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Concept Paper

A Machine Learning Approach on Illegal Fishing Detection Using RNN for the Area of Bauang, La Union, Philippines

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Abstract

Purpose — In La Union, illegal, unreported, and unregulated (IUU) fishing threatens local livelihoods and marine ecosystems. Traditional methods are not enough to monitor wide maritime areas. This study aims to apply machine learning, particularly Recurrent Neural Networks (RNN), to detect illegal fishing by analyzing fishing patterns, vessel movements, and satellite imagery. The proposed system includes a server-side geofencing feature and a mobile client for collecting GPS data.

Methodology — This research uses a mixed-methods approach, combining both quantitative and qualitative techniques. The quantitative part focuses on developing and implementing an RNN model to detect illegal fishing. The qualitative aspect involves data collection and analysis to understand the challenges and opportunities related to IUU fishing in La Union.

Result — Survey findings show a need for modern monitoring solutions. About 72% of respondents use vessel monitoring systems, 64% are aware of illegal fishing, and 66% carry

mobile phones. Additionally, 80% expressed interest in training, and 44% of respondents are aged 18–24, indicating high potential for adopting digital surveillance tools.

Conclusion — The RNN model has proven effective in identifying and monitoring illegal fishing in real time. This technology supports marine conservation and promotes the long-term sustainability of local fishing communities.

Recommendation — It is recommended to implement the RNN-based monitoring system in Bauang, La Union. This solution will enhance detection and law enforcement efforts, protect marine resources, and enable quick response actions to IUU fishing.

Practical Implications — The model has the potential for broader use. It can assist agencies like BFAR is enforcing fishing regulations and improving marine conservation nationwide. Real-time data analysis will also support sustainable fishing practices and reduce the negative impact of illegal fishing.

Keywords – Recurrent Neural Networks (RNN), satellite imagery, vessel tracking, surveillance systems

INTRODUCTION

Illegal fishing is a serious hazard to marine ecosystems because it disturbs aquatic life and jeopardizes viable fishing methods. Illegal, unreported, and unregulated (IUU) fishing is still a significant problem in La Union, a coastal area abundant in marine resources. It impacts local fishermen's livelihoods and threatens the viability of the area. It is difficult to detect and stop unlawful fishing since traditional surveillance techniques cannot keep an eye on large maritime areas. This study improves monitoring and enforcement efforts by utilizing machine learning, notably Recurrent Neural Networks (RNN), to address these issues.

Artificial Intelligence (AI) technologies offer powerful tools to help authorities enforce fishing regulations more effectively. According to Abangan et al. (2023), AI can analyze vessel behavior, process satellite imagery, and monitor marine habitats to detect violations. Technological advancements, particularly in AI and machine learning, play a vital role in combating illegal fishing. Cheng et al. (2023) highlight the importance of tracking and understanding fishing vessel activities to ensure sustainable fisheries management. AI algorithms can process vast datasets from vessel tracking systems to identify suspicious patterns, allowing for more efficient enforcement of laws. Similarly, Watson et al. (2023) demonstrate that supervised machine learning models, such as random forests and gradient boosting, are highly effective in detecting illegal fishing activities.

Other research has examined the application of AI to sustainable fisheries management. Motiramani (2023) further supports this, using Global Fishing Watch (GFW)

data to demonstrate how well classification models like Random Forest, SVM, and XGBoost identify unlawful fishing. These studies demonstrate how AI-powered monitoring and predictive modeling can greatly enhance the identification and stoppage of illicit fishing.

Given these advancements, this study aims to develop an RNN-based machine-learning model to detect and prevent illegal fishing in La Union. The research objectives include creating mobile and web platforms that utilize real-time satellite imagery and vessel tracking and developing a robust surveillance system with real-time monitoring capabilities. By leveraging AI-driven solutions, this study seeks to protect marine resources and promote sustainable fishing practices in La Union, providing a scalable model for safeguarding marine ecosystems worldwide.

LITERATURE REVIEW

In the study of Abangan et al. (2023), the authors highlight how artificial intelligence (AI) might improve the identification and stop illegal fishing. Artificial intelligence (AI) technologies can give authorities the means to more successfully enforce fishing restrictions by evaluating vessel actions, processing satellite photos, and monitoring maritime habitats.

Cheng et al. (2023) emphasized the importance of monitoring and understanding fishing vessel behavior to facilitate effective fisheries management. Their study reviews the use of AI algorithms to analyze large datasets from vessel-tracking systems. The paper synthesizes the factors influencing fishing vessel behavior and compares different data sources used for this purpose. It also explores how AI can be applied in fishery science and management, ultimately promoting more efficient and informed decision-making in the sector.

Davis and Harasti (2020) examined illegal fishing in no-take marine protected areas in Australia, finding higher activity on non-working days and in favorable weather. Using generalized linear modeling, they predicted illegal fishing patterns, highlighting their prevalence near boat launch sites. Their findings aid enforcement and management efforts.

Fernandes-Salvador et al. (2022) explored how artificial intelligence (AI) is being used in the fisheries sector. The study reviewed current laws, especially the EU's AI Act, which defines how AI should be applied and regulated. It highlighted how AI helps improve traceability of fish products, selectivity of fishing gear, and encourages sustainable practices. The study also noted that AI can create job opportunities for young people in the field. Finally, it provided policy suggestions to help EU leaders use AI more effectively in fisheries management.
This study shows that AI can support both sustainability and regulation in fisheries, helping reduce illegal fishing and improve industry practices.

González (2023) highlights that IUU fishing costs coastal nations up to $50 billion annually. Using machine learning, researchers analyzed GPS data and vessel registries to track 33,000 fishing vessels, revealing that 20% of high seas fishing may be unauthorized. The study also identifies "reflagging" as a tactic to evade oversight, with a few flag states responsible for most cases.

Huang et al. (2021) studied how to detect unusual or suspicious behavior of fishing vessels using real-time anomaly detection in a marine edge computing environment. Their system uses data from vessel movements to identify illegal or abnormal fishing activities as they happen. The study shows how advanced computing and AI can improve monitoring and surveillance at sea, helping to combat illegal, unreported, and unregulated (IUU) fishing. This research supports the use of real-time technologies to enhance maritime security and promote legal and sustainable fishing practices.

Motiramani (2023) focuses on the significant threat posed by illegal, unreported, and unregulated (IUU) fishing, which costs the global economy approximately $23.5 billion annually and endangers fish populations and marine ecosystems. This study proposes a method for identifying illegal fishing activities by using machine learning and data analytics techniques. By analyzing data from the Global Fishing Watch (GFW), which includes vessel location, type, and speed, the study employs various classification models such as Random Forest Classifier, XG Boost, SVM, KNN, Naïve Bayes, Decision Tree, and Logistic Regression. These models are used to predict illegal fishing, enabling the implementation of appropriate actions to combat violations. This approach seeks to curb the illegal fishing industry and protect fish populations from extinction.

Mühling (2023) investigates how automation and artificial intelligence (AI) might improve marine conservation, especially in identifying and implementing marine protected areas (MPAs). The study highlights how human activity endangers marine ecosystems and how artificial intelligence (AI) might enhance data collecting, monitoring, and analysis. To facilitate well-informed decision-making and efficient ecosystem management, it emphasizes the necessity of integrating new technologies into conservation initiatives ethically and cooperatively.

According to Padama (2023), Illegal, Unreported, and Unregulated (IUU) fishing remains a major issue in the Philippines, affecting marine ecosystems, fisheries sustainability, and the livelihood of coastal communities. Existing policies and enforcement mechanisms require reassessment to address regulatory gaps and challenges in implementation. The study highlights the need for clearer local ordinances, better monitoring systems, and stronger inter-agency coordination. This research aims to evaluate the current state of IUU fishing in the Philippines and identify key barriers to enforcing national laws and municipal regulations.

Terry and Donato (2024) examined the enforcement challenges of combating Illegal, Unreported, and Unregulated (IUU) fishing in Manila Bay, Philippines. By conducting a qualitative study with 22 law enforcement officers from Bataan, Pampanga, and Bulacan, the

researchers were able to pinpoint major challenges such as poor equipment, fabricated informants, bad weather, and recurring infractions. To effectively combat IUU fishing in the area, thematic analysis showed that authorities needed to collaborate and coordinate more strategically, as well as strengthen monitoring, control, and surveillance.

Tsuda, Miller, Saito, Park, and Oozeki (2023) created a machine learning-based method for automated vessel detection using the day–night band (DNB) of VIIRS remote sensing data to enhance fisheries monitoring. They developed a two-step training method to deal with the big and unbalanced dataset, addressing issues like cloud cover and moon effects. Using on-ship radar data, the algorithm was verified and showed performance on par with current detection techniques. When applied to the East China Sea, it showed a rise in night fishing activity, providing useful information to help improve stock assessment and fisheries management.

Wang et al. (2023) explored the application of deep learning techniques, particularly Long Short-Term Memory (LSTM) networks, in recognizing fishing vessel behaviors. The study demonstrated that LSTM models with Squeeze-and-Excitation (SE) modules performed significantly better than traditional models such as ResNet and VGGNet in terms of accuracy for vessel activity recognition. This suggests that Recurrent Neural Networks (RNNs), especially LSTM-based approaches, are highly effective for real-time monitoring of fishing vessels, providing enhanced accuracy and responsiveness compared to conventional deep learning models.

Watson et al. (2023) addressed the issue of unreported, unregulated, and illegal (IUU) fishing on the US West Coast by using supervised machine learning techniques. The study utilizes gradient boosting and random forest models to detect potential illegal activities in fisheries that lack comprehensive monitoring. With data from nearly 10,000 fishing trips, the developed models achieve 97% accuracy in predicting fishing locations. The study demonstrates that these models are robust and reliable, even when subjected to environmental variability, and suggests that they can be highly effective for monitoring IUU fishing in areas with limited oversight.

Willette et al. (2023) focused on the role of AI and automation in enhancing data collection, analysis, and decision-making processes critical for designating protected marine areas. The study highlights the potential of using genetic and electronic monitoring technologies to modernize global fisheries management. It emphasizes the importance of collaboration between scientists, policymakers, and technology experts to implement effective measures for protecting marine ecosystems and ensuring sustainable use of ocean resources. The research suggests that AI-driven solutions will play a crucial role in advancing global fisheries management.

Zuzanna, Tomasz, Michał, and Robert (2022) investigate how artificial intelligence and high-tech solutions can be used to fight illegal, unreported, and unregulated (IUU) fishing, which poses a danger to food security and marine ecosystems. The study examines several

cutting-edge techniques for identifying and tracking IUU activity that use machine learning and sensor-based technologies like CCTV, GPS, radars, AIS, and VMS. Additionally, it covers the state of the field, points out any shortcomings, and talks about potential future paths for enhancing IUU detection and prevention through AI-driven methods.

METHODOLOGY

This study uses a mixed-methods approach, combining both quantitative and qualitative research. The quantitative aspect involves creating and using a Recurrent Neural Network (RNN) to detect illegal fishing, while the qualitative aspect focuses on collecting and analyzing data to understand the challenges and opportunities related to illegal fishing in La Union.
The software aims to develop a machine learning system with RNNs to detect and prevent illegal fishing in La Union. It will analyze data from satellite images, vessel tracking, and historical fishing patterns to identify suspicious activities.

The system architecture includes a Data Collection Module, gathers satellite images, vessel tracking data, and historical fishing patterns using APIs and databases. Mobile Client sends GPS coordinates to the server and updates it with current location information via HTTP/HTTPS API.

Server-Side Geofencing Checks if coordinates fall within defined geofenced areas and manages event notifications to a web browser monitoring system using frameworks like Django and Node.js. Event notifications will be sent via HTTP/HTTPS API or WebSocket.

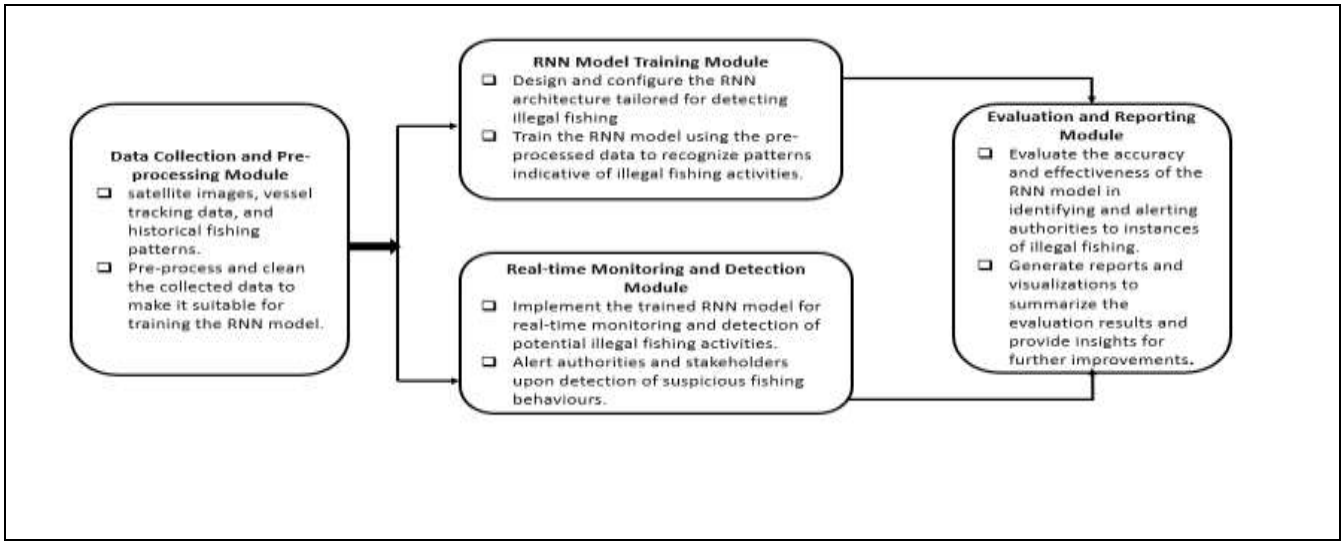

Figure 1. Conceptual Frameworks

This conceptual design describes the methodology and elements needed to create a machine learning-based system that uses Recurrent Neural Networks (RNN) to identify and

stop illegal fishing in the La Union seas. The system attempts to solve the problems associated with identifying illegal fishing methods, the deficiency of efficient monitoring systems, and the requirement for proactive and automated tactics to safeguard fisheries and maritime resources.

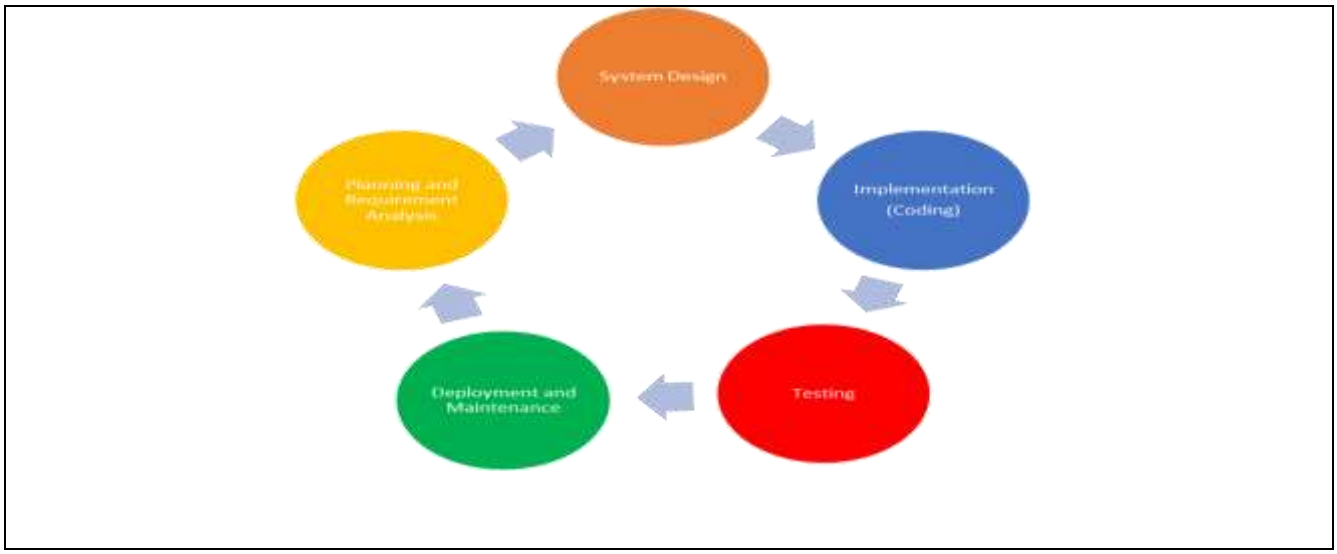

Figure 2. System Development Lifecycle

The study's System Development Life Cycle (SDLC) outlines an organized and methodical strategy for planning, implementing, and sustaining a research project targeted at detecting and combating illegal fishing in La Union utilizing RNN-based machine learning algorithms. The research intends to assure the project's success and effectiveness by following the SDLC phases, while also contributing to marine conservation efforts and maintaining local fishing communities' livelihoods.

Planning and Requirements Analysis- in this phase defines the research project's objectives, scope, and expected outcomes are defined. Identify stakeholders such as fishermen, local governments, and marine conservation organizations.
System Design- In this phase, Data Collection and Pre-processing Design, the respondents create a method for gathering and pre-processing relevant data, such as satellite imagery, vessel tracking information, and historical fishing trends. Machine Learning Model Design that can create an RNN-based machine learning model to recognize patterns suggestive of illegal fishing activities.

Implementation (Coding)- This phase will implement the data collecting and pre-processing modules with the relevant tools and technologies. Machine Learning Model Training and Evaluation and can create and train an RNN-based machine learning model utilizing collected and pre-processed data. Assess the model's performance using appropriate measures.

Implement the real-time monitoring system, including the dashboard and alerting systems, using the appropriate tools and platforms. User Interface Implementation: Use web development tools to create and implement a user interface for stakeholders.

Testing- In this phase, unit testing involves validating the functionality and performance of individual components/modules. Integration testing ensures that integrated components/modules communicate and work seamlessly. User Acceptance Testing (UAT): Invite users to test the system's overall performance, usability, and accuracy.
Deployment and Maintenance- This is where the deployment places the produced system in the intended environment, assuring adequate configuration, security, and performance optimization. Monitoring and Maintenance constantly monitor the system's performance, address any faults or defects, and provide regular upgrades and maintenance to ensure maximum functionality and reliability. Collect customer feedback and implement it into the system to ensure continual improvement and optimization.

RESULT AND DISCUSSION

The survey results highlight the need for advanced monitoring solutions in the fishing industry (Tables 1 and 2). With 72% of respondents already using vessel monitoring systems and 64% aware of illegal fishing activities, there is strong potential for adopting mobile and web platforms that utilize satellite imagery and vessel tracking for real-time alerts. Additionally, 66% of fishers carry cellphones while fishing, which can support mobile-based monitoring solutions. The high interest in training (80%) and the significant presence of young fishers (44% aged 18-24) suggest that modern surveillance systems with real-time monitoring capabilities would be well-received. These findings reinforce the necessity of deploying robust, technology-driven solutions to enhance maritime security and combat illegal fishing.

Table 1. Age Distribution

Category	**Details**
Age Distribution	44% of respondents are aged 18-24, indicating a considerable number of young adults in the fishing industry. 20% are aged 25-34, showing a significant but smaller group. 18% are aged 35-44 or 45-54, indicating a fairly constant distribution across these age groups.

CONCLUSION

This study addresses the pressing issue of illegal fishing in La Union, a region severely impacted by unregulated fishing practices that threaten marine ecosystems and local livelihoods. Integrating Recurrent Neural Networks (RNNs) into a machine learning framework offers a promising solution for detecting and preventing illegal fishing activities. By leveraging real-time satellite imagery, vessel tracking, and historical data, the proposed system can provide timely alerts and enhance surveillance capabilities over extensive

maritime areas. The research highlights a significant gap in traditional surveillance methods, emphasizing the need for technological advancements to ensure effective monitoring and conservation efforts.

Table 2. Frequency and Weighted Mean Distribution of Respondents' Fishing Practices and Perceptions.

Question	Yes	No	Weighted Mean	Interpretation
Own a Fishing Boat	25	25	0.5	50% of respondents own a fishing boat.
Go Fishing Every Day	40	10	0.8	80% of respondents fish every day.
Fish Beyond 15km from Municipal Waters	10	40	0.2	20% of respondents fish beyond 15km from municipal waters.
Received Training/Seminars on Proper Fishing	33	17	0.66	66% of respondents have received proper fishing training.
Interested in Attending Training/Seminars on Proper Fishing	40	10	0.8	80% are interested in attending training.
Bring a Cellphone When Fishing	33	17	0.66	66% of respondents bring a cellphone when fishing.
Aware of Illegal Fishing Activities	32	18	0.64	64% of respondents are aware of illegal fishing activities.
Use Vessel Monitoring or Automatic Identification System	36	14	0.72	72% of respondents use vessel monitoring systems.
Been Arrested for Illegal Fishing	0	50	0	0% of respondents have been arrested for illegal fishing.
Believe There Are Enough Regulations for Illegal Fishing	0	50	0	0% think there are enough regulations to combat illegal fishing.
Would Like to Receive Weather Updates While Fishing	45	5	0.9	90% would like to receive weather updates while fishing.

RECOMMENDATION

To address the issue of illegal fishing in La Union and set a precedent for other regions, it is crucial to develop and deploy the proposed Recurrent Neural Network (RNN)-based machine learning model. This system should integrate real-time satellite imagery and vessel tracking to provide comprehensive coverage and enhance detection and prevention efforts. User-friendly mobile and web platforms should be created to offer real-time alerts and monitoring capabilities to key stakeholders, including local fishermen and enforcement agencies.

Furthermore, it is essential to increase training programs for local fishermen, focusing on legal fishing practices and monitoring technology. Additional training sessions should address advancements in fishing regulations and technology to ensure fishermen are well-informed and equipped. Investing in robust surveillance systems is also critical, enabling effective coverage of large maritime areas with real-time data analysis and quick intervention capabilities.

Collaboration among local authorities, conservation organizations, and technology developers is necessary to ensure the successful implementation and maintenance of the RNN-based monitoring system. Continuous monitoring of the system's performance and effectiveness should be conducted, with adjustments based on user feedback and ongoing analysis of illegal fishing activities.

Lastly, advocating for stronger regulations and enforcement mechanisms is vital, as feedback from fishermen indicates that current regulations are insufficient. By addressing these recommendations, the study aims to contribute significantly to the sustainable management of marine resources in La Union and provide a model for other regions facing similar challenges.

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DECLARATIONS

Conflicts of Interest

I do hereby declare that I am solely responsible for the Study entitled, "A Machine learning Approach on Illegal Fishing detection using RNN for the area of Buang La Union"; There are no conflicts of interest to declare at the international or national level, specifically in the Province of La Union where the study and research were conducted.

Informed Consent

Prior consent was obtained and approved by no less than the Secretary of the Department of Agriculture, Republic of the Philippines, Honorable Francisco "KiKo" Tiu Laurel, Jr, before embarking on the research project and study of the fishing industry.

Ethical Standard

I will abide by and be guided by the aims of the profession in promoting public trust and protecting the welfare of research participants to ensure the highest integrity in our work and maintain responsible conduct.

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Author's Biography

I am Thomas L. Dumpit Jr., a retired Colonel of the Philippine Army, former Congressman of the 2nd District of La Union, and a dedicated public servant. Currently, I am a graduating student in the Doctor of Information Technology with a strong academic background. I hold a Bachelor of Science in General Studies, a Master's in Management from the University of the Philippines, and a Master's in Information Technology from AMA University. Additionally, I completed a Graduate Certificate in Public Financial Management at the Harvard Kennedy School of Government. I brought the leadership, discipline, and strategic thinking I developed throughout my military experience to my work in public service. As a former congressman, I supported digital transformation, infrastructure development, and national security. Having worked in technology, finance, and government for a long time, I am still dedicated to advancing the nation's development and fostering innovation.

Dr. Richard N. Monreal is an Associate Professor and the Dean of the College of Computer Studies at AMA University. I have extensive experience teaching Computer Engineering, IT, and Computer Science at institutions such as TIP-QC, University of the Cordilleras, Trinity University of Asia, and Divine Word College of Legazpi. My background in research and program management has enabled me to contribute to shaping future professionals in these fields. As a Program Head, I have managed faculty, overseen course schedules, and led various academic initiatives. My expertise in contracting, coding, testing, and maintaining software systems fuels my passion for advancing education and technology.