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Development of AI-Based Chatbots Using Feedforward Neural Network Approach for Customer Service Interaction

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Abstract

Artificial Intelligence (AI) is now an important solution to facilitate access to information, especially in the field of academic services. This research develops an AI-based interactive chatbot designed to provide information about Universitas Internasional Batam (UIB) using an intent-based approach. With the Advanced Neural Network approach (Feed-Forward Neural Network or FNN), this chatbot is capable of providing relevant responses to common questions about study programs, registration, campus facilities, and other services at UIB. The development process applies the structured Waterfall methodology, and initial testing is conducted in the Visual Studio Code environment. This research offers a foundation for the development of an intent-based informative chatbot that can assist prospective students and other users in accessing academic information at higher education institutions.

Keywords: *Artificial Intelligence (AI), Advanced Neural Networks, Feed-Forward Neural Network, Chatbot, Intent.*

Abstrak

Kecerdasan Buatan (AI) kini menjadi solusi penting untuk mempermudah akses informasi, khususnya dalam bidang layanan akademik. Penelitian ini mengembangkan chatbot interaktif berbasis AI yang dirancang untuk menyediakan informasi mengenai Universitas Internasional Batam (UIB) menggunakan pendekatan berbasis intent. Dengan pendekatan Jaringan Saraf Maju (Feed-Forward Neural Network atau FNN), chatbot ini mampu memberikan respons yang relevan terhadap pertanyaan umum tentang program studi, pendaftaran, fasilitas kampus, dan layanan lainnya di UIB. Proses pengembangan menerapkan metodologi Waterfall yang terstruktur, dan uji coba awal dilakukan di lingkungan Visual Studio Code. Penelitian ini menawarkan fondasi bagi pengembangan chatbot informatif berbasis intent yang dapat membantu calon mahasiswa dan pengguna lainnya dalam mengakses informasi akademik di institusi pendidikan tinggi.

Kata-kata kunci: *Kecerdasan Buatan (AI), Jaringan Saraf Maju, Feed-Forward Neural Network, Chatbot, Intent.*

1. Introduction

Technology has become an essential part of modern life, driving rapid developments that significantly enhance the quality of life [1]. In recent years, Artificial Intelligence (AI) has taken center stage, transforming our daily activities through advanced applications known as intelligent agents capable of performing various functions [2]. This transformation not only impacts how we communicate but also has a profound effect on service sectors, where efficiency and speed are paramount [3]. In the context of academic services, the use of AI technology such as chatbots provides an efficient solution to expand access and accelerate the delivery of information for prospective students and the public [4]. Recent studies have shown that AI-powered chatbots can enhance student engagement, streamline administrative tasks, and offer personalized learning experiences, thereby addressing gaps in traditional educational systems [5].

Previous studies have shown that AI-based chatbots have a positive impact on improving the accessibility and efficiency of customer services across various sectors. Nuruzzaman and Hussain (2018), in their survey on the application of chatbots in the customer service industry, found that the use of neural networks in chatbots enables more accurate and relevant responses to user queries, while also enhancing overall customer satisfaction [6]. In the education sector, research by Adamopoulou and Moussiades (2020) highlights the potential of chatbots in supporting quick and interactive academic information services, providing prospective students with easy access to information about study programs and registration without the need for direct interaction with staff [7]. Further, a systematic literature review emphasizes that students primarily benefit from AI-powered chatbots in areas such as homework assistance, personalized learning, and skill development, while educators gain from time-saving assistance and improved pedagogy [8].

This study aims to develop an interactive AI-based chatbot designed to provide information about Universitas Internasional Batam (UIB) using an intent-based approach. With the Feed-Forward Neural Network (FNN) approach, the chatbot is expected to process and respond to queries in real-time with high accuracy, particularly in answering general questions about study programs, registration, campus facilities, and other services at UIB. The intent-based approach enables the system to respond quickly and accurately without relying on direct data retrieval, allowing users to access it at any time [9]. Recent research supports the effectiveness of FNNs in chatbot development, demonstrating their capability to model both linear and nonlinear

relationships in diverse data sets [10]. Additionally, the Waterfall model has been effectively utilized in chatbot development projects, providing a structured and systematic approach that ensures thorough analysis, design, implementation, testing, and maintenance phases [11] [12]. The integration of machine learning techniques serves as the foundation for future development of academic chatbots, with studies indicating that such integration can lead to more responsive and adaptive educational tools [13].

Furthermore, incorporating intent classification models, such as those based on IndoBERT, has shown high accuracy in understanding user queries within academic chatbots [14]. The adoption of AI in educational settings has also been influenced by factors like perceived usefulness and ease of use, which are critical for user acceptance [15]. Innovations like the "Build-a-Bot" platform enable educators and students to create customized chatbots, enhancing AI literacy and engagement [16]. Moreover, integrating AI chatbots in education has been shown to alleviate faculty workload and enhance student support, with recent studies demonstrating their effectiveness in providing timely feedback and handling repetitive administrative queries in higher education settings [17].

2. Method

The development process of this chatbot follows the Waterfall model, one of the approaches in the Software Development Life Cycle (SDLC) [18]. In this model, development proceeds sequentially from the initial stage to the final stage, encompassing four main phases: requirement analysis, design, verification, and maintenance.

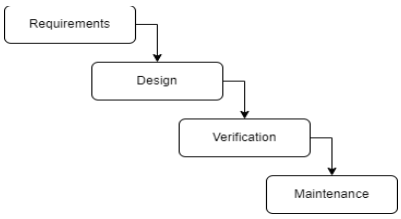

Figure 1. *Waterfall Method*

a. Requirement Phase

This phase involves gathering and analyzing data to develop the chatbot. The analysis is conducted by studying the structure and flow of the chatbot system to fully understand its functionality. Data collection methods include reviewing various scientific works, chatbot case studies, and direct observation of relevant websites.

b. Design Phase

This phase focuses on designing a stable and reliable system architecture for the chatbot. During this stage, the chatbot's operational structure and user interaction are arranged. The chatbot is designed to provide information related to the university.

c. Verification Phase

This phase aims to ensure that the scripts and codes developed function as expected. During this stage, any failures are identified and corrected to achieve software perfection. Some causes of failure may stem from coding errors, improper platform selection, or integration issues between the chatbot and the website.

d. Maintenance Phase

This phase ensures that the chatbot continues to function properly and meets user needs. It involves fixing minor errors that may be discovered after the chatbot's launch, which could arise due to system changes, environmental shifts, evolving user requirements, or coding errors.

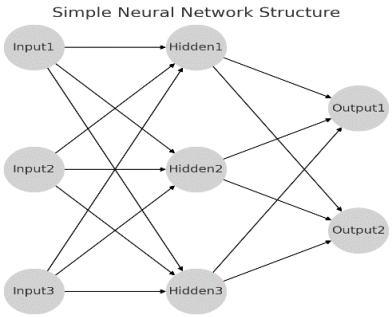

Figure 2. *Neural Network Structure*

The artificial neural network algorithm used in the development of this chatbot is the Feedforward Neural Network (FNN), also known as Multilayer Perceptron (MLP). MLP consists of several layers of fully interconnected neurons, namely the input layer, hidden layer, and output layer, each of which has the following function:

a. Input Layer

The Input Layer in this chatbot is responsible for receiving input data from users, such as text or questions, which is then processed into vector representations using the bag_of_words function. This function converts text into binary vectors, where each element is set to 1 if a specific word is present in the input and 0 if not, based on the chatbot's recognized word list. By filtering out punctuation and irrelevant words, this function retains only the relevant information for intent identification. The vector generated by the bag_of_words function is then passed to the

Hidden Layer to help the neural network better recognize user intent patterns, enabling the chatbot to provide more accurate responses.

```
# Fungsi untuk membuat bag of words
def bag_of_words(kalimat, kata_kata):
    kalimat_kata = bersihkan_kalimat(kalimat)
    tas = [0]*len(kata_kata)
    for s in kalimat_kata:
        for i, w in enumerate(kata_kata):
            if w == s:
                tas[i] = 1
    return np.array(tas)
```

Figure 4. *Bag_of_words* Function for Text Representation In The Chatbot

b. Hidden Layer

This layer processes the information received from the input layer using specific weights. During this process, complex patterns in the data are recognized through weighting and activation functions, allowing the network to "learn" from the provided data. Pattern recognition in this layer is crucial for improving intent prediction accuracy. The figure below illustrates the model construction with two hidden layers using Keras, where each layer is equipped with a **relu** activation function and a Dropout layer to prevent overfitting.

```
model = Sequential()
model.add(Dense(128, input_shape=(len(train_x[0]),), activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(64, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(len(train_y[0]), activation='softmax'))
```

Figure 4. *Model Construction*

c. Output Layer

The final layer produces the expected predictions or outputs, such as identifying the user's intent. Based on the patterns learned in the previous layers, the output layer provides the response most aligned with the user's intent. The figure below demonstrates the processing of each intent in JSON, including tokenizing each pattern to enrich the corpus and expanding the list of classes that the model will recognize.

```
# Memproses setiap intent
for intent in intents['intents']:
    for pattern in intent['patterns']:
        # Tokenisasi setiap kata
        w = nltk.word_tokenize(pattern)
        kata_kata.extend(w)
        # Tambahkan dokumen ke korpus
        dokumen.append((w, intent['tag']))
        # Tambahkan ke daftar kelas
        if intent['tag'] not in kelas:
            kelas.append(intent['tag'])
```

Figure 5. Intent Processing

3. Result and Discussion

The system is capable of providing an appropriate response to user input by matching the input with predefined keywords and responses. Accurate keyword definitions are a crucial factor in this chatbot system. Questions posed to the chatbot undergo a verification and validation process. Verification ensures that the programming logic aligns with the conversation flow diagram, while validation confirms that the system accurately represents real-world scenarios.

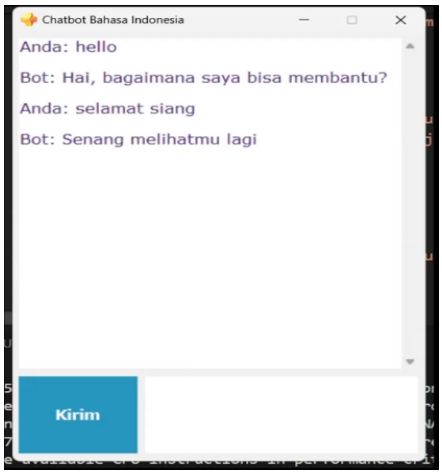

Figure 6. *Chatbot Results*

Figure 3.6 shows the performance of the chatbot based on an evaluation against various test inputs. The chatbot correctly predicted the responses for 84.75% of the queries, with 50 correct predictions out of 59 total tests. This result indicates that the model is capable of providing relevant and accurate responses to a large majority of the queries posed by users.

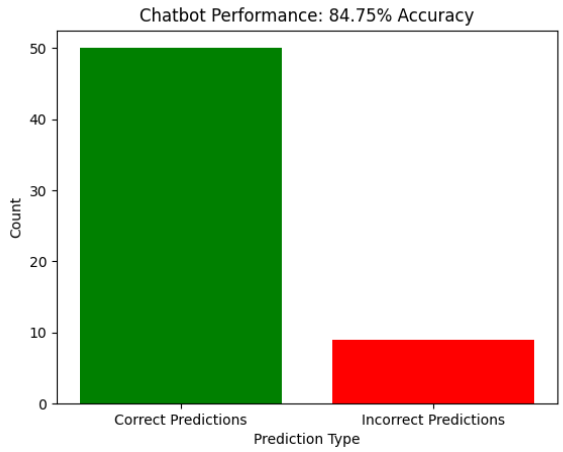

Figure 7. Chatbot Performance: 84.75% Accuracy

The graph visually illustrates the distribution of predictions, with the green bar representing the correct predictions and the red bar representing the incorrect predictions. The model performed well overall, though there is still room for improvement, particularly in addressing the 15.25% of queries where the response was incorrect.

The evaluation highlights the potential of the chatbot for handling academic inquiries at Universitas Internasional Batam, and it serves as a foundation for further model improvements and refinements.

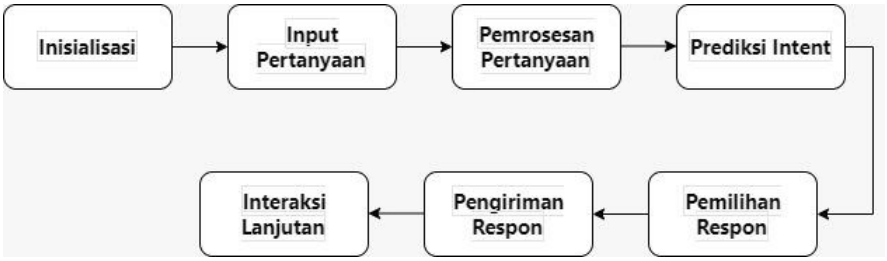

Figure 8. *Chatbot Flowchart*

This chatbot is designed to understand and respond to user questions automatically through a series of key stages. Starting with the initialization of the model and data, the chatbot receives the input question, processes it to identify the intent, and selects the appropriate response. By using artificial neural network models and language processing techniques, this chatbot ensures responsive and relevant interactions for users. Below is a detailed explanation of each stage in the chatbot's workflow.

a. Initialization

This process includes initializing variables and loading the model, intents, as well as class and word data. In the chatgui_R2.py file, initialization is performed with the lemmatizer, model, and by loading intents and classes through pickle and json.

b. Question Input

Users input their questions or messages through the GUI, which are then processed using the EntryBox. This section represents the chatbot's input layer that receives user input in text form.

c. Question Processing

At this stage, the received question is processed using methods such as clean_up_sentence and bow (bag of words) to transform the text input into a format understandable by the

model. This section identifies patterns in the user input, corresponding to the functions defined in the code for bow and clean_up_sentence.

d. Intent Prediction

The intent prediction process is carried out using the predict_class function, which leverages the neural network model to identify the intent of the user-provided input.

e. Response Selection

Once the intent is successfully identified, the getResponse function selects the appropriate response from the list of intents based on the predicted intent.

f. Response Delivery and Further Interaction

The selected response is sent back to the user through the GUI interface, and the chatbot is ready for further interaction.

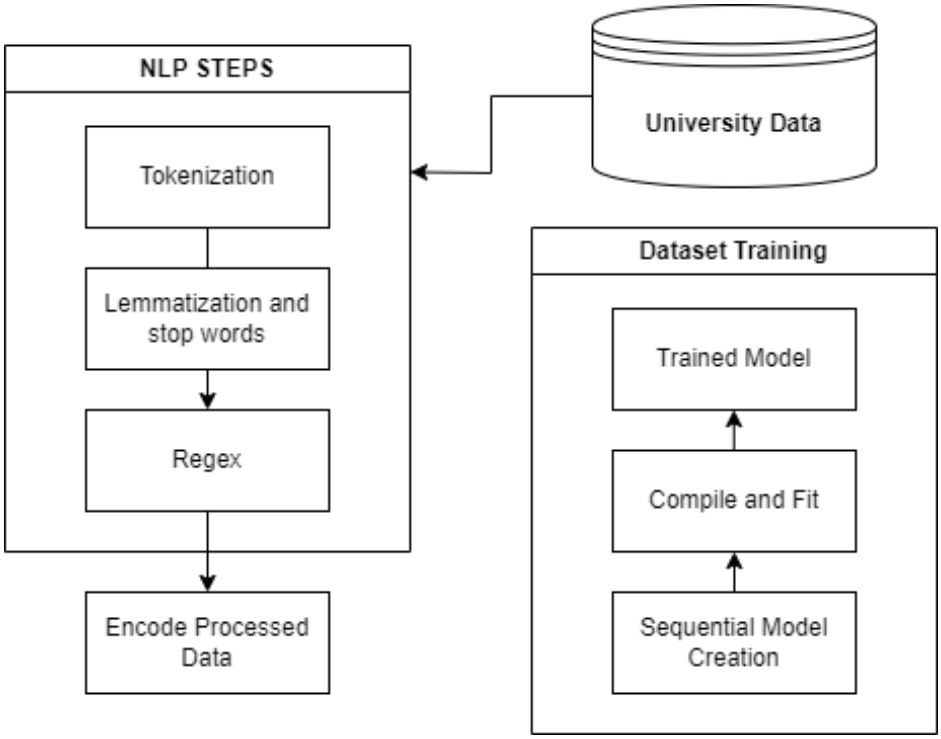

Figure 9. Training Phase

In this training phase, the prepared dataset must undergo preprocessing, a crucial step in Natural Language Processing (NLP) that includes several key tasks: (a) tokenization: breaking text into smaller units, such as words, punctuation, and spaces, (b) stemming/lemmatization: converting words into their root or base form to reduce variation in word usage, (c) regex extraction : identifying and extracting important information from the text, such as names, dates, and locations, and (d) encoding processed data : transforming the processed text into a format understandable by machine learning models, such as One Hot Encoding.

The result of this preprocessing is encoded data that is ready to be used to train the Feedforward Neural Network model. This model learns from the patterns and relationships within the data to more accurately predict the user's intent.

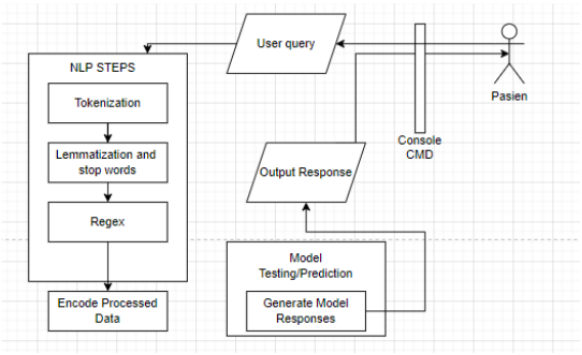

Figure 10. Prediction Phase

In the prediction phase, there is a structured process flow as shown in Figure 3.3 [19]. This flow begins when the user submits a question or query, which is then recorded and forwarded for processing.

During the processing stage, the recorded query is managed and forwarded to the testing phase. This is where the chatbot model plays a role. The model processes the query and analyzes it to understand the user's intent. After that, the model responds with a list of probabilities, indicating the model's confidence level for each possible intent, along with the dataset used in creating this chatbot conversation.

Figure 11. Intents

In the development of this chatbot, the dataset is stored in JSON (JavaScript Object Notation) format and input manually **[20]**. This dataset consists of elements such as intent, label, patterns, and responses, which play a crucial role in the interaction between the user and the system: (a) intents : intents refer to the process where users provide sentences relevant to the context of a specific question. These intents represent a dataset of question-answer pairs used to train the chatbot, tags: tags are used to group several patterns of visitor questions into a single

response. Each tag serves as an identifier for categorizing different question patterns, p**atterns :** **p**atterns contain various query templates representing the ways users ask questions, based on the methods and language used, and r**esponses :** responses are the answers provided by the chatbot for each user question template.

This dataset plays a crucial role in the process of user interaction with the system. When a user submits a question, the tag attribute identifies the intent and matches the question pattern with the corresponding response. If a matching pattern is found, the system sends the appropriate response back to the user. However, if no matching template is found, the chatbot will provide a default response.

4. Conclussion

Based on the research findings regarding the development of chatbots using natural language processing (NLP) and machine learning methods, the following conclusions can be drawn: This service chatbot, which utilizes machine learning technology and natural language processing (NLP), enhances the information service at Universitas Internasional Batam by providing faster, more accurate, and efficient responses, as evidenced by the results of the chatbot's conversational testing. With the implementation of natural language processing (NLP), the chatbot is capable of processing the natural language used by users, enabling easier and more effective communication. This chatbot provides fast, accurate, and personalized responses to users seeking information related to Universitas Internasional Batam.

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