INTELLIGENT CONVERSATIONAL AGENT INTEGRATION TO A SOCIAL MEDIA PLATFORM FOR CONTROLLING IOT DEVICES IN SMART AGRICULTURE FACILITIES

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ABSTRACT

The issue of establishing interaction methods among users, applications and systems involved in Smart Agriculture through interfaces which are simple and friendly in end-usage is considered to be essential for achieving the maximum possible penetration of the IoT technologies in this sector, for the benefit of sustainability. Herewith, in this paper an attempt is made to encounter this issue through the involvement of intelligent conversational agents in controlling IoT devices applied to Smart Agriculture facilities, by introducing the idea of developing a chatbot system which is integrated to a messenger application of a popular social media platform in natural language environment. This solution is considered to provide an efficient, effective and user-friendly mean of interaction between the end-users and the IoT devices deployed in agriculture facilities.

Keywords*:* smart agriculture, Internet of Things, intelligent conversational agents, chatbots, natural language processing**.**

1. INTRODUCTION

Sustainability is considered nowadays as one of the most imperative targets to be achieved globally in order to cope with the imminent climate change related challenges. This target leads to the stronger involvement of innovative technologies in agricultural facilities in the context of Smart Agriculture (Lipper et al., 2014), enabling accordingly the active participation of the stakeholders so as to improve productivity by maximizing the efficiency inputs and minimizing their environmental impacts.

The technology of the Internet of Things (IoT), which is continuously evolving and maturing, is considered to be a valuable asset in the development of Smart Agriculture through the extensive use of intelligent remote-controlled production equipment such as Wireless Sensor Networks (WSNs) and mobile embedded systems. The most novel solutions regarding IoT agricultural applications tend to adopt ubiquitous interconnectivity methods along with cost-effective cloud services granted by smart mobile devices (Dlodlo and Kalezhi, 2015). In this context, several applications specially designed to run on smartphones, tablets and other mobile devices have been introduced up to present with the purpose to establish interaction methods among the agricultural IoT objects (physical and artificial) accessing and transacting information via a highly distributed public network such as the Internet. Mobile applications specially addressing to the IoT for Smart Agriculture have been lately presented

(Costopoulou, 2016), offering the opportunity to increase yields through modernized production methods with respect to the environment, contributing in this way to the global sustainable growth. However, the adoption and usage of such innovative technology practices in agriculture facilities is still rather limited and fragmentary since, as several studies indicate, only a rather small proportion of agricultural stakeholders takes advantage of the opportunities offered by the consolidation of the IoT with smart mobile devices. This seems to be due to the fact that resistance to change remains an obstacle in agriculture and familiarity to the Information and Communication Technologies (ICT) features continues to be a challenge in rural areas. Since social networking has been recorded as the second largest traffic volume contributor worldwide, with an average share of over 15% of total mobile data traffic, the integration of agricultural mobile applications to social media messaging platforms could be the key for overcoming the barriers of the IoT technologies penetration in agriculture facilities (Lathiya, 2015).

This work attempts to introduce a user-friendly, efficient and secure framework for controlling IoT agricultural devices in natural language dialogues, through the deployment of an Intelligent Conversational Agent (chatbot) and its integration to an instant messaging application of a popular social media platform. On this ground, the conceptual framework focusing on the features of intelligent conversational agents and the benefits of employing chatbot systems as interfaces for IoT agricultural applications are reviewed in brief. Thereafter the architecture, the operating features as well as an overview of a chatbot system capable of controlling a group of IoT devices through the interaction via instant messaging in a popular social media platform is described. Finally, the conclusions deriving from this attempt are presented and some reference on the ongoing research work is made.

2. Conceptual Framework Overview

Spoken dialogue technology refers to the turn-by-turn interaction between humans and intelligent systems in terms of natural language communication ranging from only a small set of words (such as the digits 0–9 and the words yes/no) to large vocabulary dialogues (Dybkjær et al., 2004). At present, due to the progress in language processing and dialogue modelling, there is a broad variety of systems that deploy spoken dialogue technology methods ranging from simple question-answering models which can answer a single question at a time, to sophisticated dialogue systems, which allow extended conversational interaction between end-users and devices (Braun et al., 2017).

Conversational User Interfaces (CUI) are software dialogue systems which facilitate any average user to interact with any device, anywhere and at any time, without the need of special skills or training, by involving a variety of written or oral natural communication forms in order to simulate actual conversations in the end-users' native languages rather than in specific command-line syntax (Schnelle-Walka et al., 2016). Advanced CUIs support the situated language understanding of any probably ambiguous, insufficient or partial multimodal inputs and the deriving of completely correlated outputs, through the implementation of Artificial Intelligence (AI) techniques, using Natural Language Processing (NLP) and Natural Language Understanding (NLU) programs (McTear et al., 2016).

The recently growing need to enhance the extensive access to web services and online information through intelligent, effective, dynamic, flexible, multimodal and user friendly means of Human-Machine Interaction (HMI), through the integration of Machine Learning (ML) techniques (Schnelle-Walka et al., 2016; Stoyanchev et al. 2016) and natural language understanding functions in various services (such as localized search, dialogue management, remote control, the Internet of Things, etc.), are among the most important reasons for the recent impetus of conversational user interfaces in the form of conversational agents (Ferrara et al., 2016).

Chatbots (also known as Chatterbots or simply as bots) are the most prominent conversational agents of current conversational user interfaces. The term "Chatbot" refers to an interactive software dialogue system which enables real-time communication with the end-users by simulating and reproducing turn-by-turn intelligent conversations in natural language via textual (textbots) or even

auditory methods (voicebots). A chatbox system consists of three main modules (Braun et al., 2017): Request Interpretation, Response Retrieval and Message Generation. In the context of Request Interpretation, a "request" is not necessarily a question, but can also be any user input, while equally a "response" to this input could be any output statement. The Message Generation follows the classical Natural Language Generation (NLG) pipeline (Reiter and Dale, 2000).

Chatbot systems constitute a technological trend which strongly coordinates with the current IoT concept providing a highly effective and user-friendly interface solution (Kar and Haldar, 2016). From this prospect, there are some significant advantages in employing chatbots as an IoT interface rather than conventional applications for different platforms and versions. Some of the reasons why chatbots are such an appropriate interface solution in the field of IoT are as follows:

- Interaction in natural language as they are capable of creating triggered rules for IoT smart devices so as to activate any action requested by the end-user. Natural language processing algorithms using artificial intelligence features are responsible for unpacking the intent and pass any required instructions to the IoT gateway for processing. Moreover, the chatbot system is empowered through artificial intelligence learning techniques.
- De-parameterized environment of interaction as chatbots do not require the systematic input of all parameters in order to complete a request.
- End-users are not obliged to learn the operation of different IoT applications as they can query IoT networks of devices simply by using their native language, without having to know any interface sequence or command structure. Additionally, end-users do not have to separately download applications as these may be centrally and directly accessible through existing chat clients.
- Refining of end-user requests for subsequent interactions and control reducing in this way the problems of information abstraction which present in conventional interface solutions.
- No demand for constant application updates neither for any maintenance of older versions at the back-end of different operating systems versions or mobile platforms.
- End-users of IoT applications are offered a natural, pleasant and simple interaction environment, which operates on any messenger service platform whether this is mobile, in-app or via web chat.

3. METHODOLOGY

For the materialization of the project, data acquired by a Wireless Sensors and Actuators Network (WSAN) (Piromalis and Arvanitis, 2016) deployed in an agriculture facility were used. These raw data were transmitted via a gateway, using the LoRaWAN communication protocol, to a context-aware middleware cloud component where they were centrally processed and managed. The contextual information deriving from the middleware cloud is then made available to end-users through an AI-based chatbot, which is integrated to an instant messaging application of a popular social media platform (as communication user interface), for providing them with context-aware services related to the monitoring as well as the control of the agriculture facility of interest in question–answer sessions conducted in their native languages.

The AI-based chatbot system was chosen to be integrated to the Facebook Messenger application since it encompasses high penetration to end-users (more than 1.3 billion users worldwide) along with several features, among which open official Application Programming Interfaces (APIs) for chatbot development, WebView objects for increased control over the user interface and advanced configuration options, unimpeded file sharing (text, audio, image, video, etc.) as well as analytics and feedback. What is more the Facebook Messenger application employs Natural Language Processing and Machine Learning algorithms which allow the understanding and extraction of information (entities) out of instant messaging dialogues carried out as natural language conversations.

Although Facebook comes up with 'Wit.ai' as its own chatbot development platform, in order to grant flexible further integration of the chatbot to other popular messenger applications which provide official APIs for this purpose (i.e. Twitter, Viber, Slack, Line, Telegram, etc.), the 'Dialogflow' platform offered by Google [https://dialogflow.com] was selected for its development. 'Dialogflow' (formerly known as Api.ai) is an open-source platform which enables the deployment of chatbots through several features similarly to 'Wit.ai' and on top of that it involves an in-line code editor allowing the performance of various tasks straight from the console. The architecture of the proposed solution is presented in Figure 1.

Figure 1. Chatbot System Architecture.

The basic flow of conversation in 'Dialogflow' involves the aspects of: a) the input given by the end-user, b) the given input parsed by the agent and c) the response returned to the end-user by the agent. In this context, for defining the flow of the conversation, intents that map the end-user input to responses were created in the agent, whereas in each one of these intents, examples of user expressions triggering the intent, actions extracted from each expression and the ways of response, were properly defined. Intents consist of four main components allowing the mapping of the end-user's input to responses: a) intent name, b) training phrases, c) actions and parameters (defining the relativity of information in the expressions) and d) responses. 'Dialogflow' performs the matching of user expressions to intents using the training phrases defined and the significant values, words or phrases specified within them. Figure 2 presents an example of how 'Dialogflow' performs a successful matching of a user's expression to an intent.

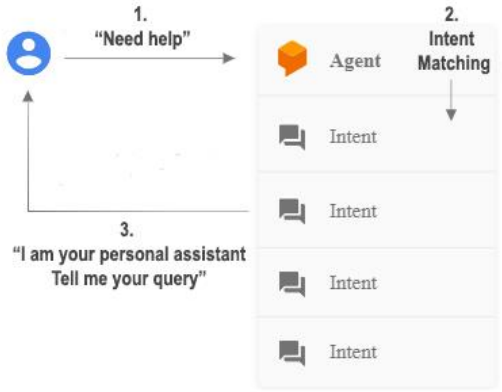

Figure 2. Indicative conversational flow when a successful matching is performed.

Moreover the 'Node.js' platform [https://nodejs.org] was used in addition to the 'Dialogflow', for providing the development of the chatbot with a server-side JavaScript run-time environment so as to create a simple webserver with two webhook (also known as HTTP push API or web callback) endpoints, the first for the initial Facebook verification and the second for being responsible for any other messages from the Facebook Messenger. Finally, in order to integrate this solution into the cloud and ensure its constant execution over the internet, the cloud computing platform services from Microsoft Azure platform [https://azure.microsoft.com] were used for the deployment of the chatbot.

4. Implementation and Results

Based on the methodology previously described, an AI-based chatbot system was developed and integrated to the Facebook Messenger application for monitoring as well as for controlling a WSAN deployed in an agriculture facility. The functionalities developed for the chatbot system, concerning its adaption to different forms of dialogue which achieve the same intents, are introduced below. It has to be noticed that although the dialogues presented in this section are in English, the chatbot system can be easily adapted to several natural languages as it is supported by appropriate NLP and ML algorithms. In Figure 3 some indicative results of the conversations and operations performed in the chatbot system are presented.

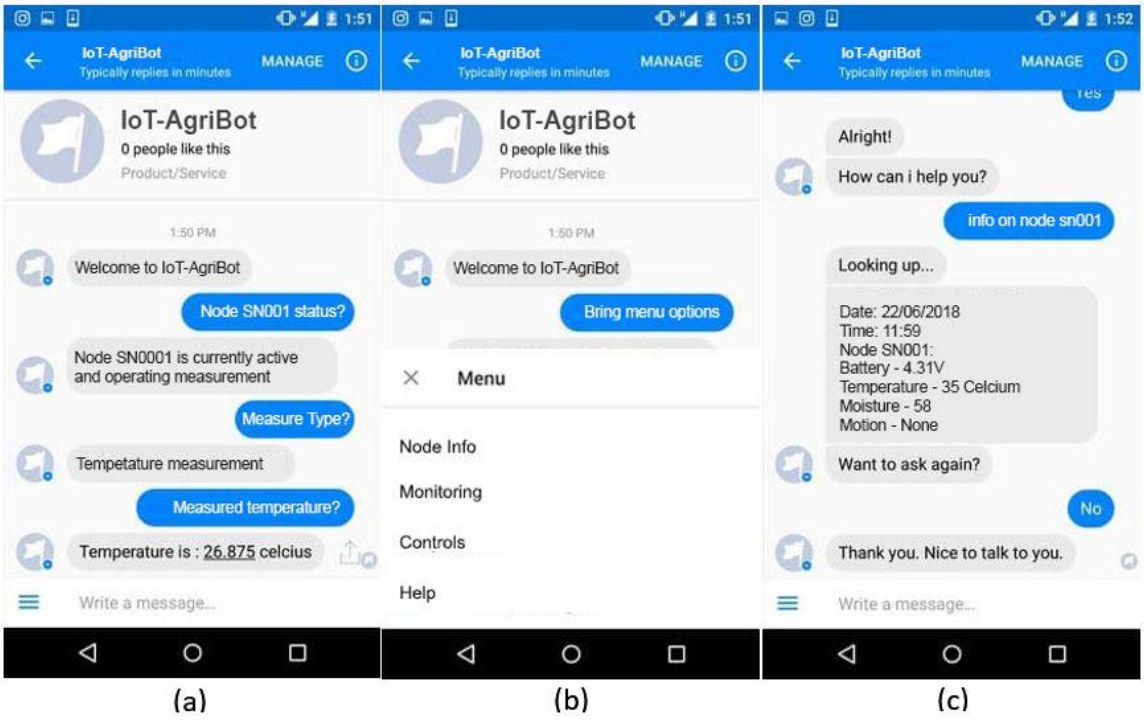

Figure 3. Indicative results of conversations and operations in the chatbot system.

Intent 1: Greeting; a greeting interaction is important in the conversation in order to make the system's usage more accessible and friendly.

Intent 2: Menu; the options menu is offered in order to provide the end-user with a more direct interaction interface with the chatbot and increase its usability.

Intent 3: Help; a help session was developed in the conversation in order to encounter any difficulties of end-users to understand the chatbot functionalities or in case any operation details have to be confirmed. In this context, the chatbot is capable of detecting the users' probable problems or doubts and offer them the help required.

Intent 4: **Monitoring and Control**; this intent concerns the establishment of interaction with the defined entities (IoT devices of the agriculture facility) offering monitoring information about the cultivation and control actions of the equipment.

5. Conclusions and Further Research

The integration of a chatbot system, as an intelligent conversational agent, to the instant messaging application of a popular social media platform is considered to assist the automation of agriculture in a great extent through achieving the maximum possible penetration of the IoT technologies in this sector. Given the observed aspects in this research, it was possible to achieve this objective, presenting a promising solution which provides an efficient, effective and user-friendly mean of interaction

between the end-users and the IoT devices deployed in agriculture facilities, based on the Facebook messenger application and the cognitive services of the 'Dialoglow' platform and 'Node.js' technology. As future work, the chatbot system is planned to be also integrated to other popular social media platforms and tests will be performed in order to obtain results regarding its performance and ascertain its efficient operation.

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