An Open-Source Socially Assistive Robot for Multisensory Healthcare Therapies

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Socially Assistive Robots (SARs) are a class of robots that are at an intersection between the class of assistive robots and that of interactive social robots. Besides providing some kind of assistance, SARs can provide user stimuli through interaction with the robot. SARs have been explored to assist in different healthcare therapies. This work is based on an open-source SAR called EVA. We have extended EVA's capabilities for multimodal interaction and integration with light sensory effects. This paper presents our current research and future steps to use EVA for healthcare therapies.

CCS Concepts: • **Computer systems organization → Robotics**; • **Software and its engineering → Simulator / interpreter**; • **Information systems → Multimedia content creation**; • **Applied computing → Health informatics**; • **Human-centered computing → Sound-based input / output**.

Additional Key Words and Phrases: Socially Assistive Robots, Healthcare Therapies, Multisensory Experiences

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1 INTRODUCTION

Assistive robots are expected to transform our everyday lives and to be widely used in healthcare therapies [16]. Socially Assistive Robots (SARs) are a class of robots that are at an intersection between the class of assistive robots and that of interactive social robots [6, 15]. The purpose of SARs is not just to provide some kind of assistance, but to provide stimuli through interaction with the robot. SARs have been explored to assist in the diagnosis and treatment of children with ASD (Autism Spectrum Disorder) [12] for example. However, comercial robots are usually very expensive and not always available to people and institutions in developing countries.

This work is based on an open-source SAR called EVA. As it is open-source, we can assembly robot parts and use it for research and development more easily. EVA was originally developed by CICESE (Centro de Investigación Científica y de Educación Superior de Ensenada), Baja California, in Mexico, and it has been used in therapies with patients with dementia and Alzheimer's disease [3]. We have extended EVA's capabilities for multimodal interaction and integration with light sensory effects [11], towards offering more immersive therapy sessions. This paper presents our current research and future steps to use EVA for healthcare therapies, introducing EvaSIM, a simulator for the EVA robot.

The remainder of the text is structured as follows. Section 2 describes the robot hardware and software components. Section 3 presents EvaSIM, a software simulator for EVA. Section 4 presents how EVA has been used for healthcare therapies. Finally, Section 5 concludes with final remarks and future work.

2 EVA ROBOT

EVA (Embodied Virtual Assistant) is an open-source robotics platform that was created to assist in the development of research in the area of HRI (Human-Robot Interaction). Its creators provided a repository[1] with all the information necessary for the robot to be replicated and used. EVA, in its basic version, has verbal and non-verbal communication skills. It is capable of recognizing human voice and is able to speak; expressing emotions through the eyes; moving its head; running animations with the LEDs on its chest.

Figure 1 shows the image of the EVA robot with its entire body structure printed in 3D and its hardware components. The robot uses a Raspberry PI 4[2] board that runs the Raspbian operating system. Attached to it is a Matrix Voice[3] board, which has seven microphones and a LED ring. EVA implements a set of animations using these LEDs as a form of non-verbal communication. The robot also has an ArbotiX-M board that controls two servomotors that are responsible for moving its head. EVA uses a display to render its gaze expressions and a bluetooth speaker to play all sorts of sounds, such as music, sound effects and the robot's speech audio. These mentioned hardware components are part of the basic version of the EVA robot. An enhanced version of the robot [11] has a smart bulb and a webcam that is used for user facial expression recognition.

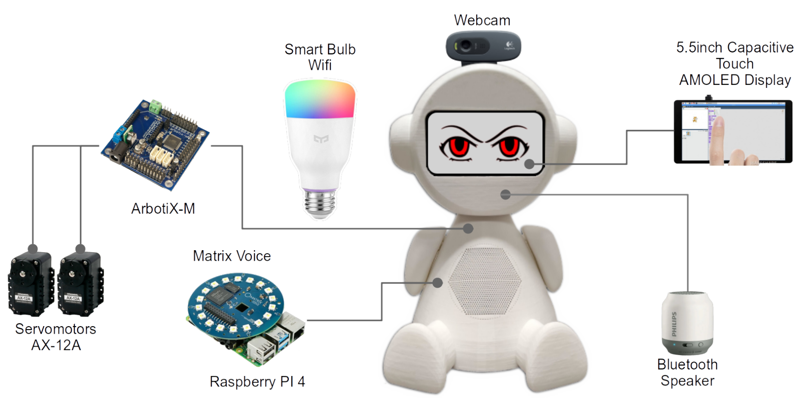

Fig. 1. Eva - Hardware Components

The robot software architecture can be seen in Figure 2. It was built using the *MEAN* stack, which is composed by *MongoDB*, *Express*, *AngularJS* and *NodeJS*. The architecture also uses the IBM Watson external services for TTS (Text-To-Speech) services and uses the Google Cloud Speech API for STT (Speech-To-Text) services. To develop an interactive session, the user accesses a web application. The application *frontend* sends requests to the *backend* using HTTP protocol methods. The application uses TCP/IP to communicate with the database, making it possible to save, load or delete the interactions already created, also accessing the robot file system to process audio files. The commands to the robot are sent through two communication interfaces: a serial port, which is used to communicate with the board responsible for controlling the servomotors, and *Websockets*, for controlling EVA's eyes.

[1]https://github.com/eva-social-robot
[2]https://www.raspberrypi.org
[3]https://store.matrix.one

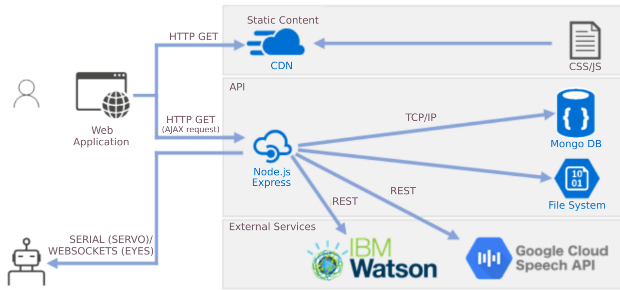

Fig. 2. EVA - Main Software Components [9]

The web application provides a VPL (Visual Programming Language) to developers, which allows the rapid development of interaction scripts using only simple drag and drop elements, without worrying about syntactic details of a traditional programming language.

To provide multimodal and multisensory capabilities for EVA, two new components were added as first-class elements to the VPL. The first component gave the robot the ability to control light sensory effects. This new feature can make sessions more attractive and immersive, especially for children. The robot can connect to a smart bulb via a wireless network, controlling its state, on or off, and determining its color. The second component gave the robot the ability to recognize facial expressions using a webcam. Facial recognition capability was added to the robot through the use of an external Python module. The recognition process starts with the execution of the *userEmotion* component, which communicates with the Python module. The module activates the webcam and makes a series of captures of the user's facial expression, processing these images and returning one of the seven expressions: "neutral", "angry", "disgust", "fear", "surprise", "happy" and "sad". After processing, the module returns the inferred expression. In [11], tests were carried out to assess the accuracy of the facial expression module to recognize the user's emotion when "HAPPY", "ANGRY" and "SAD". These three types of facial expressions were chosen because they are the ones that can currently be expressed by EVA and were used in the therapy session that was implemented. A program with EVA was implemented to recognize 30 facial expressions and two users have tested this program with 5 expressions of each type "HAPPY", "ANGRY" and "SAD". Therefore, considering 30 facial expression recognition events, EVA correctly recognized 24, obtaining an accuracy of 80%.

3 EVASIM

Although the EVA robot is an open-source and low-cost platform, it is not always practical to have a physical robot, particularly during the iterative design of therapies. It is very difficult to test a therapy session if you do not have the robot assembled with all its components and this also makes it difficult to train people, teaching them how to program an interactive session using VPL. In order to assist in the development/testing of scripts developed using VPL, we are currently working on a simulator called EvaSIM.

EvaSIM is also open-source tool, cross-platform, easy to install and use. Figure 3 presents its graphical user interface divided into four regions. The first region contains the graphic elements that simulate the robot parts, such as: display, LED ring, smart bulb, and webcam. Region 2 contains the buttons to control a script simulation. A terminal emulator is represented in the third region and it shows which commands are being executed and also some error messages that may occur during the script execution. Region 4 contains two tables that present the contents of the variables stored in the memory of the robot.

An interaction script developed for the robot using VPL is stored in a file using JSON (JavaScript Object Notation) format. EvaSIM can import this file and run it, simulating the operation of the physical robot. The simulator can show the robot's gaze expressions, it can represent the animations with the LEDs on the EVA's chest, it can transform text into audio using IBM Watson (TTS) service, it works with variables and can process logical and arithmetic expressions used in the script, it can represent the state and colors of the smart bulb and can, using additional windows not shown in Figure 3, simulate the physical robot's listening and facial expression recognition capabilities.

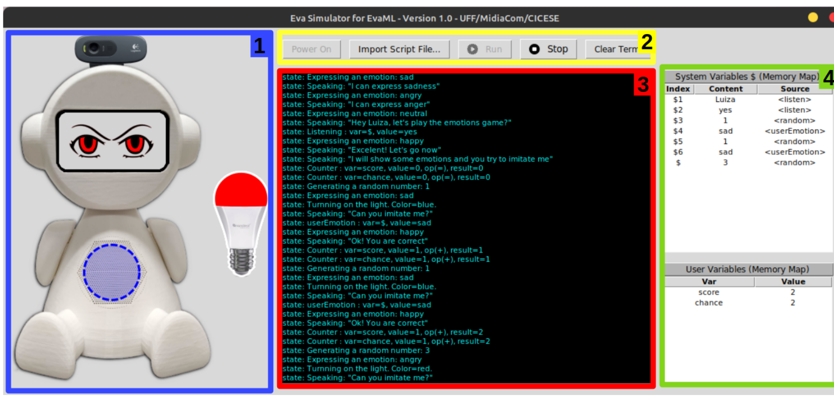

Fig. 3. EvaSIM - User Interface

4 HEALTHCARE APPLICATIONS

Several studies [7, 14] show that the use of SAR technologies can enrich healthcare interventions, facilitate communication between therapists and patients and support data collection and assessment in the diagnosis of patients. EVA has been proposed as a tool for healthcare therapies for elderly and also for children.

The increase in the prevalence of people with dementia, associated with the greater demand for health services, represents a challenge for society. The use of innovative technologies, such as robotics, may be one of the solutions for this situation. The SAR project is a multidisciplinary field that needs to incorporate the diverse needs of people with dementia and their caregivers [10]. The EVA robot has been used to assist non-pharmacological interventions based on verbal communication and social interaction [2], [5], [4].

SARs have also been explored to aid in the diagnosis and treatment of children with ASD (Autism Spectrum Disorder) [1], [13], [8] . In order to offer immersive therapies for autistic children, in a previous work [11], we have developed a serious game to evaluate the use of the robot in therapies for patients with ASD. The work was evaluated by 44 health professionals and showed positive results in the use of light sensory effects and facial recognition capability for emotion regulation therapies for ASD children.

5 FINAL REMARKS

This paper presented our current work with the EVA robot, an open-source socially assistive robot that can assist in healthcare therapies for elderly and children.

As future work, we intend to run usability tests of EvaSIM with developers to refine the simulator. We also intend to evaluate the use of EVA with ASD children as a tool for helping emotion regulation. We are currently working on an XML-based format to specify multisensory therapies for EVA, as an alternative for VPL. Our intention is to provide a high-level format that facilitates the specification of EVA scripts so that therapists could use it to adapt existing therapy sessions or create new ones for their own patients.

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