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Towards implementing an AI chatbot platform for museums

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Abstract

Recently, understanding their unique role in storytelling and aiming to attract more visitors, several museums have integrated modern ICT technologies. The problem with these technologies however is that gradually tend to be of no real interest to visitors, lack of significant interaction, cannot be continuously updated, and eventually distract visitors from experiencing the exhibits. Museum visitors do not need to be impressed by a technological application but need to learn about the stories of the exhibits in a creative, human-centered and interactive manner. This paper presents an ongoing work towards implementing a new interactive technological trend for museums, i.e., a museum chatbot platform, namely MuBot. The MuBot platform aims to provide museums the opportunity to create simple, interactive and human-friendly apps for their visitors. Such apps will integrate an intelligent chatbot that uses some of the most advanced AI technologies of Machine Learning, Natural Language Processing/Generation, and the Semantic Web. Museum visitors will be able to use a chatbot application that will be created through the MuBot platform, to chat with a 'smart' exhibit. They will be able to ask questions through text or voice (in natural language) and receive audible or written answers. The more the visitors ask, the more MuBot will learn and store new knowledge in its knowledge base. The paper presents a preliminary design of the proposed MuBot platform, experimenting with first prototype implementations using the well-known Dialogflow framework, as well as using a Knowledge Graph-based approach.

Keywords:

Museums, Chatbots, Artificial Intelligence, Machine Learning, Conversational Systems

1. Introduction

Museums are complex organisations as they carry the responsibility to gather, document, protect and preserve artefacts from our past, artefacts that carry ideas and practices that prove our intelligence. Also have the responsibility to present and carry this knowledge to all the members of the community in a creative, human-centered and interactive manner.

Recently, several museums, understanding their unique role in storytelling and at the same time aiming to attract more visitors, have integrated modern ICT technologies. Doing so, their visitors are now able to walk around exhibits using not only the assistance of a human or audio guide, but also using high-end technologies such as digital guides, smart mobile apps, virtual and augmented reality devices/glasses, smart tags, and more. The problem with these modern ICT technologies however is that, after the first impression and use, they tend to be of no real interest to visitors, since they either distract them from the exhibits or their application lack of significant human-like/natural interaction. In addition, these technologies cannot be

continuously and promptly updated, and become less functional and more disturbing over time. It is conjectured that museum visitors do not need to be impressed by a technological application, but rather need to learn about the stories of the exhibits in a creative, human-centered, human-like and interactive manner.

The aim of our ongoing research work is to use AI technologies to develop intelligent applications for supporting museum visitors before, during and after their visit to a museum. In this paper our preliminary efforts are presented towards implementing a new interactive technological AI trend for museums, i.e., a *Museum chatbot* platform, namely MuBot.

The motivation of our work is the real need to go beyond the current status in museums' technological advances by introducing a new way of attracting visitors to exhibitions, by making technologies friendly and useful, and by turning museums into an interactive learning and social economic development environment. To do this, the proposed MuBot technological initiative will bridge the following gaps:

- the lack of communication and continuous human-centered/human-like interaction of modern museums with their visitors,
- the limited visibility of museum content to the public through high technological applications, and
- the lack of exploiting the content of museums as a key of economic development for both the local community and the global community.

The main contribution of our work is to enable museum curators and administrators to create simple, interactive and human-friendly chatbot apps for their visitors with the support of the MuBot platform. Intelligent chatbots that use some of the most advanced Artificial Intelligence (AI) technologies of today such as Machine Learning (ML), Natural Language Processing (NLP) and Semantic Web (SW), will be designed and implemented. The visitors will be able to use a chatbot application that will be created through the MuBot platform, to chat with a 'smart' exhibit when they are in front of (or close to) it. They will be able to ask questions through text or voice (in natural language) and receive audible or written answers with the use of AI technology. The more the visitors ask, the more MuBot learns and stores new knowledge in platform's knowledge base.

The MuBot platform is currently in the design phase, however, an experimental ML-based chatbot using Google's Dialogflow has been implemented for evaluation of the related technology¹. In addition, we are already experimenting with an alternative approach (as another MuBot instantiation) based on SW technology (Ontologies and Knowledge Graphs). Our vision is to combine the advantages of both technologies with NLP/NLG technology, towards a state-of-the-art chatbot platform for museums.

The rest of the paper is structured as follows: Section 2 presents the related work concerning the use of AI chatbots technologies with specific examples from museums. Also, this section provides a brief introduction of the basic terminology of the AI technologies that are under research for integrating in the MuBot platform. The section concludes with the recording of the requirements of a museum chatbot application and platform. Section 3 presents the MuBot platform, its purpose, the special features, and the architectural design. Also, in this section, the Cretan MuBot is presented, the first experimental chatbot of the MuBot Platform, which will be evaluated in the Heracleum Archaeological Museum. Section 4 discusses future steps in MuBot platform development. Finally, section 5 concludes the paper.

¹ <http://tiny.cc/d56a6y>

2. Related Work and Technologies

In this section Artificial Intelligence technologies that have been used in the development of chatbots are briefly presented. Also, this section includes a short review on the chatbot applications that have been implemented for museums.

2.1. Artificial Intelligence technologies and chatbots

Chatbots are rapidly evolving AI applications used by several companies and organizations all over the world in order to engage and serve the users' needs by exploiting the most common skill of them, which is chatting. A short selected (from the literature) definition of a chatbot is: "Chatbot (or chatterbot, Bot, smartbot, Conversational interface or Artificial Conversational Entity) is a computer program or an artificial intelligence which conducts a conversation via auditory or textual methods" (Bilange, 1991; Vassos, Malliaraki, Falco, Maggio, Massimetti, Nocentini & Testa, 2016; Følstad & Brandtzaeg, 2017; Valtolina, Barricelli, Gaetano & Diliberto, 2018). Their major advantage is that they can serve their users anytime and if they get smart enough, they can provide a satisfactory human-like assistance. Chatbot applications are using advanced AI technologies, as presented in the following subsections.

2.1.1 Machine Learning (ML)

Machine Learning is the field of AI science that focuses on getting machines to "learn" and to continually develop autonomously. ML utilizes supervised or unsupervised algorithms, such as decision trees, neural networks, deep learning and others, that enable computer systems to optimize the ways of problem solving (Sukhbaatar, Weston & Fergus, 2015; Serban, Sordoni, Bengio, Courville & Pineau, 2016, Wehle, 2017). For chatbots, ML is used to understand what users are saying, learning from examples provided for training the system on what a user might say when interacting with the chatbot, analyzing and understanding user intent in real-time.

2.1.2 Natural Language Processing (NLP)

Understanding natural language is the most difficult task of an AI chatbot system, as language is an evolving entity with different levels of complexity. NLP allows computers to segment, assign meaning, and analyze human communication in its natural forms. NLP is a process that uses several AI techniques such as entity recognition, relationship extraction, language parsing, sentiment analysis, speech recognition and others in order to become effective and natural (Orth, 2017; Rivero, 2018).

2.1.3 Semantic Web and Ontologies

As Tim Berners-Lee wrote in the May 2001 issue of *Scientific American*, "The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation.". In the Semantic Web, data/information must have/convey meaning and for this to happen new technologies have been introduced. As W3C describes, Semantic Web technologies enable people to create data/information stores on the Web, build commonly agreed and shared vocabularies, and write formal and explicit rules for handling linked data. Linked (and open) data are empowered by technologies such as RDF, SPARQL, OWL (W3C.org, 2015; Cahn, 2017). Such technologies play a crucial role in the formal representation and structuring of information and knowledge that chatbots must be fed in order to be able to support accurate machine-processable and machine-understandable conversations/dialogues (in the form of human-like questions/answers).

2.1.4 Knowledge graphs (KGs)

KGs can be viewed as a new AI technological trend that has its origin to the Semantic Web. As it is still evolving, several definitions can be found. A selected from recent literature definition

is: “A knowledge graph (i) mainly describes real world entities and their interrelations, organized in a directed graph, (ii) defines possible classes and relations of entities in a schema, (iii) allows for potentially interrelating arbitrary entities with each other and (iv) covers various topical domains”. KGs are very flexible and could potentially give to a chatbot unlimited access to stored and structured knowledge (Riedl & Bulitko, 2013; Stichbury, 2017; Bonatti, Decker, Polleres & Presutti, 2019).

All the above technologies, with all their detailed specifications, extensions and modules, are important and necessary components for developing an AI chatbot. Programmers have a choice to create their own custom-made solution for the development of a chatbot, which will give them full freedom and flexibility but a lot of coding time. On the other hand, today, IT companies and individual consortiums have created AI Chatbot platforms (as discussed in following section) that can be used by developers to create their chatbots fast and with low effort.

2.2. AI Chatbot Platforms

Before using a readymade chatbot, a developer must define the reasons and the goals that the chatbot is designed for. There are mainly three types of chatbot platforms: No-programming platforms, conversation-oriented platforms, and platforms backed by the industry (Couto, 2017).

1. The no-programming platforms are simple task-oriented platforms that do not have NLP or ML capabilities. They are easy in use and in construction of chatbots and can answer to simple questions concerning simple tasks such as order a pizza or buy a ticket. The generated chatbots can be easily integrated in social media and webpages. The most famous platforms are Chatfuel (2019), Octane.ai (2019) and Motion.ai (2019).
2. The conversation-oriented platforms on the other hand are not built to serve a task but are designed to make a conversation. Most of them use the Artificial Intelligence Modelling Language (AIML) (2019) in order to model the conversation with a user and manage to conduct good discussions. They don't use NLP or ML techniques so the developers must keep them manually updated. The most famous conversational bots' platform is PandoraBots (2019).
3. The platforms backed by the industry are advanced chatbot platforms that are using ML and/or NLP technology, and may integrate large external sources of data/information/knowledge such as Web pages, ontologies, and Knowledge Graphs. The most famous of these platforms are Google Dialogflow (2019), Facebook Wit.ai (2019), KITT.AI (2019), IBM Watson Assistant (2019), Microsoft Luis (2019) and Amazon Lex (2019).

2.3. Chatbots and the Museum

Museums have been experimenting with chatbots for more than a decade. The first chatbot applications were conversational bots that were interacting with the audience through screens as avatars or through phone or text services (Boiano, Gaia & Caldarini, 2003; Boiano, Borda, Gaia, Rossi, & Cuomo, 2018).

Gradually with the rise of new advanced AI technologies and the use of social media, new more advanced chatbot apps were introduced and used in several sectors. Chatbots in museums are providing a new way of increasing visitors engagement by functioning as museum guides or as simple question/answer (QA) info agents or in a more sophisticated way as visit planners or by using, for example, gamification techniques (Schaffer, Gustke, Oldemeier & Reithinger, 2018; Roussou, Perry, Katifori, Vassos, Tzouganatou, & McKinney 2019). A brief review of recent efforts in creating bots for museums is provided in the following paragraphs.

At the National Art Museum of the Republic of Belarus, a simple QA Facebook messenger bot has been created. This bot can answer simple questions about the artefacts of the museum, and it can be called as a simple Infobot. However, this bot lacks quality conversational skills (Boiano, Borda, Cuomo, Gaia & Rossi, 2018).

At Anne Frank House in Amsterdam, an off-site Facebook messenger bot is developed and implemented. The content of this bot is well curated as the user is guided to follow a predetermined route. The bot is in control of the conversation and gives to the user's different ways to move through the life of Anne Frank and the museums exhibits. The bot is not designed to answer free questions and it gets confused when this happens. The designed scenario is helpful and safe for the museum as it provides protection from bad usage (Tzouganatou, 2018).

The Maxxi's Chatbot is developed at the National Museum of the 21st Century Arts in Rome. The Facebook messenger bot uses predefined content and leads the visitor through selections to plan or follow a certain route path. The bot is lacking conversational skills but provides engagement through rewards (Tzouganatou, 2018).

At the House Museum of Milan an advanced Facebook messenger bot was created, named *Di Casa in casa adventour* bot. The bot uses gamification techniques as sole users or groups of visitors play a search tour game, trying to find clues and learn new things. The bot is providing strong visitors' engagement, though there is not a lot of conversation involved (Boiano, Borda, Gaia, Rossi, & Cuomo, 2018).

At Catal Hoyuk Neolithic site an advanced FB Messenger bot was developed and implemented by a group of experts. The bot had the skill not only to inform through a Q/A dialogue but also to provoke the user about a certain issue. The bot surprises its users, takes control of the conversation, and awakes emotions and thoughts. It is designed to make conversations that have a meaning. For example, the bot can start a conversation about the concept of death in the Neolithic period. The final scope of the bot is to alter the perception of the users about an issue and engage them (Roussou, Perry, Katifori, Vassos, Tzouganatou, & McKinney 2019).

Considering all the above examples about bots implemented in museums, we can distinguish and categorize four different types of bots in the museum's application domain:

- Simple Q/A infobots
- Predefined conversation routes chatbots
- Gamification and reward bots
- Provoking bots

The main challenge of the newly designed museum bots is for the developers and the museum stakeholders to decide whether the bots that they implement will stay simple and predefined or will follow the recent trends, become "smarter" using advanced AI technologies and methods, and engage audience through meaningful human-like (near human-intelligence) conversations (Thies, Menon, Magapu, Subramony, & O'Neill, 2017; Schlesinger, O'Hara & Taylor, 2018; Tzouganatou, 2018).

2.4. Requirements and motivation

A chatbot application in order to be effective and useful for the museum, must combine the recent AI technological advances with the museum needs and purposes. A museum chatbot must fulfill a large percentage (if not all) of the following requirements and characteristics (Sameera, A. Abdul-Kader, & Woods, J., 2015; AbuShawar & Atwell, 2015; Radziwill & Benton, 2017; Nahdatul, 2018).

2.4.1 Non-functional Requirements

A museum chatbot must be simple, informative, accurate and precise. It must have strong conversational skills and provide meaningful content. The museum bot should be entertaining and should engage the audience in the whole experience/tour duration. Furthermore, it must be able to avoid prejudice and misuse by its users and overcome unexpected input. In addition, it could be positive if there is a capability by the bot to provoke users to find and learn more, but at the same time to be sensitive and understanding on human emotions.

2.4.2 Functional Requirements

The developers of a museum chatbot must be able program/configure it to have the ability of NLP/NLG and to achieve continuous learning with ML technologies. Also, it must be programmed to respond to text messages and to voice input with the use of text or speech recognition technologies. Furthermore, it must have the infrastructure to be available anytime, to have an attractive graphical design and to be easy to use, without profound technical parameters and problems. In addition, considering the possibility to be used during a museum visit, its location should be pointed out with GPS or other techniques and it should be enriched with multimedia content, so it could provide to the visitors a complete museum tour. Finally, the developers should consider all the security threats and take all the necessary measures to develop a secure app for the museum visitors and the museum content.

The challenge of our work is to realize the usefulness of these requirements and create chatbots that can serve the complex needs of the visitors and the museums curators.

3. The MuBot Platform

3.1. Aim, Technologies and Architecture

The proposed MuBot platform will provide museums the opportunity to create simple, interactive and human-friendly chatbots for their visitors. The visitors will be able to use a chatbot application that will be created through the MuBot platform, to chat with a ‘smart’ exhibit when they are in front of (or close to) it. The users will be able to ask questions through text or voice (in natural language) and receive audible or written answers.

The more the visitors ask, the more MuBot will “learn” and store new knowledge in their knowledge base. Visitors will chat with the exhibits in real-time, and on the other hand, exhibits (through chatbot and the use of AI technology) will be able to provide the right answers to their visitors, in different forms (text, voice, image, video, etc.).

The MuBot Platform will use advanced ML, NLP and Semantic Web technology. Also, will be able to connect with external resources like domain-specific Webpages, AIML libraries, ontologies, knowledge bases and knowledge graphs. In Figure 1, we present the early architectural design of the proposed MuBot platform:

This preliminary architecture that is proposed relies on three aspects (Hallili, 2014): i) A Knowledge Base that relies on a Semantic Web technology (RDF, SPARQL query language, and OWL ontologies), for data extraction, representation, linking, reasoning and querying, ii) NLP for interpreting users input, and iii) NLG for creating the proper well-defined answers. The proposed platform will be evaluated in the domain of museums. The MuBot domain-specific instantiation of the proposed platform will be able to conduct dialogues/conversations such as the one designed for our experimental chatbot, the Cretan MuBot:

- *User: Where was Snake Goddess figurine found?*
- *MuBot: The Snake Goddess was found at Knossos Palace.*
- *User: And where was Knossos Palace located?*
- *MuBot: Knossos Palace was in Crete.*

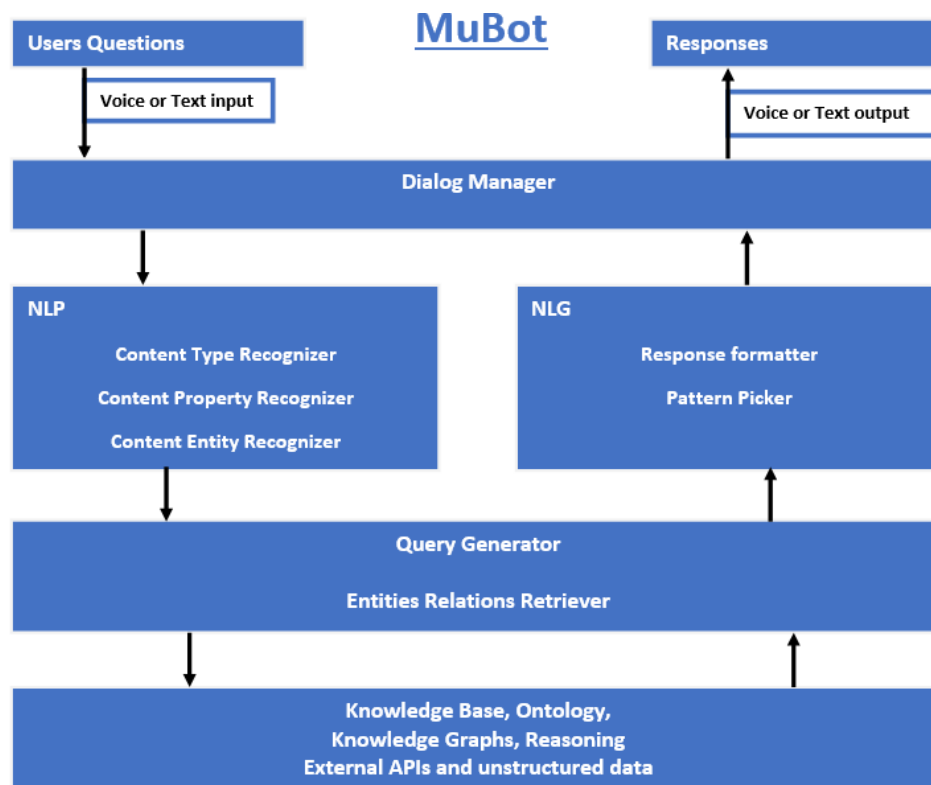


Fig.1. Museum Bot (MuBot) platform early design architecture.

3.2. Use Case Scenario: Cretan chatbot in Dialogflow

As MuBot platform is currently in the design phase, a demo chatbot was developed for the Archaeological Museum of Heraklion with the use of Google’s Dialogflow Platform (Orth,2017). The demo chatbot is called Cretan (i.e., from Crete) MuBot and allows users to chat with a famous exhibit of the museum, the “Snake Goddess” figurine. The Cretan MuBot is online for demonstration at <http://tiny.cc/d56a6y>.

The snake goddess figurine

The two famous figurines of the Minoan earth goddess with the snakes, possibly representing a mother goddess and a daughter, are exquisite examples of Minoan miniature sculpture. The smallest of the two shows the goddess standing, holding snakes in both of her raised hands. She wears the elaborate Minoan garment – a tight vest with sleeves, which bares her ample bosom, and a long skirt with seven horizontal tiers and a short apron – and an equally elaborate head-dress on which a panther sits. The rather flat, lifeless body is enlivened only by the opulent garments and head-dress. By contrast, the triangular face is dominated by the huge expressive eyes, which convey all the tension of the figure. This figurine was found together with another similar but larger figurine, and other precious objects.



Fig. 2. The Snake Goddess figurine in Cretan MuBot experimental application environment.

For the creation of the Cretan MuBot, specific guidelines suggested by the Dialogflow platform (2019) were followed:

1. A small scale archaeological scientific research was carried out with the scope of defining the purpose of the chatbot, conducting a detailed documentation of the exhibit and researching of external sources and further content.
2. Considering the internal architecture and functions of the Dialogflow platform (2019), certain categories, types of content, relations, possible questions and answers for the Cretan MuBot experiment exhibit were engineered. For the Snake Goddess figurine, the categories of *chronology*, *material* and *purpose* of the figurine were defined. Also, some questions and answers were designed for each content category. For example, some of the questions that were designed for the type of content Chronology were: “When is the figurine dated?”, “What is the chronology of the figurine?”. Possible answers were also defined and engineered.
3. The next step was the use of Dialogflow platform for the creation of the infrastructure of the bot. Intents, entities and relationships were created and through QA inputs the Cretan MuBot was trained. The Entities that were defined were: *chronology*, *material*, *location* and *purpose*. Some of the intents were: *What is the material of the figurine?* *Why does she hold snakes?* *Where was the figurine found?* Dialogflow platform’s ML and NLP technology assisted in making the Cretan MuBot “smarter”.
4. Afterwards, the API was created and the connection of the Cretan MuBot with the experimental Web page was established. At that point the developers considered the graphic design parameters and the usefulness of the bot, so it could be attractive and easy in use.
5. Finally, the Cretan MuBot got into a testing period by expert users which were making certain questions to the bot. In specific, 3 experienced Web and mobile app programmers and 5 cultural and museum informatics specialists tested with their questions the Cretan MuBot.

The first results were that the bot provided the correct answers only when the predefined or a highly similar question was made. Each time the bot could not answer, a fixed predefined answer was provided. After each test the developers were evaluating the results and tried to train the Cretan MuBot by creating new intents, entities and relations. The Dialogflow had the technical ability to use ML in order to identify similar questions and train the bot, and also could store all the questions that were made, so developers could train the bot by providing the right answers, give alternatives to the intents and define new entities. The Cretan MuBot conversational skills were not fascinating and there is a lot of work to be done in order to be classified as “smart”.

As for the abovementioned methodology it must be pointed out that for the creation of a chatbot every Chatbot platform provides basic guidelines that follow the basic principles of Web apps development methodologies: requirements analysis, design, development and testing. This methodology has different extensions and variables according to the domain that is implemented. The specification of a more detailed methodology for the development (as well as for the evaluation) of museum chatbots must (and will) be researched and defined in our future work.

3.3. Use Case Scenario: Cretan chatbot in MuBot proposed KG-based architecture

In addition to the ML-based implementation of our Cretan MuBot (using Dialogflow), we have experimenting with the proposed knowledge graph-based preliminary architectural design, as depicted in Figure 3 and described in the following subsections. In the following paragraphs, we demonstrate an example knowledge base and related queries that have been engineered for this purpose.

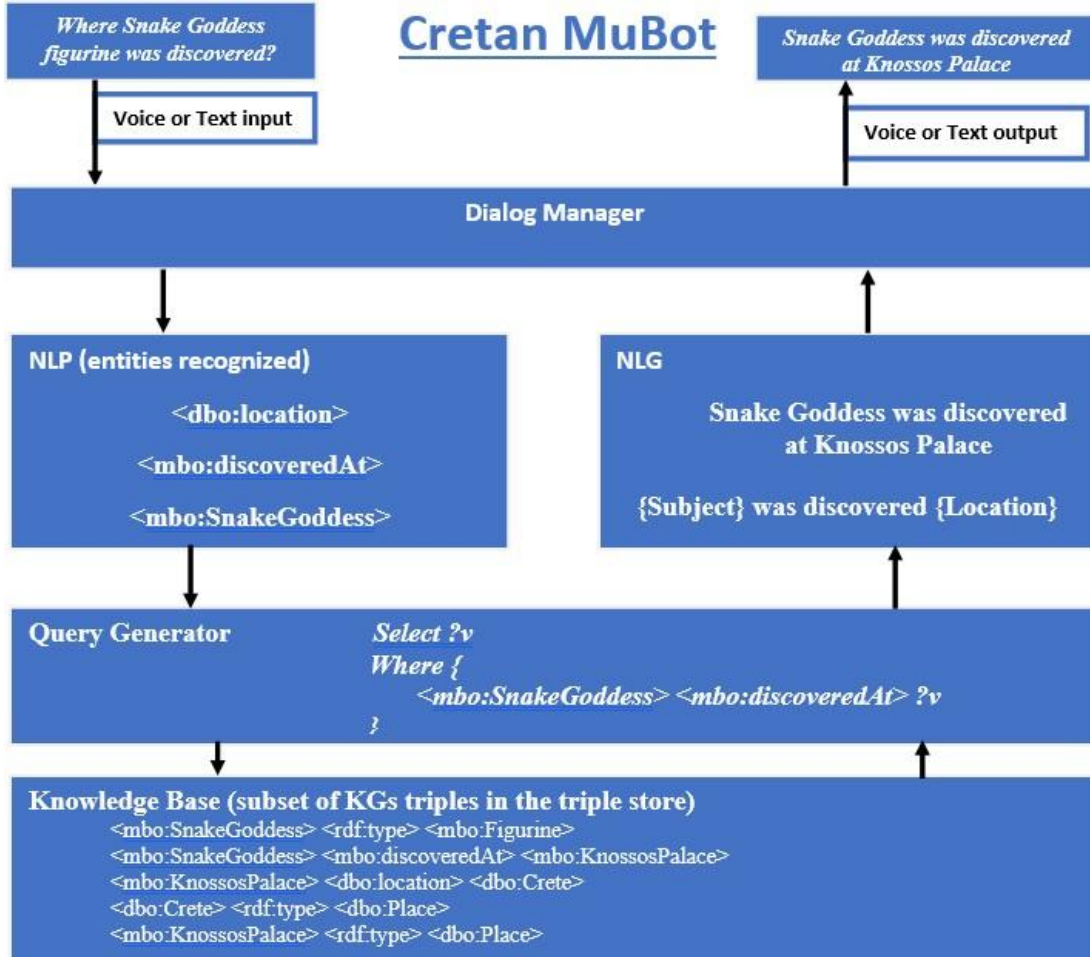


Fig. 3. The Cretan MuBot KG-oriented instantiation.

3.3.1. Knowledge Base

The knowledge base uses an example MuBot ontology engineered for the specific scenario, with IRI: <http://i-lab.aegean.gr/ontologies/mubotOnto/> and prefix “mbo”. Also, uses ontologies from external sources such as the DBpedia ontology, with IRI: <http://dbpedia.org/ontology/> and prefix “dbo”.

The data of the MuBot experimental (RDF) model is represented in the triples form: <subject>, <predicate>, <object>. In our example, the statement “*Snake Goddess figurine was discovered at Knossos Palace*” is expressed in RDF with the following triples:

- a) <mbo:SnakeGoddess> <rdf:type> <mbo:Figurine>
- b) <mbo:SnakeGoddess> <mbo:discoveredAt> <mbo:KnossosPalace>

By extending and enriching the model with external semantic data derived by DBpedia and the MuBot ontology, the following triples can be added:

- c) *<mbo:Figurine> <mbo:discoveredAt> <dbo:Place>*
- d) *<mbo:KnossosPalace> <dbo:location> <dbo:Crete>*
- e) *<dbo:Crete> <rdf:type> <dbo:Place>*
- f) *<mbo:KnossosPalace> <rdf:type> <dbo:Place>*

The classes that are used for the example instantiation are: *mbo:Figurine* and *dbo:Place*, and the properties are: *mbo:discoveredAt*, *rdf:type*, and *dbo:location*. Both classes and properties may be enriched with synonyms so the system would be able to understand different questions with the same meaning. The connection/linkage of the MuBot platform with external KGs such as DBpedia (2019), as well as the reasoning engine (inferencing mechanism) will provide/add a range of RDF triples that will make the Cretan MuBot more ‘intelligent’ and effective in understanding users’ questions (as presented in the following lines).

3.3.2. Question understanding with NLP

MuBot platform supports textual or vocal input of user-made questions. This input can be interpreted using several NLP techniques. Related work (Hallili, 2014; Cabrio, Cojan, Aprosio, Magnini, Lavelli & Gandon, 2012) describes three aspects of identification: i) Expected Answer Type (EAT) which in our architecture is named as Content Type Recognizer (CTR) and is what the input is looking for, ii) the property that relates the question with the possible answer, and iii) the NE (Named Entity) which in our architecture is named Content Entity Recognizer (CER) and represents the subject of the question made. In the presented example the question made is “*Where Snake Goddess figurine was discovered?*”. The CTR is *mbo:location*, the property is *mbo:discoveredAt* and the CER is *mbo:SnakeGoddess* and *mbo:Figurine*. Up to this point, NLP techniques were used in the example in order to identify the entities, its properties and the expected answers. These NLP techniques are using pattern matching, entities relevance, scoring strategy and others.

When all the above elements are processed the system is generating a query that produces results from the KB. The example query (in SPARQL query language) looks as follows:

```
PREFIX mbo: <http://i-lab.aegean.gr/ontologies/mubotOnto/>
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT? v? z
WHERE {
  mbo: SnakeGoddess mbo:discoveredAt ?v.
  ?v dbo:location ?z.
}
```

After query execution and pattern matching, the following triples are matched and returned:

- a) *<mbo:SnakeGoddess> <mbo:discoveredAt> <mbo:KnossosPalace>*
- b) *<mbo:KnossosPalace> <dbo:location> <dbo:Crete>*

In a more elaborated example engineered to demonstrate the inferencing/reasoning capabilities of the proposed approach, the following statement is defined (in terms of properties and property hierarchy):

- c) *<mbo:discoveredAt> <rdfs:subPropertyOf> <mbo:foundAt>*

The restriction of *mbo:foundAt* object property has as domain the class *mbo:Figure*, and as range the class *dbo:Place*. Inferencing will add the following inferred triple in the model:

- d) *<mbo:SnakeGoddess> <mbo:foundAt> <mbo:KnossosPalace>*

This allows for querying the inferred model (tested in Snap SPARQL plugin of Protégé 5.5) with the following queries also:

I. “Where Snake Goddess figurine was found?”:
PREFIX mbo: <http://i-lab.aegean.gr/ontologies/mubotOnto/>
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?v ?z
WHERE {
 mbo:SnakeGoddess mbo:foundAt ?v.
 ?v dbo:location ?z.
}

The returned data in variables are: ?v = mbo: KnossosPalace, z? = mbo:Crete.

II. “What was found in Crete?”:
PREFIX mbo: <http://i-lab.aegean.gr/ontologies/mubotOnto/>
PREFIX dbo: <http://dbpedia.org/ontology/>
SELECT ?s ?v
WHERE {
 ?s mbo:foundAt ?v.
 ?v dbo:location mbo:Crete.
}

The returned data in variables are: ?s = mbo:SnakeGoddess, v? = mbo: KnossosPalace, allowing for NLG module (described in next section) to provide answers such as “Snake Goddess was found in Knossos Palace, in Crete”.

The example Cretan Mubot model (in .owl and .ttl serializations) and the related queries in SPARQL can be accessed from <https://github.com/KotisK/muBotOnto-example>.

3.3.3. NLG responses

The last step of the question/answer processing of the MuBot is the creation/formation of the appropriate response/answer to the given question(s). The system uses NLG techniques in order to pick a response pattern that matches with the query-provided triples and proceed to the final response formatting.

In the presented example the NLG module will be able to generate the following answers:

- a) “Snake Goddess was found at Knossos Palace”
- b) “Knossos Palace is located in Crete”

Or better, by synthesizing the two statements above:

- c) “Snake Goddess was found at Knossos Palace, in Crete” (replacing ‘is located in’ with ‘, in’).

The generation processes could be more creative and exploit other semantic properties that, for example, could return as a response multimedia files like photographs of the figurine.

4. Future work

The Cretan MuBot is the first step for the creation of the MuBot chatbot platform for museums. The Cretan MuBot will be fully developed, enriched with more exhibits, tested with different AI technologies and types of display (webpage bot, FB messenger bot, real time museum app

bot) in the museum and evaluated with a certain evaluation strategy. Radziwill and Benton (2017) describes a chatbot quality evaluation strategy that tries through a literature review to derive the best quality attributes that a chatbot must have.

In the following design and development stages of our ongoing work, all the available AI technologies that can be integrated in a chatbot platform will be researched and recorded, especially those related to ontologies, Knowledge Graphs, and Linked Open Data. Also, one critical aspect for us to put in the context of a chatbot development is the identification of the special requirements of a museum for the integration of intelligent bots that can deliver meaningful conversations and change the way users think of the exhibits/exhibitions and their hidden ideas. Finally, the definition of a specific development methodology as well as an evaluation strategy for museum chatbots are left for future work.

5. Conclusions

The integration of the AI chatbot technology in the museum domain is an intriguing ongoing project for the museum's stakeholders and the AI developers. The design and implementation of such bots must consider several variables. The museums are not a commercial organization and has different scopes to fulfill. A museum bot must provide meaningful content and to adjust to the visitor's choices and habits. The bot must be simple and use the AI technologies in a way that visitors will not be abstracted from the content. The museum bot must have strong AI conversational skills, but developers always must consider the limitations of the content and to care for the privacy and security issues. A full understanding of all the aspects of the implementation of an AI chatbot for museums is the main purpose of the MuBot Platform ongoing project. This paper has presented the first steps and preliminary research outcomes of such a project.

References

- AbuShawar, B., Atwell, E. (2015). ALICE Chatbot: Trials and Outputs, *Computación y Sistemas*, Vol. 19, No. 4, 2015, pp. 625–632
- Amazon Lex. (2019). Conversational interfaces for your applications, <https://aws.amazon.com/lex/>, Last accessed: 20/10/2019
- Artificial Intelligence Markup Language. (2019). The open standard scripting language for chatbots, <http://www.aiml.foundation/>, Last accessed: 20/10/2019
- Bilange, E. (1991). A task independent oral dialogue model. In *Proceedings of the Fifth Conference of the European Chapter of the Association for Computational Linguistics*, pages 83–88, Berlin, Germany. Association for Computational Linguistics.
- Boiano, S., Borda, A., Gaia, G., Rossi, S., & Cuomo, P. (2018). *Chatbots and New Audience Opportunities for Museums and Heritage Organisations*. (September). <https://doi.org/10.14236/ewic/eva2018.33>
- Boiano, S., Gaia, G., & Caldarini, M. (2003). Make Your Museum Talk: Natural Language Interfaces for Cultural Institutions. *Museums and the Web 2003*, Retrieved from <https://www.museumsandtheweb.com/mw2003/papers/gaia/gaia.html>

- Boiano, St., Borda, A., Cuomo, P., Gaia, G., Rossi, S. (2018). Chatbots in Museums: Hype or Opportunity?, MuseWeb, in <https://www.museweb.net/chatbots-in-museums-hype-or-opportunity-%E2%80%A8/>
- Bonatti, P. A., Decker, S., Polleres, A., & Presutti, V. (2019). Knowledge graphs: new directions for knowledge representation on the semantic web. *Report from Dagstuhl Seminar*, 8(9), 29–111. <https://doi.org/10.4230/DagRep.8.9.29>
- Cabrio, E., Cojan J., Aproso A. P., Magnini B., Lavelli A., and Gandon F. (2012). Qakis: an open domain QA system based on relational patterns. In International Semantic Web Conference (Posters & Demos)
- Cahn, B. J. (2017). *[Thesis] Chatbot Literature Review*. Retrieved from https://static1.squarespace.com/static/569293741c1210fdda37b429/t/59160b6bff7c50104e601a85/1494616940469/CHATBOT_thesis_final.pdf
- Chatfuel, chatbot platform for Facebook Messenger. (2019) Retrieved from <https://chatfuel.com>
- Couto, J. (2017). *Building a Chatbot: Analysis and Limitations of Modern Platforms - DZone AI*. Retrieved from <https://dzone.com/articles/building-a-chatbot-analysis-amp-limitations-of-mod>
- DBpedia. (2019). Structured Wikipedia data, Retrieved from <https://wiki.dbpedia.org/>
- Dialogflow. (2019). Build natural and rich conversational experiences, Retrieved from <https://dialogflow.com>
- Følstad, A., & Brandtzaeg, P. B. (2017). Chatbots and the New World of HCI. *Interactions*, 24(4), 38–42. <https://doi.org/10.1145/3085558>
- Hallili, A. (2014). Toward an Ontology-Based Chatbot Endowed with Natural Language Processing and Generation. 26th European Summer School in Logic, Language & Information, Aug 2014, Tübingen, Germany. hal-01089102.
- IBM Watson Assistant. (2019). More than a chatbot, Retrieved from <https://www.ibm.com/cloud/watson-assistant/>
- Kitt.ai. (2019). Conversational Understanding as a Service, Retrieved from <http://kitt.ai/>
- Language Understanding (LUIS). (2019). A machine learning-based service to build natural language into apps, bots, and IoT devices. Retrieved from <https://www.luis.ai>
- Medhi Thies, I., Menon, N., Magapu, S., Subramony, M., & O'Neill, J. (2017). How do you want your chatbot? An exploratory Wizard-of-Oz study with young, Urban Indians. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 10513 LNCS, 441–459. https://doi.org/10.1007/978-3-319-67744-6_28
- Motion.Ai. (2019). A visual chatbot builder, Retrieved from <https://www.motion.ai/>

- Nahdatul, A. (2018). Review of Chatbots Design Techniques, *International Journal of Computer Applications* (0975 – 8887) Volume 181 – No. 8, https://www.researchgate.net/publication/327097910_Review_of_Chatbots_Design_Techniques
- Octane.ai. (2019). Commercial and social media bots, Retrieved from <https://octaneai.com/>
- Orth, A. (2017). Building chatbots with Dialogflow and Grank.AI in Grank.ai, Retrieved from <https://blog.grakn.ai/chatbots-and-grakn-ai-67563c64cfde>
- PandoraBots. (2019). Intelligent conversational agents, Retrieved from <https://home.pandorabots.com/home.html>
- Radziwill, N. M., & Benton, M. C. (2017). *Evaluating Quality of Chatbots and Intelligent Conversational Agents*. Retrieved from <http://arxiv.org/abs/1704.04579>
- Resource Description Framework (RDF). (2019). Concepts and Abstract Syntax, Retrieved from <https://www.w3.org/TR/rdf-concepts/>
- Riedl, M.O., Bulitko, V. (2013). Interactive narrative: An intelligent systems approach. *AI Mag.* 34 (1), 67–77, <https://www.aaai.org/ojs/index.php/aimagazine/article/view/2449>
- Rivero, A. (2018). Next generation of chatbots with NLP services and Graphs in Chatbots Life, Retrieved from <https://chatbotslife.com/next-generation-of-chatbots-with-nlp-services-and-graphs-cd811a8165d7>
- Roussou, M., Perry, S., Katifori, A., Vassos, S., Tzouganatou, A., & McKinney, S. (2019). *Transformation through Provocation?* (627), 1–13. <https://doi.org/10.1145/3290605.3300857>
- Sameera, A. Abdul-Kader, & Woods, J. (2015). Survey on Chatbot Design Techniques in Speech Conversation Systems. *International Journal of Advanced Computer Science and Applications*, 6(7), 72–80. <https://doi.org/10.14569/ijacsa.2015.060712>
- Schaffer, S., Gustke, O., Oldemeier, J., & Reithinger, N. (2018). Towards chatbots in the museum. *CEUR Workshop Proceedings*, 2176, 1–7.
- Schlesinger, A., O'Hara, K. P., & Taylor, A. S. (2018). Let's talk about race: Identity, chatbots, and AI. *Conference on Human Factors in Computing Systems - Proceedings, 2018-April*. <https://doi.org/10.1145/3173574.3173889>
- Stichbury, J. (2017). WTF is a Knowledge graph? in Hackernoon.com: <https://hackernoon.com/wtf-is-a-knowledge-graph-a16603a1a25f>
- Tzouganatou, A. (2018). Can Heritage Bots Thrive? Toward Future Engagement in Cultural Heritage. *Advances in Archaeological Practice*, 6(4), 377–383. <https://doi.org/10.1017/aap.2018.32>

- Valtolina, S., Barricelli, B. R., Gaetano, S. Di, & Diliberto, P. (2018). Chatbots and conversational interfaces: Three domains of use. *CEUR Workshop Proceedings, 2101*, 62–70.
- Vassos, S., Malliaraki, E., Federica dal Falco, Jessica Di Maggio, Massimetti, M., Nocentini, M., Testa, A. (2016). Art-Bots: Toward Chat-Based Conversational Experiences in Museums, in https://link.springer.com/chapter/10.1007/978-3-319-48279-8_43
- W3C.org. (2015). Semantic Web, Retrieved from <https://www.w3.org/standards/semanticweb/>
- Wehle Hans-D. (2017). Machine Learning, Deep Learning and AI: What's the Difference?, Retrieved from https://www.researchgate.net/publication/318900216_Machine_Learning_Deep_Learning_and_AI_What's_the_Difference
- Wit.ai. (2019). Natural Language for Developers, Retrieved from <https://wit.ai/>