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# Embodied Conversational Agent-based Control Interfaces for Home Automation System

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**Abstract:** Embodied conversational agents can be categorized as virtual assistants which provide quick easy access to the required information and also provide help and service in carrying out complex tasks. Owing to their high computational requirements, they are mostly implemented using desktop computers. However, with growing technology and advancements in handheld devices in the software and hardware fields in recent past, use of ECAs has progressed and taken over the mobile environment. In this paper, the platform described is an open-source platform which provides for the development of ECA- based interfaces for Android-equipped devices. To support this development process, a prototype of a home automation system installed on an Android tablet to control a home automation system has been illustrated.

***Keywords:*** *Embodied Conversational agents, Hand-held devices, Android, Open-source platform, Home Automation System*

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## I. INTRODUCTION

Embodied Conversational Agents are animated virtual characters which approximate human nature and behaviour. They act as a companion for humans in a computer-based environment. In early stages, ECAs were fully implemented only on desktop computers. However, hand-held devices support much less computational requirements in comparison to desktop computers. As a result, ECAs made an advancement into the mobile environment. In the development of ECAs, the most common architectures of the ECA-based android applications are handled by an external server. This server performs all the intensive processing tasks such as speech recognition, language understanding and conversion of text to speech. In this paper, we describe the platform used for development of ECA-based interfaces for android-equipped hand-held devices. The platform supports open-source free libraries. The functionality of this interface has been illustrated through a prototype developed to control a home automation system. The technique used in this development is the build-out of wireless smart systems capable of immaculate monitoring and controlling localized devices or devices networked with a smart-phone. This is achieved through a secure two-way communication between the smart-phone and other connected devices.

The current existing system known as “Smart-Grid” is an integrated system characterized by the capability to increase flexibility and efficiency of an electric network by establishing two-way flow of electricity and information. In this system, the clients customize their energy consumptions in accordance with the price an environmental concerns. As a result, the load burden on the system is reduced thus providing service in lieu with high customer demand without employing any expensive infrastructure. Furthermore, integration of renewable energy sources also reduces our dependence on fossil fuels and greenhouse gases thus increasing power diversity. The pitfalls of this system are that long distance information cannot be transmitted across wide area networks because these kind of transmissions are limited from phone-to-phone or phone-to-computer for pure transmissions to be achieved. As a result, human-device interfaces such as home automations systems and car-driven interfaces are limited to local-area and personal-area networks. In contrast to this, our proposed system designs mobile-based monitoring and control of devices applicable in fixed and moving LAN scenarios such as vehicle electronics.

The paper is organized in the following sections. Section II explains the system architecture and the various modules deployed into the development of the ECA-based interfaces for Android-equipped devices. Section III gives a brief of other related work in this field which have added advancements to current technologies. Section IV specifies the hardware and software requirements for the implementation of this system.

## II. SYSTEM ARCHITECTURE

The proposed system includes 6 different modules. This includes the Voice Activity Detector, Automatic Speech Recognition, Virtual Head Animation, Conversational Engine, Control Interface and Text to Speech conversion. Each of these modules add their own functionalities to improve the system efficiency. The diagram below represents the system architecture:

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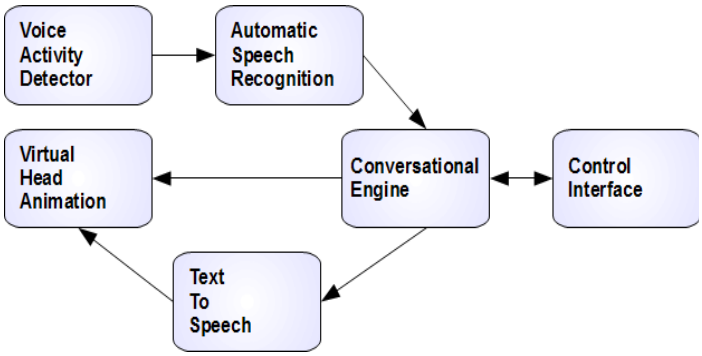


## III. RELATED WORK

Some of the previously published work in association with the title of the paper has been elucidated below:

1. **Efficient Query Processing in Geographic Web Search Engines:** In this paper, the problem of efficient query processing in geographic search engines is studied. Geographic search engine query processing uses a combination of text and spatial data processing techniques. Several algorithms are used for efficient query processing in geographic search engines. These algorithms are then integrated with existing web search query processors and evaluated with large sets of real data.
2. **Mining User Preference Using Spy Voting for Search Engine Personalization:** This paper throws light on search engine personalization. User preferences are mined from search results through a new approach called Spy NB where the assumption is made that the search results already clicked by the user indicate failure to meet his preferences. However, no conclusions are drawn from the search results left unaccessed by the user. The discovered results are then used to improve search quality of the search engine.
3. **Applying Co-training to Click through Data for Search Engine Adaptation:** This paper involves the study of a new algorithm-Ranking SVM in a Co-training Framework(RSCF).This algorithm takes the data items of the search results clicked by the users as input. These data items are then analyzed and mapped into labelled and unlabelled data sets. These two data sets are then augmented together to produce a larger data set used for training the rankers. This algorithm generates a list of the adaptive rankers as output.
4. **Privacy-Enhancing Personalized Web Search:** This paper illustrates a study on ascendible ways allowing users to build rich profiles. These profiles represent a summary of the user's interests and categorize them into different hierarchical organizations based on specific interests. The user is provided with two parameters to help specify the privacy requirements. This helps user to choose the content and degree of details from their profile which can be exposed to the search engines.
5. **Personalized Concept-Based Clustering of Search Engine Queries:** This paper introduces an effective approach to capture user preferences so as to provide personalized query suggestions. This is implemented through two strategies .The first strategy involves development of online techniques for extraction of concepts from web snippets of search results returned by the query. These concepts are then used identify other similar queries. The second strategy involves initiation of a 2-phase personalized agglomerative clustering algorithm with the ability to develop personalized query clusters.
6. **Personalized Web Search with Location Preferences:** This paper presents a new web-search personalization approach which involves mining of the search results to capture user's interest and preferences in the form of concepts. Since location data plays a very essential role, The captured concepts are categorized into content and location concepts. These concepts are then organized as ontology-based multi-facet(OMF),thus facilitating capture of user's interests and location interest. This improves search engine accuracy. Under this approach, the amount of content and location information associated with each query and the amount of content and location information that interest the user is also measured.

## IV. IMPLEMENTATION

Functionalities of the system modules in implementation of the system are described below:

1. **Voice Activity Detector:** The functionality of this module is to read the digitized audio samples acquired from the user through the microphone and discriminate the audio samples from noise. The filtered raw audio is then sent to the ASR module. Implementation of this module is based on the Sphinx Base Library integrated to Android.
2. **Automatic Speech Recognition:** This module is responsible for speech to text conversion .It reads the speech mapped from the user audio samples sent by the VAD and converts into text. This text is then sent to the CE module for further processing. Implementation of this module is based on the Pocket Sphinx speech recognition library.

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3. **Conversational Engine:** Response from this module depends on the current input, the conversational flow and he dialog history. It extracts the meaning of speech made in the audio samples and handles the flow of dialogs .It also produces the required necessary actions for the target domain.
4. **Control Interface:** This module translates the commands given by the user into a structure suitable for the target services or applications running on current or other remote devices. Since this module depends on each application and its user ,it is said to be domain-specific and needs to be restructured and readapted for each different application.
5. **Text-to-Speech Conversion:** This module generates a the output voice for the incoming text samples sent by the CE module .To match up the artificial speech and animation, it sends a list of phonemes for the converted audio to the VHA module. Implementation of this module depends on the eSpeaks library.
6. **Virtual Head Animation:** This module reads the information generated by the CE module and the phonemes' duration list provided by the TTS module as inputs. These inputs are then processed o generate appropriate visual representations of the phonemes along with facial expressions for the generated audio.

   The software features of this system are implemented on Android and XML using JSP and Servlet technologies whereas the hardware features are implemented using a PIC Microcontroller

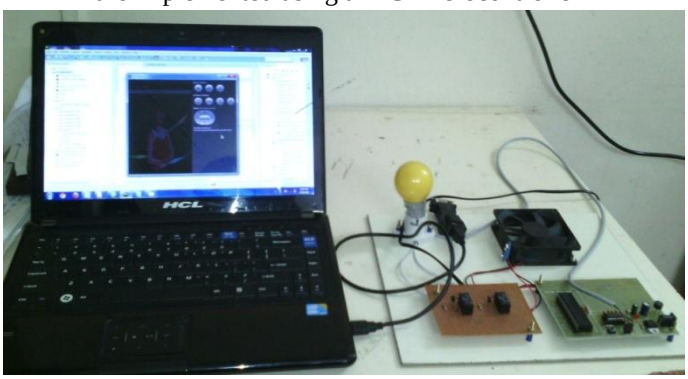

Fig. PIC Microcontroller interfaced with USB Adapter and Relay

PIC microcontrollers ( Programmable Interface Controllers), are small electronic circuits that can be programmed to be timers or to control a production line. The make use of a USB to Serial Adapter to receive input data for processing and the circuit is then controlled with the help of relays. The microcontrollers along with the softwares together are used for implementation of the open-source platform for the ECA interfaces.

## V. CONCLUSION

The main intent of this publication is to describe an open-source free platform which provides support for development of ECA-based interfaces for Android-equipped hand-held devices. In this paper, we have represented the system architecture and explained the various modules involved in the implementation of such a platform. The first prototype for this platform was developed for controlling a home automation system and installed in a tablet. Due to limited computational requirements of hand-held devices over desktop computers, all architectures used to perform extensive processing work such as query processing, speech recognition for theca-based interfaces are handled by an external server. Future prospect of this research involves carrying out experiments on real time users to measure stability, usefulness and performance of the platform and also incorporating security features for client-side applications.

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