A Cognitive Agent for University Student Support

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***Abstract*—In this paper we present a use-case of cognitive agents in university student support. We have developed a cognitive agent called Beautiful ARtificial Intelligence Cognitive Agent (BARICA) that is based on number of artificial intelligence (AI) techniques and technologies including but not limited to natural language processing (NLP), speech recognition, speech synthesis, motion generation and system automation. The implemented system is based on a AI microservice orchestration platform. The cognitive agent has been situated at the Faculty of Organization and Informatics and is connected to a growing number of services that students can use in their daily interaction with the faculty.**

***Index Terms*—cognitive agent, artificial intelligence, microservice orchestration, student support**

I. Introduction

Cognitive agents are a form of artificially intelligent agents that utilize various AI methods including but not limited to machine learning (ML), NLP, belief-desire-intention (BDI) models, knowledge bases (KBs), system automation, speech to text (STT) and text to speech (TTS) in order to allow interaction and learning from humans [1]. There have been many applications of cognitive agents including industrial applications for example based on Internet of things (IoT) and fog computing [2], home service robots [3], cognitive radio [4], mental health therapy [5] and of course education [6].

The implementation of cognitive agents, especially for direct interaction with humans has always been a challenge. Herein we report on an attempt on implementing a cognitive agent for student university support called BARICA that has been established at the Faculty of Organization and Informatics, University of Zagreb.

The implemented agent is able to provide students with various information about the city, the faculty building, the staff, working hours, schedules and similar using spoken Croatian language. The agent is aimed to be of help especially to first year students to get to know the faculty and its education process as well as to make the job of administrative staff in the student's office easier. Additionally, BARICA, which is an ongoing open source project,[1] has been subject to study and contribution by students and staff of the Artificial Intelligence Laboratory of the faculty.

Whilst there have been reports about particular aspects of BARICA in media and student works (see for example [7, in Croatian]), this is the first report on the actual architecture of the system, the used technologies as well as the implementation of the casing used for situating the agent in a blended Faculty environment.

The rest of this paper is structured as follows: firstly in section II we provide an overview of related work. In section III a detailed description of the BARICA architecture and implementation process is given. Afterwards in section IV we show the various use-cases of BARICA whilst in section V we discuss the implications of its usage and provide possible upgrades. In the end in section VI we draw our conclusions and provide guidelines for future research.

II. Related Work

There have been many attempts of using various AI approaches and particularly chatbots in education systems. Various systems have been built in recent years that take a step forward in how AI enhances the aspects of education. In a systemic review [8] Zawacki-Richter et al. have identified four major application domains: (1) Profiling and prediction (including but not limited to admissions decisions and course scheduling; dropout and retention; student models and academic achievement); (2) Intelligent tutoring systems (including but not limited to teaching course content; diagnosing strengths and automated feedback; curating learning materials; facilitating collaboration; the teacher's perspective etc.); (3) Assessment and evaluation (including but not limited to automated grading; feedback; evaluation of student

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[1]Which is freely available on GitHub here: https://github.com/AILab-FOI/B.A.R.I.C.A.

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understanding, engagement and academic integrity; evaluation of teaching etc.); as well as (4) Adaptive systems and personalisation (including but not limited to teaching course content; recommending personalized content; supporting teachers and learning design; using academic data to monitor and guide students; representation of knowledge in concept maps etc.). The BARICA system falls into the last category using a cognitive chatbot agent interface.

There is a wide area of use-cases and technologies that improve possibilities of education systems for example: (1) Chatbot [9] that can detect questions posed by students and is able to answer them using NLP techniques and domain ontologies, (2) FIT-EBot [10] a chatbot, which can automatically provide replies to student's question about services provided by the education system on the academic staffs' behalf, (3) FAQBot [11] a chatbot that acts as undergraduate student advisor in the information desk, (4) Chatbot system [12] which models conversations related to software engineering education, and many others. Herein, due to space contraints, we would like to focus on two chatbot implementations that have the most similarities to the research at hand: Doly, a Bengali chatbot for Bengali education [13] and Smarty [14], a chatbot developed for usage at Zagrebačka škola ekonomije i managementa (ZŠEM).

Doly is a chatbot that serves as a base to build on top of as it provides fundamentals for Bengali language. The primary purpose of it is to be used within the Bengali education systems. The chatbot focuses on properly processing the given input so that it could be used for generating appropriate output [13]. The main AI methods used for the development of Doly are NLP and ML. The development team behind this project used Python technologies to achieve the goals. That being said, to employ NLP, the team used natural language toolkit (NLTK)[2], the conversation logic is built with ChatterBot[3] as well as input adapters. Going forward, ML is used to search predefined corpus of answers and select the most appropriate one for the response to a user [13]. This approach is fairly similar to the approach we have taken in BARICA using almost the same tools, but for the Croatian language and a different approach in selecting appropriate answers: our algorithm is based on a hybrid AI approch combinig numerous regression ML models and finite state machines.

ZŠEM developed Smarty in collaboration with their partners at IBM, a chatbot that answers on frequently asked questions regarding the study at this school. Smarty is based on the IBM Watson Assistant. Some of the main topics that the chatbot is trained to give answers to are: information about study programs, enrollment documentation, mentoring programs and similar. Smarty has been trained to answer questions in Croatian [14]. BARICA on the other hand is not based on any existing chatbot model and has been developed from scratch.

As opposed to both Doly and Smarty, BARICA has a STT and TTS interface including visualization which makes her enact a virtual avatar and thus is much more user-friendly as well as focused on user experience (UX). Also, BARICA is not only a software system, but has also a physical embodiment in form of a specially designed casing which we shall describe in the following sections.

III. BARICA Architecture

The development of the BARICA system can be broadly divided into two parts: (1) software development and (2) casing / hardware development. The software architecture (as shown on figure 1) consists of a cloud-based back-end and an on-site front-end.

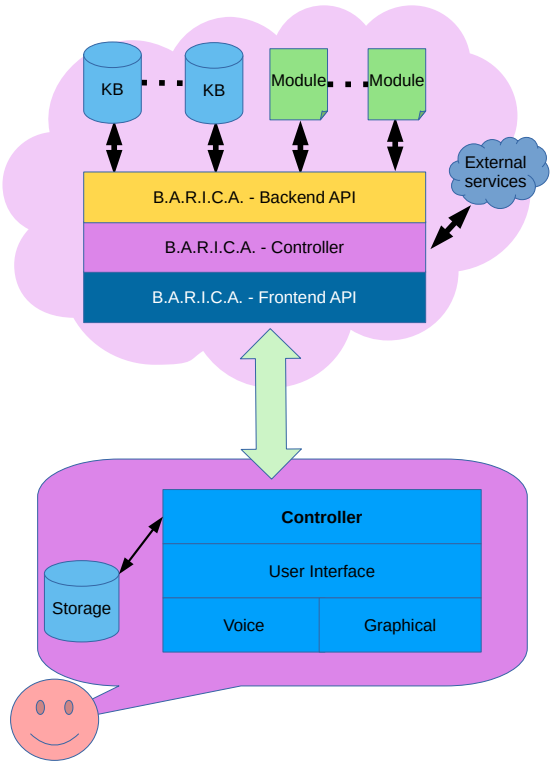

Fig. 1. BARICA software architecture

The cloud-based back-end is part of a larger framework being developed by the O_HAI ④ Games project (Orchestration of Hybrid Artificial Intelligence Methods for Computer Games) described in more detail in [15], [16]. An initial proof-of-concept implementation of the back-end has also been described in [17]. The back-end comprises a microservice orchestration platfrom based on holonic multi agent systems (HMASs) [18] having (1) a back-end application programming interface (API),

[2]Available here: https://www.nltk.org/
[3]Available here: https://chatterbot.readthedocs.io/en/stable/

(2) a controller and (3) a front-end API. The back-end API allows connecting various microservices including but not limited to knowledge and databases, AI related modules and external services. The controller behaves as microservice orchestration system that allows connecting these various microservices into a coherent system. The front-end API allows for the implementation of front-end applications one of which is the BARICA front-end. The cloud based back-end is implemented mostly in Python. For the sake of BARICA we have used the mentioned NLTK and Chatterbot Python modules to implement the chatbots NLP capabilities for the Croatian language using regression models and finite state machines. For the STT part an external service, namely VoiceNotePad[4], has been used. For user interface automation we have used PyAutoGUI[5].

The presentation layer, as shown on figure 2, has been implemented using Hovercraft[6] with some help of jQuery[7], plain JavaScript and Selenium[8] for browser automation. The STT capabilities have initially been implemented using the speech synthesizer eSpeak[9], but have later been prerecorded for better performance and more natural UX. The lip sync animations have been implemented using CrazyTalk.[10]

The casing / hardware development was a typical do it yourself (DIY) upcycling project that used old furniture (a makeup closet), old electronics (old TV set, old analog telephone), new electronics (flat-screen TV set, PC workstation, microphone etc.) to create a casing that is currently situated in front of the student's office at the Faculty of Organization and Informatics.[11] The whole process of creating the casing has been documented in a digital repository.[12]

Figure 3 shows a photograph of the final casing. The system consists of a PC workstation hidden in the makeup closet running Ubuntu Linux, a TV set enclosed into the casing of an old TV set and a microphone hidden in the old telephone's handset which is used for interacting with the system.

IV. Example Use-Cases

The intended user-base of BARICA are local and visiting students, as well as faculty and staff that may be

[4]Available here: https://voicenotebook.com/
[5]Available here: https://pyautogui.readthedocs.io/
[6]Available here: https://hovercraft.readthedocs.io/
[7]Available here: https://jquery.com/
[8]Available here: https://www.selenium.dev/
[9]Available here: http://espeak.sourceforge.net/
[10]Available here: https://www.reallusion.com/crazytalk/
[11]One should mention that there is a good reason why BARICA is developed the way it is. The Faculty of Organization and Infomatics, a modern and state-of-the-art technology oriented research and higher-education institution is situated in the Jesuit and Pauline monastery in Varaždin from 17th century. Similarly BARICA a modern cognitive agent is situated in an old retro-style casing.
[12]Available here: https://www.dropbox.com/sh/gjmwnf7w3m5dna6/AABM2AZCqN6GxRgXuV9pfXOka?dl=0

Fig. 2. BARICA presentation layer

Fig. 3. BARICA casing as situated at the Faculty of Organization and Informatics

visiting, or any occasional visitors. This is based on the possible communication flows that are implemented at the present moment, although the possible set of interaction and communication instances can be expanded, and is envisioned to.

According to an insight gained through a series of unstructured interviews with the staff, the faculty, and the students (both local students and incoming exchange students), the most sought-after information resided in the area of lecture hall and laboratory locations, locations of the faculty members' offices, and working hours of members of the faculty. The use-cases described hereafter are based on these scenarios. It should be noted that all the conversation is conducted using spoken Croatian language, both on the side of BARICA, and on the side of the (student) client.

The use-cases described in the following subsections feature a high-level description. The back-end that provides the described functionalities operates in a similar manner for all the three described cases. Before receiving any real spoken commands, BARICA must be initiated, i.e. her listening mode must be started. This is performed by simply voicing her name. Any sound BARICA receives is converted to text, and that resulting

string is used in further processing of the input.

Having received the textual version of input through VoiceNotePad, the underlying agent performs a query on their data sources, searching for the input data, i.e. determining whether the input data should be recognised as a specific command, or ignored. If the input data can be found in the database of trained input-output pairs, the accompanying function is retrieved and performed. Based on the results of the performed action, data is either delivered to the user using a pre-rendered animation with audio, or is shown on the screen.

A. Locating a Room

Locating lecture halls and laboratories in the two buildings of the Faculty of Organization and Informatics is no trivial task, especially for the freshmen and people who are not very well acquainted with the layout of the buildings, due to a seemingly confusing numbering of the relevant rooms.

A freshmen, having visited the main building for only a couple of times, may be confused when, for example, late for their lecture. Therefore, they use BARICA located near the main entrance, pick up the phone, and ask her to tell them about the rooms, and where the wanted room is, in simple standard Croatian, for example: "Barice, zanimaju me dvorane." BARICA recognises their intention, and asks them to provide further information, i.e. to tell her the number of the room they want to know more about. In Croatian, the students simply states the number of the lecture hall, e.g. "Dvorana 9." BARICA searches her data sources and delivers the relevant wanted information.

B. Office Hours of the Faculty

More often than not, students need to have a word with members of the faculty, for various reasons. Even more often, it is true that those members of the faculty do not have inexhaustible amounts of free time, and have specified office hours when they are available to talk to students. With this information available online, a student can walk up to BARICA, and ask her to give them information about a specific member of the faculty. In such a case, BARICA opens a browser window, and displays the web page featuring the available, and wanted, information about the specific member of the faculty.

The interaction is, again, simple and concise. First, BARICA is guided by telling her that the person is interested in members of the faculty, in Croatian, for example "Želim informacije o profesorima." BARICA replies with a question demanding more information, i.e. the name of the specific member of the faculty that the person is interested in. Upon receiving the name, the information is delivered in the manner stated above, focusing on the office hours or the location of the office, as per the original request.

C. Information About the Schedule

The longest currently implemented communication flow is tasked with retrieving a student group's schedule. The complexity of this particular use-case is founded in the fact that there are several study programmes being taught at the Faculty of Organization and Informatics, with several orientations each. Each of these study programme orientations features differences in their schedules. Furthermore, students of bachelor-level programmes are usually divide in several study groups, and each group's schedule is slightly different from the others.

Retrieving a specific schedule is, therefore, a modelled decision tree. BARICA guides her users through the necessary decisions using her spoken replies. A member of the staff, or any other end-user, can engage in a conversation with BARICA and ask her to provide them with information on schedules, in Croatian for example "Koji je moj raspored." BARICA guides them through the information necessary for her to provide the initially requested information, i.e. the schedule of a specific study group of a specific study programme's orientation.

V. Discussion

BARICA is an on-going project that is being developed by members of the AILab and interested students. Having the basic functionalities and adequate APIs in place, it can be extended at will. Thus, there is always room for improvement. BARICA could be extended in different directions and also targeting different audiences. For example, we could also be looking into extending it to produce video materials (either in educational purposes or for motivation). Perhaps, it might be beneficial for some audiences if it could print out an asset like a confirmation or certificate.

Personalizing content based on who BARICA speaks to may also be of high impact. This would need an implementation of an authentication system, like for example, face recognition. Currently, the main targeting audience doesn't go too much outside the scope of institutional personnel, as in, students and teachers, and thus also a simpler authentication systems like voice recognition or 2-factor authentication could be used.

The chatbot has priorly been taught conversations and vocabulary through NLP. However, it is no longer involved in the active learning, therefore, it may end up in situations where it doesn't have proper understanding of what user asks it. It would make sense to involve BARICA in active learning utilizing reinforcement learning strategies. Obviously, it might be challenging to define rewards and penalties for its (in)correct answers. We are currently collecting extensive log data on the usage of the system with hope to use it for such purposes. Extending BARICA to speak different languages may also have a lot of value, especially since more and more

students from outside Croatia decide to study at the faculty.

Another direction of improvement may as well be scaling access of BARICA. The architecture is already put in cloud meaning it has great fundamentals to build upon that to serve many users at the same time. That would mean it could be previewed through any source that provides the required input and output - we would be speaking of mobile phones, tablets, Agumented reality (AR)/Virtual reality (VR) etc.

Being given the overview of potential improvement directions, we can now speak more about concrete use-cases how to make BARICA even more useful.

By bringing awareness to BARICA in terms of knowing who it speaks to, BARICA may be able to execute tasks for a specific user. From a student's stance, that could be checking its schedule, printing documentation and so on. Looking from a teacher's perspective, that could be executing some of the predefined processes, for example, grading, scheduling exams etc.

VI. Conclusion and Future Work

In this paper we have provided an overview of the BARICA system which is a cognitive agent for university student support. Whilst there have been many implementations of various AI related methods for student and education support, BARICA is the first from scratch developed cognitive system using the Croatian language in this context that has a voice interface, as opposed to other similar systems usually featuring textual interfaces. We have described its architecture and implementation for both the software and hardware components and provided a number of currently implemented use-cases. Since BARICA is open-source there are many possibilities for improvement and a number of future use-cases as outlined in section V.

Our future work on BARICA will thus be aimed at implementing additional functionality including but not limited to: (1) better integration with existing faculty services, (2) an authentication system for students and staff, (3) self-optimizing and learning facilities, (4) other interfaces like web and/or mobile services.

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