

A Review on Recent Advances in Chatbot Design

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Abstract: *A chatbot is a dialog-exchanging system designed to facilitate meaningful and empathetic conversations between humans and computers. Chatbot emerged like a machine which interacts with a human by spoken/ textual conversation and response similarly but now there has been a tremendous increase in development of Assistants and Chatbots with advanced technologies. This paper provides a comprehensive review of the latest advancements in chatbot design, focusing on the dynamic field of Artificial Intelligence (AI) and its applications in conversational agents. As chatbots continue to play a pivotal role in enhancing user experience across various domains, a thorough understanding of the evolving design strategies is imperative. The paper explores key elements such as Natural Language Processing (NLP) techniques, machine learning models, Deep Learning Models and user experience considerations. By synthesizing recent studies and real-world implementations, this review aims to offer insights that will contribute to the ongoing progress in chatbot development and deployment.*

Keywords: Chatbot, Natural Language Processing, Intelligent Responses, Machine Learning, Deep Learning

I. INTRODUCTION

In today's world driven by technology the incorporation of intelligence (AI) has completely transformed how we engage with our digital devices. One significant advancement that symbolize this progress is the emergence of chatbots. These chatbots are designed to facilitate empathetic conversations, between humans and computers. They have the capability to understand natural language inputs, whether spoken or written and respond in a way that mimics expression.

As a result chatbots have found applications, across industries. From streamlining customer support in e-commerce platforms to providing medical consultations in the healthcare sector, the real-life applications of chatbots are as diverse as the industries they serve. These virtual conversational agents have stepped into roles traditionally filled by human operators, demonstrating their capacity to enhance efficiency, accessibility, and user experience.

The latest developments, in chatbot design showcase the forefront of this technology. Apart from traditional chatbot development techniques that use rule-based techniques, or simple machine learning algorithms, many chatbots now a days are using advanced Natural Language Processing (NLP) techniques, deep learning techniques like Deep Reinforcement Learning (DRL) and Deep Neural Network (DNN) and computational intelligence. There has been a splendid enhancement in variety of algorithms and techniques like Neural Networks, Pattern matching techniques, voice recognition methods, and much more which if embedded in Chatbots make them equally like a Human.

II. LITERATURE SURVEY

The evolution of chatbot technology can be traced back to the early ELIZA program developed by Joseph Weizenbaum in the 1960s. Since then, there has been a continuous progression in the sophistication and capabilities of chatbots. Early chatbots relied on rule-based systems and simple pattern recognition. However, recent advancements have shifted towards employing machine learning and Natural Language Processing (NLP) techniques to enhance chatbot capabilities.

Recent research in chatbot design has placed a significant emphasis on the refinement of Natural Language Processing techniques. Studies have explored advanced NLP methodologies, including sentiment analysis, entity recognition, and semantic parsing [Jurafsky and Martin, 2019]. Techniques such as word embeddings, attention mechanisms, and transformer models have shown remarkable improvements in language understanding and generation.

The integration of sophisticated machine learning models has been a major advancement in chatbot design. Deep learning architectures, such as recurrent neural networks (RNNs) and transformers, have demonstrated superior performance in processing complex language inputs. Additionally, reinforcement learning algorithms have been employed to optimize chatbot responses through iterative interactions.

III. RECENT ADVANCES IN CHATBOT DESIGN

A chatbot is programmed to answer questions formulating it into natural language and response back as real human via messages or voice commands. The responses of chatbot are based on a combination of predefined scripts, machine learning and deep learning techniques and algorithms. Due to increasing efficient learning algorithms, Chatbot is learning from human interaction, emotions and behaviours which is rising its relevance in future. Techniques like NLP (Natural language processing) which includes NLTK in combination with Java and python, Artificial Intelligence Mark-up Language, Recurrent neural networks, LSTM and Tensor-flow. These can be used to analyse Speech and generate intelligent responses to interact with humans.

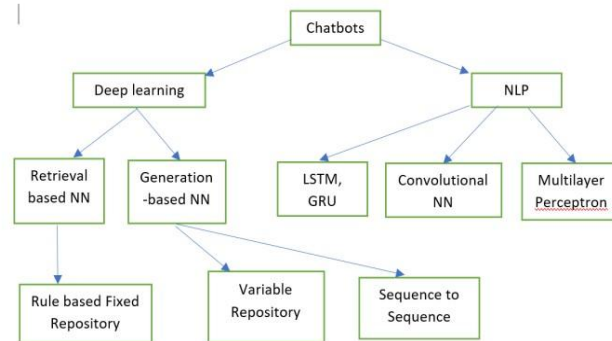


Fig 1: Recent Techniques for Chatbot Design

Machine Learning with AI has been traditionally used for building neural conversational chatbot. The machine is designed as to provide informative answers and be indistinguishable from the human by maintaining the context of the Dialogue. It includes Natural language Processing, Artificial Neural Network, LSTM, AIMA, optimization algorithms and mathematical processes for analysis and evaluation of Chatbot data and working performance. Machine learning algorithms are designed to easily perform pattern recognition, feature extraction, Automated Speech recognition, POS tagging and text generation (phonemic, hyponyms and semantics). Using machine learning algorithms, chatbots can now offer tailored product or content recommendations based on user preferences, behavior, and historical data.

NLP is one of the primary branch of Artificial Intelligence (AI) for language processing that allows interaction between computer and human languages. It can be used not only for text translation but for recognizing speech also. One of the successful NLP system developed in early 1960's was ELIZA which used pattern and keyword matching based on substitution methodology. Most of the NLP's were designed based on some set of hand-written rules. Later they were augmented with Machine Learning (ML) algorithms for language processing. Advanced chatbots are now capable of real-time language translation, facilitating communication between users who speak different languages. Xiaoice is a chatbot developed by Microsoft that utilizes deep learning for natural language understanding and generation. It has been used in various applications, including customer service, social companionship, and even poetry writing.

Artificial Neural Network (ANN) is a Mathematical model designed to train, visualize, and validate neural network models just like Human Brain. ANN is also known as a model-free estimator as it does not rely on an assumed form of the underlying data. Recurrent Neural Network (RNN) is an extension of general feed forward network used for training datasets in which the network not only consider the current input, but also takes the previous output to generate a response. Moreover, RNN's have memory which can be used to remember the input sequence. Like other neural network, RNN has an input layer, output layer and some hidden layers. Chatbots are now capable of processing and responding to inputs in various formats, including text, speech, images, and videos. This allows for richer and more interactive conversations. The main drawback with RNN is they cannot remember the input for a long sequence but this

problem can be solved by Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) which serves as an extension of RNN and can remember long sequences of data.

Speech is one of the most natural and powerful modes of communication, which is now “widely accepted as the future of interaction with computer and mobile applications.”. Because they are more natural than graphic-based interfaces, spoken dialogue systems are beginning to form the primary interaction method with a machine. HCI (Human Computer Interaction) has made researchers ambitious to take this concept to improve and enhance speech process between the computer and the human which will help to simulate human speech interaction. Therefore modern networked computing devices with Speech interaction has received enormous interest in humanising machines for users in the future. For Speech based Chatbots Speech-To-Speech or Speech-to-text conversion usually starts with a process known as Automatic Speech Recognition (ASR). Amazon's Alexa uses deep learning models to process voice inputs and generate responses. It can perform tasks like setting reminders, providing weather updates, controlling smart home devices, and more.

A Deep learning Chatbot learns everything from its data and human-to human dialogue. In this process, the chatbot is traditionally created using machine learning algorithms. The first step is to prepare data then depending on the source, data reshaping is performed which is followed by data pre-processing. Data pre-processing involves tokenization, stemming and lemmatizing of the chats which makes chats readable for deep learning chatbots. Ones done with pre-processing deep learning chatbots are selectively designed based on Generative type or Retrieval-based. Various methods are used for chat data evaluation such as generating word vectors using python scripts and training the data using word2vec model like TensorFlow.

Google's Duplex is an advanced AI system that uses deep learning for natural language understanding and generation. It can make phone calls on behalf of users to perform tasks like booking appointments or making reservations. ChatGPT, developed by OpenAI, is based on the GPT-3 model. It can engage in dynamic and contextually relevant conversations with users. It has been used for tasks like content drafting, answering questions, and providing conversational interfaces for applications.

Table I: Technical Approach and Algorithms of chatbots

Technology	Techniques	Models	Usage
Natural Language Processing	Feed forward network (FFN), Natural Language Tool Kit (NLTK)	Multilayer Perceptron framework, Multiple reference translation	Pattern matching, Speech recognition, Speech translation
Neural Networks	Linear Regression, Naïve Bayes, AIMA, GRU Support vector machines (SVM), Recurrent Neural Network, LSTM	Generative models, Intent classification, Soft-max, regression Ranking model, Seq2Seq model, Google's neural network translation	Pattern extraction, feature engineering Feature detection chatbots, development translation recognition, Dialogue data detection Text generation, image Captioning, machine translation, POS Tag, Dialogue generation
Deep Learning	Tensor-flow, DRL, DNN, Convolutional Neural Networks(CNN)	Open AI Gym Toolkit, VGG-19 model	Representation learning, reduce complexity of networks Part of Speech (POS) tagging, Semantic analysis, computer vision tasks

IV. CONCLUSION

Chatbots have been around the world for decades. Reasons for this increasing interest in chatbots include tremendous advances in artificial intelligence (AI) and AI based technology design and technical development approaches. One of the major usage shift from online to mobile messaging apps and to real interactive agents as robots. Major Internet

companies such as Google, Facebook, and Microsoft have already done marvellous work on chatbots and popularized it as a popular technology for all. In this paper we reviewed various journals including related books, and presented a survey on Chatbots discussing about the recent advancements design of developing Chatbots along with a broad application domain of using them world-wide from working as personal assistants chatbots which have helped users explore online content and services. Developers and designers now have an urge to know more about the user needs that motivate the future use of Chatbots and understand how people experience it. Still miles to cover for becoming humanoids, Chatbots are now part and parcel of our lives.

REFERENCES

- [1] Tarun Lalwani, Shashank Bhalotia, Ashish Pal, Shreya Bisen, Vasundhara Rathod, IJIRCST, "Implementation of a Chat Bot System using AI and NLP Volume-6, Issue-3, May 2018.
- [2] Tiha, A. (2018). Intelligent Chatbot using Deep Learning. (April), 1–22. <https://doi.org/10.13140/RG.2.2.14006.75841>
- [3] Dale, R. (2016). The return of the chatbots. Natural Language Engineering, 22(5), 811–817. <https://doi.org/10.1017/S1351324916000243>
- [4] Anupam Mondal, Monalisa Dey, Dipankar Das, Sachit Nagpal, Kevin Garda, "Chatbot: An automated conversation system for the educational domain", IEEE 2018.
- [5] Dr. John woods, S. A. A.-K. (2015). Survey on Chatbot Design Techniques in Speech Conversation Systems. IJACSA, 7. <https://doi.org/10.17148/iarjset.2018.596>
- [6] T Mutiwokuziva, Melody W Chanda, Prudence Kadebu, Addlight Mukwazvure, Tatenda T Gotora "A Neural network based Chat Bot", 2018.
- [7] Kumar, P., Sharma, M., Rawat, S., & Choudhury, T. (2019). Designing and Developing a Chatbot Using Machine Learning. (1), 87–91. <https://doi.org/10.1109/sysmart.2018.8746972>