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Artificial Intelligence-Powered Chatbots for Waste Management: A Vision for Circular and Smart Cities

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Abstract

Innovative solutions are needed to address the major issues associated with the efficient management and recycling of garbage in metropolitan environments. To overcome these obstacles, this study abstract investigates the use of artificial intelligence (AI) in trash management. Municipalities and recycling centers can increase garbage collection efficiency, improve sorting accuracy, forecast waste generation patterns, inform the public, identify illicit dumping, and advance a circular economy by utilizing AI-driven solutions. Smart garbage collection is one important area where AI shows its potential. We used the study of these five chatbots to help us construct the processes for gathering data, instruction, developing, and testing a chatbot using different natural language processing (NLP) techniques, which are covered in the second section of this work. We also present some conclusions and comments on all facets of the topic to evaluate if they might be useful to us in future research. Additionally, the successful development of a chatbot devoted to the circular economy will be the aim of our research on this subject in the future.

Keywords: Chatbots; Artificial Intelligence; Smart Cities; Waste Management; WSN.

1. Introduction

Since 70% of people on Earth are expected to live in urban areas by 2050 [1], the urban clusters that result will require intelligent infrastructure to effectively manage residents' requirements and provide a growing range of more varied and effective services. To achieve sustainable development, the circular economy (CE) concept—which holds that resources should be preserved and employed for as long as possible—has received a lot of attention recently? Within this framework, the digital CE stands for a novel method by which digital technology might facilitate the growth of a more regenerative and circular global economy. Within the scope of the CE, waste is deliberately reduced by careful product layout and an industrial method that uses a "closed-loop system" to continuously

circulate resources. By reducing the linear path from resource extraction to disposal and encouraging a cyclical and resource-efficient method of manufacturing and consumption, this paradigm places a higher priority on durability.

Furthermore, in the dynamic landscape of smart cities—where urbanization and cutting-edge technology intersect—the execution of waste management and recycling is crucial. This calls for an advanced approach to environmental control. Sustainable waste management techniques are becoming more and more important for smart cities' sustainability as trash volumes in metropolitan areas rise. Furthermore, there is an unparalleled need for raw materials due to the widespread prevalence of trash on a global basis. Approximately 70% of all materials and consumer items need to be disposed of, according to data, which adds to the growing difficulty. Comprehensive waste management techniques are critically needed, as evidenced by the worrisome excess of over 40% of processed food that is tossed away within the complex food supply chain.

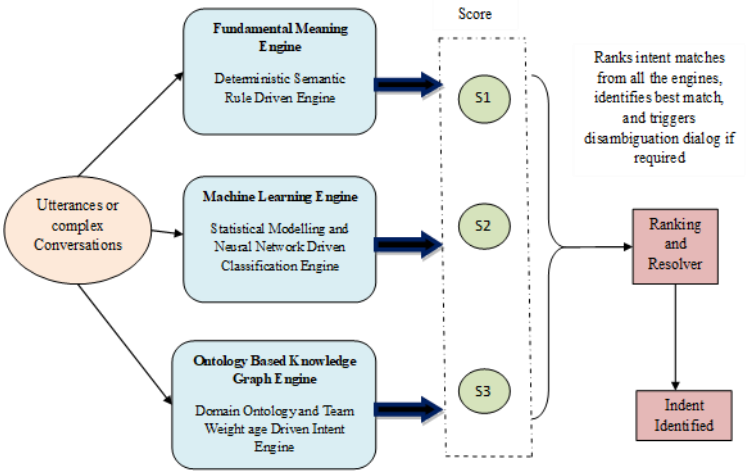

Fig. 1.1. An example use case for a NLP

The ability of a conversation bot to comprehend human interactions is largely dependent on its capacity to discern the user's goal, glean pertinent details from their speech, and associate those details with pertinent tasks or activities [2]. The study of inferring purpose and related information from real interactions is known as NLP (see Figure 1.1).

Applications of smart cities, including smart communities, smart industries, smart healthcare, smart education, and intelligent growth, make extensive use of natural language processing (NLP). Better healthcare facilities can be found in smart cities by utilizing the data from digital health records for clinical research utilizing NLP to discover patients, premedicate diseases, forecast surgical problems, and much more. Additionally, NLP is being used to modernize a range of industrial and corporate operations. It particularly aids in the analysis of business documents and the forecasting of various market trends. The developments in NLP [3], which may be used for a variety of tasks like document classification, patent evaluation, and answering another, have also benefitted academic learning and research. Detecting hate speech, creating headlines, smart requirement design, and legal forecasting are a few more diverse NLP application areas in smart cities.

NLP has also been utilized for generating seamless and friendly user experiences for IoT systems employed in smart households, offices, transportation systems, or public centers. Consequently, NLP is playing a bigger role in the technological toolkit that smart cities are using to address contemporary issues and give their residents greater amenities.

The structure of the paper is as follows: A background of NLP and its relationship to AI is given in Sect. 2. Section 3 provides information on current NLP techniques used in various smart city domains. Finally, Section 4 acknowledges the difficulties and potential avenues for further research in this field. Section 5 provides a conclusion.

2. Literature Review

Businesses should focus more on the invention and management of IP as AI propels the digital economy [4]. Therefore, it is anticipated that a compilation of patent data will reveal the most recent developments in chatbot creation. Important technological trends can be assessed, significant international manufacturers' development directions can be identified, and global technology benchmarks can be consulted when making future decisions about R&D expenditure. All of these things can be done through the invention layout (or environment). AI's NLP technology is a significant subfield. It investigates how computer programs, such as machine learning (ML), can analyze natural language effectively.

Out of all the potential uses of the ITC sector in the circular economy, we have concentrated on the ways that advancements in AI can help the circular economy grow [5]. Our focus has been on chatbot systems that leverage AI to advance the sustainable economy, as numerous AI technologies could be useful in this regard. Using the notion of chatbots as computer programmers that use artificial intelligence to have conversations with people as a starting point, we have found and examined two extremely intriguing chatbot applications that support the circular economy. Considering the great potential of these kinds of solutions, we plan to develop chatbots in the future that may be used in the context of the green economy.

NLP techniques enhance visitors' experience by making recommendations that are relevant to their emotional state based on their emotions, sentiments, and moods [6]. For example, advice for soothing or relaxing activities like yoga lessons, meditation sessions, or spa treatments may not be appropriate for someone who is stressed or anxious. As information-intensive sectors, tourism and hospitality necessitate constant contact between businesses and travelers. However, a high degree of interaction between the staff members providing tourist services may increase the degree of discontent resulting from humiliation caused by emotionally charged service encounters. Therefore, businesses should look for cost-effective solutions in addition to chatbots to preserve consistency in tourist interaction and lower the risk.

Modern customer service tactics are increasingly relying on AI-driven self-service systems that make use of natural language processing. These websites frequently have interactive documentation and FAQs that let users solve issues on their own without help from human beings. The main benefit of these systems is their efficiency; they can manage a high number of inquiries concurrently and are always available, which lessens the workload for human support representatives [7]. Furthermore, a

lot of clients like self-service choices since they provide rapid and easy access to data, which can raise client satisfaction.

Software on portable electronics is gradually being replaced by chatbots due to their cognitive abilities and user-friendliness. By 2020, about 80% of businesses will either have used chatbots already or have plans to do so [8], according to a recent business magazine research. Natural language processing techniques are the source of chatbot intellect. The best chatbots will be able to comprehend the context of a discussion, take notes during the exchange, and gradually get better. Numerous DL and ML methods can be used to accomplish this. It facilitates the computer's ability to comprehend text like a person. Machines translating, finding data, inquiry responding, and many other crucial domains can all benefit from the many practical uses of NLP.

However, due to the nature of the catastrophe information, analyzing and utilizing the relevant data effectively during disaster situations is frequently difficult for decision-makers. For example, catastrophe data normally are not updated frequently, resulting in the complete method of data updating not only time-consuming but additionally labor-intensive. In addition to the problem of updating data [9], another barrier that requires to be addressed is the temporal sensitivity of catastrophe data. To make accurate and efficient judgments during the disaster response phase, decision-makers may require data that is updated dynamically and instantaneously. Thus, a system that facilitates both horizontal and vertical data flow should be an integrated catastrophe information management system.

Solutions for emergencies have been suggested that do not rely on chatbots or natural language processing. One such option is an iOS or Android prototype. It allows you to make urgent calls using an LCD cellphone and using icons instead of audio communication. This program is crucial for the deaf and elderly, as well as for those who find it hard to speak while panicking or experiencing other unexpected events. Conversely, an all-encompassing system suggested in [10] allows the emergency client or partner to use a smartphone application to seek medical equipment and emergency assistance. This drone-based solution was created to give consumers accurate and dependable support in urgent medical circumstances.

3. Methods and Materials

3.1 The Algorithm for Chatbot Training

The chatbot training method will be created following the SeqtoSeq model's execution. Building a chatbot that gives the right response involves following the steps shown in Figure 3.1. First, several NLP approaches are applied to the data that are gathered to train the chatbot. This leads to the development of the Seq2Seq model [11]. Hyperparameters will have default values that can be altered in the future to produce a chatbot with a faster training period and better responses.

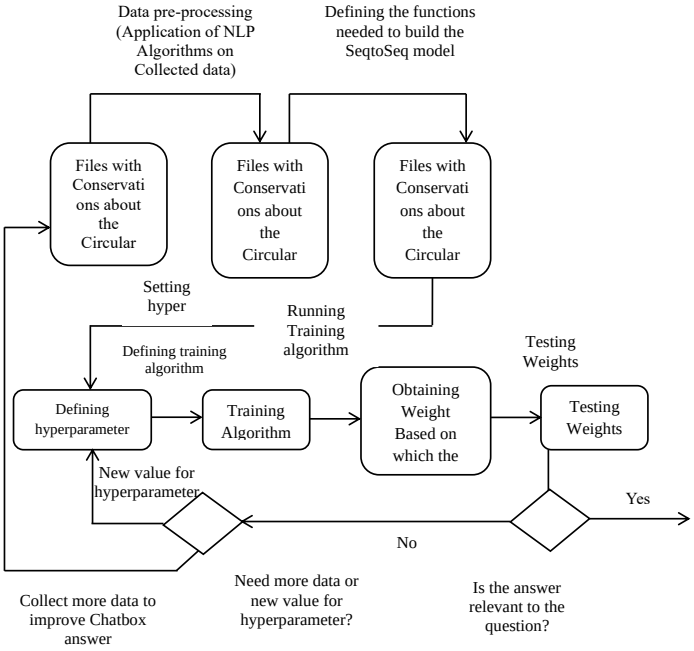

Fig. 3.1. The process of training a chatbot

AI is still underutilized in its whole; a plethora of fresh, creative solutions and alternatives are encountered, changed, examined, and refined. In a similar vein, performance can be consistently increased by testing, evaluating test findings, comparing outcomes from various periods, and identifying strengths and weaknesses. The implementation of the chatbot drive algorithm occurs after the hyperparameter values have been set. The goal of running the complete code is to provide weights on which the chatbot can respond. It will take a while to do this. After a specific amount of time, additional weights will be acquired. They will be upgraded if they surpass the prior versions. You can start interacting with the chatbot as soon as you obtain even the initial weights. The first weights won't produce very impressive results since, like a kid, they have little room for comprehension and response to the chatbot [12]. The chatbot needs additional time to train to gradually improve its comprehension and response times.

Next, we engage with the chatbot and assess the outcomes after finishing the entire or a portion of this procedure. Tests can be used to determine new hyperparameter values. If the new principles have a beneficial effect on the chatbot, it is advised that you continue the chatbot training session. The chatbot training process is restarted once further data is gathered if the chatbot is discovered to be providing ambiguous or lacking answers.

Since this chatbot is still in its early stages of development, the creator will decide whether or not the responses it provides are accurate. The program will pose several queries to the chatbot following the training phase. The responses provided will be used to determine whether more data collection or the setting of new parameter values is necessary. Once the responses have been greatly enhanced, an assessor will be added to verify the chatbot's functionality and identify any areas that still require work as well as the kinds of data that may be included to raise the standard of the responses. The

training process will need to be redone each time fresh information is uploaded or hyperparameter settings are modified.

The procedures required to get an answer from the chatbot are shown in Figure 3.2. Through a messaging app, the user starts the process by posing a query to the chatbot. NLP techniques are applied once the query is taken from the app and sent to the chatbot. The query is made simpler for the chatbot to understand using the same methods that were applied during data collecting. As demonstrated by earlier research, the question is first handled by NLP methods and then submitted to the Seq2Seq approach, which serves as an encoder. The chatbot generates a decoder, or the answer, based on the data encoded and the weights learned during training. The answer is provided inside the context of the algorithm that serves as a go-between for the chatbot and the messaging app. It can be ascertained whether the response is accurate, lacking, or unclear by the developer of this algorithm by adding more rules.

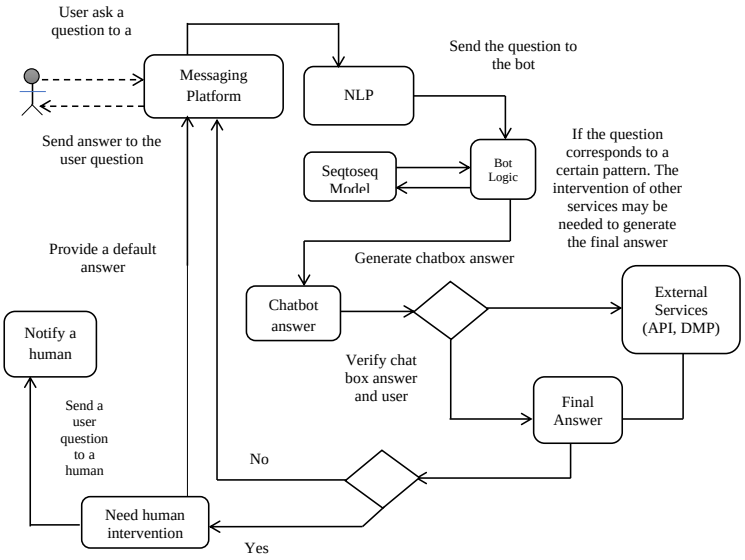

Fig. 3.2. Chatbot generates Responses Automatically

After receiving the chatbot's response, the thinking algorithm will need to contact the external service if the chatbot is unable to provide the user with a complete solution and their assistance is required. The final response given to the user will be obtained by concatenating the two responses obtained after contacting the service. When a chatbot responds with a predetermined response [13], human involvement is required. As a result, the chatbot will respond to the user with a present reply and notify a human to respond to the user.

3.2 Artificial Intelligence-Driven Chatbot Consultation Platform

Python is the preferred framework for deploying the design phase execution. The chatbot is implemented on Telegram via lengthy pull requests and API calls.

3.2.1 Establishing the Agent

An intelligent part of a chatbot is called an agent. It's the component that communicates with the user. In this case, the mainTrain.py file imports the chatbot framework. This file uses inheritance, a

feature of Python OOP, to call all other files. Installing the library creates a log session in the mainTrain.py file. This package enables Python to record user interactions with programs and chatbots. The chatbot receives talks from the List Trainer library. The conversation begins with the words “Type anything to get started,” which are initiated by the function start command. When the bot is launched, the user sees this notification. The chatbot receives two arguments: updating and contextual. During API requests, it carries the contents of these variables using a technique known as long pulling. The handle_message function manages each of these operations. The area where text is transmitted by a user or chatbot is called a text.

3.2.2 Using the corpus to train the chatbot

It is important to distinguish the corpus used for training the chatbot from the one used for storing messages without a response. The chatbot's exchanges are managed by that corpus. The code following uses the corpus's data to train the chatbot by reading through it since it is formatted like a document.

3.2.3 Setting Goals

Intents are used by the chatbot to determine the user's desires and requests. All of the information gathered during data collection is used to train the chatbot, which is what is meant to be its intended purpose. The data and responses are entered into a function that is called in the main Train.py file, and a Python file called Response.py is generated. The routines that save the human-generated data used to train the chatbot are displayed here.

3.2.4 Implementation of the Telegram Network

The Telegram API keys must be requested, which was completed on Botfather for this endeavor to use them. The Telegram API keys, the bot description, and its description are generated by Botfather. The Telegram package is used to interface the API keys with the source code wherein inquiries are sent to the text editor.

The package is used to retrieve responses using the keys. After gathering the question and variables, an answer is given back. The Telegram SDK receives the API keys, and everything is automatically reflected on the Telegram UI.

3.3 Features of Chatbots

Two categories—open domain and closed domain—can be used to classify most virtual assistants. Because it’s primary goal is to train and assist an operator on a set of particular activities, our chatbot is built as a closed-domain chatbot. The taxonomy will be consulted to define the specifications and features that a chatbot ought to possess.

Using a structured methodology and taking into account 103 real-world chatbots, their research produced taxonomy of design traits for domain-specific virtual agents [14]. There are three tiers of evaluation perspective identified by the design taxonomies:

- Twelve parameters pertaining to the look, information, and personality of chatbots;
- Seven dimensions centred on the viewpoint of chatbot-user interactions

- Three aspects of the user's viewpoint. For the optimal achievement of the goal, the developer must take into account each dimension while deciding which feature to put in the chatbot.
- The taxonomy encompasses elements including the chatbot's character, system integration, drive, role and communication style, time frame, frequency and quantity of interactions, and technical.

4. Implementation and Experimental Results

The WSN's sensors and nodes can provide data, as well as persistent new data like the addition of a new node, over the API. Table 1 lists the REST API routes along with the HTTP verbs that correspond with them and an explanation of the possible actions on each route.

Table 1. API Method

URL	HTTP verb	Sensor	Monitored Variables
http://ipservidor:2500/v1/registros/es1201	GET/POST	ES2201	Relative Humidity, Temperature, Dew Point
http://ipservidor:2500/v1/registros/es1110	GET/POST	ES2110	External Soil moisture
http://ipservidor:2500/v1/registros/es1301	GET/POST	ES2301	Leaf Wetness
http://ipservidor:2500/v1/registros/es1401	GET/POST	ES2401	Solar Radiation
http://ipservidor:2500/v1/registros/es1100	GET/POST	ES2100	Internal Soil moisture

When the HTTP verb GET is used in conjunction with one of these URLs, a JSON document comprising all the recorded records of a specific sensor is returned. In this way, the API can avoid needless data management if an application just needs one variable and can make it available independently [15]. Every WSN node has inbuilt electronics to track battery charge and solar energy capability in addition to outside sensors.

4.1 Dialogue Interface for Telegram

Create chatbots that can connect to Telegram's messaging system with ease using their Bot API [https://core.telegram.org/bots/api]. Telegram Bots are unique platform identities that can be set up without the need for a second phone number. These accounts function as a dialogue interface that can carry out commands sent in via their API. Based on guidelines for the construction of the others, the Telegram messenger itself uses a bot (called BotFather). An authorization token is issued after the procedure to route incoming messages to the newly established bot (Figure 4.1).

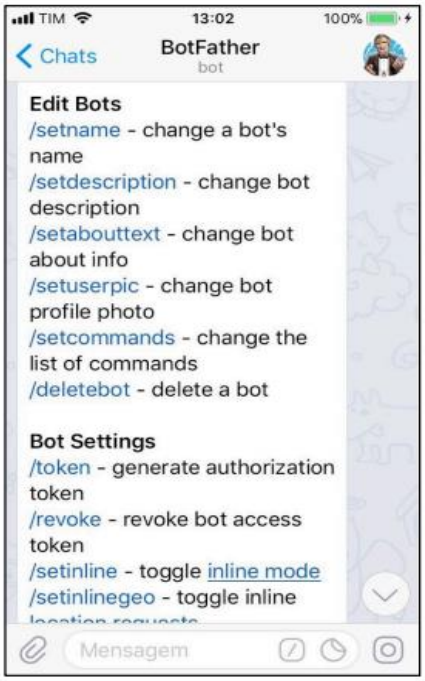

Fig. 4.1. The setup screen for BotFather

4.2 Module for Understanding Natural Language

Since it establishes the guidelines, the initial stage in setting up an engine for a chatbot is also the most crucial. The availability of an interface with graphics for its specification has facilitated progress. Throughout the chat, the bot can identify seven potential intents in aggregate. IBM Watson's formed intentions are depicted in Figure 4.2.

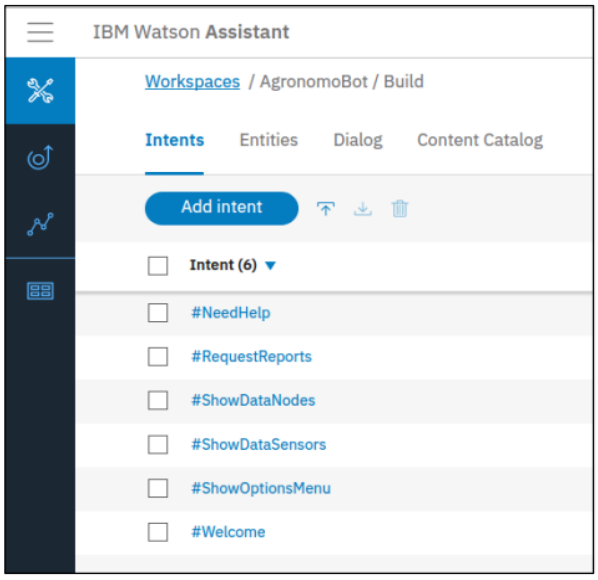

Fig. 4.2. Setting up a chatbot's intention on IBM Watson

To help IBM Watson train the dialogue model for recognizing patterns, examples of potential inquiries showing various approaches to fulfill the request should be provided for each intent. It is important to note that, provided the added message serves the intended purpose, IBM Watson can learn from new dialogues that are conducted with the user.

Determining the user's intention holds significant value in the progression of the conversation. Furthermore, it is crucial to understand the entity with which that goal is associated. Two individuals, referred to as Node and Sensor, were defined for the chatbot in this way. Based on the program's domain and the information found in the WSN API, this categorization was completed. The conversation flow was designed to bring the user's goal and the linked entity together. It works like a decision tree, where the dialogue's flow is decided by evaluating circumstances as true or false. The tree in the created dialogue flow includes just a single level of split in eight potential leaves, which correspond to the seven intentions, plus an extra option for situations where none of the intentions apply, such as when a request was made without sufficient context, or a classification error occurs.

The criteria for categorization and the possible chatbot responses in a given scenario need to be established for every leaf in the dialogue flow tree.

5. Conclusion

The Chatbot is a very useful tool for individuals or medical institutions to obtain textual or audio-based information about any illness. The trained data and artificial intelligence algorithms served as the foundation for the creation of this intelligent chatbot. Therefore, this profession will undoubtedly increase users' knowledge of health issues and successfully save many lives.

The research presented here made it possible to offer an AI-powered chatbot application to help the specialist obtain soil and climate data via a WSN. An AI and NLP chatbot named AgronomoBot was created as a proof of concept. It can search a WSN for the information a user wants and converse with them while adjusting to various conversational styles. The chatbot system's created functions are then presented. For ease of comprehension, the dialogues presented in this part have been translated from Portuguese to English. However, AgronomoBot's NLP algorithm facilitates easy adaptation to any language.

Future research can focus on implementing voice communication capabilities through text-to-speech and speech-to-text, taking into account the unique characteristics of spoken language, which is more fluid and fuller of colloquial terms boosting interaction even further and closing accessible gaps for those who struggle to use devices or have impairments. AgronomoBot will also be expanded to other messaging applications, which serve as the foundation for the development of chatbots, and new features like continuous data analysis and categorizing images sent via messaging apps will be included. The goals were accomplished, and a workable solution for the search and display of data on a WSN used in wine production was presented. This was made possible by the use of naturally occurring language, which combines the capabilities of IBM's Watson artificial intelligence platform with the features of the online communication service Telegram.

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