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Concept Paper

Data-Driven Barangay Services Recommendation System using a Recurrent Neural Network (RNN) Algorithm

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Abstract

Purpose - This research focuses on the development of a Data-Driven Barangay Services Recommendation System using Recurrent Neural Networks (RNNs) to enhance the efficiency and responsiveness of Barangay Local Government Units (BLGUs).

Method – The research employs the Recurrent Neural Networks (RNNs) Algorithm in a data-driven recommendation system. Research and Development (R&D) and Descriptive Research methods will both be used in the proposed study. Survey data will be gathered using the descriptive research method, which attempts to give a thorough and accurate picture of the topic being studied.

Conclusion - The data-driven barangay services recommendation system has a function to create a reliable platform that meets the specific needs of Barangay Local Government Units, providing them with enhanced data security, accuracy, and efficiency in managing documents and records. BLGU can streamline its administrative processes, reducing paperwork, minimizing errors, and optimizing resource utilization.

Recommendation – The study recommends the implementation of the Data-Driven Barangay Services Recommendation System to enhance document management, streamline administrative processes, and ensure data security and authenticity, ultimately creating a more efficient and technologically advanced local government unit.

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Practical Implication – The implementation of the RNN algorithm Data-Driven Barangay Services Recommendation System may serve as advancement and innovation in terms of improving the process.

Keywords – RNN algorithm, recommendation system, data-driven

INTRODUCTION

The foundation of the Philippines rests upon its Barangay Local Government Units (BLGUs), the smallest units in the nation's administrative structure. The communities in barangays serve as the launching pad for local initiatives and endeavors. From the initial idea to its implementation, Barangay Local Government Units (BLGUs) are the productive ground where resident-driven projects take root and are implemented. The BLGUs hold data that is essential for developing efficient policies and initiatives that address individual requirements. Currently, certification requests are processed by Barangay Local Government Units (BLGUs) through both computerized and manual methods, incurring expenses for the printing of essential documents (Alrashidi et al., 2022). However, the current reliance on manual processing for these essential transactions creates a significant bottleneck. The meticulous paper-based method is laborious, prone to human error, and less secure in safeguarding private resident data. These restrictions make it more difficult for barangays to provide services effectively and efficiently. Herein lies the crucial role of digitization. By embracing existing technology, barangays unlock a treasure trove of new possibilities to elevate the quality of service offered to their residents. Digitization can help barangays enter a new era of responsive and efficient governance by improving data security and advancing document processing. In addition, the integration of information and communication technology (ICT) in government sectors has demonstrated benefits in terms of improving governance and streamlining government recordkeeping processes (Mousa et al., 2022).

Recognizing this knowledge gap, this paper focuses on the discussion of opportunities, challenges, and future directions in the area of algorithmic engagement in the BLGU. Machine learning (ML) algorithms learn from the data and concentrate rules from the data, then apply the learned insight to assess new data, allowing their gained insights to solve many distinct problems. Machine learning has already demonstrated considerable potential to enhance the effectiveness and accuracy of many decision-making scenarios (Yuli, 2021). This study explores the development of a Data-Driven Barangay Services Recommendation System using Recurrent Neural Networks (RNNs) to provide Barangay Local Government Units with dynamic service recommendations.

LITERATURE REVIEW

RNN Algorithm

Recurrent neural networks (RNNs) are neural network architectures with hidden states that use feedback loops to process a sequence of data that ultimately informs the final output. Therefore, RNN models can recognize sequential characteristics in the data and help predict the next likely data point in the data sequence (Oord, 2013). The Recurrent neural network model is effective in predicting user preference based, it also demonstrated that the RNN model produced more accurate prediction. The performance of the model can improve significantly using RNN implementation that can handle variables (Guan, 2024). RNNS can process this data efficiently because they can remember the output of the previous state and use this information for processing the current input (Yang, et al., 2021). The application of Long Short-Term Memory (LSTM) networks, a specialized type of Recurrent Neural Network (RNN), in enhancing collaborative learning through personalized recommendations (Mendoza, et al., 2022). The RNN-based recommendation system can help identify areas where students need additional support and offer resources that align with their learning pace and style (Kwapong, et al., 2020). Compared with traditional digital signal processing algorithms, deep learning methods perform better in dealing with high-dimensional and nonlinear problems. RNNS can process this data efficiently because they can remember the output of the previous state and use this information for processing the current input (Yang, et al., 2023). According to Hidasi, et al., (2016).

Recommendation System

A recommendation algorithm that leverages RNNs to capture temporal patterns in user behavior. The focus is on improving the accuracy of recommendations by considering the sequential nature of user interactions, making it suitable for dynamic environments where user preferences change over time (Mohak, 2021). Data collection, data processing, recommendation, and result output are the sequential steps that make up the process of creating a recommender system (Mhamdi, et al., 2023). Recommendation systems have become increasingly important in various domains, aiming to provide personalized suggestions to users. With the advent of deep learning, there has been a significant advancement in developing more accurate and efficient recommendation systems (Xie, et al., 2021). The significant evolution of recommendation systems, particularly noting the role of deep learning techniques like Recurrent Neural Networks (RNNs). These methods have been increasingly adopted to enhance recommendation accuracy by effectively modeling and capturing complex interactions between users and items over time. RNNs, with their ability to process sequential data, are particularly suited to understanding temporal patterns in user behavior, making them invaluable in contexts where user preferences and interactions evolve dynamically (Das, et al., 2023) Recommendation systems have made extensive use of deep learning

techniques such as graph neural networks, convolutional neural networks, and recurrent neural networks, according to review (Reyna, 2023). By using RNNs to analyze the temporal structure of music and user listening habits, the system can provide more accurate song recommendations. The study also compares the performance of RNNs with other neural network architectures in the context of music recommendation.

E-Government

According to Pastoril (2023), Inefficient management of documents and records affects the performance of an organization. This is when records are not well stored or managed. Since the early 2000s, the Philippine government has actively supported e-governance, with many significant efforts influencing the current state of affairs. The E-Government Masterplan 2022 proposes a "One Digitized Government, One Nation" with the goals of improving public service delivery, increasing transparency, and promoting citizen participation. E-government, or the general use of government services, provides transparency, automated reporting, streamlined integration, and cost savings (Taculao-Deligero, 2024). E-government research did not receive the same level of interest in the Philippines as it did elsewhere in the world. Motivated by the latest study findings and computer technology breakthroughs, the researcher is reexamining the field of e-government to evaluate its changing function in public service delivery (Bajar, 2020) Through the use of ICT, the concept of transparency becomes a tool for empowering individuals to achieve the aims and objectives of local government units (LGU). Numerous local governance projects investigated the involvement (or engagement) of the Philippine civil society in local (sub-national) governance, which was mainly made possible by the Philippine decentralization legislation (Masagca, et al., 2019). This technology allows the government to make data-driven decisions about how to improve and expand the services offered through the platform.

PROPOSED METHODOLOGY

Research and Development (R&D) and Descriptive Research methods will both be used in the proposed study. According to Kessler (2020), R&D is particularly effective in bridging the gap between theoretical knowledge and practical application, making it well-suited for the technological advancements proposed in this study. A comprehensive literature review will be conducted to understand the current state of research in data-driven services, recommender systems, and the use of RNN algorithms within the SDLC framework. The system will undergo iterative development, allowing for continuous refinement and improvement based on testing outcomes. Purposive sampling will be employed to intentionally select participants who meet specific criteria relevant to the study's objectives. This sampling technique is advantageous for targeting individuals or groups with particular characteristics, thereby ensuring that the collected data is highly relevant (Patton, 2021). The integration of R&D and Descriptive Research methods is essential for the success of this study. While R&D will drive the development and testing of new algorithms, Descriptive Research will provide the contextual understanding

necessary to ensure that these innovations are relevant and effective. By combining these approaches, the study will not only advance the state of technology in barangay services but also ensure that these advancements are grounded in a deep understanding of current practices and user needs.

System Evaluation

The ISO/IEC 25010:2011 is a standard for software quality requirements and evaluation. It provides a set of criteria for evaluating the quality characteristics of a software product. A survey questionnaire will be given to the participants of the study. It aims to evaluate the features of the system such as correctness, completeness, interoperability, performance efficiency, usability, reliability, and security. The evaluation will ensure that the developed software is functioning properly and adheres to software quality standards (Table 1).

Statistical Treatment of Data

The weighted mean is the mean of set values wherein each instrument has a degree of importance (Equation 1).

$$w = \frac{\sum_i^n = 1wiXi}{\sum_i^n = 1w1} \qquad \textit{Equation 1}$$

Verbal Interpretation
W = Weighted Mean
n = Total number of Respondents
Wi = weights applied to x data values
Xi = data values to be averaged.

Table 1. The Likert Scale Method

Scale	Range	Verbal Interpretation
5	4.50-5.00	Highly Acceptable
4	3.50-4.49	Acceptable
3	2.50-3.49	Moderately Acceptable
2	1.50-2.49	Less Acceptable
1	1.00-1.49	Not Acceptable

Conceptual Design

Figure 1 outlines the conceptual framework of the proposed system, which serves as a high-level blueprint for its functionalities. The system interface will be using the Laravel PHP framework, which integrates with Bootstrap for responsive design, CSS for styling, and JavaScript for client-side scripting. The system gathers data from various

sources to generate recommendations. This includes residents' data as input for the system. Once collected, the resident and barangay data are stored within the MySQL database, hosted by XAMPP. This data serves as the foundation for the recommendation generation process. The primary output of the system is the generation of personalized recommendations. A Python-based recommendation engine is employed to process the data and generate personalized recommendations. This Python engine interfaces with the web application, ensuring seamless data flow and user interaction. The entire system is designed to be hosted on a local computer, enabling efficient and secure data management and processing within a localized environment.

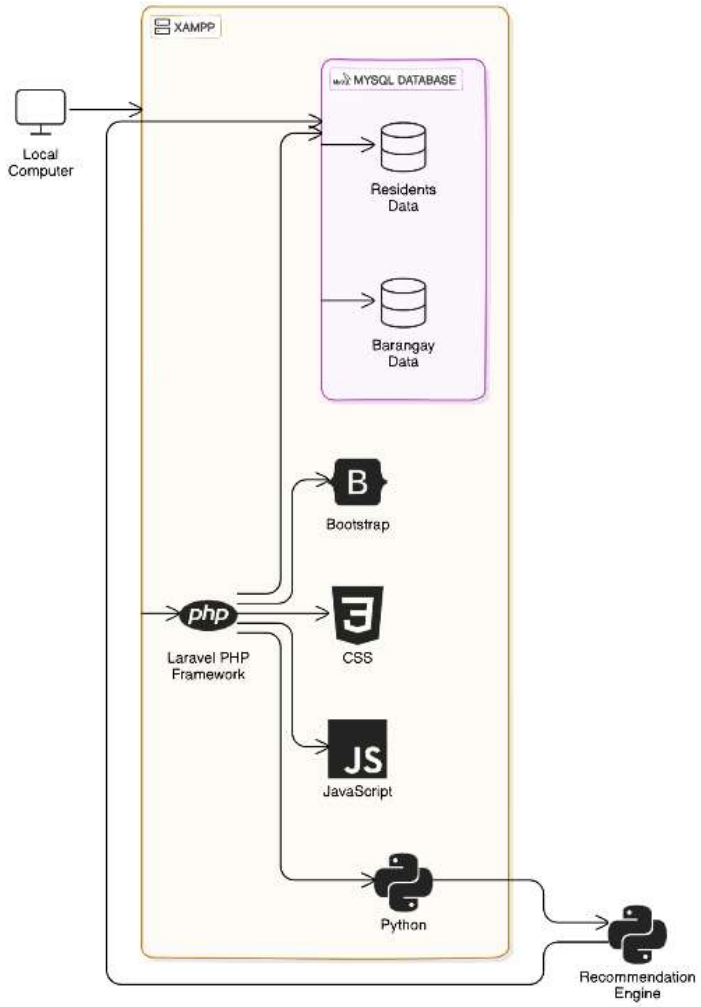

Figure 1. Conceptual Framework

System Architecture

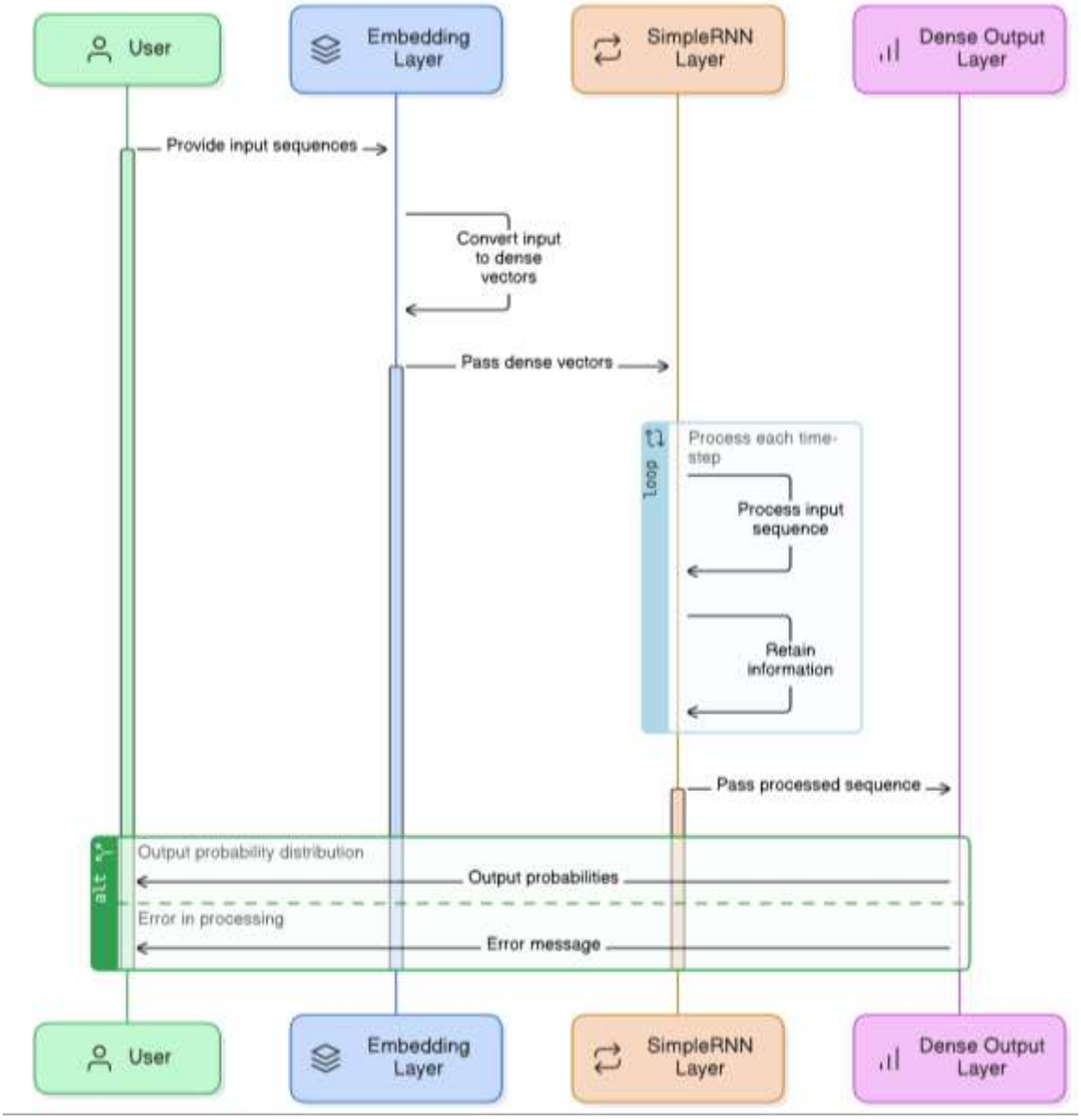

Figure 2. RNN Layer Architecture

The model architecture is designed to leverage the strengths of RNNs. The key layers include an Embedding Layer, which will convert input features into dense vectors of fixed size (10 dimensions). The input layer will accept sequences of categorical features with specified time steps. This transformation is crucial for handling categorical features effectively. A SimpleRNN Layer, consisting of 50 units and using the ReLU activation function, processes the input sequence and retains information through its recurrent connections. Finally, a Dense Output Layer utilizes the softmax activation function to output a probability distribution over the possible programs, corresponding to the

number of unique programs in the dataset. The SimpleRNN model's architecture, consisting of a SimpleRNN layer and a Dense layer, will provide an efficient and effective solution for the data-driven barangay recommendation system.

Algorithm Use

In the development of a Data-Driven Barangay Services Recommendation System using a Recurrent Neural Network (RNN) algorithm, RNNs incorporate resident demographics (population, age structure, individual status) and socioeconomic status. By feeding this data into the RNN, the system allows the RNN to recommend services tailored to specific demographics and socioeconomic situations.

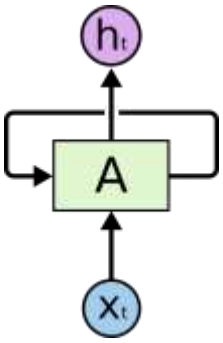

Figure 3. Recurrent Neural

The figure shows that the output at each step is fed back into the network as input at the next step. The input layer (Xt) receives the current input in the sequence. The hidden layer (h) maintains a state that captures information about the preceding elements in the sequence. This state is updated at each step based on the current input and the previous hidden state. The output layer (A) generates the output for the current step, based on the current input and the hidden state.

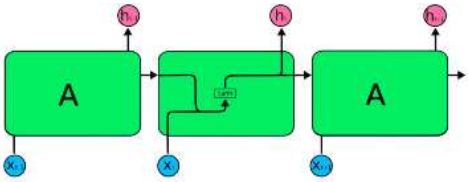

Figure 4. RNN Cell

The RNN updates its state based on the current input and previous state:

$$h_t = f(h_{t-1}, x_t)$$

Where:

h_t = current hidden state
h_{t-1} = previous hidden state
x_t = current input
f = activation function

CONCLUSION AND RECOMMENDATIONS

Barangay Local Government Units should consider implementing the Data-Driven Barangay Services Recommendation System to enhance their document management and processes. Barangay Local Government Units planning to adopt the data-driven barangay services recommendation system should provide comprehensive training to their staff members. Raising awareness about the system's benefits and functionalities will ensure its successful integration into daily operations. For Barangay Local Government Units with pre-existing document management systems, the data-driven barangay services recommendation system should be designed to integrate seamlessly, allowing for a smooth transition without disrupting ongoing operations.

PRACTICAL IMPLICATIONS

The proposed implementation of a Data-Driven Barangay Services Recommendation System using a Recurrent Neural Network (RNN) algorithm has transformative potential in BLGU. By leveraging the RNN's ability to analyze and predict patterns in temporal data, the system can provide more accurate and personalized service recommendations to residents. This may result in more efficient service delivery, better resource allocation, and enhanced community satisfaction. Moreover, the system's predictive capabilities can assist barangay officials in proactive decision-making, anticipating the needs of the community before they arise. This approach also sets a precedent for the integration of advanced machine learning techniques in public administration, potentially paving the way for more intelligent and responsive local governance structures.

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DECLARATION

Conflict of Interest

The author declared that there were no conflicts of interest in the study.

Informed Consent

Not applicable.

Ethics Approval

Not applicable.

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Author's Biography

Felix L. Huerte Jr. is an educator with a background in computer science and instructional technology. He is currently a faculty member at the School of Computing Studies, National University - Laguna. His academic journey is marked by his pursuit of advanced degrees, having completed a Master of Arts in Instructional Technology from Rizal Technological University and a candidate for a Master of Science in Computer Science major in Cybersecurity from AMA University. He also holds a Bachelor of Science in Computer Science and an Associate in Computer Science from Laguna University. He has been recognized for his contributions and expertise at various educational institutions.