
RNN Based Customer Service Chatbot for Information Support at Gleamore

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Chatbot; Customer Service; NLP; RNN

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Abstract

In the rapidly evolving digital era, PT.Gleamore Digital Solution faces challenges in managing a high volume of customer inquiries, often leading to response delays that affect service quality and customer satisfaction. This study aims to design and develop a customer service chatbot using the Recurrent Neural Network (RNN) method to support automated and efficient information services. The research involves several key stages, including data preprocessing (tokenization, stemming, case folding, and bag of words), model training, and evaluation. The dataset, obtained from company administrators, consists of frequently asked questions categorized into multiple service-related intents. Experimental results show that the RNN model outperformed the combined RNN-LSTM method, achieving a validation accuracy of 93.55% with a final loss of 0.2908 and faster training time. Model evaluation using a confusion matrix achieved an accuracy rate of 98.70%, indicating high reliability in intent recognition and response generation. Black Box Testing also confirmed that the chatbot consistently provided valid and relevant responses to various user queries. The results imply that the RNN-based chatbot effectively improves the efficiency of customer service operations, reduces administrative workload, and enhances user satisfaction by enabling accurate and real-time responses through automated digital interaction.

1. Introduction

In this ever-evolving digital age, PT.Gleamore Digital Solution faces challenges in handling the high volume of customer inquiries, which reach around 300–400 per day and are currently only handled by one customer service administrator. This situation often causes delays in response times, which can reduce customer satisfaction and affect the company's professional image. However, despite rapid technological advancements, there are still limitations in implementing an efficient automated service system within the company. Therefore, an innovative solution is needed to provide quick and continuous information services, such as through the implementation of a customer service chatbot. This chatbot is designed to answer customer questions automatically and in real-time without direct staff involvement, enabling 24/7 service, reducing the workload of administrators, and improving the efficiency and quality of customer interactions through various digital platforms such as websites and instant messaging applications.

1.1 Literature Review

1.1.1 Natural Language Processing

Natural language processing (NLP), a subfield of artificial intelligence, is dedicated to exploring the complex relationship between computers and human language (Ardiyanto et al., 2023; Salman, 2025). Its main objective is to understand, examine, and generate textual information in a way that mimics human capabilities (Nurwanda et al., 2024). Natural Language Processing, abbreviated as NLP, in a chatbot application is a way for computers to understand and manipulate natural language text to obtain specific information. NLP in chatbots is used to process incoming messages and analyze source documents to provide the best and most appropriate answers (Nasution et al., 2024). NLP involves solving several challenges in human language processing. Human language has a complex structure, including grammar, ambiguity, the use of different words in different contexts, figurative expressions, and much more. Therefore, NLP uses a computational approach to understand and process human language (Rivaldi & Wismarini, 2024).

1.1.2 Chatbot

A chatbot is a computer program designed to simulate conversations or interactive communication with users (humans) through text, voice, or visuals (Erlina et al., 2023). Chatbots act as conversation agents that can assist or replace the role of a consultant. Chatbots have a knowledge base that can be used to interact with customers. Chatbot technology is a form of Natural Language Processing (NLP), which is a branch of Artificial Intelligence (AI) that studies communication between humans and computers through natural language (Puspitasari et al., 2024). Along with technological developments, NLP chatbot assistants continue to be developed with various advanced technologies, such as using machine learning and deep learning approaches, to improve their ability to process human language naturally and enhance their performance (Khaqiqi & Harani, 2024).

1.1.3 Recurrent Neural Network (RNN)

Recurrent Neural Network (RNN) is a Deep Learning method that can learn patterns found in sequential data. Recurrent Neural Network (RNN) has the ability to “remember” data elements that have been “learned” previously (Afandi et al., 2022; Lubis et al., 2024). RNN, also known as a feedback network, is a type of neural network where there is a loop as a feedback connection in the network. An RNN network is a network that accommodates the network output to become input to the network, which is then used to generate new output (Tarkus et al., 2020). Long Short Term Memory (LSTM) is an evolution of the RNN architecture introduced by Horchreiter & Schmidhuber (1997) (Selle et al., 2022). LSTM is often chosen in chatbot research because of its ability to receive input and generate output in the form of data sequences, as a development of Recurrent Neural Network (RNN). LSTM is a variant of RNN that is capable of storing information for longer periods and overcoming challenges that arise in sequential data processing (Ahda et al., 2024; Sulistyoyo et al., 2023).

$$ht = ReLU(Wxh \cdot xt + Whh \cdot ht - 1 + bh) \quad (1)$$

$$y^{\wedge} = Why \cdot hT + by \quad (2)$$

The above formula shows how RNN works in processing sequential data. The first equation calculates the hidden state by combining the current input and information from the previous step using the ReLU activation function. The second equation generates the final output from the last hidden state, which is used to predict the chatbot's response.

1.1.4 Preprocessing

Data Preprocessing is an important process in data mining analysis that aims to clean, change the format, and prepare data to make it easier and more accurate in the analysis process (Daniswara & Nuryana, 2023; Fathoniah & Rozikin, 2022; Shevira et al., 2022; Sulistyoyo et al., 2025).

1. Tokenization, a method that roughly divides a series of characters in text into words to distinguish between certain characters that may or may not be treated as word breaks (Albab et al., 2023; Rifaldi et al., 2023).
2. Stemming, is one method used for upgrading performance summary text with the method transforming the words in a module learning to the basics for then the base word is given weight to

achieve aim summary text that can represent the whole from the document original (Ashari et al., 2024; Djawa & Ahda, 2024).

3. Case Folding, is a process where text consisting of various uppercase and lowercase letters is standardized (Afrad et al., 2024).
4. Bag of Words, is a fundamental technique in text processing and natural language processing that represents text data by disregarding grammar and word order while maintaining word frequency (Mahadwija & Ahda, 2024; Suryanti & Prasetyaningrum, 2025).

2. Research Methods

2.1 Data Collection

During the data collection stage, the data used in this study was obtained directly from the administrator of PT. Gleamore Digital Solution. The data consisted of general information that customers often asked the company about. The information collected covered various topics related to service information, service usage procedures, transaction procedures, contact information, client information, operating hours, processing time, package price estimates, technology and tools, revision terms, and cooperation policies. This dataset was then used as the basis for chatbot development, as it contained representations of questions and answers relevant to actual user needs. The topics and example sentences can be seen in Table 1.

Table 1. Question, topics and example sentences

QUESTIONS	TOPIC
<i>Apa saja layanan yang tersedia di PT. Gleamore Digital Solution?</i>	Service Information
<i>Apakah saya harus datang langsung untuk memesan layanan?</i>	Service Usage Procedure
<i>Bagaimana sistem pembayaran di Gleamore</i>	Transaction Procedure
<i>aku bisa menghubungi kamu lewat mana?</i>	Contact Information
<i>Tampilkan portofolio klien Gleamore Digital Solution?</i>	Client Information
<i>Kapan jam operasional PT. Gleamore Digital Solution?</i>	Operating Hours
<i>Berikan informasi tentang estimasi waktu pengerjaan proyek?</i>	Project Duration
<i>Berikan informasi mengenai paket pembuatan website?</i>	Package Price Estimates
<i>Sebutkan teknologi yang kalian gunakan dalam proyek?</i>	Technologies and Tools
<i>Berikan informasi tentang kebijakan revisi di Gleamore?</i>	Revision Terms
<i>Tampilkan kebijakan kerja sama antara klien dan Gleamore?</i>	Cooperation Policy

The dataset will be divided into two parts, namely training data and testing data. The data will be divided proportionally, with 80% for training data and 20% for testing data.

2.2 Design System

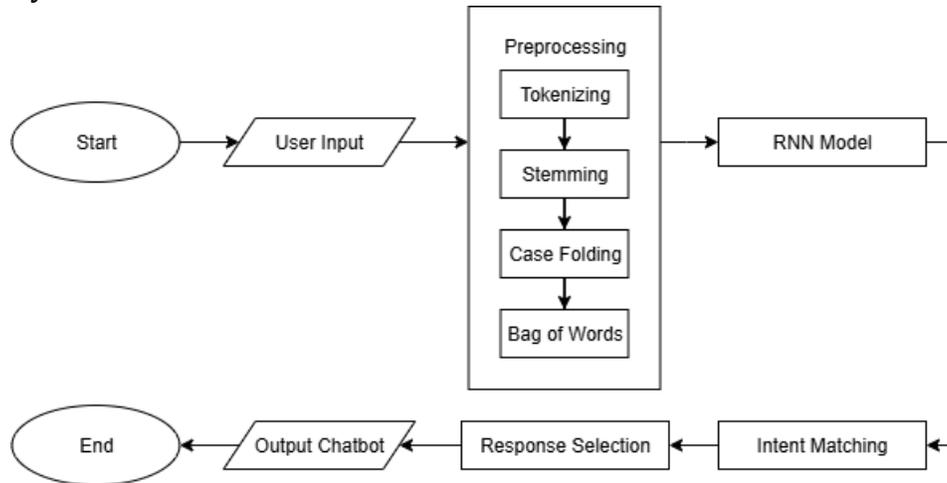


Fig. 1 Flowchart system chatbot

The system design in the image above illustrates the workflow of a Recurrent Neural Network (RNN)-based chatbot, starting from the user providing input to the chatbot generating a response. The process begins with the Start stage, where the user enters text in the form of a question or statement into the system. The input then enters the Preprocessing stage, which cleans and prepares the text data so that it can be understood by the model. At this stage, there are several steps, namely Tokenizing to break sentences into word fragments, Stemming to convert words into their basic form, Case Folding to standardize letters to all lowercase, and Bag of Words to convert words into numerical representations that can be processed by the model.

The results of the Preprocessing stage are then fed into the RNN Model. This model is used because it is capable of understanding the context and word order in sentences, enabling it to predict the intent or meaning of user input. After the RNN model generates a prediction, the process continues to the Intent Matching stage to match the prediction results with the list of intents in the chatbot dataset. If a matching intent is found, the system enters the Response Selection stage, which is the selection of the most relevant response to the user's intent based on the intent matching results. The final stage is Chatbot Output, where the selected response is displayed to the user as a reply from the chatbot. This process then ends at the End stage. Overall, this system design shows the flow of how the chatbot understands text, processes it with a machine learning model (RNN), and provides appropriate responses based on the context of the conversation.

2.3 Pseudocode

Table 2. Pseudocode

```
RNNNet:
  Input: x
  If x is 2D:
    Ubah x jadi 3D
  h0 = zeros(num_layers, batch_size, hidden_size)
  out, _ = RNN(x, h0)
  out = FC(out[:, -1, :])
  return out
```

The pseudocode in Table 2.3 serves to illustrate the logical flow of the RNN model in performing forward propagation in a Recurrent Neural Network (RNN). This pseudocode explains how input data is processed from the initial stage to produce the final output. The process begins by receiving input x , where if the input is still in two dimensions, it will be converted into three dimensions to match the format required by the RNN. Next, the hidden state (h_0) is initialized with a value of zero based on the number of layers (`num_layers`), batch size (`batch_size`), and hidden size (`hidden_size`). After that, the input and initial hidden state are processed through

the RNN layer to produce output and a new hidden state. The output result from the last step of the sequence (out[:, -1, :]) is then passed to the fully connected (FC) layer to obtain the final result. The resulting out value becomes the final output of the forward process in the RNN model.

3. Result and Discussion

3.1 Comparison of RNN Methods with Combined Methods

Table 3. Comparison of Methods

Method	Epoch	Final Train Loss	Final Val Loss	Final Val Accuracy	Spend Time Train
RNN	49	0.0090	0.2908	93.55%	10 second
RNN&LSTM	31	0.0214	0.7873	83.87%	13 second

Based on Table 3, the RNN method shows better results than the RNN&LSTM combination. The RNN model achieved a validation accuracy of 93.55% with a final validation loss of 0.2908, while the RNN&LSTM method only achieved an accuracy of 83.87% with a validation loss of 0.7873. In addition, the RNN training time was also faster, at 10 seconds, compared to 13 seconds for RNN&LSTM. This shows that in this case, the RNN architecture is more efficient and capable of providing more accurate prediction results to support the performance of the customer service chatbot at PT. Gleamore Digital Solution.

3.2 Model Evaluation

In this study, model testing was evaluated using the Confusion Matrix method. This Confusion Matrix shows the relationship between the actual label (True Label) and the model's predicted label (Predicted Label). The darker main diagonal values indicate the number of correct predictions for each category, while the values outside the diagonal indicate classification errors. The values in the confusion matrix table can be seen in Figure 2.

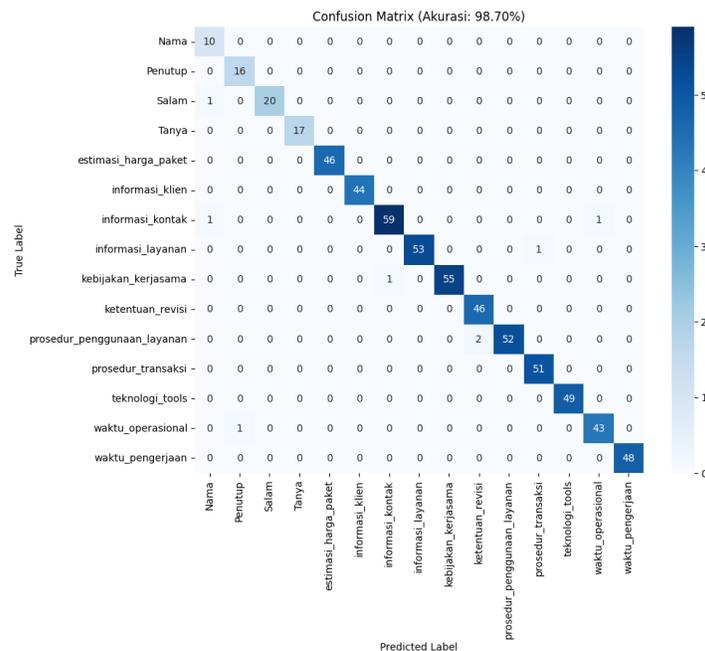


Fig. 2 Confusion Matrix with RNN model

Overall, these results show that the RNN model used performs very well and consistently in recognizing the intent of user input, with a very low error rate. An accuracy rate of 98.70% indicates that the chatbot system is highly effective in understanding the context of questions and providing appropriate responses based on predetermined categories.

3.3 Testing

In this study, software testing uses Black Box Testing, which is a software testing method that focuses on testing software functionality without considering the internal implementation or structure of the code within it (Fiddin et al., 2024). To test the chatbot's ability to understand questions, several pre-prepared questions were given to the chatbot. These questions covered various topics related to the services provided by PT. Gleamore Digital Solution. In this test, the chatbot was evaluated based on its ability to identify the essence of the question. The question and answer test can be seen in Table 2 Question and Answer Test.

Table 4. Question and Answer Testing

Topic	Question Pattern	Responses	Remarks
Service Information	<ol style="list-style-type: none"> 1. ada brp aja layanan yg disediakan 2. Informasi layanan 3. Apa saja layanan yang tersedia di PT. Gleamore Digital Solution 4. apa saja layanan yang ditawarkan 	Gleamore.id menyediakan layanan digital marketing meliputi: Pembuatan website, SEO (Search Engine Optimization), Social Media Management, Google Ads dan iklan digital lainnya, Marketplace ads & management.	VALID
Work Time	<ol style="list-style-type: none"> 1. berapa lama pengerjaannya 2. untuk waktu pengerjaannya berapa lama ya 3. berapa lama sih waktu pengerjaannya 4. Berikan informasi tentang estimasi waktu pengerjaan proyek 	Waktu pengerjaan tergantung pada layanan dan skala proyek. Sebagai contoh: Website sederhana: 2 hari – 1 minggu, Website lengkap dengan SEO dan integrasi: 3–4 minggu, Social Media Management dan SEO adalah layanan berlangganan bulanan.	VALID
Package Price Estimates	<ol style="list-style-type: none"> 1. harga paket 2. estimasi harga paket berapa 3. untuk kisaran harga paketnya berapa 4. Berikan informasi mengenai paket pembuatan website 	Paket Website Mulai Rp1,5 Juta!, Gratis Hosting & Domain, Desain Responsive (Mobile/Desktop), Unlimited Email (di paket tertentu), Bonus SEO & Artikel (di paket 5 juta)	VALID
Technology and Tools	<ol style="list-style-type: none"> 1. menggunakan tools apa 2. menggunakan teknologi apa 3. teknologi dan alat apa saja yang dipakai 4. Sebutkan teknologi yang kalian gunakan dalam proyek 	Kami menggunakan berbagai teknologi dan tools sesuai kebutuhan proyek, khususnya untuk SEO kami menggunakan tools seperti Ahrefs, SEMrush, Google Analytics, Google Trend, Moz, Ubersuggest dan lainnya.	VALID

4. Conclusions

Based on the research results, the Recurrent Neural Network (RNN) method showed the most optimal performance compared to the combination of RNN&LSTM methods, with a validation accuracy of 93.55% and a validation loss of 0.2908, as well as a more efficient training time of 10 seconds. The evaluation results using the Confusion Matrix showed an accuracy rate of 98.70%, which confirms the RNN model's ability to understand context and accurately classify the intent of user questions. Black Box Testing also showed that the chatbot was able to provide valid and consistent responses to various customer question patterns. However, the limitations of this study lie in the relatively small dataset size and the limited scope of topics to specific service contexts. Therefore, further research is recommended to expand the dataset with more diverse user language variations, integrate the chatbot with the company's database system to provide dynamic information in real-time, and develop multi-turn conversation features so that the chatbot can understand continuous conversations more naturally.

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