User Interface System of an Assistive Kitchen for Aging People

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Abstract—Performing the daily living activities (dla) without anybody’s aid becomes challenging for aging people. The ones in the kitchen among dla plays a crucial role. Despite serious research efforts and well-documented progress in user interface systems for human machine interface; comparatively small amount of work has been reported on designing an user interface system for aging people to perform the dla in the kitchen.

This paper reports the development of an user interface system to provide aid in overcoming planning, initiation and attention which the user may experience while performing dla in the kitchen. The system is comprised of an electrically isolated virtual switch based user interface module and a finite state machine based decision making unit (DMU). The user interface generates cues and prompts in the form of texts and graphics as visual feedback of the status of interaction by the user and facilitates to select the items to be used for a desired activity. The DMU seek to understand the user’s intention, derive the decision for the intended activity and accordingly generate a command for the assistive systems in real time.

Index Terms—User Interface System, Human Machine Interface, Finite State Machine

I. INTRODUCTION

The development of assistive technology have remarkable impact on aging individuals to fully retain their activities in home and work environment. The activities in the kitchen are among the most challenging environments to enjoy self dependence. Addressing this issue, a number of assistive technologies have been proposed to be incorporated in the kitchen. Maurizio et al. [1] have presented an interactive kitchen system based on a speech synthesizer and visual interface module. The system assist the user in storing and retrieving items from automated cabinet shelves of the kitchen. Ju et al. [2] proposed an interactive kitchen cook-book with interaction, video and work sections in it. The user can interact with the system by physical contact in the interaction section; the video section displays the instructional pictures as guidance to work by the user in the work section. An augmented reality interface which assist in item retrieving by providing cues like illuminating the appropriate drawer handle where the desired item is located have been presented by Bonanni et al. [3]. Siio et al. [4] developed a computer-Augmented kitchen environment system equipped with interactive cooking navigation for providing proper guidance in carrying out cooking activities in the kitchen. Another cooking assistant system was proposed by Sato et al. [5] wherein the system integrates a computer, a projector, and a depth camera for step by step instructions to guide the user. Sugiuira et al. [6] developed a system for incorporation of robotic and human specific elements in a shared work-space for achieving a cooperative rudimentary cooking capability. The proposed system is capable of cooking meals with the help of small robots instead of built in arms robots to provide safety and improved flexibility. Graphical user interface was used in the proposed system for the user to provide detailed cooking instructions. Amutha et al. [7] presented the design and development of a smart kitchen cabinet which identifies the grocery items in the kitchen store. The prototype uses radio frequency (RF) identification technique to identify the items placed in the cabinet. A context aware utility system in which augmented tool like cutting board and knife are incorporated with sensors to detect the type of food handled during the preparation of meals was proposed by Kranz et al. [8]. The problem of remembering recipe or steps in carrying out cooking activities in the kitchen by the people having cognitive impairments is sorted out by Wasinger [9] through a speech recognition technique. An E-Kitchen design, implementation and evaluation intending increase in comfort, energy efficiency, usability and safety for elderly people has been reported in [10].

Although a number of technologies have been developed for assisting the user activities in the kitchen, very few works concentrated on a simple yet capable of planning and deriving the decision for kitchen activities based on cognitively poor user input. This is a need for enabling a self independent life for the aging people as the available human support is a question in coming decades. The work presented in this paper emphasizes on the development of a user interface for assisting the aging people in performing dla in the kitchen. The focus is on overcoming the planning, initiation and attention which the user may experience while performing dla in the kitchen. The system is comprised of an electrically isolated virtual switch based user interface module and a finite state machine based decision making unit (DMU). The user can indicate their intended action/activity through the virtual switch which displays essential kitchen activities like making beverages, cleaning and ordering food. The sub-items from the main display links the details of the food items, beverages and cleaning activities. The series of indicated activities are considered as states and the DMU derives the decision of the intended tasks based on the indicated states by the user. The user interface generates cues and prompts in the form of texts and graphics as visual feedback of the status of interaction by the user and the DMU seek to understand the user’s intentions.
derive the decision for the intended activity and accordingly generate a command for the assistive systems in real time.

II. PROPOSED ARCHITECTURE

The proposed architecture for the user interface system of an assistive kitchen for aging people is shown in Fig. 1. The architecture is comprised of four units: virtual switch based user interface module, communication module, finite state machine based DMU and the display unit.

![Fig. 1. Proposed Architecture of the User Interface System](image)

A. Virtual switch based User Interface Module

The user can communicate with the DMU through the user interface module. The interface module is equipped with five pairs of infrared sensors creating six coordinates of infrared rays intersection or grid points. Fig. 2 shows the schematic of the user interface module wherein the circle, rectangle and diamond shapes represent the receiver, transmitter and grid points respectively.

![Fig. 2. Schematic of User Interface Module](image)

The intersection coordinates are projected with the visuals and text from the display unit. Momentary placement of the user’s hand in any of the coordinates inhibits the infrared to incident on the corresponding receiver and thus generate the information about the text or display indicated by the user.

B. Communication Module

The coordinate indicated in the user interface module is remotely communicated to the DMU through the communication module. The transmitter section is comprised of a microcontroller with a RF transmitter and the receiver section is equipped with a RF receiver and microcontroller followed by RS 232 serial communication to Matlab wherein the DMU is developed.

C. Finite State Machine based DMU

The DMU based on finite state machine derives the user’s intended activity using the input through the user interface module. Each input from the user is considered as a state. The state transitions display possible cues for selection of the next state by the user in the form of text and visuals. With a definite set of states selected by the user following state transitions, a set of possible intended activities are evoked of which the most reasonable activity is derived as the decision.

D. Display Unit

It provides visual information about the states through graphical icons and text. These state visuals are projected on the grid point of the interface module. The transitions in the display of visuals are following the state transition in the DMU. The prompts and cues in the form of text and graphical icons allow the user to have a friendly access to select the items that likely to be required for an intended activity.

III. HARDWARE INFRASTRUCTURE

Object detection using beam breaker method is used for user input selection in the proposed architecture. The grid points on the user interface module acts like virtual switches where in the display unit projects the cues in the form of text and graphical icons. Fig. 3 shows the different sections of the hardware infrastructure.

![Fig. 3. Hardware infrastructure of the user interface system](image)
As and when the user indicate one of the grid points for the selection of the displayed item, the two sensors corresponding to that grid point gets activated. The simultaneous outputs provided by the two IR receivers are processed by using logic gates to generate a single output indicating the selection of the user. The input provided by the user through the user interface module are transmitted using a 433 MHz RF wireless transmitter modulated at 38 KHz. The output of the receiver corresponding to the user input through the user interface module are fed to the finite state machine based DMU developed in Matlab.

IV. SOFTWARE INFRASTRUCTURE

The reasoning and decision making by the proposed architecture is accomplished in the DMU based on an event driven finite state machine using state transition methodology. A state represents the input by the user through the user interface module. State transition defines switching of the visuals on the grid point from one to another based on the current input state. Conditions refers to the set of rules which must be satisfied to allow a state transition. The conditions depicting the state transitions through transition matrix are shown in Table I.

<table>
<thead>
<tr>
<th>General Activities</th>
<th>Assistance Provider</th>
<th>Waiting</th>
</tr>
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<tbody>
<tr>
<td>General Activities</td>
<td>E1</td>
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<tr>
<td>Assistance Provider</td>
<td>E5</td>
<td>E2</td>
</tr>
<tr>
<td>Waiting</td>
<td>E4</td>
<td>E3</td>
</tr>
</tbody>
</table>

Where
E1: Selection of any activity state by the user through the user interface module
E2: Allowing the user to provide input based on the hints and clues about the next activity state
E3: Selection of any of the items displayed in the assistance provider state
E4: User confirms or cancels or no item selection activity state
E5: Completion of activity state

The finite state machine consists of three states: General Activities, Assistance Provider and Waiting state. Fig. 4 shows the state flow diagram of the finite state machine used in the proposed architecture. The general activity state corresponds to the input of the user through the user interface module. It provides the process of selection of the kitchen items according to the user choice. In the assistance provider state, the finite state machine generates the required assistance feature for the user. The assistance features include the hints or clues for making selection through the user interface in the form of text and graphics related to the previous activity state. Waiting state provides time to the user for activity input through the user interface.

V. TESTING AND RESULTS

The proposed architecture have been implemented in real time for assisting an user in dealing with the tasks in the kitchen. The cues in the form of visual graphics and text directs the user to select the proper items required for a particular task in the kitchen. The proposed architecture have been tested for assisting an user for beverage preparation, cleaning, cutting and ordering food in the kitchen. A case study of preparing a milk coffee for discussing the testing and results of the proposed architecture is detailed in this section.

Fig. 4. State diagram consists of three states: General Activities, Assistance Provider and Waiting state

Fig. 5. A Case Study: State transitions for assisting an user to select milk coffee
Fig. 5 shows a case study of the proposed architecture in assisting an user during selection of milk coffee through finite activity, waiting and assistance provider states using the user interface module. Figure 6 through 11 shows the visual displays projected on the user interface module of the proposed architecture during the selection of milk coffee by the user.

Fig. 6. Initial graphical user interface of the proposed architecture

Fig. 7. Visuals of graphical user interface after beverage selection in the assisting state

Fig. 8. Visuals of graphical user interface after coffee selection in the assisting state

Fig. 9. Visuals of graphical user interface after sugar selection in the assisting state

Fig. 10. Visuals of graphical user interface after milk selection in the assisting state

Fig. 11. Visuals of graphical user interface after confirming the selection in the assisting state

The state estimation accuracy of the developed user interface system for the case study of preparing milk coffee is shown as the confusion matrix in Fig. 12; wherein each of the required user input states (as shown in Fig. 6 through Fig. 10) were fed as input to the system for 60 times and the correct state estimation over total inputs were recorded as the accuracy. The Numeric value on bars in Fig. 12 represent the number of states estimated correctly. The incorrect estimations are considered as invalid input and depicted in the output column 6. For example corresponding to input 1: the input for ‘PLEASE SELECT THE MAIN ITEM’ were fed for 60 times; out of which it was estimated correctly for 56 times (aka input 1) and as invalid input for 4 times (aka output 6). Furthermore, the user input state in Fig. 8 was estimated correctly for 58 times (aka input 3) and as invalid input for 2 times (aka output 6). All other input states were estimated correctly for 60 times. The user interface system achieved an
average accuracy of 98% for the considered case study.

VI. CONCLUDING REMARKS

An user interface system of an assistive kitchen for aging people is proposed. The developed architecture aids an user to overcome the planning, initiation and attention which the user may experience while performing daily activities in the kitchen. The system is comprised of an user interface module and a finite state machine based DMU.

The user can select the items to be used for a desired activity through the user interface system. The user interface generates cues and prompts in the form of texts and graphics as visual feedback of the status of interaction by the user and the DMU understands the user intention in real time. This is followed by the derivation of the decision for the intended activity and accordingly generate a command for the assistive system.

The proposed architecture have been tested for assisting an user for beverage preparation, cleaning, cutting and ordering food in the kitchen. An average accuracy of 98% have been achieved for a case study of preparing milk coffee using the developed system. Furthermore, the developed user interface system has been proved as a reliable one in terms of timing synchronization of the user input vis-a-vis the intended activity estimation for a delay of 1-5 seconds in the user input. It is seen that the user interface system aids the user in the kitchen without much planning and knowledge; which holds promise for an assistive kitchen for aging people.

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REFERENCES