrow’s technological innovations. I wish ComURS2026 every success and look forward to witnessing the innovative solutions our students have developed.

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## Message from the Dean of the Faculty of Computing

It brings me immense pride to welcome you to the third edition of the Computing Undergraduate Research Symposium (ComURS2026), organized by the Faculty of Computing, Sabaragamuwa University of Sri Lanka. This year's theme, **"Next-Gen Solutions for a Digitally Connected World"**, reflects our commitment to developing innovative technologies that address the challenges of an increasingly interconnected global society. As we advance into an era defined by digital transformation, our students continue to demonstrate exceptional creativity and technical excellence in bridging technology with real-world impact.

ComURS2026 provides an invaluable platform for our undergraduates to showcase their research across four key computing domains: Information Systems, Software Engineering, Data Science, and Open Computing. This symposium enables students to present their findings, engage in meaningful academic discourse, and collaborate with peers, faculty, and industry experts. Since the inaugural ComURS in 2024, we have witnessed remarkable growth in both the quality and scope of undergraduate research at our faculty. What began as an ambitious initiative has now evolved into a cornerstone event that defines our research culture. Our students are no longer simply learning about computing; they are actively contributing to it through innovative solutions that address both local challenges and global opportunities. The Faculty of Computing has consistently fostered academic excellence through comprehensive mentorship programs, state-of-the-art research facilities, and strategic industry partnerships.

Our students and facultymembers have made significant contributions through publications in reputed journals, presentations at national and international conferences, and participation in research initiatives that advance the field of computing. I extend my sincere gratitude to the Vice-Chancellor of Sabaragamuwa University of Sri Lanka for continued support. My heartfelt appreciation goes to the Evaluators, Heads of Departments, faculty members, and all stakeholders who have contributed to our vibrant research ecosystem.

Special recognition is due to the organizing committee of ComURS2026 for their exceptional dedication and tireless efforts in ensuring the success of this symposium. To all participants, I extend my warmest wishes as you present your innovative research. May this symposium inspire groundbreaking ideas and contribute significantly to the advancement of computing in our digitally connected world.

Prof. S. Vasanthapriyan
Dean
Faculty of Computing
Sabaragamuwa University of Sri Lanka

## Message from the Symposium Chair of ComURS2026

Over the years, ComURS has grown into a distinguished platform that highlights the research potential of undergraduate students and their meaningful contributions to the field of computing. This year the third edition of the Computing Undergraduate Research Symposium (ComURS2026) is held under the theme **"Next-Gen Solutions for a Digitally Connected World."** This theme reflects our continued commitment to leveraging emerging technologies to address contemporary challenges and to develop innovative solutions for an increasingly interconnected global society. ComURS2026 brings together undergraduates, academics, and industry professionals to share knowledge, explore cutting-edge research, and foster collaborative engagement. The symposium provides an invaluable opportunity for undergraduate researchers to present their work, receive constructive feedback, and further develop their scholarly and professional skills in preparation for future academic and industry endeavors.

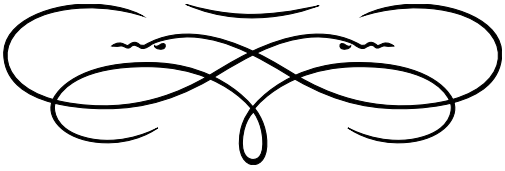
This year's symposium features research presentations across four tracks: Information Systems, Software Engineering, Data Science, and an Open Track. Best Presenter Awards will be conferred in each track to recognize outstanding research contributions, celebrating the innovation, dedication, and academic excellence demonstrated by our students.

I extend my sincere gratitude to the Vice-Chancellor of Sabaragamuwa University of Sri Lanka, the Dean of the Faculty of Computing, Heads of Departments, and all academic and non-academic staff for their unwavering support. I also wish to acknowledge the invaluable contributions of the Advisory Panel, Abstract Reviewers, Evaluation Panel Members, and volunteers, whose dedication has been instrumental in the successful organization of this symposium.

Mr. G.A.C.A. Herath
Symposium Chair
ComURS2026

# INFORMATION SYSTEMS

TRACK



Proceedings of ComURS 2026

# Exploring Financial Literacy Gaps and Business Analysis-Driven Strategies for Enhancing User Engagement in PFM Apps in Sri Lanka

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Personal Finance Management (PFM) applications are being marketed all over the world to enhance budgeting, savings discipline, and financial inclusion. Nevertheless, the penetration of advanced PFM features in Sri Lanka remains low despite the high ownership of smartphones. This paper analyses the major impediments affecting PFM app adoption (Dependent Variable) and offers Business Analysis-based solutions to facilitate greater adoption. A web-based questionnaire was created in a stratified fashion ($n = 421$). Six theoretically based constructs were measured: Low Financial Literacy, Low Feature Awareness, Low Usability, Lack of Trust, Cultural and Behavioral Habits, and Limited Support and Guidance. The reliability results indicated good internal consistency (Cronbach's $\alpha = 0.760$ to 0.941). Principal Axis Factoring (Exploratory Factor Analysis; Promax rotation) results showed that sampling adequacy was reached (KMO = .888; Bartlett $p < .001$) and yielded five factors that explained 60.3 percent of variance. Usability was interrelated with guidance, language, interface clarity, and support-related items, indicating that users perceive direction, language, and interface clarity as one construct. The final model was selected as containing five empirically validated predictors. The multiple regression analysis indicated that the predictors explained 74 percent of the PFM app adoption variance ($R^2 = .74$). The most important negative predictors were trust and security issues, along with usability problems. Cultural propensities towards cash and passbook-related financial behaviors hindered usage, but greater awareness towards features enhanced the chances of using PFM. The paper suggests an integrated approach that would include simplified and localized interfaces, onboarding, culturally sensitive features including community savings tracking and open-line security communication. Business Analysis strategies, such as stakeholder mapping, user-story development and repetitive usability testing are hypothesized to translate these findings into applicable developer, financial, and policy improvements.

***Keywords:*** *Business Analysis, Financial Literacy, Personal Finance Management (PFM), User Engagement*

# Work-life balance and job satisfaction among female IT professionals in Sri Lanka's technology sector

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The number of women in the technology field in Sri Lanka is on the rise, but women in technical jobs complain of struggling to have a balance of work and life (WLB) as they strive to meet the demands of high performance and household women. This paper will look at the predictability of perceived WLB on job satisfaction among female IT professionals in Sri Lanka in response to the paucity of local evidence that is specific to women in technical roles. A cross-sectional survey, conducted online was quantitative and involved 115 female IT professionals working in various fields. WLB and job satisfaction were measured by validated Likert-scale questions. Due to the composite scores, simple linear regression (job satisfaction as the dependent variable) were to be used in order to analyze them. The correlation between WLB and the satisfaction with the job was moderate and positive ($r = 0.512$, $p < 0.001$). In regression analysis, the results show that WLB is a significant predictor of job satisfaction ($b_1 = 0.744$, $SE = 0.118$, $t = 6.335$, $p < 0.001$) with 26.2% of the variance ($R^2 = 0.262$, Adjusted $R^2 = 0.256$). Results of this sample indicate that the enhancement of the working expectations, and conducive flexibility can become the source of improved job satisfaction of women in Sri Lankan IT environments. To illustrate this point, a simple predictive model (linear regression) was fitted to learn job satisfaction based on WLB; performance on the test was moderate ($R^2 = 0.18$), suggesting that more organizational and personal predictors would probably be required.

***Keywords:*** *Career Growth, Female IT Professionals, Job Satisfaction, Sri Lanka, Work-Life Balance.*

# Cross-Modal Predictive Modeling of Mental Health Treatment Outcomes: A Machine Learning Framework for Comparing Psychiatric Counseling Therapy and Therapeutic AI-Chatbots

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Mental health problems are becoming the order of the day and burdening the traditional psychiatric guidance frameworks in terms of expenses, unreachability and waiting durations. Conversely, mental health chatbots that are based on AI have become popular because of their anonymity, 24/7, and low cost. Although both traditional counseling and chatbot approaches have feasible advantages, no standard way of operating has been established to compare the efficacy of the two with individual patients. This has been a barrier to the use of individualized mental health interventions. The paper examines the application of machine learning and in this case, the Random Forest algorithm to predict and compare the results of conventional therapy and AI chatbot assistance. Available references define the major signs of treatment success and provide an overview of the benefits and shortcomings of chatbot interventions, yet no model exists to evaluate how people can react to the alternative medium. To solve this, a random forest model was created using data on clinical therapy outcome and the results were used on the data of chatbot users to forecast possible outcomes. The reported chatbot outcomes were compared statistically and through the qualitative feedback with the expected therapy outcomes. The research will establish personal characteristics that relate to increased benefits in either form of therapy. The expected outcomes will be used in clinical decision making, enhancement of digital mental health tools and help in choosing the most appropriate treatment.

***Keywords:*** *Mental health, Personalized decision making, Predictive analytics, Comparative treatment evaluation, AI chatbots*

# Deepfake Image and Video Detection System for Sri Lankan Facial Features Using Machine Learning

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Deepfakes and other AI-generated manipulated images and videos have become an increasing cyber threat to Sri Lanka as AI-generated multimedia content becomes more accessible to consumers. Global AI-generated multimedia datasets used in global deepfake detection models do not include sufficient representation of Sri Lankan characteristics including: darker/mixed brown skin tone; South Asian facial structure; ethnic diversity (Sinhalese, Tamil, Muslim, Burgher); traditional clothing; and lighting found in a variety of local environments. Therefore, many international deep fake detection systems are either fail to accurately identify manipulated images of Sri Lankan faces, or fail when detecting low resolution video content captured on mobile devices that are commonly used in Sri Lanka. A system designed to detect deep faked images and videos of Sri Lankan faces is presented in this research. The system uses a CNN-based image forensic model in combination with frequency domain-based artifact analysis and landmark consistency checks to evaluate each image submitted by a user. Additionally, the system also analyzes video submissions for deep fakes by extracting frames from the input video and evaluating each frame individually using the trained image model. Finally, the results from each individual frame are aggregated into an overall decision regarding the authenticity of the video submission. A custom dataset was developed for the purposes of training the system's models, which focuses on a variety of aspects of Sri Lankan skin tones, facial structures, cultural elements, and environmental factors.

***Keywords:*** *Deep Fake Detection, Frame Extraction, Machine Learning, Sri Lankan Faces, Video Forensic Analysis*

# Explainable Artificial Intelligence Approaches in NLP-Based Text Classification: A Systematic Literature Review

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Artificial Intelligence plays a crucial role in this digital era by enabling the processing of large amount of textual information. However, tools built based on large language models, such as ChatGPT, can produce incorrect results when certain conditions are present, including factual hallucination, mismatched domains, or a lack of contextual grounding. Despite their impressive accuracy, Natural Language Processing models built using Deep Learning models lack transparency and interpretability because they usually operate as "black boxes" without providing explicit reasoning. Explainable Artificial Intelligence addresses these challenges by providing human understandable explanations for model predictions. This Systematic Literature Review examines peer-reviewed articles published between 2020–2025 and retrieved from major academic databases, chosen according to the predefined inclusion and exclusion criteria under the PRISMA framework. A narrative synthesis method is used to examine and classify XAI methods used in NLP-based text classification. The findings show that the most popular XAI techniques are LIME, SHAP, Attention Visualization, and Natural Language Explanations. Model-agnostic approaches such as LIME and SHAP are suitable for general interpretability and regulatory analysis, whereas attention-based and natural language explanation methods are more suitable to transformer-based models and user-focused applications. Furthermore, the recent studies point to the significance of Human-Centered and domain-specific explainability, especially in the context of healthcare, misinformation recognition, and emotion recognition. The review recognizes that the lack of standardized evaluation measures, limited scalability to large language models, and that there was a weak user centered validation as the main research gaps and offers suggestions on future research.

***Keywords:*** *Explainable AI (XAI); Natural Language Processing (NLP); Text Classification; Transparency; Human-Centered AI*

# Machine learning-based performance prediction framework for real-time 3D asset optimization in 3D modeling

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This study presents a machine learning–based performance prediction framework that enables 3D artists and game developers to estimate rendering cost. such as frame rate, CPU/GPU usage, memory consumption, and draw calls during the asset creation process. With the rapid growth of the gaming and real-time graphics industry, the demand for performance optimized 3D assets has increased significantly. However, existing tools such as Unity Profiler and Unreal Insights are inherently reactive, providing feedback only after assets are imported into an engine, which leads to iterative, time-consuming optimization cycles and production delays. To address this gap, the proposed system introduces a proactive, real-time prediction approach that operates at the modeling stage. A structured dataset of 3D asset features including polygon count, vertex density, texture resolution, and shader complexity is combined with runtime performance metrics collected from Unity. Using Random Forest, XGBoost, Multi-Layer Perceptron, and Graph Convolutional Network models, the framework predicts key performance indicators with high accuracy. Preliminary experiments show best $R^2$ values for frame-rate prediction, while maintaining millisecond-level inference latency suitable for interactive use. The trained model is integrated into Blender through a plug-in and REST based service, providing instant feedback to artists as they modify meshes, materials, and textures. A user survey indicates that 90% of participating artists perceive the tool as practically valuable for reducing optimization effort. Overall, this work introduces a proactive surrogate model for 3D asset performance prediction, with strong potential to reduce iteration cycles and streamline real-time content production pipelines.

***Keywords:*** *3D Assets,Machine Learning, Rendering Performance, Optimization,Game Engine*

# Enhancing user interface and user experience design of digital banking platforms: a usability-focused approach for senior citizens in Sri Lanka

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Digital banking services are rapidly expanding in Sri Lanka, offering customers convenient and efficient access to financial services, yet many senior citizens still face difficulties when using mobile and internet banking platforms due to age-related changes in vision, cognition and motor skills, as well as low levels of digital literacy and confidence. This study aims to enhance the user interface and user experience design of digital banking platforms for senior citizens in Sri Lanka through a usability-focused, human-centred approach. The research follows a mixed-methods sequential explanatory design to identify key challenges and barriers older adults encounter when using existing digital banking applications. Initially, quantitative data are collected via a structured questionnaire ($N = 60$–$80$) to capture demographic characteristics and perceived difficulties. This is followed by qualitative semi-structured interviews and baseline usability testing of existing banking apps (HNB Digital Banking and BOC Flex) with 10–15 participants. Measures include task success rates, error counts, time on-task, and System Usability Scale (SUS) ratings. Findings inform the development of a high-fidelity Figma prototype incorporating age-friendly features like larger touch targets, high-contrast text, and simplified navigation. The prototype is validated through a second round of iterative usability testing to measure improvements in effectiveness, accuracy, and user confidence. Results from this evaluation show higher task completion rates and reduced errors compared to existing systems. The study develops practical, evidence-based design guidelines to show how inclusive design can be applied in real systems to make digital financial services more accessible and to increase the independence of older users in Sri Lanka.

***Keywords:*** *Digital Banking,Senior Citizens,Usability, User Experience,Sri Lanka*

# Optimizing Red and White Wine Quality Prediction Using Hybrid Ensemble Learning and Interpretable Feature Engineering

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The conventional method of wine quality prediction has always been based on sensory testing by human analyst and this has been subjective as well as time consuming, and this type of evaluation is hard to scale to the modern wine production system. The current development of machine learning allowed predicting wine quality based on physicochemical data; however, the current models are often characterized by the class imbalance, low interpretability, and poor consistency in working with red and white wine samples. This paper hypothesizes a hybrid ensemble learning model, which combines classification and regression models with interpretable feature engineering to enhance predictive performance and interpretability. The dataset of red and white wines in the region of Vinho Verde was utilized, with comprehensive preparations and feature scaling, feature selection, and resampling, including SMOTE and SMOTE-ENN to overcome an uneven distribution of classes. Several models of base line, such as Support Vector Machines, Naïve Bayes, Ridge Regression, Artificial Neural Networks, Random Forest, and Gradient Boosting, were compared and tested against ensemble and stacked hybrid models. The performance of hybrid ensemble models is shown to be more accurate, has a higher recall and a larger F1-score, especially when compared to single baseline models. SHAP and LIME analysis of interpretability found alcohol content to be a positively strong predictor of wine quality, whereas volatile acidity was significantly negative. The explanations present practical recommendations that can be used by the winemakers in an attempt to make better production choices. Altogether, the suggested framework provides the best predictive results with reasonable interpretability, justifying the application of machine learning-based wine quality assessment in the wine industry practically.

***Keywords:*** *Feature Engineering, Hybrid Ensemble Learning, Machine Learning, Model Interpretability, Wine Quality Prediction.*

# SOFTWARE ENGINEERING

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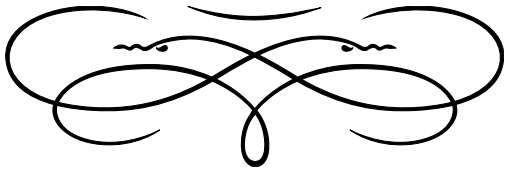

Proceedings of ComURS 2026

# A Hybrid LLM-Driven Recommendation System for Selecting Flutter Packages Using Structured Metadata and Stack Overflow Knowledge

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The rapid growth of the Flutter ecosystem has built significant challenges for the developers in choosing the right third-party packages. Existing popularity-based methods fail to capture developer intent or semantic alignment with real-world requirements. To address this gap, this research presents a hybrid LLM-based recommendation system that integrates structured metadata from Flutter repositories with unstructured knowledge from Stack Overflow. With three LLMs comparatively evaluated, GPT-4- Turbo was chosen based on the accuracy, consistency, and low hallucination rate. The final recommendation model uses a weighted scoring method that integrates popularity, recency, likes, downloads, accepted answers and LLM-based semantic relevance, which generates ranked package recommendations based on the user's requirements. Experimental evaluation across multiple test scenarios achieved a precision of 93.2%, recall of 91.5%, F1-score of 92.3%, and an average semantic relevance score of 94/100. Expert evaluation by Flutter practitioners with six to ten years of experience confirmed that 92% of the recommendations aligned with realworld development requirements. Even though the paper focuses on state management packages, the approach methodology can be generalized to other Flutter package categories. The results highlight the potential of LLMbased hybrid systems to improve developer decision-making.

***Keywords:*** *Flutter, Flutter Packages, Large Language Models, Recommendation System, Software Engineering*

# AI-Driven Risk Prediction in Software Development Environment

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Software development projects are constantly carried out in circumstances that are highly unexpected and dynamic. Unpredictability caused by frequent demand changes, shifting responsibilities, and delivery schedule concerns can all have a negative impact on the process. The implementation of traditional risk management approaches can be quite challenging, and in many situations, manual processes rely on periodic assessments. This research aims to establish machine learning as a unique approach for prediction and decision-making in software project management, with the goal of overcoming the limits of existing methods. The research was built on a thorough collection and investigation of past project data. Before evaluating several machine learning algorithms on structured project datasets, the data was thoroughly preprocessed and feature extracted. XGBoost was the most effective model, capturing the complicated nonlinear relationships between many project variables and identifying risk indicators. The model achieved 83.54% accuracy, 84.19% precision, 83.54% recall, and a low F1-score of 79.49%, indicating that it is an acceptable option for predictive risk analysis in real-world applications. The data from the current project, which was used in short-term live validation findings, show that the model can detect high-risk processes faster than manual evaluation approaches. This allows project managers to take rapid action, such as altering resource allocation, revising task orders, and addressing developing difficulties. The study states that using machine learning techniques improves the accuracy, speed, and reliability of software project risk assessment while also transforming current project management practices through large-scale data-driven advancements and the integration of intelligent, automated monitoring systems.

***Keywords:*** *Machine Learning, Predictive Analytics, Project Risk Management, Risk Prediction.*

# AI Based Flutter Interface Generator Using Natural Language Commands with Social and Ethical Considerations

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The accelerated pace of development of Artificial Intelligence (AI) and the emerging opportunities to automate the generation of user interfaces (UI) are explored in this research, especially within the context of cross-platform development tools like the Flutter platform. This research aimed to develop customed and open access LLM models, to create User Interfaces (UI) effectively. Then, the social and ethical implications of AI based UI design creation were assessed through a questionnaire survey. The new framework combines all free-tier Large Language Models (Gemini, Groq, Cohere, Hugging Face, Open Router) with individually developed models created via MPNet-Base sentence transformers. The individually developed model performed training on newly developed data sets of 10,000 samples, defining varied UI designs such as authentication pages, dashboards, form elements, and e-commerce UI designs. The new framework allows real-time generation of UI source code for both texts and voice commands developed via Flutter and Python FastAPI development tools. The methodology to evaluate technological advancements utilized performance assessment and conducting surveys to measure UI source-code accuracy and related social-ethical perceptions from 220 IT professionals. The new framework resulted in 87.01% accuracy and 93.31% F1 scores. Analysis disclosed major defects such as pattern repetition, color contrast issues, and incongruent points as significantly prioritized among IT professionals. The new framework showed technological feasibility along with justified needs to introduce social and ethical considerations to ensure greater monitoring and human control in generating UI via AIs.

***Keywords:*** *AI-generated Interfaces, Flutter, Natural Language Processing, Social and Ethical Considerations, Large Language Models*

# Detecting Developer Burnout Through Sentiment Trends in Software Repositories Using DistilBERT

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Recent studies have indicated that severe chronic stress relates to burnout, and Software Engineering (SE) is no exception, having greater than 57chronic stress. Conventional methods of evaluation employ surveys and biometric measurements, which are extremely intrusive. In the domain of remote working teams, continual real-time measurement lacks feasibility. This study investigates the feasibility of reliably detecting early signs of developer burnout using a sentiment-focused framework, unobtrusively. Using the 20 Years of Issues and Commits of Mozilla and Apache Development (20-MAD), the dataset of 2,166,239 messages of communication (2,390 developers) is processed using a negation-aware preprocessing technique, DistilBERT sentiment-analysis framework, and Zscore temporal analysis to quantify and capture burnout. Findings highlight the detection of weekly and monthly burnout signals with a weighted classification of 84.09% precision, traditional models vs. DistilBERT. Statistically significant differences in sentiment, with a significant effect of true vs classification, were demonstrated. 462 developers demonstrated evidence of mild stress, 3 severe, and 24 moderate burnouts, during the week. The latter, independently, demonstrated evidence of sustained burnout across the period, which was confirmed by the monthly analysis of 13 severe moderate chronic stress cases and 24 sustained burnout cases. Integration based on GitHub has been made available for the real-time monitoring of burnout using advanced machine learning methods, which allow for high-speed inference within 100ms on a message to provide privacy to the user. The framework permits monitoring the well-being of developers, which consequently gives organizations the ability to run preventive programs.

***Keywords:*** *Deep Learning, Developer Burnout, DistilBERT, Sentiment Analysis, Temporal Analysis*

# Semantic Metadata-enhanced Deep Learning Techniques for Duplicate Bug Report Detection

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Duplication of bug reports poses a significant impact on software development efficiency with 12-25% of bugs report being duplicated on large projects. Manual identification techniques are both time consuming and prone to error. This study examines whether semantic metadata that encodes content-level similarities together with simplified deep learning architectures can be more effective than relying on complex models. We aim to examine existing practices and determine weaknesses, research and prove semantic content-based metadata to be useful in robust identification, structure and test various deep learning models to define the best methods to use to achieve higher levels of performance. Existing studies reveal that machine learning methods outperform traditional information-retrieval techniques by a significant margin, while deep learning approaches achieve higher accuracy but often suffer from limited feature diversity. We collected 535,477 of quality pairs with a 70%-10%-20% split for training, validation, and testing. Our feature engineering on DistilBERT yielded a mean correlation of 0.1888, surpassing traditional metadata. We compared 6 architectures, namely, LSTM, CNN, LSTM+Metadata, Hybrid+Attention, Hybrid+Attention with Metadata, and proposed LSTM+CNN+Metadata, evaluated through accuracy, precision, recall, F1-score, and AUC-ROC metrics. The proposed architecture resulted 92.53% F1-score, which is better than complex attention-based models. Contextual processing is proven to be better, as LSTM performs higher than CNN. This paper highlights that the quality of features is more critical for model performance than model complexity, presenting a cost-effective, accurate, and scalable method for automated duplicate bug detection in real-world applications.

***Keywords:*** *Deep Learning, Duplicate Bug Detection, LSTM Networks, Semantic Metadata, Software Maintenance*

# Optimizing API and framework design for improved usability, maintainability, and developer productivity

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The use of APIs/ Frameworks in software development today cannot be done without and yet numerous of them still have design defects that hinder usability, maintainability and developer productivity due to lack of systematic and actionable guidelines to respond to bad design, documentation and tool support. This paper defines the most frequent API errors, documentation efficacy, IDE tool influence which was empirically checked based on survey data representing 100 software developers in Sri Lanka. The analysis of error patterns shows that the three most frequent error categories are caused by inconsistent naming conventions (40.2%), bad or vague error messages (41.2%), and absence of real-life examples (35.1%), which proves that a lot of mistakes are indeed caused by the flaws in the design, but not the misunderstanding of the developers. Regarding the quality of the API/Framework documentation 47.4% of the respondents rated it at only 3 out of 5 and only 4.1% rated it excellent, which shows that the gap between what developers require and what is available is very wide. Additionally, this paper has also determined that over 70 percent of the respondents think that intelligent autocompletion, inline documentation, and real-time detection of errors in their IDE are some features that have a major impact on their productivity. This piece incorporates the information concerning different design principles that offer a concise API toward addressing the typical software design issues. It serves as a contribution to the field, bringing together fragmented thoughts, suggesting what is missing in current practices. Altogether, this paper indicates that the improved API and framework design may help to decrease the intellectual load on the developers, decrease technical debt, and enhance the efficiency and sustainability of the software development process.

***Keywords:*** *API Design, Software Frameworks, Usability, Maintainability, Developer Productivity*

# An Empirical Evaluation of Clean Architecture: Impact on Software Quality and Developer Productivity

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Clean architecture(CA) is one of the most reliable and most productive architectures in the modern world. By organizing code into distinct layers, each with a clear responsibility, allows developers to build robust, flexible applications and enhance it quality. However, there no enough empirical evidence to prove that CA has impact on enhance software quality and maintainability. To fill this gap, this study aims to conduct a systematic review of the effects on software quality CA and developer productivity. In order to achieve it, 106 CA users participated in a survey. Likertscale and open-ended questions were used to improve the outcomes.Participants selected through LinkedIn ,GitHub platforms and snowball sampling. After the data collection and cleaning correlation test was conducted and its analysis outlines CA adoption links with major ISO/IEC 25010 standards quality attributes. Significant positive correlations were found between the implementation of CA and overall software quality ($r = 0.428$, $p < .001$). In this respect, managing dependencies results in the most substantial impact on quality ($r = 0.707$) and productivity ($r = 0.691$), followed by Separation of Concerns ($r = 0.485$ for quality; $r = 0.443$ for productivity). These findings demonstrate that developers are accustomed to utilizing CA in their applications. Results from open-ended questions demonstrate the CA's adaptability. The overall advantages of CA can be greatly increased under appropriate mentorship, to help reduce technical debt, and to provide an appropriate architectural template. There are certain issues, such as steep learning curves, particularly for younger engineers during onboarding; tools and framework constraints cause developers to deal with greater complexity. All of this demonstrates that CA may improve software quality and developer efficiency, offering insightful information on its successful adoption and sustainability to industry teams, academics, and researchers.

***Keywords:*** *Clean Architecture, Developer Productivity, Empirical Study, Maintainability, Software Quality*

# Enhancing software quality and team productivity in agile development environments through machine learning-based sentiment analysis

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Communication in Agile software development plays an important place for task coordination, clarifying requirements and sprint activities supervision. The sentiment shown in these communication messages can provide useful information about the progress of sprint, and how well the team is working together. This study presents a machine learning based sentiment analysis approach to classify the sentiment expressed in sprint communication and to define a numeric value ranging from 0 to 1, where value closer to 1 indicate more positive communication patterns, while values approaching 0 indicate increasingly negative compositions within each sprint. These sentimental outputs can be generated at the end of the sprint or at any point during the sprint. This enables real-time tracking of the sentiment during a sprint and identifying communication problems that could inhibit the productivity of teams or impact the quality of software. Various machine learning models were trained. Logistic Regression provided the best compromise between generalization, interpretability, and stability and was therefore selected as the final model for this study. A prediction pipeline was developed to evaluate the sentiment on a sprint basis. This utilizes a trained Logistic Regression model and an integrated weighted probability method. The pipeline produces predictions of sentiment category distributions and forecasts of the score of the sentiments of a sprint. The patterns of communication that appeared to suggest that there were coordination issues or disruptions of the work process were often linked to low sentiment scores whereas the ones that appeared less problematic allowed the process to proceed smoothly. These findings show that sentiment scoring is a feasible and actionable metric for Project Managers and Scrum Masters to use in lightweight but effective sprint health monitoring to support proactive sprint management, strengthens task coordination and helps identify coordination issues that may influence team productivity and software quality in Agile development.

***Keywords:*** *Agile development, Logistic regression, Machine learning, Sentiment analysis, Sprint monitoring*

# Analyzing developer misguidance in AI code suggestion tools: a large-scale empirical study

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Artificial Intelligence (AI)-based code suggestion tools are widely used in current software development. These tools save time and help developers at many stages. At the same time, they produce code with some issues-the code looks correct but contains logical mistakes, security weaknesses, or outdated patterns. This kind of issue is commonly referred to as misguidance. Misguidance affects developers in many ways, such as reduced productivity and developer confidence, and it is more harmful for beginners who heavily depend on these AI code suggestions. This study focuses on analyzing the misguidance issues in AI-suggested code. For this purpose, 112,689 developer feedback posts were initially collected from GitHub, Stack Overflow, and Reddit, which were preprocessed and filtered to 33,766 relevant misguidance posts using keyword-based and semantic classification methods. Initially, 200 random posts were manually reviewed and labeled by two people until full agreement was reached, from which a six-category classification of misguidance was developed. A fine-tuned BERT model was then trained using this balanced dataset and achieved 96.6% accuracy and 97.1% macro-F1 accuracy. This model was used to classify all 33,766 posts. From the entire dataset, the most common issue identified was Debugging & Edge Cases (28.5%), then Integration Issues (24.5%) and Performance Issues (20.3%). Logical Errors appear in 16.6% of the posts and Security & Privacy Risks appear in 8.4% of the posts, and Training Data Problems in 1.8%. According to the posts, beginners often face Performance Issues (74.1%). Trust is another factor affected by this AI code misguidance. Both beginner and experienced developers say they cannot fully trust AI suggestions. From this study, some practical guidelines were derived to help developers who are affected by misguidance, such as always testing AI-generated code and seeking human review for beginners without accepting it blindly.

***Keywords:*** *AI code generation, Beginner impact, Developer trust, Misguidance taxonomy, Mitigation guideline*

# Time Series Forecasting of User Engagement in Python Software Applications Based on Usage Logs

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Understanding users' engagement in Python-based software applications is important for improving usability, maintaining user satisfaction, and strategic future planning. Python usage logs contain important but rarely used variables like timestamps, functional interaction, session and download counts to analyze user engagement. However, existing traditional analysis mainly supports statistical analysis rather than capturing temporal dependencies, irregular usage patterns, and domain specific variables like feature updates or version releases and these studies mainly focused on single applications like Instagram, Facebook and TikTok but not considered as Python-based applications. Therefore, research addresses this gap by developing a time series forecasting framework with use of Python application usage logs. This research study analyzes and compares three types of forecasting model like traditional statistical models (ARIMA, SARIMA and Prophet), deep learning models (LSTM and GRU), and hybrid models (Prophet-LSTM, SARIMAX-GRU and Prophet-ElasticNet), guided by research questions assessing by evaluating their forecasting performance and testing under different use cases, such as sparse logs and bursty activity, to examine their robustness and practical suitability for Python application forecasting. The study started with literature reviewing of limits of existing forecasting models, limits of features and application types, and fewer studies on Python applications. Continuing with accurate methodology including data analysis preprocessing, feature engineering, models development, evaluation (MAE, RMSE, and MAPE) and testing and comparison of models. This study involves a Python native forecasting tool developed with Django, React, REST-API, TensorFlow, Prophet and Python libraries with developed model artifacts. Findings explain that hybrid models got high performance (MAPE are 6.35than both statistical and deep learning models particularly under the sparse logs and bursty conditions. The research concludes that irregular features and hybrid residual prediction methods gave high forecast performance and offered valuable insights for Python developers and product teams.

***Keywords:*** *Time Series, Engagement Forecasting, Prophet-LSTM, Python Software Applications, Usage Logs*

# An explainable AI-based approach for Java code smell detection to improve software maintainability

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Code smells are early indicators of design flaws that compromise long term software maintainability. Traditional static analysis tools often generate false positives or fail to detect context dependent smells because they rely on fixed thresholds. As software systems become sophisticated, machine learning (ML) approaches provide a viable alternative for capturing deeper structural and semantic patterns. In order to detect three maintainability critical code smells in Java applications Complex Method, Long Parameter List, and Multifaceted Abstraction; this study proposes an explainable machine learning driven methodology. Using the DACOS dataset, containing 10,341 method level and 4,424 class level samples, separate binary classification pipelines were developed for each smell to guarantee sufficient granularity and domain specific feature engineering. Models, including XGBoost, LightGBM, Random Forest, Gradient Boosting, Decision Tree, SVM, KNN, and Logistic Regression, were trained using an 80/20 stratified split for preserving class distribution, SMOTETomek for resampling, and GridSearchCV for hyperparameter tuning to enable an unbiased performance assessment. From intending individual model performance, the top three models for each code smell were integrated to build weighted voting ensemble model to further improve robustness. The findings suggest relatively consistent performance across the cross-validation folds. For Multifaceted Abstraction, XGBoost achieved an accuracy of 0.9401 (SD=0.0043) and an F1 score of 0.9073 (SD=0.0059), while for Complex Method and Long Parameter List, XGBoost achieved accuracy 0.8222 (SD=0.0101) and 0.8104 (SD=0.0085), respectively. Key features were highlighted in the instance level explanations provided by LIME. These insights increase transparency and enable better informed refactoring approaches. However, the results are derived from only a single dataset and a limited number of code smell type, which may limit their generalizability and external validity. Overall, this study presents the potential of a reliable, precise, and interpretable ML based technique for automated code smell detection within the evaluated context to software maintainability.

***Keywords:*** *Code smells, Explainable AI, Java, Machine learning, Software maintainability*

# Classification of Non-Functional Requirements in Software Development using Deep Learning

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Non-functional requirements are the most significant quality attributes that define a software system as being reliable, secure and efficient under the real-world conditions. But, NFRs are often not taken into account in industry practice compared to functional requirements, which may contribute to project failures, increasing costs, and lower user satisfaction. The existing research on requirement classification has mostly concentrated on differentiating between functional and non-functional requirements and lower attention has been paid on determining the specific NFR subcategories. Moreover, existing research tends to apply a small and domain-related dataset, and traditional techniques of machine learning which cannot be applied in different contexts of software development. This study aimed to fill these research gaps by testing several deep learning models that could recognize the fine-grained categories. The study included multiple architectures that discuss the deficiencies of current NFR classification approaches and the performance of deep learning in classification. The XLNet, ELECTRA-Base, DistilRoBERTa, RNN, Bidirectional GRU, CNN, DistilBERT, DeBERTa-v3-small, were used for evaluation. The significance of the application of transformer-based models was encouraged in the present work. The experimental findings show that DistilRoBERTa has the best results and has a 0.77 accuracy, a macroaveraged precision of 0.78, a recall of 0.76 and F1-score of 0.75. Overall, the study supports the idea that deep learning can contribute to making the requirements engineering processes more efficient and predictable to help analyze the software quality at the early stages. Further optimization of deep learning architectures to improve accuracy may be included in future work, as well as expansion of the datasets.

***Keywords:*** *Non-Functional Requirements, Deep Learning, DistilRoBERTa, Classification, Software Quality*

# Comparative Analysis of Sentiment Classification Models for Algorithmic Trading

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Market sentiment, as driven by news and online discussion sites is increasingly impacting algorithmic trading systems. In this work, we analyze financial news headlines from Yahoo Finance, enhanced with related discussion context from Reddit, to identify market sentiment for Bitcoin. We trained various machine learning and deep learning sentiment classifiers with a dataset of 11,293 Bitcoin-related text samples primarily extracted from Yahoo Finance news headlines and aligned with relevant Reddit discussion content. The dataset had three classes of sentiment which were Positive, Neutral and Negative. The extracted data was fetched from news headlines ranging for five years. Multiple classification models were testes, the classical machine learning models, deep learning architectures and then transformer based language models, which enabled a systematic comparison across different models. In baseline models, Logistic Regression achieved the best performance (accuracy 71.7%, F1=0.704), and among neural network-based ones, BiLSTM does so with accuracy of 70.5%. Transformer-based models were subsequently fine-tuned and evaluated for comparative performance. The model FinBERT achieved improved classification performance (accuracy of 83.7%, F1=0.835), which was further confirmed statically by McNemar's statistical test as compared with the other models. FinBERT showed the effectiveness of domain specific contextual pretraining for the financial sentiment because it was able to outperform all the other models by a large margin. This study highlights the importance of incorporating sentiment aware modeling into the financial prediction workflows and also provide insights that would be needed for future development of reliable trading strategies.

***Keywords:*** *Algorithmic Trading, Bitcoin, Cryptocurrency, Machine Learning, Market Sentiment*

# Automated detection of developer mental health status in collaboration platforms using NLP and activity analysis

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Software developers experience significant mental health challenges due to workrelated stressors, making it essential for workplaces to adopt systematic and proactive strategies for identifying and supporting employees with psychological difficulties. This study proposes a novel NLP-based model that predicts developers' mental health by analyzing the emotional patterns embedded in their chat messages. The methodology consists of two main stages: (1) categorizing developers' messages into emotion classes using fine-tuned language models and (2) evaluating monthly emotion distributions to derive individualized mental health risk scores. A fine-tuned DistilRoBERTa-base model, trained and evaluated on the Gitter Emotion Dataset, achieved a weighted accuracy of 62.8% on developer-specific messages, demonstrating the feasibility of domain-adapted emotion classification for software engineering communication. Using 30-day holistic assessments, mental health scores ranging from 38 to 57 were produced, effectively differentiating developers exhibiting a higher proportion of negative emotional expressions from those whose communication patterns were predominantly neutral or positive. This research provides a continuous, non-intrusive method for collecting and interpreting mental health signals by leveraging communication tools that software developers already use as part of their daily workflow. This study builds upon previous studies in this area, all of which have used either facial emotion recognition or text analysis derived from social media to do their work, by being the first study to use developer-centric chat to connect emotion expressed in writing to subsequent mental health assessments. As demonstrated in this study, emotion expressed in text in the context of software development can be reliably used as an indirect measure of an individual's mental health. Therefore, the scope of emotion-based mental health rating methodologies can be extended beyond simply using expressive face information. The model developed in this study has implications for both practitioners wanting to monitor employees' well-being at work, as well as researchers in the field of computational psychiatry by demonstrating that the emotion represented in domain specific text can serve as a proxy for assessing severity of an individual's mental health.

***Keywords:*** *Developer mental health, Text emotion classification, Natural language processing, Occupational wellness, Predictive modeling*

# Evaluating the security of JavaScript code generated by GitHub Copilot using static analysis tools

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Artificial Intelligence (AI) tools are changing the way code is written in software development. According to a Sonatype (2023) report 97% of developers use Large Language Models (LLMs) for their work and improve software development. However, there are still concerns about the security of AIgenerated code. This paper examines the security weaknesses of the JavaScript code generated by GitHub Copilot. Addressing the type of the frequencies and Common Weakness Enumeration (CWE) weaknesses, the comparison of various static analysis tools, and the possibility of prompt refinement to reduce insecure output. Previous studies have demonstrated that AI-written code often has exploitable vulnerabilities (Fu et al.2023) found 29.5% of Python and 24.2% of JavaScript affected of CWEs in Copilot-written code when rewritten to code of actual projects on GitHub. We gathered 500 real-world developer tasks on Stack Overflow and GitHub Issues, and they included the tasks like API usage, input validation, and DOM manipulation. Prompts were translated and GitHub Copilot in Visual Studio Code generated the generated JavaScript code corresponding to each task. Our analysis, we found that there were vulnerabilities to security in the generated JavaScript code. ESLint identified 323 issues and 345 issues were identified by CodeQL, respectively. In total, these results span 31 distinct categories of Common Weakness Enumeration (CWE). The vulnerabilities were repeated many times; they were prototype pollution (CWE-915), improper output encoding (CWE-117), regex-based denial of service (CWE-1333), DOM-based cross-site scripting (CWE-79), and path traversal (CWE-22). Especially, seven of those CWEs are among the 2025 CWE Top 25, highlighting their severity. The security flaws were mitigated by 51.8% which indicates that security-centric prompts are effective when they are carefully refined. The results indicate that Copilot-generated JavaScript code frequently contains security vulnerabilities. To achieve responsible development with the help of AI, we suggest applying a multi-tool analysis pipeline and security-conscious prompts.

***Keywords:*** *GitHub Copilot, JavaScript, AI Code Generation, Security Weaknesses/CWE, Static Code Analysis*

# A Context-Aware Multi-Task Learning Framework for Developer Recommendation in GitHub Issue Triage

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GitHub is most important collaborative tool for the design, development, and maintenance of software projects. In large-scale collaborative software development, manual issue assignment to developers creates management overhead and potential delays in issue resolution. To reduce these challenges many recent researchers are discovered automated issue assignment. The model begins with baseline approaches using TF-IDF features and traditional classifiers. There are two steps. The first step filters candidates, focusing on members within the organization and those actively involved in related projects to ensure the relevance of suggestions. The second step is a ranking process leveraging a Deep Multi-Task Learning (MTL) model, which addresses three tasks concurrently the assignment of developers, issue types, and priorities. This MTL model integrates semantic embeddings from SBERT with individual developer behavior data. Tested on a largescale dataset comprising more than 20,000 GitHub issues, the model obtained a -Top-1 Accuracy of 92.38% and an MRR of 0.9353 in the main assignment task. Besides, the secondary tasks involving issue type and priority classification obtained weighted F1-scores of 0.94 and 0.96, respectively. The successful deployment of the model as a working GitHub app illustrates the effectiveness of the model in offering real-time and relevant recommendations in order to simplify issue triage.

***Keywords:*** *Software Engineering, Issue Triage, Developer, Deep Learning Recommendation, Multi Task Learning, Context-Aware Systems*

# A Rule-based Self-healing Baseline for Hybrid AI Repair of Common Python Syntax Errors

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Python has become a popular language of beginners due to its simplicity. However, syntax errors remain as a hurdle to productivity and learning. Although automated program repair (APR) has improved, in the majority of cases the existing solutions have difficulties in trading the deterministic accuracy of rule-based systems with the flexibility of AI-guided models. This paper deploys a rule-based repair agent in the form of a self-healing agent as the initial step in a proposed hybrid repair system, concerned with the automatic detection and correction of common Python syntax errors, including missing colons and indentation errors. The agent is modeled upon the MAPE-K (Monitor, Analyze, Plan, Execute, Knowledge) control loop and is tested on 37,639 real-world Python snippets with raw syntax errors that are mined on the public GitHub repositories. The agent based on rules is able to fix 14,149 snippets with a repair accuracy of 37.59% and an average fix time of around 0.0008 seconds. These results indicate that a rulebased layer can efficiently handle most low-complexity syntax errors with minimal delay, and represents a promising approach to rapid preprocessing. Meanwhile, the 62.41% of the unresolved cases also show the constraints of the use of static heuristics in context-sensitive or structurally complicated errors. This long abstract provides the empirical base to the rule-based stage and gives the impetus to the subsequent stage of the project, where a learning-based part will be added to create a hybrid repair architecture.

***Keywords:*** *Python Syntax Errors, Self-healing Systems, Automated Program Repair, Hybrid AI, Rule-based Approaches*

# Predicting Developer Burnout and Enhancing Team Performance through Multi-Modal Workload Analysis from Jira and GitHub Activity

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Developer burnout has become a critical challenge in agile software development, as faster delivery cycles, high task-switching demands, and sustained cognitive load affect mental well-being and gradually reduce productivity. Although existing studies reveal that nearly 80% of software developers tend to face burnout symptoms, burnout detection methods are often reactive and solely rely on traditional surveys or isolated metrics. This study addresses this limitation by proposing a proactive, all-in-one, datadriven framework that combines task management data from Jira and code contribution activity from GitHub to predict burnout in agile teams. The research problem is derived from the necessity for a unified system capable of detecting early indicators of workload imbalance in an organization, answering stakeholder queries regarding employee burnout, and supporting real-time intervention. The study extracts multi-modal metrics from the Mozilla–Apache dataset, which consists of issue-tracking and version control data collected from Jira and GitHub. Several types of machine learning models were trained and evaluated to predict developer burnout. The Artificial Neural Network (ANN) revealed superior predictive performance, obtaining 98.48% accuracy with a F1-score of 97.41%. Moreover, correlation analysis indicated that factors such as commit count, total lines changed, issues handled, and off-work time commits show the strongest associations with burnout risk.

***Keywords:*** *Developer Burnout, Multi-Modal Analytics, Jira, GitHub, Machine Learning*

# Comparative evaluation of traditional and neural models for multi-class classification of GitHub commit messages

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Commit messages are a critical source of information within software repositories, documenting changes made to code entries. While they are important to empirical software engineering and development cycles, these messages are often highly heterogeneous, informal, and brief. This results in a variety of challenges, especially when analyzing large scale repositories with thousands of commits. The lack of standardization makes it difficult to analyze the content of these repositories, leading to a need and opportunity to automate the processing of commit messages. Automated processing would enable the development of release notes, code change impact analyses, and maintenance analytics. This study evaluates the use of several text classification models aimed at analyzing messages within the software development life cycle (SDLC). In particular, these models attempt to classify the commit messages from the repository hosting service GitHub into ten SLDC tasks: build, chore, continuous integration (ci), documentation (docs), feature (feat), fix, performance (perf), refactor, style, and test. After identifying a public repository containing a balanced dataset of 2000 commit messages, several hours of data cleaning and manual labeling were conducted to ensure a dataset of high quality. Each of the ten classes was assigned 200 commit messages after which the dataset was fully categorized. Across the different model architectures, a stratified split was applied to each. These included the Optuna-tuned TF-IDF + LinearSVM, the Bi-LSTM, and the Fine-tuned BERT, and the Hybrid BERT-SVM model. As for the transformer models, I customarily encountered convergence problems with this domain-specific data, and for this reason I applied the additional simplifying techniques of Layer-wise Learning Rate Decay (LLRD) and a weighted loss for BERT as part of the loss function. BERT (or any transformer model) for the task of sequence classification is known to suffer from convergence problems. The findings indicate that, of all the BERT architectures, the Optuna-tuned TF-IDF + LinearSVM secured the maximum validation accuracy of 0.635 and macro F1 of 0.631. The primary challenge was the generalized language of the developers that blurred the semantic distinctions between chore and refactor and confused all of the models. This sets a solid scholarly foundation for subsequent work that aims to incorporate source code differences to address the existing gaps in classification.

***Keywords:*** *BERT, Commit Messages, Software Repositories, Support Vector Machine, Text Classification*

# DATA SCIENCE

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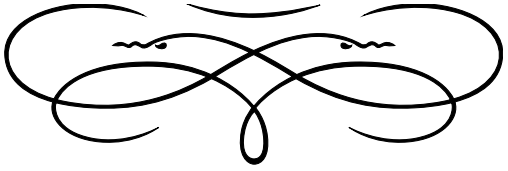

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# TikTok Video Classification Based on Emotions Using Convolutional Neural Networks

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Emotion recognition is a product of AI and computer vision, which enables systems to decipher human emotions during a range of uses. As TikTok grows, expressions made by users in the short videos offer valuable information that can be used in real life to study emotions. Detection of emotions in these videos is, however, a challenge because of changes in lighting, angles, and user behavior. Emotion-based TikTok video classification can be essential to enhance content recommendations, interaction, and emotion-driven social media analytics. To overcome this challenge, as an objective of this research, a Convolutional Neural Network (CNN)-based approach is prepared to categorize TikTok videos based on their emotions. This study is novel in its comparative evaluation of CNN-based emotion recognition models on real TikTok videos, an area largely ignored by existing methods. A sample of 4,000 TikTok videos were gathered, containing the main four emotions, namely happiness, sadness, anger, and surprise. Videos were processed during preprocessing, which involved compression, frame conversion with Python and OpenCV, and normalization and data augmentation. The features were extracted, and models were trained and tested using the three CNN architectures, namely, MobileNet, VGGNet, and ResNet. The data was divided using a percentage split, as well as 5-fold and 10-fold cross-validation, with different epochs and batch sizes to achieve the best model performance. Accuracy, precision, recall, F-score, and error rate were used as a measure of model performance. ResNet was the most accurate with 96% accuracy, which is far better than VGGNet (71%) and MobileNet (58%). These results prove the usefulness of CNN architectures to classify emotions in TikTok videos and how they can be applied in social media analytics and affective computing. Future research will focus on multimodal audio-text methods for real-time emotion analysis on social media.

***Keywords:*** *Computer vision, Convolutional neural networks, Emotion recognition, Social media analytics, TikTok*

# A Study of Machine Learning Models for Text-Based Mental Health Prediction in Sri Lanka

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The widespread use of social media has revolutionized the way people share personal problems, which is a new line of identifying the occurrence of mental illness at an early stage. This approach becomes especially vital in such circumstances as the Sri Lankan context, when cultural stigma is a real obstacle in the process of seeking help. In order to fill the gap of machine learning applications in this field, this paper explores the automated detection of mental health conditions on Facebook posts in Sinhalese. A mental health expert annotated a corpus of 3,096 posts with a multi-label classification schema (Anxiety, Depression, Suicidal Ideation, Irrelevant) to indicate possible comorbidities. A traditional Random Forest classifier and the new transformer-based models, BERT and RoBERTa with explicit hyperparameter settings, were tested and compared to perform this multilabel classification task. The performance analysis indicated that there are serious gaps. The Random Forest model obtained a low efficacy, indicated by its macro F1-score of 0.45, which is poor at predicting the important suicidal ideation class (F1-score: 0.33). This baseline was significantly low in comparison to the transformer models. The BERT model had a strong macro F1-score of 0.83, and the RoBERTa model had the best overall score of 0.85. These findings indicate the superiority of transformer-based models, namely RoBERTa, in this sensitive classification task. The analysis shows that natural language processing has the potential to be successfully used to detect the indicators of mental distress in the specific sociolinguistic environment of Sri Lanka. While limitations include depending on a single annotator and platform-specific data, ethical issues associated with the application in the real world. This study serves as a foundation for developing proactive digital solutions that can enforce mental health surveillance and early intervention, potentially overcoming the stigmatization barrier.

***Keywords:*** *Mental Health Detection, Multi-Label Classification, Natural Language Processing (NLP), RoBERTa, Transformer Models*

# Classification of Dental Lesions Using Camera-Captured Images with Convolutional Neural Networks

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Oral cavity is a central part of the appearance of a person and their health condition and oral care is crucial. The consideration of good habits and the early identification of lesions are paramount, and their diagnosis is normally performed with the help of visual examination, radiographies and biopsies. While these methods are widely used, they present several challenges. Early lesions are often small or resemble healthy tissue, making detection difficult. Diagnosis is further limited by the subjectivity of visual assessment and the time-consuming nature of radiograph interpretation. Because of these challenges, researchers are increasingly looking at how artificial intelligence can help detect periapical lesions. Many studies have focused on identifying teeth or dental diseases using X-ray images, but research using RGB (color) images is rare. RGB images are easy to capture, non-invasive, and more accessible during routine dental check-ups, making them useful for practical AI-based diagnostic tools. To fill this gap, the objective was to use deep learning model to automatically detect dental lesions and improve diagnostic accuracy. In this approach, we evaluate and compare different convolutional neural network (CNN) architectures for identifying three major dental lesions namely, Gingivitis, Calculus, and Hypodontia from 4000 optical color images captured in front of the mouth. After pre-processing and extracting features, the dataset was trained with three pre-trained architectures: EfficientNetB0, DenseNet121, and ResNet50. The findings indicate obvious variations in performance, and DenseNet121 has always got the maximum accuracy of 86.91% and higher precision, recall values, f-measure values compared to other models. The future dental industry may benefit from this research as it will be easier to detect issues early and offer cheap equipment to improve oral health. The research compares the CNN performance on dental lesion classification and prepares the way to predict the severity and medical application in the future.

***Keywords:*** *Artificial intelligence, Calculus, CNN, CNN architectures, Deep learning*

# Deep Learning Framework for Predicting LinkedIn Follower Count Range

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LinkedIn has become a key platform for professional networking, where follower count increasingly reflects visibility, credibility, and digital influence. Existing research offers only limited insight into how different factors jointly shape follower growth. Insights from other social media platforms do not translate well to LinkedIn's professional context. This study examines factors influencing LinkedIn follower count using a multiinput deep learning model. The model integrates three major data modalities professional, demographic, and facial-emotional features allowing a comprehensive multimodal prediction approach. The study focuses on three key areas: determining whether a 1D CNN based multimodal model performs better than classical machine learning models; identifying which feature groups most strongly influence follower count; and evaluating the extent to which a multi-input 1D CNN can learn complex non-linear interactions more effectively than traditional approaches. Structured and LinkedIn profile data and facial-emotional indicators obtained based on profile images were used in classification. Standardized cleaning, one-hot encoding and MinMax scaling were used to process features. The classical models used were compared to a 1D CNN with a multi-input. Accuracy, F1-score, MAE, MSE and Explainable AI techniques were used as model evaluation. According to the results, LinkedIn user following is mainly motivated by career advancement and profile display and not by demographical factors. The research conclude that multimodal deep learning is a highly effective way to predict and interpretable in professional network analytics, which has both a methodological and practical implication on understanding digital influence.

***Keywords:*** *LinkedIn Analytics; Deep Learning; Multi-Input 1D CNN; Follower Count Prediction; Machine Learning Comparison*

# A Machine Learning-Based Approach for Predicting Milk Quality in Sri Lanka

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Quality of raw milk is necessary to assure food safety, human health and the survival of the dairy industry in Sri Lanka, though the existing approaches to quality assessment are mostly manual, time consuming, and are not viable in making immediate and accurate decisions by the dairy suppliers in the rural collection centers. The traditional tests like the Alcohol test, Resazurin test, Fat percentage, Solid Non Fat (SNF) percentage and pH value involve laboratory methods and experienced operators and result in a significant disparity in effective field-level quality monitoring. This paper suggests a method to identify the status of milk quality using periodically measured parameters of physicochemical tests on the milk samples at Sri Lankan milk collection centers. Following the consultation with domain experts, reading of industry guidelines, and referring to existing work major features such as Alcohol stability, Resazurin reduction time, pH, fat content, SNF value, temperature, etc. were chosen as predictive features. 1056 milk sample data were collected from milk collection centers in the Uva Province of Sri Lanka, and was preprocessed. Then the preprocessed dataset was trained and evaluated using various Machine Learning (ML) models. This research mainly focuses on six ML algorithms to predict the milk quality. Here, above 80% of accuracy has given by Deep Neural Network (DNN) and XGBoost models, above 75% accuracy from SVM and Random Forest models and Logistic Regression and KNN models give an accuracy of below 75%. The results of the experiment show that DNN had the best accuracy followed by Random Forest and SVM, which proves that machine learning has the potential to improve the quick and reliable quality of milk in Sri Lanka.

***Keywords:*** *Dairy Industry; Deep Neural Network; Machine Learning; Physicochemical Tests; Quality Assessment*

# Early Detection of Psychological Risk in Sri Lankan University Students through Interpretable Machine Learning Approach

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Psychological distress among university students in Sri Lanka is an increasing issue, which is compounded by academic, financial, and lifestyle issues. Traditional screening tools do not effectively predict the "At-risk" students early enough to help them be treated in time. This study will create interpretable machine learning model early binary classification of psychological risk among Sri Lankan university students using behavioral, demographic, and clinical indicators. This ML model will be able to identify whether a student is “At-risk” or “Not-at-risk” based on the behavioral, demographic, and clinically validated indicators. The survey data were obtained on 500 undergraduate students who represented various faculties and contained demographic factors, lifestyle behaviors, and results of the Depression, Anxiety and Stress Scale (DASS-21). The responses on DASS21 were converted to a binary risk label using clinical scoring guidelines, in which a moderate or greater severity on any of the subscales was a precursor of psychological risk. Several baseline models such as Logistic Regression, Support Vector Machine, Decision Tree and Gradient Boosting were trained and assessed on the basis of accuracy, precision, recall, F1-score, and ROC AUC. Logistic Regression exhibited the highest precision (90%) which is important in order to reduce false positives at the cost of screening mental health, as the regression showed the highest accuracy (84%) and AUC-ROC (90.8%). The critical predictors of psychological risk were severity of DASS-21, sleep disturbances, spending much time on the screen, and lack of social contact. Interpretable machine learning models especially the Logistic Regression are a feasible and scalable method of early psychological risk detection in universities. This instrument enables proactive, data-driven support for university counseling services in Sri Lanka.

***Keywords:*** *Early detection; Mental Health; Binary Classification; University Students; Sri Lanka*

# Comparative analysis of machine learning models on predicting non-alcoholic fatty liver disease stages in Sri Lanka

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Non-Alcoholic Fatty Liver Disease (NAFLD) is emerging to be a significant problem in the worldwide, including in Sri Lanka, where it has become a major contributor to chronic liver disease. The conventional diagnostic methods, including liver biopsy and high-quality imaging, are precise, although they are still invasive, expensive, and unavailable in the rural and resource-constrained clinical environment. The paper is a comparative analysis of machine learning (ML) models of prediction of the non-invasive stages of NAFLD. For training the ML model, regularly measured biochemical and demographic data of 1,280 Sri Lankan NAFLD patients who had confirmed the stage according to the imaging and biopsy-confirmed diagnoses. Parameters that were used include age, sex, liver enzymes, bilirubin fractions, serum proteins, renal markers, electrolytes, and inflammatory indicators. Clinical labels for the patient's stage were given according to the imaging and biopsy-confirmed diagnoses from expert consultants. The patients were divided into four stages of NAFLD, which included Simple Steatosis, Non-Alcoholic Steatohepatitis (NASH), Fibrosis, and Cirrhosis. Six ML models, like Logistic Regression (LR), KNearest Neighbors (KNN), Random Forest (RF), Gradient Boosting, LightGBM, and XGBoost, were trained and assessed to find out the most successful predictive algorithm. Gradient Boosting showed the best performance with an accuracy of 91.7% followed by XGBoost with 90.6indicating that the models have a good predictive ability on the basis of routine laboratory markers. The comparative findings suggest that the staging of noninvasive NAFLD using ML is very practical and clinically significant in the Sri Lankan healthcare setting. This research represents a region-specific, datadriven model for NAFLD stage prediction in Sri Lanka. These findings indicate the potential of ML to support early detection, enhance risk stratification, improve clinical decision-making, and prioritize patients who need immediate treatment, especially in hospital settings with limited access to special diagnostic tools.

***Keywords:*** *Biochemical indicators; Comparative model analysis; NAFLD staging; Non-invasive diagnosis; Sri Lankan patient data*

# Sentiment Analysis of Self-Published vs. Traditionally Published Books using Machine Learning

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The rapid growth of the self-publishing channels, such as Amazon Kindle Direct Publishing (KDP), has greatly changed the model of distribution of books across the world today because authors are able to bypass the traditional publishing framework. The conventional publishers have well-established editorial and marketing procedures, but the self-published authors have full creative freedom with more or less quality control. However, in spite of this change, there is a shortage of academic studies that use computational sentiment analysis to compare the perception of books by the readers under these two models in a systematic way. In this work, this gap is filled by comparing the attitudes of readers to self-published and traditionally published books based on the large dataset of Goodreads reviews. The study aims at (1) determining the patterns of sentiment between the two publishing models, (2) identifying the critical themes that determine the perceptions of the reader, and (3) assessing the contribution of platform visibility and metadata in modulating the trend of sentiment. Text normalization, tokenization, and publisher classification by metadata preprocessed the reviews. In identifying the reviews in self-published and traditionally published classes, a TF-IDF vectorizer and a Logistic Regression classifier were used. This model was able to accomplish an accuracy of 0.80 with a test sample of 125,757. The performance measures showed a precision of 0.82 and a recall of 0.78 for self-published books and a precision of 0.79 and a recall of 0.82 for traditionally published books. Furthermore, a DistilBERT model was used as an additional robustness test. The findings indicate that the sentiment of readers is fairly equal on both publishing models; however, selfpublished books have a greater diversification of sentiment distribution. The consistency of traditional books is probably higher because of the professional editing and the publication organization. The research has implications for those publishing and those being published in terms of marketing approaches, content suggestions and implications to authors in their choice of publication pathway.

***Keywords:*** *Goodreads; Machine Learning; Sentiment Analysis; SelfPublishing; Traditional Publishing;*

# Automated Evaluation of Responses Using Embedding-Based Similarity with Explainable AI Support: A Comparative Study of all-MPNet-basev2 and all-MiniLM-L6-v2

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With the rapid expansion of digital and large-scale learning environments, automated grading of student responses has gained greater significance among educators. In manual grading, there are many difficulties like time consuming, inconsistency, and difficulty to manage large scale responses. Advances in Natural Language Processing, especially transformer-based sentence embeddings, enables researchers an opportunity to develop more meaningful evaluation tools. Motivated by this need, this research examines the efficiency of semantic-similarity-based Auto-Grader system aided by Explainable AI (XAI) to provide a transparent and fair evaluation. This study focuses How well can transformer-based sentence embeddings evaluate essay and MCQ type responses? and to what extent can XAI make automatic grading judgments more transparent? The objectives include creating a semantic similarity based scoring mechanism, evaluating the performance of the all-MPNet-base-v2 and all-MiniLM-L6-v2 models, and integrating XAI techniques. The framework was tested on datasets of essay and MCQ type responses If the similarity of the response exceeding the predefined threshold, were classified correct. To determine the words which contributed mostly to the overall similarity, Local Interpretable Modelagnostic Explanations (LIME) and SHapley Additive exPlanations (SHAP) style approximation are used. Such explanations help instructors to know why an answer has been rated as right or wrong. Findings indicate evaluation results that all-MPNet-base-v2 scored 97.78% and 81.46respectively, in MCQ answers and essays while all-MiniLM-L6-v2 scored 96.67% for MCQ and 74.26% for essay responses respectively. Overall allMPNet-base-v2 performed slightly well. In conclusion, this paper outlines a fair, scalable and interpretable automated grading system, suggesting adaptive feedback and future extensions of multimodal assessment.

***Keywords:*** *Automatic Grading; Semantic Similarity; Sentence Embeddings; Explainable AI (XAI); Natural Language Processing*

# Voice-Based Accessibility for Disabled Users in Websites Using Data Mining and Regression Analysis

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Web accessibility remains a major challenge for users with physical and motor disabilities, as most websites rely on mouse- and keyboard-based interactions that are unsuitable for hands-free navigation. Existing voicebased solutions mainly depend on speech-to-text systems, which require large datasets, high computational resources, and language-specific transcription, limiting their effectiveness for lightweight, real-time accessibility support. This research proposes a prediction-based voice accessibility system that enables web navigation without full speech transcription.A dataset of approximately 3000 short audio samples was collected from 30 participants, covering ten common accessibility commands such as scrolling, zooming, and navigation control. MelFrequency Cepstral Coefficients (MFCCs) were extracted as compact audio features, and multiple machine learning classifiers were evaluated. Model performance was assessed using stratified train–test splits, cross-validation, precision, recall, F1-score, and confusion matrices.A tuned XGBoost classifier achieved an overall accuracy of approximately 72%, outperforming logistic regression, support vector machines, and random forests while maintaining low latency suitable for real-time use. The model was deployed as a browser extension, enabling language-independent, realtime voice-controlled web navigation and improving digital accessibility for disabled users.

***Keywords:*** *Voice Recognition; Accessibility; Machine Learning; Regression Analysis; Web Navigation*

# A Multimodal Emotion-Aware Product Recommendation System Integrating Real-Time Facial Expression Recognition and BERT-Based Sentiment Analysis

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This study presents a multimodal emotion-aware product recommendation system that integrates real-time Facial Expression Recognition (FER) and transformer-based sentiment analysis to enhance personalization in digital environments. Traditional recommender systems rely mainly on historical interactions or textual reviews and often overlook users' current emotional states, leading to inappropriate recommendations. To address this limitation, the proposed system fuses emotional cues from facial expressions and usergenerated text. FER is performed across seven emotion categories—happy, sad, angry, fear, disgust, surprise, and neutral—using a fine-tuned EfficientNetB0 model trained on JAFFE, CK++, FER subsets, and selfcollected webcam images, achieving an overall accuracy of 88% in realtime conditions. Sentiment analysis uses a fine-tuned DistilBERT model that classifies text into positive, neutral, and negative categories with accuracy exceeding 90%. A rule-based multimodal fusion strategy combines outputs from both modalities, resolving conflicting emotional cues and improving emotional inference reliability by approximately 10–12% compared to unimodal approaches. The inferred emotional state is mapped to a structured recommendation database, generating personalized product suggestions. The system is implemented using a Streamlit-based interface. Experimental results indicate that the multimodal approach produces recommendations that are better than those of single-modality systems.

***Keywords:*** *Emotion Recognition; Sentiment Analysis; Multimodal Fusion; Recommender Systems; Affective Computing*

# Enhancing Sri Lankan textile export forecasting using social media sentiment with machine learning

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The apparel industry has continued to be the largest export economic activity in Sri Lanka. However recent shocks such as the COVID-19 pandemic and the 2022 financial crisis revealed large vulnerabilities in conventional forecasting mechanisms. Linear econometric models including ARIMA and SARIMA are slow to detect behavioural turning points that precede significant changes in trade flows. This study addresses this gap by combining a high-frequency Social Media Sentiment Index with traditional macroeconomic indicators to assess the importance of sentiment-based information in improving the predictability of the textile export performance. Three forecasting architectures were built through a comparative modelling framework, based on SARIMA, econometric framework as a benchmark, XGBoost as a nonlinear ensemble learning model, and (LSTM) networks as a deep learning framework. The monthly export statistics between 2012-2024 were matched with the sentiment ratings based on around 46000 scraped social media postings (tweets). Findings indicate that there is a clear model performance hierarchy. SARIMA generated consistent forecasts with an RMSE of 31.50, whereas the sentiment-enriched XGBoost was the most accurate overall with an RMSE of 28.93 demonstrating the strongest generalization. LSTM also had the lowest performance and had the highest RMSE of 48.26, indicating overfitting, since the macroeconomic time series is of low frequency and low sample. These findings affirm that sentiment predicts behavioural dynamics that other basic indicators do not capture and that ensemble learning is better than deep learning in this scenario. The results reveal that sentiment-enriched machine learning models provide a clear development in predicting exports in unstable economic conditions. This underlines the importance of combining behavioural information, which is not structured, with economic measures in a structured manner offers a methodological basis of the real-time nowcasting instruments in the export management and policy planning.

***Keywords:*** *Textile exports; Sentiment analysis; Xgboost; Sarima; Economic forecasting.*

# Enhancing Sinhala Hate Speech and Offensive Language Detection through XAI

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The rapid growth of social media has sped up the spread of hatred, abusive and offensive content, creating an urgent need for automated detection systems especially for low-resource languages such as Sinhala. This study develops, and evaluates standard deep learning (DL) models, transformerbased architectures, and a newly proposed hybrid model using DL models with Sinhala Offensive Language Dataset (SOLD) for detecting hate speech in Sinhala. Among Conventional DL models, Bi-LSTM demonstrated the strongest performance with 82% accuracy and a ROC score of 0.88, despite the challenge of informal expressions, and rich morphology in Sinhala language. Among transformer-based models, XLM-R large achieved the best results with 84% accuracy and an ROC of 0.92, demonstrating their effectiveness in modeling nuanced semantic and syntactic structures in Sinhala online discourse. Moreover, a hybrid model integrating multiple DL models was developed and evaluated, achieving superior performance with an accuracy of 86% with a ROC of 0.93 on Sinhala hate speech detection task, outperforming all baseline deep learning and transformer-based models. Beyond predictive performance, this study also contributes important interpretability of model predictions with Explainable AI (XAI) techniques - SHAP and LIME - which detail the local and global contributions of tokens. These explanations provide clear pathways to make decisions about models. Overall, this study presents a comprehensive evaluation about model's performance and interpretability analysis of model's predictions to detect hate speech in Sinhala with exciting brevity for future multilingual and explainable NLP applications.

***Keywords:*** *Deep learning; Hybrid model; Sinhala hate speech; Transformerbased models; XAI*

# A Novel Sentiment Analysis-Based Hybrid Machine Learning Approach for Forecasting Financial Indices Under Economic Instability

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Forecasting financial market behaviour during periods of economic instability presents a significant challenge for traditional predictive models, such as ARIMA and standard machine learning classifiers, which often rely on assumptions of linearity and historical stationarity. Market volatility driven by exogenous shocks, such as the COVID-19 pandemic, frequently renders these conventional methods ineffective. This research introduces a novel multi-modal hybrid machine learning approach that integrates technical market data with unstructured sentiment signals to enhance forecasting precision and risk identification during crisis periods. The proposed architecture utilises a Gated Recurrent Unit (GRU) to capture temporal dependencies in financial time series, complemented by a dense Artificial Neural Network (ANN) that processes static context vectors derived from macroeconomic indicators and global news sentiment (via GDELT). A cross-attention mechanism is used to dynamically weigh the influence of diverse data inputs. The model was empirically evaluated using S&P 500 data, specifically covering the COVID-19 crisis period from 2019 to 2021. Experimental results indicate that the proposed hybrid model achieved a directional accuracy of 60.76Random Forest baseline, which recorded 59.34effectively mitigated bull market bias by substantially improving the recall for market downturns from 0.00 to 0.30, demonstrating an enhanced capability to identify negative market movements. Moreover, the attention mechanism dynamically prioritized sentiment-related features during the March 2020 market crash, thereby empirically supporting the hypothesis that sentiment information functions as a critical leading indicator under periods of market instability.

***Keywords:*** *Attention Mechanism; Deep Learning; Economic Instability; Financial Forecasting; Sentiment Analysis*

# Comparative analysis of deep learning architectures for Sri Lankan sign language recognition using MediaPipe landmarks

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In Sri Lanka, Sri Lankan Sign Language (SLSL) is the main way of communicating among the deaf community; however, the present recognition systems do not have the culturally adaptive methods that come with high accuracy. This study is going to fill this gap through a comparison of the different deep learning approaches for SLSL recognition based on hand landmark sequences. The dataset used is the SSL400 from Kaggle (50 SLSL signs, 3,092 training samples, 546 test samples), where MediaPipe has tracked 132-dimensional hand landmarks per frame to cover 50-frame sequences. There were four architectures created and examined: TCN-SE, BiLSTM-Attention, 1D CNN-GRU Hybrid, and Lightweight Transformer. Out of the four, TCN-SE was the one that got the highest accuracy of 90.48%, which was way above the accuracy of BiLSTM-Attention (52.20%), CNN-GRU (49.45%), and Lightweight Transformer (50.37%). The analysis of feature importance showed that the combination of multiscale dilated convolutions and adaptive attention mechanisms truly capture both the short-term and long-term temporal patterns in sign language movements. TCN-SE with a training time of just 30 minutes can be called a suitable candidate for practical real-time SLSL recognition systems. The current study provides the first thorough comparative analysis of the cuttingedge architectures solely for SLSL recognition, thus giving the researchers the practical guidance to design the sign language recognition technologies for the hearing-impaired community that are not only efficient but also lowcost.

***Keywords:*** *Deep Learning; MediaPipe; Sign Language Recognition; Sri Lankan Sign Language; Temporal Convolutional Networks*

# Tab-Net Powered Assessment for Early Recognition of Neurodevelopmental Disorders in Children Below Three Years using Symptom Analytics

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Neurons are the basic building blocks of the human brain and nervous system. In the past few years, Neurodevelopmental Disorders (NDD) in toddlers has been increasing in the world year by year and this is becoming a major issue in pediatric portion health. Specifically, Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD), are significantly affecting complex disorders, for children's main motor function. Early intervention for these disorders is strictly effective to improve outcomes of toddlers. However, due to the traditional screening techniques and lack of clinical resources in Sri Lanka, there is a massive delay in diagnosis. This research aims to fill this gap by early recognition disorders and providing more accurate results. This exploratory study proposes a static, Tab-Net based interpretable deep learning model by analysing behavioral symptoms and signs in children below 36 months age. Evaluated the model using quantitative strategy applied a merged dataset of behavioral analytics. Tab-Net model differs from the traditional black box classifications by interpretable feature selection evaluations. Various models were built using same dataset including Decision Trees (95.40%), SVM (95.40%) and Random Forest (95.82%) to compare the performance of the TabNet model. The Tab-Net model achieved impressive performance with 97.07% testing accuracy, 97.08% precision, 97.07% recall and F1-score, and 99.46% ROC-AUC. The results demonstrate that Tab-Net provides competitive performance with early NDD diagnosis in resource limited settings.

***Keywords:*** *Attention Deficit Hyperactivity Disorder (ADHD); Autism Spectrum Disorder (ASD); Early Childhood Symptoms; Neurodevelopmental Disorders (NDDs); Tab-Net*

# Detecting scam job advertisement using machine learning techniques

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Automated detection of scam job advertisements is critical for ensuring safer online recruitment. This study proposes a machine learning–based approach for detecting fraudulent job postings using textual and metadata features. Experiments were conducted using the publicly available Fake Job Posting Prediction Dataset from Kaggle, which contains approximately 17,880 job postings with 18 features, exhibiting a significant class imbalance between legitimate and fraudulent advertisements. Text preprocessing and feature extraction techniques were applied to identify discriminative linguistic patterns associated with scam postings. Multiple machine learning classifiers, including Logistic Regression, Support Vector Machines, Random Forest, and Gradient Boosting, were trained and evaluated. Model performance was assessed using accuracy, precision, recall, F1-score, and ROC–AUC metrics. Experimental results demonstrate that ensemble-based models outperform baseline classifiers, achieving superior detection performance. In addition, feature importance analysis highlights key linguistic indicators such as exaggerated benefits, vague job descriptions, and abnormal salary patterns, contributing to improved interpretability of scam detection. The findings indicate that the proposed approach can serve as an effective automated scam job advertisement detection system to support safer recruitment practices. Future work will focus on validating the proposed framework using real-world job advertisement datasets and deploying it as a practical decision-support tool.

***Keywords:*** *Scam Job Detection; Machine Learning; Fake Job Advertisements; Text Classification; Recruitment Security*

# Predictive modeling for injury risk and performance analysis in collegiate and female basketball players

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This paper examines a machine-learning model of injury prediction and performance assessment on female and collegiate-level basketball players through interpretable workload-based models. The dataset was gathered among the players in the university and district teams based on training logs, sprint tests (20 m, 30 m, 50 m), records of each weekly session, player survey, and team performance databases, including variables of ACWR (Acute-toChronic Workload Ratio is a metric that compares short-term training load to longer-term load), fatigue rating, minutes played, points per game, history of previous injuries, and environmental conditions. The data consisted of 180 player-weeks of data in two training cycles. The exploratory analysis revealed obvious changes in workloads and increased ACWR spikes in female athletes. Logistic regression was used to predict injuries and it was found that fatigue scores and ACWR were significant predictors with 78 percent accuracy and 0.74 recall. Performance prediction using linear regression revealed that training intensity, sprint performance and minutes played were a combination of variables that could explain 62 percent of the variance in player output. Transparency of the research was achieved by the interpretation methods that could be used in practical coaching. The results have shown that ACWR with the use of playerspecific factors can offer valuable information on the concept of workload management, injury probability downplay and inform evidencebased decisions on behalf of the underrepresented athletic groups. This study can be used in the creation of non-discriminatory and understandable sports analytics to match the digital performance tools of the next generation.

***Keywords:*** *Predictive Modeling; ACWR; Basketball Analytics; Injury Prediction; Interpretable Models*

# Data-driven prediction of university admission cutoff marks in Sri Lanka using machine learning

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Admissions into universities in Sri Lanka are determined through the cutoff marks published annually in the University Grants Commission (UGC), although the procedure itself is not only unclear but opaque to students as well as counselors. Since the procedure is unclear, students end up making academic choices based on misleading information. This research proposes a machine learning model for accurate determination of the cutoff marks in the UGC university admissions. The proposed approach uses the UGC cutoff dataset (2020-2025), with features like the year, the district quota, the stream, the university, the degree, the intake capacity, and the cutoff marks. The final supervised regression approach using XGBoost with year-related features and lag features for cutoff points is proposed. In this work, the error in the regression method is calculated by the RMSE, MAE, and $R^2$ values. The regression analysis will be done by the subgroup error analysis for districts and streams, and the regression results will be explained by SHAP values. The RMSE, MAE, and $R^2$ score of the XGBoost algorithm come out to be 0.2062, 0.1446, and 0.7484, respectively. Among various factors given importance by the algorithm, Z score is given maximum importance, followed by subject stream, district quota, university, intake capacity, and previous year cutoff trends. On checking the equity of the algorithm, it is found that the disparity of errors is very low, which makes it a fair algorithm. This study has shown the viability and accuracy of using machine learning algorithms to predict the admission cutoffs of UGC admissions. This work fills the very significant research gap created by the absence of publications focusing on the educational data-mining domain. This work can form the basis of an effective and transparent decision support system that can help students, counselors, and policymakers make educated decisions regarding educational planning and access to higher education.

***Keywords:*** *Educational Data Mining; Machine Learning; Sri Lanka; University; Admissions*

# AI-powered predictive modeling and comparative machine learning analysis for improving hospital operational efficiency

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The study addresses the critical problem that Sri Lankan state-run hospitals have no data-driven predictive tools of patient movement and resource allocation that have led to longer patients waiting and poor bed utilization. This study was done in the face of problems such as long patient waiting time and ineffective bed management owing to manual operations. The study followed an organized machine learning pipeline, where 500 records of patients from 01/2023 to 12/2023 were used to train and test predictive models that would predict Length of Stay, Readmission and Resource Requirement. The most important algorithms were the Random Forest, Gradient Boosting, and XGBoost, and they were tested according to the cross-validation and hyperparameter optimization. Findings confirmed that XGBoost was superior to the other models in that it was able to manage the complex interactions between features effectively and the test accuracy of 82.7% with F1-score of 0.809 indicating readmission prediction. Whereas, the Mean Absolute Error of the model in predicting length of stay (LOS) was approximately 9 days against a mean LOS of 15 days. It was also found that clinical and demographic factors such as Infection condition type, age group to 41-60, and department Intensive Care Unit are the most powerful predictors due to feature analysis, which indicated that the clinical presentation and patient characteristics were stronger indicators of the decision-making process of bed management than administrative characteristics. This study has shown that decision-support systems can be utilized based on solid ground using AI predictive models to optimize work processes in resourcelimited healthcare environments.

***Keywords:*** *Artificial Intelligence; Healthcare Resource Optimization; Predictive Modelling; Patient Flow Management; Machine Learning*

# A machine learning-based evaluation of English-to-Sinhala translation: comparing Google Translate, large language models, and human translators

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Reliable translation from English to Sinhala is still a great challenge for many sophisticated translation systems using Sinhala as a low-resource language. Although Google Translate is widely used for translationpurposes, recent breakthroughs in large language models such as ChatGPTand DeepSeek provide entirely new opportunities for translation tasks. This study proposes one of the first thorough comparative analyses of English-Sinhala translation systems compared with human translation, both qualitatively and quantitatively. Google Translate, ChatGPT, DeepSeek, and human translations done by native Sinhala speakers were compared for translation quality on a carefully prepared dataset of 150English sentences for general, technical, and academic purposes. Translation quality was compared using BLEU, METEOR, and COMETscores, in addition to human assessment of fluency, grammatical accuracy, and semantic translation quality done by qualified human raters using a prepared rubric with inter-rater reliability tests. Machine learning models were also prepared for predicting translation quality using language-basedpredictors for translation efficiency and translation system identification. The experimental results show that human translations were rated highest on all translation quality measures. Among the automatic translationsystems, LLM-based translation systems performed better on contextual understanding of complex sentences than Google Translate, whichperformed reasonably on simple inputs. Correlation tests showthat COMET correlates better with human translation quality than BLEUandMETEOR. Moreover, the prepared machine learning models were able todetect translation quality trends accurately for translation systempredictions, making these models promising for translation qualityassessment in low-resource language environments.

***Keywords:*** *Large language models; Low-resource languages; Machine translation; Sinhala language; Translation evaluation*

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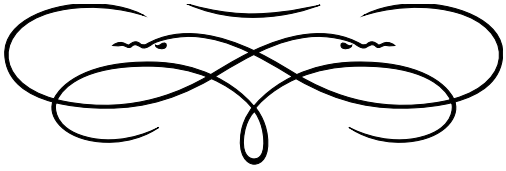

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# A Multi-Dimensional Analysis of Infrastructure Considerations in Industrial Facility Placement Using Machine Learning

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Increasingly complex global economies are making the process of choosing factory locations much more difficult for policymakers and investors. In their traditional form, assessments of factory site locations no longer represent current factors affecting factory placements such as new and improved transportation infrastructure and the growth of Industry 5.0, and as a result do not give a long-term perspective on future industrial site placements. Therefore, the study presents a data-driven approach, combining industrial location theory and modern predictive analytics, to identify potential future factory locations. The approach recommended in this study will require that these factors be analyzed on a national level using predictive analysis techniques to determine the likelihood of future location suitability. Site selection factors will include analyzing six primary determinants (electric service reliability, transport/logistics performance, gross domestic product, inflation, trade openness, and political stability) influencing industrial location decisions in 151 countries from 2000-2024. Various forecasting techniques, such as vector auto-regression, random forest, XGBoost, linear regression, LSTM, and a VAR-XGBoost hybrid, determined each factor's projected 2024 value. MSE and R2 metrics indicated the model's accuracy. The random forest combination achieved the highest accuracy. The unique combination random forest achieved the highest level of accuracy. By also aggregating predicted values into a weighted Composite Factory Suitability Index allows for the establishment of a predictor of industrial location potential as well future location of factories. This research offers an adaptive, predictive approach to evaluating factory site suitability, enabling strategic decision-making for policymakers, investors, and industries globally in a rapidly changing business environment.

***Keywords:*** *Hybrid Time-Series Modelling; Factory Suitability Index Forecasting; Vector Autoregression (VAR); XGBoost Correction Model*

# Hybrid Approach for Automated University Academic Timetable using Graph Coloring Techniques and Linear Programming Mathematical Resource Optimization Model

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University course timetabling is a complex optimization problem that must satisfy multiple hard and soft constraints. These include avoiding clashes among courses and lecturers, allocating limited classroom and laboratory spaces, and ensuring efficient use of academic resources. Traditional manual or semi-manual timetabling methods often result in scheduling conflicts, inefficient utilization of facilities, and significant time wastage, which adversely affects academic activities. To overcome these challenges, this study proposes an integrated approach that combines graph coloring techniques with a linear mathematical optimization model to automate the university timetabling process. The proposed methodology is adaptable to different academic environments and institutional contexts. Its effectiveness is validated through a real-world case study conducted at the Faculty of Computing, Sabaragamuwa University of Sri Lanka, using academic and scheduling data analyzed with MATLAB. The study is organized into two main phases. In the first phase, a graph-based model represents courses as vertices and scheduling conflicts as edges. An adjacency matrix and the Welsh–Powell graph coloring algorithm are employed to assign a minimum number of conflict-free time slots. In the second phase, a linear programming model is applied to optimize room allocation with the objective of maximizing the utilization of available lecture halls and laboratories. The results indicate that the proposed system can produce completely conflict-free timetables while significantly enhancing lecture room utilization. As a next step, the study aims to evaluate seat wastage by analyzing unoccupied seating capacity. Future enhancements include increasing automation through the development of a more user-friendly interface. Overall, this research provides a structured and practical solution to the university timetabling problem, contributing to improved administrative efficiency and effective resource utilization.

***Keywords:*** *Automated Scheduling; Graph coloring; Linear Programming; Resource optimization; Timetabling Optimization*

# An innovative heuristic algorithm for multi-objective transportation problems using improved ant colony algorithm

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The transportation problem is a well-known optimization challenge that aims at minimizing the total costs for distributing resources from different sources to numerous destinations. In complicated logistical situations, many objectives such as cost, time, and distance are optimized together. This leads to the multi objective transportation problem where a productive compromise solution is sought. Although literature has established various methods like goal and fuzzy programming, these approaches often fall short for large-scale instances due to high computational demands. In this study, an innovative heuristic algorithm is established using an Improved Ant Colony Optimization approach combined with a harmonic cost matrix to aggregate conflicting goals. The incremental novelty of this work is distinguished by the introduction of a static probabilistic penalty mechanism. Unlike traditional methods requiring dynamic recalculations, this deterministic approach utilizes a desirability matrix to simplify decision-making. Furthermore, this research eliminates the standard reliance on dummy variables, maintaining the original problem dimensionality and saving significant computational resources. The efficiency of this technique is validated through benchmarks comparing the Improved ant colony optimization method to other methods. Performance results demonstrate superior outcomes: Example 1 achieves a 3.8% reduction in distance; Examples 2 and 5 yield identical optimal solutions; Example 3 reduces time by 5.8%; and Example 4 achieves a 28.6% cost improvement. It can definitely be concluded that the algorithm could be a highly powerful, flexible, and efficient tool for dealing with large classes of optimization problems likely to occur in real-world logistics.

***Keywords:*** *Ant Colony Optimization; Multi-Objective Optimization; Transportation Problem*

# Five-color incidence coloring of the recursive modified claw graph

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Graph theory is a branch of mathematics that studies how objects are connected using vertices and edges. An important concept within this field is incidence coloring, where colors are assigned to vertex edge pairs, called incidences, rather than to vertices or edges alone. The minimum number of colors required to ensure that no two adjacent incidences receive the same color is known as the incidence chromatic number, denoted by $\chi_i(G)$. This research introduces the Recursive Modified Claw Graph, constructed from a four-edge base graph with one central vertex of degree four with four leaves. The graph is expanded level by level attaching new duplicates of the base graph to the leaves created in the previous level according to a fixed recursive pattern, while maximum degree remains four. The general structure $(G_n)$ has $V(n) = 6 \times 3^{n-1} - 1$ vertices and $E(n) = 6 \times 3^{n-1} - 2$ edges for all $n \geq 1$, where $n \in \mathbb{Z}^+$. A cycling five color palette is introduced by rotating a level color $c_n$ through $\{1,2,3,4,5\}$ while each new center vertex uses the remain four colors, and all new leaf-side incidences use $c_n$. An induction proof shows this always gives a proper incidence coloring with $\chi_i(G_n) \leq 5$ for all $n \geq 1$ with potential applications in areas such as timetable scheduling, network optimization and resource allocation, where conflict-free assignments are essential. This work extends existing incidence coloring theory beyond trees and standard cactus graphs to structured claw-based recursive families, contributing both theoretical insights and a scalable algorithmic framework.

***Keywords:*** *Incidence Chromatic Number; Incidence Coloring; Mathematical Induction; Network Optimization; Recursive Modified Claw Graph*

# An automated approach for selecting the most suitable AWS EC2 instance for software projects prior to deployment

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Cloud computing is now a staple of a modern software development with provisioning of scalable and on-demand resources. Amazon Web Services (AWS), the cloud services leader, offers great variety of types of the Elastic Compute Cloud (EC2) instances, and it makes the decision about the adequate instance to be chosen before deployment a difficult task. A poor decision will result in a reduction in performance, redundant costs, and slow deployment times. Available tools like AWS Compute Optimizer and Instance Type Finder are based on CloudWatch telemetry which means that applications must be deployed first and then it can recommend something, which in turn adds additional cost and delays. This study suggests the pre-deployment EC2 instance recommendation framework which is independent of cloud-generated telemetry. The proposed system analyzes local workload behavior using a hybrid prediction approach that combines machine learning with rule-based reasoning. System-level and application-level profiling tools are used to collect performance metrics from representative workloads, including CPU-intensive, memory-intensive, I/O-intensive, and mixed workloads. The collected metrics, such as CPU usage, memory consumption, disk throughput, and network activity, are preprocessed and transformed into structured feature vectors. In parallel, an EC2 instance specification dataset is constructed using official AWS documentation. A supervised XGBoost classifier is then applied to map workloads to the most suitable EC2 instance family, with initial labels generated through rule-based feature matching. After identifying the instance family, a secondary rule-based decision layer selects the specific instance type based on vCPU requirements, memory demand, network performance, and EBS usage patterns. To improve transparency and user understanding, a Retrieval-Augmented Generation (RAG) module retrieves relevant AWS documentation to support each recommendation.

***Keywords:*** *Cloud computing; AWS EC2; Instance selection; Workload profiling; Automation*

# Developing a privacy-preserving federated learning framework for intrusion detection in IoT networks using ethical hacking simulations

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The Internet of Things has transformed modern systems by integrating artificial intelligence, cybersecurity, and real-time analytics into billions of interconnected devices. However, decentralization and resource constrained IoT networks are vulnerable to cyberattacks such as Distributed Denial-of-Service and data poisoning. Conventional centralized intrusion detection systems require the transmission of raw data to a central server, which violates privacy regulations such as GDPR and introduces single points of failure. Existing federated learning (FL) approaches for IoT IDS employ differential privacy, homomorphic encryption, or blockchain on static, such studies are mainly based on offline assessments and do not include the simulation of real-time ethical hacking against dynamic threats. This research addresses this gap by proposing a privacy-protecting FL system based on Federated Averaging. A binary classification model was trained, with an accuracy of 89%. A simulation of ethical hacking was performed on hping3 to generate a live SYN flood attack, which produced malicious packets that were captured under the use of tcpdump and verified in Wireshark. The framework was able to identify most attack packets, and this indicates it has robust real-time performance. The framework mitigates privacy risks in centralized systems and shows scalability for resource constrained devices. Limitations include reliance on simulated rather than physical IoT devices and evaluation focused primarily on DoS attacks.

***Keywords:*** *Federated Learning; Intrusion Detection System; Internet of Things; Ethical Hacking; Simulation*

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