Can Natural Language Processing Technologies Help the Digital Transformation of Local Public Administrations?

Ángel Lloret[1,*]

[1]Department of Software and Computing Systems, University of Alicante, 03690 Alicante, Spain

Abstract

In this article, we present an investigation with its conclusions and results on the pivotal role of Natural Language Processing (NLP) technologies in the ongoing digital transformation of our society, specifically within local public administrations. Our research is focused on the utilization of chatbots as tools for interaction, information retrieval, and provision, which we justify as the central objective to our study.

This advanced tool facilitates the acquisition of crucial information for public managers regarding usage patterns, behaviors, statistics, and other data collected from citizens, tourists, or other groups interacting with their local public administration. Monitoring will be conducted via indicators and data compiled in a control panel or dashboard, aiding data-driven decision-making, enhancing user experience, and increasing satisfaction. The justification for employing chatbots as a communication channel lies in their simplicity, ease of understanding, and user-friendly nature. Key contributions of this NLP tool include the selection, compilation, and classification of datasets, as well as the provision of various functionalities (such as search, reading comprehension, chat, recommendation, and classification) that ensure users receive the requested information with the highest possible accuracy. The research based on the hypothesis outlined below will ultimately confirm the results presented in this study affirmatively answer the question posed in the title of the article.

Keywords

Natural Language Processing, Local Public Administrations, chatbot, Smart City, Citizen,

1. Introduction: Justification of the research

Firstly, it is crucial to note that this research is part of a Doctoral Thesis titled "Modeling the Degree of Digital Transformation of Local Public Administrations: NLP and IoT Technologies as Catalysts for Change." The thesis aims to develop a methodology to measure digital transformation in local public administrations. This work will build on the ASIS study by Lloret et al. (2021) [1], which involved creating a technological questionnaire, collecting technical data, and developing a dashboard. The thesis proposes the hypothesis that natural language processing technologies have significantly contributed to this digital and cultural shift, and the proposed article will explore this hypothesis in greater depth.

In recent years, digital technologies have profoundly transformed the economy and society, affecting all sectors and daily life. The European Union has promoted digitalization strategies

to support this shift [1]. Specifically, the cities are pivotal in the digital transformation process, making research into digital components and their implementation levels highly valuable. This study, which is part of our doctoral investigation, emphasizes the role of local public administrations as they are closest to citizens and crucial in driving this ongoing change.

One of the earliest discussions on digital transformation in academic literature appeared in 2005 by Larsen and Milakovich (2005) [2], who emphasized the need for strategies to manage relationships between public administrations and citizens through electronic government. They highlighted the use of Customer Relationship Management (CRM) strategies, originally from the private sector and primarily based on telephone communication, as essential for addressing the challenges faced by public administrations. The article also identified digital divides and the necessity to overcome them to improve citizen engagement, governance, democracy, and public administration.

Within the different Natural Language Processing technologies we are going to focus in this paper on chatbots, but it is important to concisely list the natural language processing techniques along with their most common uses [3]:

- Machine Translation. Automatic translation converts texts from one language to another using complex algorithms. It is based on machine learning of semantics, syntax and real-world context.
- Discourse Analysis. Discourse analysis identifies the structure of the text used. It is based on the design of algorithms that classify and categorize speech structures.
- Morphological Analysis, Analysis, morphological analysis separates words into morphemes and categories based on the complexity of the structures and words of the language.
- Natural Language Generation and Understanding. Natural language generation translates data into human-readable language, while understanding converts text into formal notations, involving semantic recognition and the creation of ontologies.
- Named Entity Recognition. This technique classifies phrases in the text as named entities, such as organizations or people.
- Text Analysis. Text analysis creates trees from initial study and analysis in order to study the grammar of sentences, address ambiguity in natural language grammars, and attempt to resolve the multiple interpretations that can occur in natural language.
- Speech Recognition. Speech recognition transcribes audio into written text. This is a complex task that requires continuously segmenting speech into units that can be processed independently and the result makes sense and is coherent.
- Sentiment Analysis. Sentiment analysis extracts subjective information from texts, such as reviews on social networks, to determine the polarity of certain elements. It is commonly used in advertising or in the detection and identification of fake news.
- Word Segmentation and Detection. This technique divides continuous text into individual words. It is straightforward in languages with spaces, like Spanish or English, but challenging in languages like Japanese, Chinese, and Thai where spaces are not present in the grammar.
- Word Sense Disambiguation. Word sense disambiguation determines the correct meaning of a word based on the context in which it is used.

In the case of chatbots, which use natural language processing (NLP) to simulate conversations with users, they have been widely adopted by both local public administrations and private companies, occupying a prominent place on their main websites. The main features that drive its use are constant availability, 24/7 access, multilingual support and anonymity in web interactions. Notable examples are virtual assistants such as Siri and Alexa, widely used for efficient information retrieval.

Specifically, Van Noordt and Misuraca (2019) [4] highlight in their article that advances in artificial intelligence have generated growing interest in chatbots in both the public and private sectors. In public administration, chatbots can improve service delivery by managing frequent queries and facilitating transactions, thus alleviating routine staff tasks. Note that the proposed article makes the following contributions:

- Justify the importance of natural language processing technologies in the digital transformation of Local APPP.
- Specify the Chatbot tool as a driver of this digital transformation.
- Transform the social change that these technologies have brought about in the way in which the local public administration communicates with its citizens.
- Improve, local public administrations can use human language technologies to modernize the quality and management of their data in order to make decisions that benefit their cities, providing a better service to their citizens.
- Propose, a chatbot architecture that meets the needs of local public administration
- Create an information retrieval system, validated by experts in its content and legality (to allow the citizen to search for the requested information), a question generator (to help the citizen) and an administration information classifier system (to quickly and successfully identify the information requested by the citizen).

2. Research background

In this section we will mention the various research studies carried out in this regard. We will focus on human language processing technologies, specifically chatbots, and influence within public administration. The theoretical basis of modern virtual assistants and chatbots originates from Alan Turing's 1951 work on machine intelligence, particularly the "Turing Test", which assesses a machine's ability to exhibit intelligence similar to human through conversational indistinguishability [5]. Since then, the development of chatbots has evolved significantly, starting with Joseph Weizenbaum's ELIZA in 1966, which simulated a psychotherapist's responses based on the recognition of keywords [6]. This was followed by Kenneth Colby's 1971 chatbot, PARRY, which mimicked a paranoid patient with a more advanced set of predefined responses [7]. The evolution continued with the creation of human-like avatars, which improve user interaction by adding gestures and expressions, as commented by Klopfenstein et al. (2017) [8]. Today, conversational agents such as Google Assistant, Siri, Cortana, and Watson have become an integral part of modern technology, performing a variety of tasks through text and voice interfaces. Recently, there has been a notable increase in the integration of chatbots on local public administration websites, a trend that accelerated significantly starting in 2021 [9]. This rapid increase is attributed to several factors:

- The COVID pandemic and its confinement forced the accelerated implementation of these communication systems with citizens.
- The advancement of Natural Language processing technologies at the level of Research and transfer to society.
- And as a consequence of the above, the sudden appearance of artificial intelligence

3. Hypothesis and Methodology

The hypothesis presented in this article, which extends from the Doctoral Thesis as explained in Section 1, is to verify that the implementation of natural language processing tools in public administrations, specifically chatbots, aids in the digital transformation of these organizations. To prepare this article, we have undertaken the following steps:

- Use bibliometric methods to investigate the most relevant scientific literature related to the topic.
- Propose a chatbot architecture, based on scientific studies, that is most suitable for the public administration environment, as outlined in Section 4, including a specific use case for citizen interaction.
- Propose three successful use cases derived from scientific publications that help to confirm the proposed hypothesis, as discussed in Section 5.

We adopted the bibliometric review method. Bibliometrics is defined as a scientific field that uses mathematical and statistical methods to study and analyze scientific literature (Vlachý, 1985) [10]. In the mid-20th century, E. Garfield [11] introduced bibliometrics to scientific studies, making it widely used in scientific research to facilitate the review of knowledge (Karaskus et al., 2019) [12]. Therefore, bibliometric indicators measure information about the results of scientific activity in various manifestations. Bibliometric analysis collects citations from articles and publications to determine the impact of the topics, authors, institutions, countries, journals, and keywords mentioned in this article (Zupic & Cater, 2015) [13].

In the case of our article, an analysis was carried out using bibliometric techniques to search for scientific articles related to the topic presented. This approach aims to provide a comprehensive vision of the development and evolution of the proposed research, evaluating the collaboration between authors and institutions, as well as key terms related to natural language processing techniques and digital transformation in local public administration.

The research was carried out using the Web of Science as the main scientific source, due to its extensive and useful background for this article. Our research began by identifying search terms in the Web of Science database. The initial search used a combination of terms related to digital transformation in local public administration, chatbots, citizen processes and the Boolean operators "AND" and "OR" to refine the results. ("local public administration" AND "digital transformation") OR ("Natural language processing" AND "chatbot") OR "local public administration") AND ("digital transformation")

4. Architecture of a chatbot for local public administration

The architecture of chatbots is based on a set of applications whose objective is to help, in our use case, interactions between citizens and local public administrations.

The essential natural language processing components or applications that make up a chatbot are part-of-speech taggers, parsers, and semantic resources from FreeLing [14], as well as the Natural Language Toolkit (NLTK). Additionally, information retrieval tools and machine learning classifiers based on language-specific tags.

Task flow: Initially, users access the chatbot via computers or mobile devices to ask their questions. If the interaction involves procedures with the public administration, users must register to receive updates on the status of their requests. The chatbot architecture is based on the interaction of several key modules:

- (1) Speech manager
- (2) Information retrieval engine
- (3) Question generator
- (4) Classifier

Below we will explain these modules and their operation.

Following the scheme in figure 1, the operation would be as follows:

- Request or initial interaction: a citizen initiates a request to the chatbot through different devices (for example, mobile phones, tablets, computers...), starting a conversation with the chatbot of the local public administration.
- NLP module management: Citizen interactions are managed using various natural language processing (NLP) modules. The Discourse Manager (DM) determines the user's intent and directs them to the appropriate module, such as Information Retrieval or Question Classification, while simultaneously providing a help icon to assist the user.
- Interruption Handling: The chatbot allows citizens to interrupt the conversation at any time using natural language or by clicking on a help icon. The Discourse Manager module handles these interruptions to adjust the flow of interaction and resume the conversation if necessary.
- Topic Classification: During interactions, the chatbot starts by asking a question and after each user response the Topic Classification engine identifies and confirms the most relevant topic based on the user input.
- Data storage and tracking: User conversations and interactions are recorded in files, such as XML, with timestamps, to allow tracking of user progress and collection of usage statistics.

5. How chatbots have helped the digital transformation of local public administrations

In this section, we will examine three chatbots implemented in Lithuania, Vienna and Bonn, which were documented in the referenced article.[4]. The first significant implementation of a
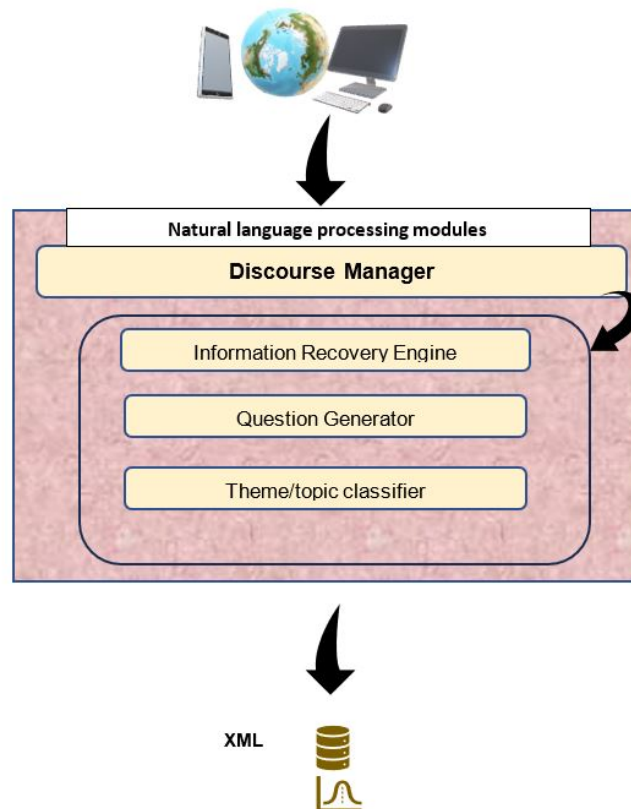
Figure 1: *Chatbot architecture (own source)*

chatbot for citizen services occurred in Latvia in 2018. The Latvian Business Registry launched a chatbot called UNA to address frequently asked questions about business registration. UNA, "Future support for entrepreneurs" in Latvian [4], is available both on the Commercial Registry's website and on its Facebook page, taking advantage of the Facebook messaging application, the most popular social network in 2018, figure 2 . UNA was designed to address common questions about business registration, including tax and fee queries, and to allow citizens to check the status of their ongoing applications.

The UNA chatbot was implemented to solve the problem of managing the large volume of phone calls that were produced and emails that were received, requesting the same information from users. These repetitive tasks consumed a lot of officials' time and frustrated citizens due to the long wait times to receive the response. The introduction of this chatbot, UNA, led to a significant reduction in the time that officials dedicated to these low-value tasks, favoring dedication to higher-value tasks and improving the quality of the services provided to the user. Overall, the use of artificial intelligence and natural language processing techniques simplified administrative operations.

A second notable example of chatbot implementation in local public administration occurred in Vienna in 2017 with the launch of WienBot [4]. This conversational agent was designed to
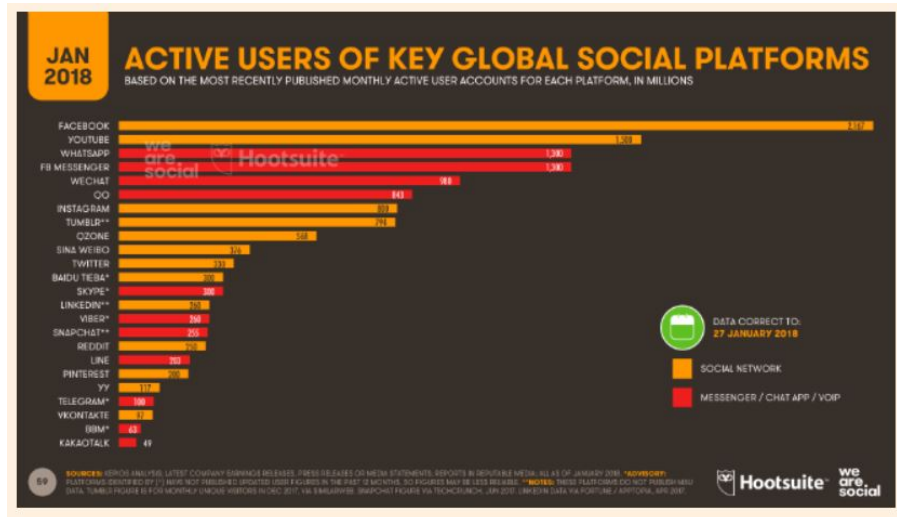
Figure 2: *Digital in 2018: Social networks add 11 new users every second. (source https://www.expansion.com/blogs/think-social/2018/02/02/digital-in-2018-las-redes-sociales-suman.html)*

answer frequently asked questions from residents and improve access to information from the city's online services, which previously required browsing the municipal website, searching and finding the requested information. WienBot was developed to simplify access to various city services, such as public parking availability, opening hours... and won the World Summit Award in 2017 for the best Government and Citizen Participation application. Although it provides extensive information, WienBot does not facilitate service transactions, but instead directs users to relevant pages for more details, this functionality was developed later.

Our last case is the implementation of GovBot in Bonn, Germany, in 2018 [4]. GovBot was developed to help citizens with administrative tasks, such as requesting forms, checking opening hours, and scheduling appointments with local public administration. The success of GovBot was such that other German public administrations adopted this technological solution for their processes. It is based on the use of machine learning and a comprehensive knowledge base, which aims to reduce the workload of public personnel by handling repetitive queries and, in turn, guiding users in completing forms. The implementation took into account the growing trend of using smartphones to access municipal services, figure 3

6. Conclusions: How chatbots have helped the digital transformation of local public administrations

In conclusion, this preliminary analysis demonstrates that chatbots using natural language processing (NLP) tools provide substantial benefits to citizens and serve as critical drivers for the digital transformation of local public administrations,[15], [9] and [4] highlighting the following key points:

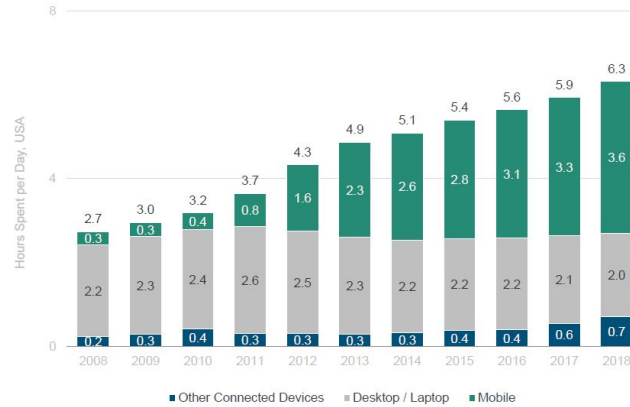- Provide a new digital communication channel to the citizen.

Figure 3: *Devices used to access the internet (source Meeker, M., & Wu, L. (2018). Internet trends 2018)*

- Implementing, a chatbot cuts across the entire organization of a local public administration, which requires training in digital capabilities in all municipal areas.
- Modernizing, requires the implementation of ICT infrastructure, data processing centers, software tools, hardware systems... which requires having more budget for the IT departments of local public administrations.
- Change, change management, serves as a lever to promote change management towards a digital local public administration, it will be done in a much more participatory way and with more involvement on the part of municipal workers.
- Innovate, the application of natural language processing technologies will be accepted by IT departments that will require further developments in NLP technologies to apply in their city council processes, both internal and external.
- Data-Driven Analysis, The analysis of data derived from chatbot interactions can inform policy decisions, enhancing satisfaction among citizens and municipal workers alike. This, in turn, encourages further investment in digital transformation projects and progress towards Smart City initiatives.

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