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A Cognitive Agent's Infrastructure for Smart Mobility

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Abstract

Cognitive agents are artificial intelligence systems that are able to communicate in a way that is as much as possible acceptable to humans. Technologies like natural language processing (NLP), text to speech (TTS), speech to text (STT) and motion capture (MoCap) are usually applied to provide such an interface. In this work-in-progess paper we present the current state of the Beautiful ARtificial Intelligence Cognitive Agent (B.A.R.I.C.A.) infrastructure that we have developed. This infrastructure allows for the implementation of open source cognitive agents in a wide spectrum of domains that are able to communicate using the Croatian language. The aim of this study is to analyze possible applications of B.A.R.I.C.A. to smart mobility in order to highlight possible gaps to be overcome, applications that are possible as well as provide guidelines for implementation.

Keywords: cognitive agent; smart mobility; agent infrastructure; implementation guidelines

1. Introduction

A cognitive agent is a specific class of intelligent agents employing numerous artificial intelligence (AI) methods including, but not limited to, machine learning (ML) and deep learning (DL) models, speech to text (STT) and text to speech (TTS) technologies, natural language processing (NLP), knowledge bases (KBs), belief-desire-intention (BDI) models as well as system automation for the sake of interaction with and learning from humans Lee (2010). Cognitive agents have gained major popularity through various systems by major software development vendors like Google (*Assistant*), Microsoft (*Cortana*), Apple (*Siri*) and Amazon (*Alexa*) and their application domains include Internet of things (IoT) and fog computing Foukalas (2020), education Baylor (1999), home service robots Van Dang et al. (2017), mental health therapy Suganuma et al. (2018), cognitive radio Mitola (2002) and many more.

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Smart mobility which represents a network of intelligent services, systems, processes, models and people with the objective to make transportation easier is a combination of different technologies and elements of mobility, which allows us to rethink the transportation infrastructure used in daily life and business.

Herein, we will present the current state of the Beautiful ARtificial Intelligence Cognitive Agent (B.A.R.I.C.A.) cognitive agent infrastructure that we are actively implementing Schatten et al. (2021) and show how it can be used to implement smart mobility applications. In addition to the aforementioned, this study will use the Design Science Research Methodology (DSRM), which is used in information technologies and offers specific guidelines for evaluation and iteration within research projects Peffers et al. (2020). The paper at hand focuses on the first three activities of the design science research process, namely: (1) Problem identification and motivation (a selection of application areas of cognitive agents to smart mobility are provided), (2) Objectives of a solution (problems that can be solved using our infrastructure are described), and partly (3) Design and development (implementation steps needed to accomplish a solution are outlined).

The rest of this paper is organized as follows: firstly in section 2 we provide an overview of the B.A.R.I.C.A. infrastructure and its implementation. Afterwards in section 3 we describe and provide guidelines for smart mobility applications using this infrastructure. In the end we discuss our findings and draw our conclusions in section 4.

2. B.A.R.I.C.A. Infrastructure

The main motivation behind the B.A.R.I.C.A. system was to provide an open source cognitive infrastructure for the development of cognitive agents using the Croatian language. Insofar we were able to implement the basic infrastructure as well as two use-cases (one as an presentation assistant agent and a second for university student support Schatten et al. (2021); Šokec (2019)). The B.A.R.I.C.A. cognitive agent system's software architecture is shown on Fig. 1. The two primary components it consists of are a cloud-based back-end and an on-site front-end.

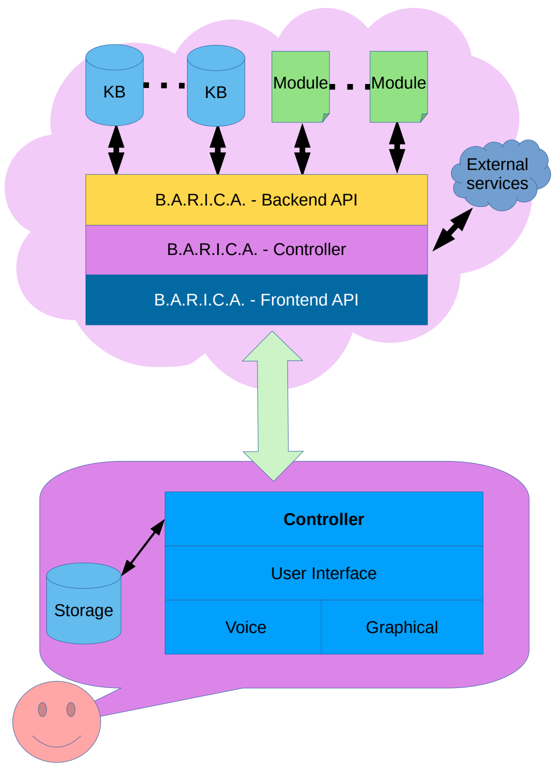

Fig. 1. B.A.R.I.C.A. software architecture Schatten et al. (2021)

The cloud-based back-end has been a part of a larger framework that encompasses a microservice orchestration platform that embodies concepts of holonic multi agent systems (HMASs) Rodriguez et al. (2011) and large-scale multiagent systems (LSMASs) Schatten et al. (2017, 2016) through its main components: a back-end application programming interface (API), a controller, and a front-end API. This framework is being developed by the Orchestration of Hybrid Artificial Intelligence Methods for Computer Games - project O_HAI ④ Games Schatten et al. (2020a,b). Each component has a particular purpose:

1. The back-end API is to provide access to various microservices, including but not limited to, KBs, AI and other modules, as well as external services. That being said, the back-end API can be considered as the main source of intelligent actions that the overall system is capable of.
2. The controler, which is a middle layer, serves as a microservice orchestration system with the goal of combining various back-end microservices with front-end API functions to provide a a coherent system.
3. The front-end API which provides front-end applications with easy to use functionality and abstracts away all logic related to microservice orchestration.

Technologies used to build the cloud based back-end are primarily based on various Python-related technologies. The cognitive features of B.A.R.I.C.A. are implemented by using NLTK and Chatterbot Python modules as they provide chatbot and NLP capabilities. In order to transform text into speech, the external service named VoiceNotePad has been utilized.

The main front-end application is web based and relies on JavaScript technologies such as jQuery, and Selenium for browser automation. The Python library Hovercraft has been used to provide the graphical user interface (GUI). In order to support motion capture (MoCap) animations for speech sequences, CrazyTalk has been used. B.A.R.I.C.A. is open source and available for free use to anyone who wants to implement cognitive agents.

3. Possible Applications to Smart Mobility

There have been numerous applications of smart mobility in both industry and academia. Herein we provide a short selection of applications which might benefit from cognitive agents based on a literature review Faria et al. (2017); Viechnicki et al. (2015); IZIX (2021). The applications have been selected based on two criteria: (1) simplicity of implementation using the B.A.R.I.C.A. infrastructure and (2) potential benefits for end-users if such a services is implemented. The list is not extensive, and there might be other application areas that could benefit from cognitive agents.

Additionally, we provide guidelines on how such services might be implemented using the B.A.R.I.C.A. infrastructure with focus on components that are possibly missing and need to be integrated or developed from scratch. Fig. 2 provides a conceptual overview of the various components that have to be employed.

Electronic toll systems are systems that allow for automation of toll payments usually using an embedded computing system connected to various traffic equipment like ramps or card recognition systems. Cognitive agents can provide a natural language interface, automated detection of vehicle types and/or passengers, automated payment etc. In order to use the B.A.R.I.C.A. infrastructure in electronic toll systems, as well as in any other embedded hardware, depending on the type of embedded software and operation system used a new embedded interface might have to be developed. In case an advanced micro-controller like the RaspberryPi which runs a whole Linux operating system is used, the standard interface can be used since it only depends on standard operating system's software. In any other case, where for example no browser is available, a new interface controller has to be developed and likely a new user interface. Additionally, a new module for electronic toll systems has to be developed and connected to the back-end API to allow the cognitive agent to understand the domain and allow usage. Other services including for example a payment system can either be developed as part of the electronic toll system or as an additional module. From a hardware perspective a microphone and a loudspeaker have to be added to the installation if none is available.

Variable information panels can be extended with cognitive agents to provide a natural language interface and two-way communication. In order to use the B.A.R.I.C.A. infrastructure in variable information panels, under the

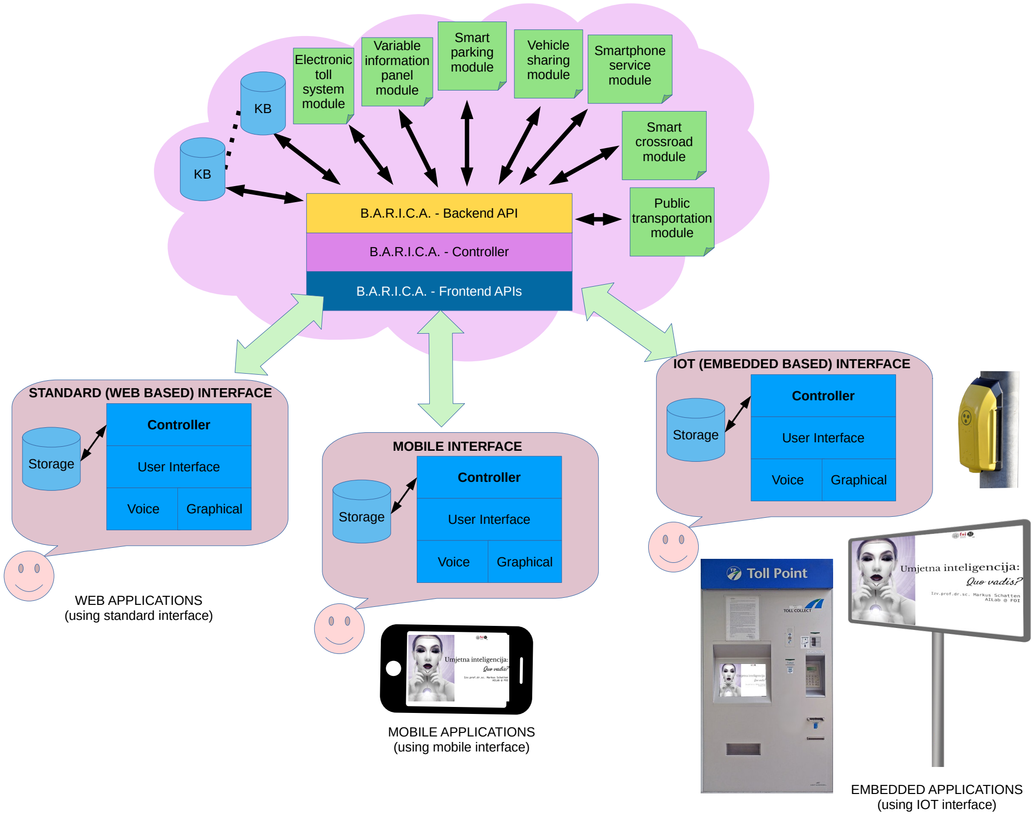

Fig. 2. B.A.R.I.C.A. software architecture for Smart Mobility

presumption that a PC computer or more advanced micro-controller is driving the panel, no changes have to be made to the client. An additional module for the given information domain of the panel has to be implemented and connected to the back-end API. If no microphone and not loudspeakers are available on the information panel, they have to be installed in order to provide two-sided communication facilities. Since variable information panels are primarily designed to provide visual information, by the introduction of a cognitive agent, the panels would also provide information via audio with possibility of answering individuals' questions. Thus, expanding on pool of information that may be provided through the panel.

Smart crossroads In order to use the B.A.R.I.C.A. infrastructure in smart crossroads, a new embedded interface may have to be developed depending on a type of device that crossroad wish to be covered with. Smart crossroads module would have to be developed and implemented into the back-end API to cover features for the said domain. Depending on a use-case, there may be need of various sensors to track events at a crossroad, which the module would have to account for. That being said, a cognitive agent may be set up to help people with sight disabilities by informing them when they may cross the road.

Smart parking lots In order to use the B.A.R.I.C.A. infrastructure in smart parking lots, they should be equipped with sensors to keep track of available spots, and a module that has access to that information. That being said, the cognitive agent could be valuable in navigating an individual to an empty parking slot, but also to help them pay for a ticket. These modules would then be integrated with the the back-end API in order for parking lot availability information to be accessed by a cognitive agent. That implies that a parking lot would also need to have a device present that an individual may interact with. Depending on a type of a devices available, the client may or may not have to change.

Vehicle sharing In order to use the B.A.R.I.C.A. infrastructure in vehicle sharing, a vehicle should have a smart-device built in. Most of new vehicles already do have such device, however, their software is usually not to flexible for adding additional applications. Hence a new client may have to be developed in order to work with the available software. Where we see opportunity for cognitive agent to enhance vehicle sharing experience is by assisting multiple individuals who share the vehicle to specify destinations, answer any questions about arrival times, help them with payments, etc. To support two-sided communication, a microphone should also be included if none is present sine most newer vehicles already have them. For this use-case, a separate module needs to be developed and implemented with the back-end API which would provide support for vehicle sharing features such as navigation, payments handling, etc.

Public transport In order to use the B.A.R.I.C.A. infrastructure in public transport, under the presumption that there are smart-devices (monitors or TVs) present in it, there should be no changes required on the client side, since such smart-devices already have support for Internet browsers. However, additional modules for the transport domain would have to be integrated into the back-end API to support these use-cases. In public transport, a cognitive agent may serve the use of helping users with purchasing and verifying their tickets, providing information about possible routes, checking arrival time to the destination and similar use-cases that may potentially combine information from different transports.

4. Conclusion & Future Research

In this paper we have given an overview of the B.A.R.I.C.A. cognitive agent infrastructure which is an open source platform for developing cognitive agents in the Croatian language. We are actively developing this infrastructure as part of the O_HAI ④ Games project and a larger context dealing with smart microservice orchestration.

As part of a design science research methodology process, we have developed a conceptual overview model of various components that can be employed to implement smart mobility applications using B.A.R.I.C.A. as well as a number of possible use-cases of this infrastructure and cognitive agents in general with focus on benefits for end-users. Additionally, we have provided guidelines on how such applications could be implemented by using our infrastructure.

Whilst B.A.R.I.C.A. is open source and free to use, it still includes a number of constraints for its usage in smart mobility applications, mainly concerned with the current client interface which heavily relies on a certain operating system (Linux) and browser automation (Chromium, Selenium). Thus, in order to take full advantage of the infrastructure new client interfaces have to be developed that are either platform specific or even better platform independent and, thus, available on most platforms.

Our future research is aimed towards building such interfaces especially with the goal of making them platform independent in order to reach as many as possible end-user platforms. A possibility which we are considering is to use web assembly or pure JavaScript to embed the main functionality of the client interface into any browser allowing usage on any device that can start a modern Internet browser.

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- https://en.m.wikipedia.org/wiki/File:Smartphone_icon_-_Noun_Project_283536.svg
- https://commons.wikimedia.org/wiki/File:Toll_Collect_Automat.jpg

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