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An Intelligent Mirror for Parenting, Supporting Aid and Personal Agent

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Abstract— Everybody loves to be in front of the mirror at least once a day. Such a mirror can also be used as an intelligent device that can enable lot of opportunities. Intelligent mirror can help in effective parenting. Looking after child needs and keeping track of their activities like homework, eating, tuitions, sports/dance classes and others is difficult. The intelligent mirror can help by communicating child different alerts and messages, as soon as the child stands in front of mirror. Parents can keep updating instructions to mirror. Disabled people find difficulty in checking daily updates, keeping reminder systems and receiving notifications of their friends/relatives. They have to depend on someone to support all these tasks. Such people just need to be visible in front of the smart mirror and get all the required updates and notifications. Apart from these, every individual has lot of reminders, updates, and tasks to be done every day. Daily news, weather forecasts, streaming of desired videos, user interest driven advertisements need to be displayed as soon as user comes in front of mirror. The proposed intelligent mirror is developed using Raspberry Pi, two-way mirror, camera module, face recognition and server side technologies. An easy to use Android App has been developed in Kotlin to facilitate updating activity schedules, record and upload Audio messages, user to customize their interest and profile settings and view the history of schedules.

Keywords—Smart Mirror, Convolution Neural Networks, Raspberry PI, IoT, Android

I. INTRODUCTION

Disabled people find difficulty in checking daily updates, keeping reminder systems and receiving notifications of their relatives/friend's activities. They have to depend on someone to support all these tasks. They might also have to rely on someone to remind them of the medications that they are supposed to take. It's a busy life and both father and mother need to work. Looking after child needs extra time and keeping track of their activities like homework, eating, tuitions, sports/dance classes and others is difficult. Every individual has a lot of reminders, updates, and tasks to be done every day. Like paying premiums, scheduling of important meetings, birthday wishes and others. Daily news, weather forecasts, streaming of desired videos, user interest driven advertisements need to be displayed as soon as user comes in front of mirror.

The proposed system is intended to solve the following problems: effective parenting of children for busy parent; need of an exclusive assistant for the disabled people; tracking of interests of user, the reminder notifications in hectic work culture, getting updates as and when needed. The aim would be to help easier management of children, helping disabled people and making them self-dependent and personalized tool/agent for every individual.

Section I contains the introduction of proposed Intelligent Mirror System. Section II contain the related work on Smart Mirrors. System architecture is put forth in Section III. Implementation details are explored in Section IV. Section V describes results and discussion with an analysis of experimental results with respect to response time and identification accuracy. Section VII concludes research work with future directions.

II. RELATED WORK

An exhaustive literature review on existing Smart Mirrors has been made and reported in the following.

Smart Mirror detailed seeks to move semeiotic analysis of the face to normal life settings [1][2]. The goal is to promote primary prevention of cardio-metabolic diseases. "ICT solutions to foster behavioural change have been shown to be effective in implementing primary prevention in terms of a healthy lifestyle. Primary prevention is the most viable approach to reduce the socio-economic burden of chronic and widespread diseases, such as cardiovascular and metabolic diseases". A novel multisensory device, the Smart Mirror, detects and monitors over time semeiotic face signs related to cardio-metabolic risk, and encourages users to reduce their risk by improving their lifestyle [3].

The work on the design and implementation of a multi-user smart mirror system is conceived to promote wellness and healthier lifestyles in the work environment through persuasive strategies [4]. Using RFID reader, the

interactive mirror recognises different users through their personal corporate ID card, which allows them to have access to their personalised user-interface. "The smart mirror provides work place's indoor environmental conditions (thermal, humidity and light), personal physical exercise data obtained from wearable device sand general purpose information (e.g. weather and daily news)". The implemented mirror has assessed and the quantitative data has been accumulated.

The Interactive mirror operate in two different modes by placing a dielectric coated mirror over the LCD display. "The modes of operation are 1) Normal Mirror: When the display is OFF, it will act as a normal reflective mirror; 2) Interactive Mirror: When the display is ON, it will act as a see-through glass and the display can be viewed. A web camera of resolution 640 x 480 is used for capturing the images in front of the mirror. A weighing platform, designed using four load sensors is placed in front of the mirror to measure the person's weight". A RFID reader and an antenna are connected to the system for recognizing the tags attached with the garments [5][6][7].

Kinect is a motion sensing input device developed by Microsoft in [8][9][10] . It is primarily used in Xbox 360 console and for Windows PCS . For Windows, a Kinect sensor consists of an RGB camera which can store up to three channel data of resolution 1280×960. "It has an IR (infrared) emitter which emits lights beams and an IR depth sensor that reads the reflected beams and process the information to measure the distance between the object and the sensor. It also has multi-array microphone that can capture sound and detect the location of the source and direction of the audio wave".

The system on an open platform for discrete display development. It renders an aesthetically pleasing mirror, with a hidden smart display underneath is proposed [11]. With a generic display, the mirror can be built to any size so the information can be both in your face while showing you your face. The product differs from the competition with an easy-to-use interface that is both simple for the average user and open for the advanced developer. "A sleek display gives all levels of users a modern hub of technology for their personal daily interaction, one which both displays visually all the information one could need or want, and operates with a simple interaction that one could fit into your daily routine. By creating a platform open to modification, developers will also be add new functionality at their own pace". A web application provides the interface that the user sees and interacts with. An online configurator performs streamlined development of dynamic modules. This smart mirror will possesses a great potential for expansion by developers[12][13].

Hence, the pitfalls in some of the existing systems is the application of smart mirrors for effective parenting and used to help disabled people. The voice output of smart mirrors is not integrated in the existing work. Integration of the smart mirror with the Android APPs lacks in the existing work. The user should be able to get personalized updates on the mirror like targeted advertisements, videos and news updates missing in the existing works.

The following are the key objectives of this work: Real time and dynamic updation of alerts and notifications. Face recognition to find individual facing mirror. Display of notifications, schedules and updates on the mirror. A speaker integrated to mirror that can speak of important alerts and notifications. A user friendly integrated APP to interface smart mirror. Integration as a single product

III. DESIGN

Apart from objectives specified in previous section, various non-functional requirements also need to be satisfied. They are: Face recognition and detection should exhibit higher accuracy. Speed of recognition is very essential because the face must be detected and processed faster. Faster switching for processing of different actions enabled in the Smart mirror. Such requirements can be found in existing systems such as [14][15]. User friendly GUI in Application that can be used by a novice user too. The design of the proposed system for an intelligent mirror is laid out. The system composes of hardware and software modules. The architecture is shown in Fig. 1. It is designed using a modular architecture comprising of following modules:

- Hardware modules include IoT device in the form of Raspberry PI, Camera module, speaker and LCD panel connected to IoT device using HDMI cable.
- The two way mirror is mounted infront of the LCD panel and can be packaged as a wooden frame.
- The prospective users stand infront of mirror. RPI camera module captures the face and gives it to the software subsystem developed inside RPi.
- After successful face recognition, relevant data/notifications/alerts are fetched from server side modules using software subsystem.
- The fetched results are displayed on the mirror and communicated to speaker (in case of audio).

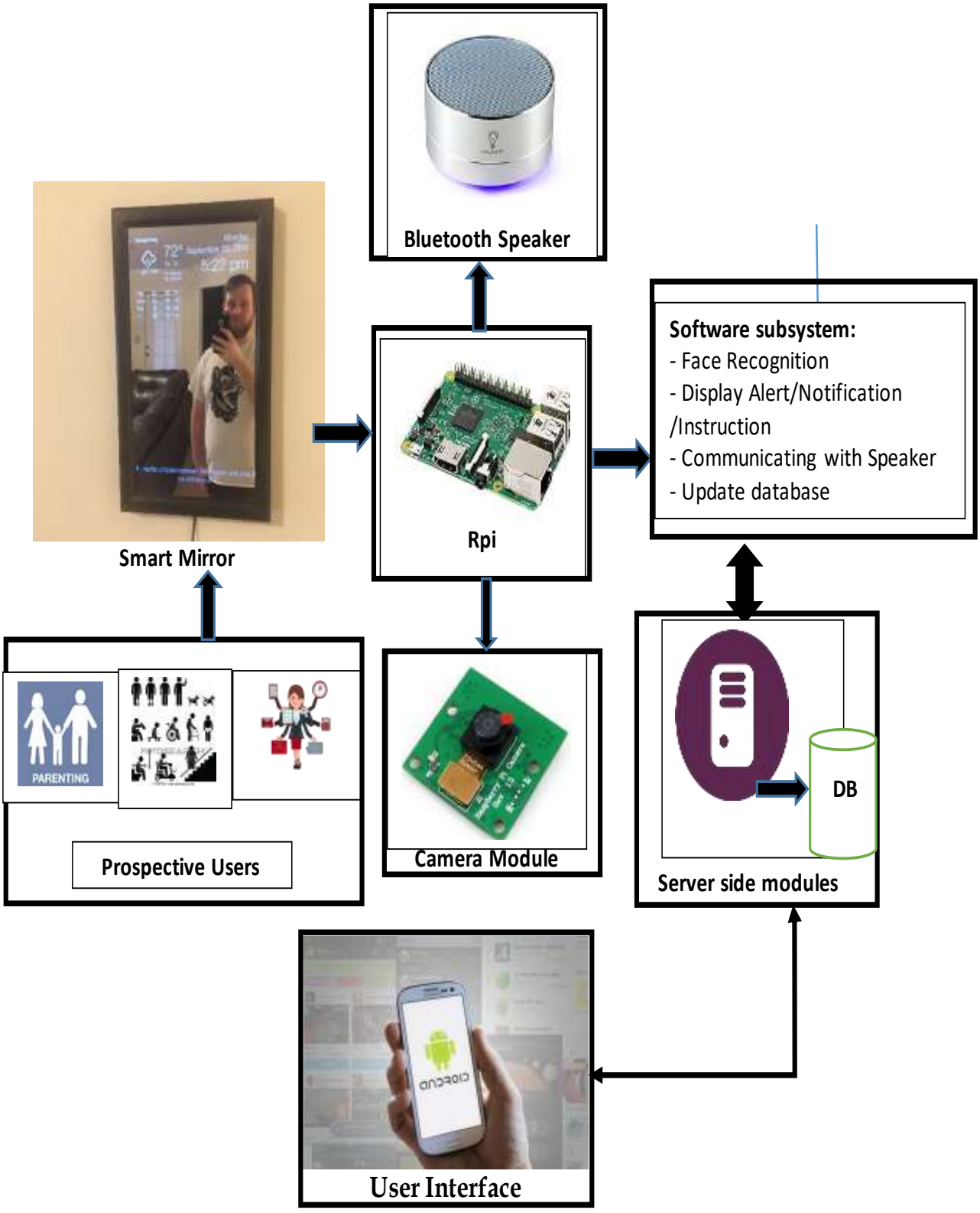

Figure 1. Intelligent Mirror Architecture

IV. IMPLEMENTATION

A. *Smart Mirror Interface*

The implementation of smart mirror interface is shown in Fig. 2. The face recognition recognizes face of the registered user and the face exists the server-side script fetches record matching id from database and prepare response data and sends back response data from the client and fetches user type child, elderly or personal agent and displays appropriate message if present through text and audio.

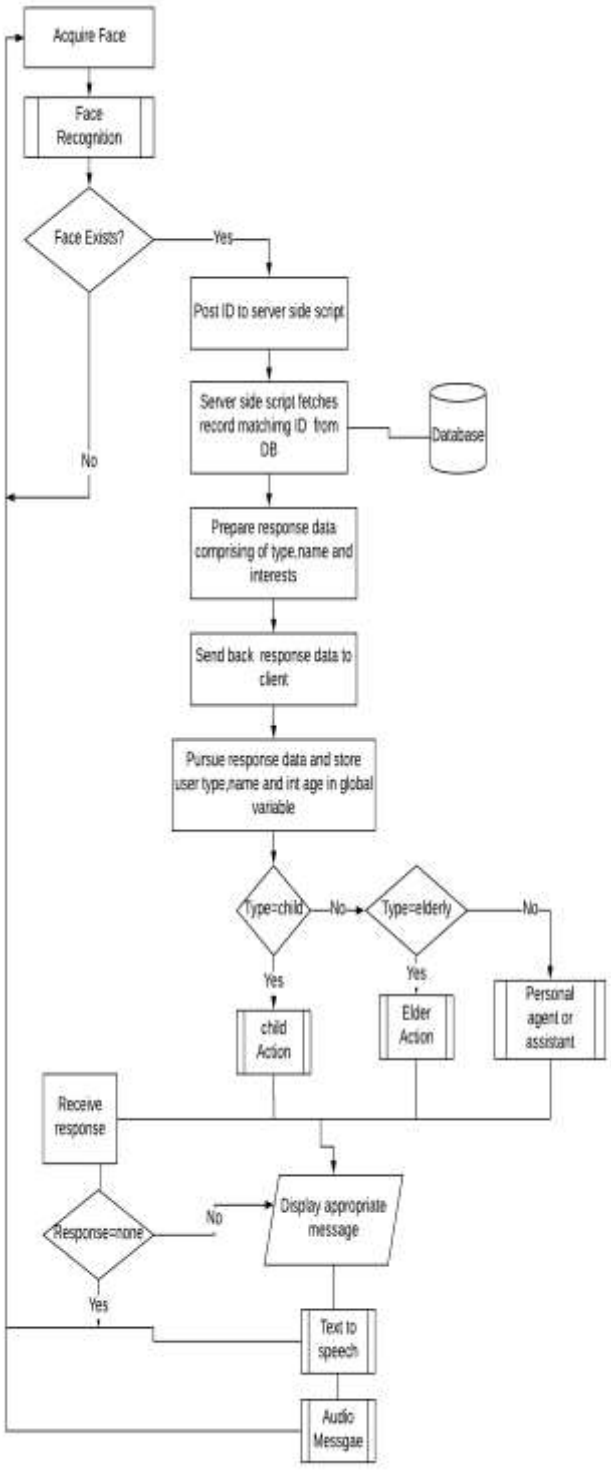

Figure 2. Intelligent Mirror Interface

B. Elder Action Implementation

If the user type elder is recognized, post id along with type and check for a matching record in elder table. If found, checks for current date and time with one fetched from database. The actions for elder is usually reminders about medical prescriptions, daily dietary routines and important notifications as shown in Fig. 3.

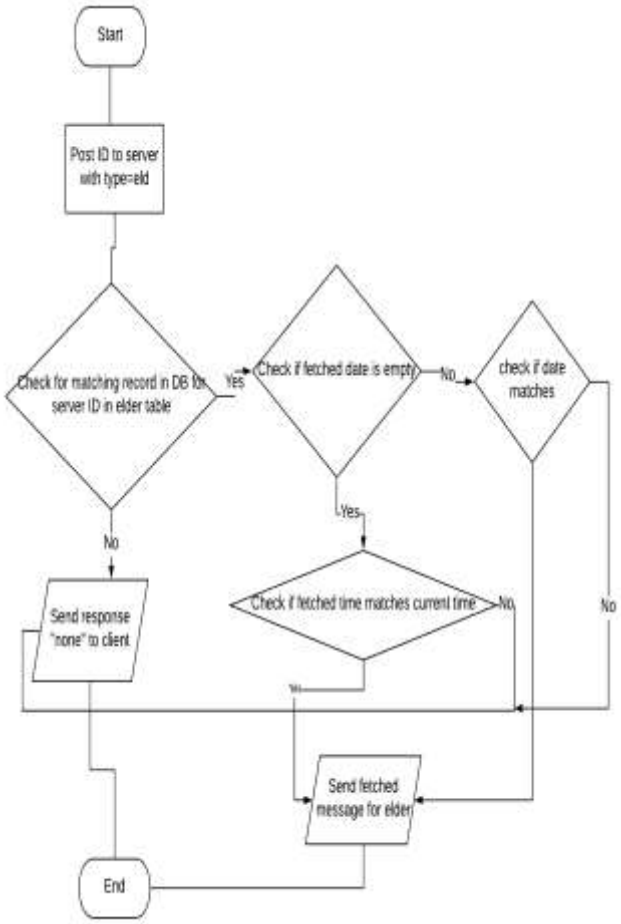

Figure 3. Action for "Elder" User type

C. Personal Assistant Module Implementation

If the user type is personal, check for any record(s) matching the ID post to the server. The personal assistant matching records will contain information like daily activities, birthday reminders, notifications, event checklists and other important events. The flowchart for implementation is presented in Figure 4.

D. Parenting Module Implementation

The parent of child is also another prospective user of this Smart Mirror system. The flowchart for implementation of effective parenting is shown in Figure 5. The routinely activities to be carried out by child is reminded or notified by parent through smart mirror. Further important messages and alerts can also be conveyed.

E. User Registration Implementation

User registration is done by scanning details like id, name, type, and interest and phone number. A USB camera connected to smart mirror captures the video frame by frame and apply Haar classifier to extract face window. The extracted face window is output to the file. Further details are sent to server-side script and the same is inserted/updated into database. This process flow is depicted in Figure 6.

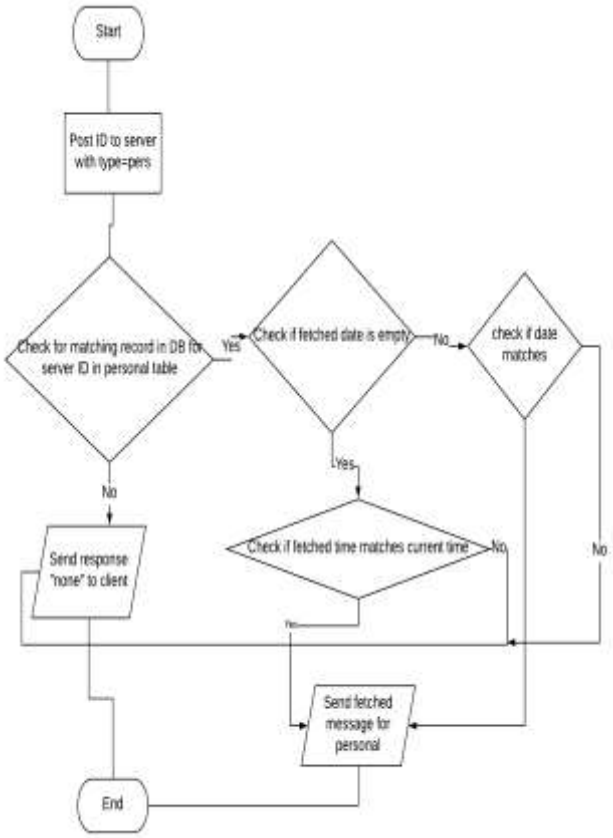

Figure 4. Action for "Personal" User type

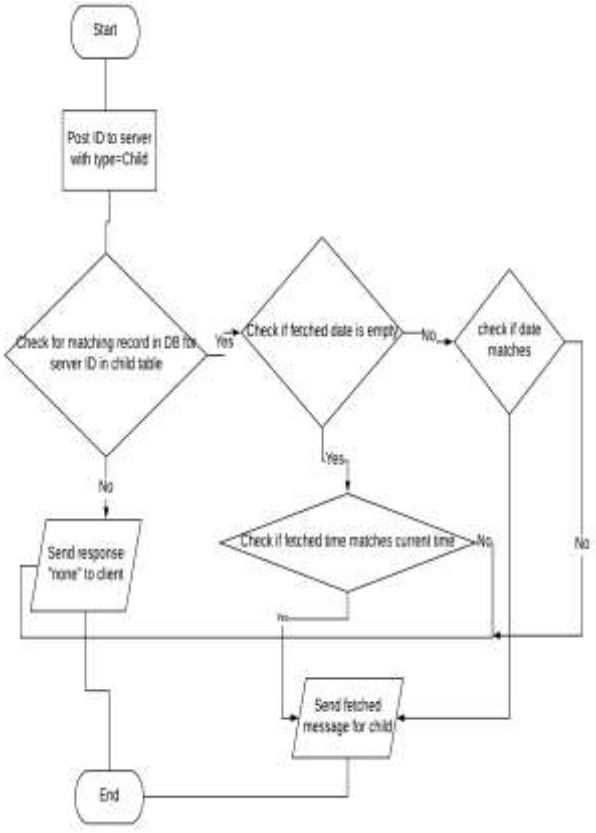

Figure 5. Action for "Child" User type

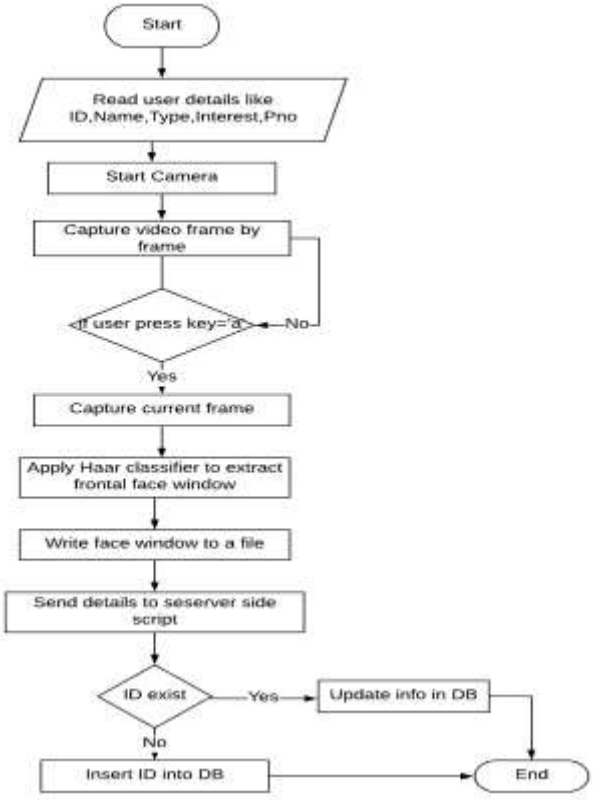

Figure 6. Flowchart for User Registration

F. Front-End GUI Implementation

Implementation of front end interface action is shown n Figure 7. In this process, Login activity matches user id with password and if user id exists in the server. Different modules are further navigated and different activities are integrated are as shown in Figure 7.

G. Configuration of User Settings

The user settings are for changing the settings of the user. The corresponding flowchart is shown in Figure 8. It sends user id to the server script and fetches details for the corresponding to the user Id. User can edit any of the fields by using edit button and then modified fields are sent to the server side along with the script and server updates in the database and displays confirmation message.

H. Activity Schedule Implementation

The flowchart for activity schedule is shown in Figure 9. User can enter the activity schedule if date button is pressed record date information, then time is also recorded and submit button is pressed then activity is sent to the server side script to the database

I. Audio Upload Implementation

The user can also upload the audio file and its implementation is shown in Figure 10. The audio recording can be done by pressing the record button and the user can also either pause or resume. If it is resume then stop the button pressed create the file of the record and date,time is entered upload audio file to corresponding date and time entered displays confirmation message.

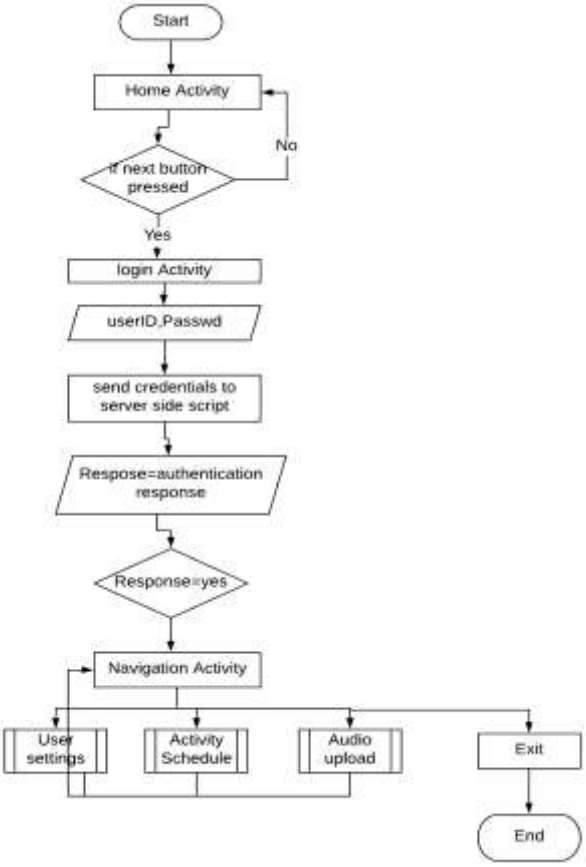

Figure 7. Front End GUI process flow

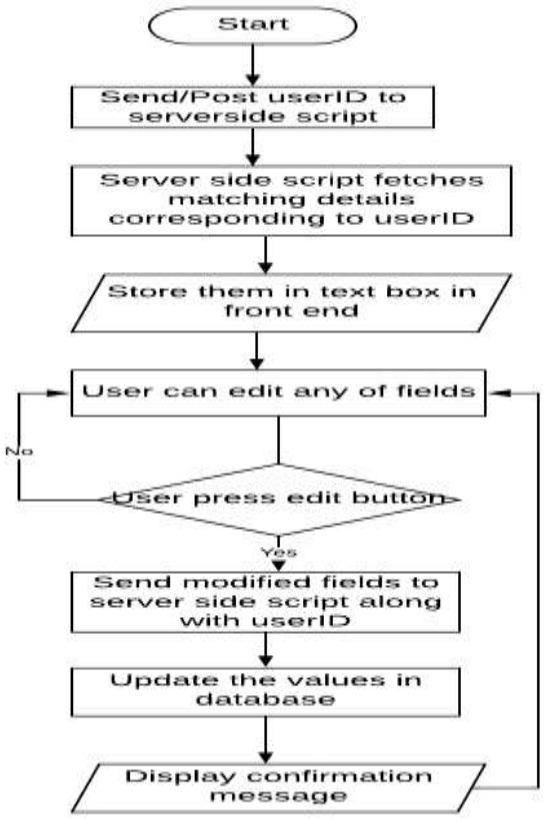

Figure 8. User Settings Configruation flowchart

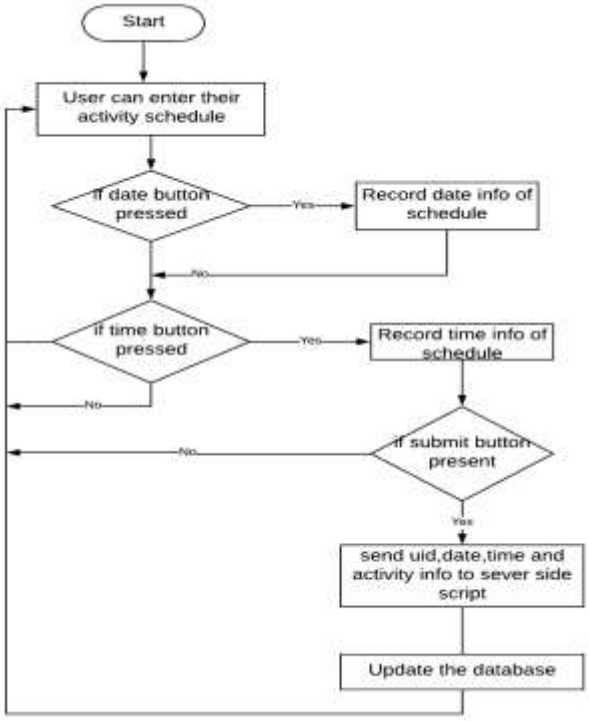

Figure 9. Activity Scheduling flowchart

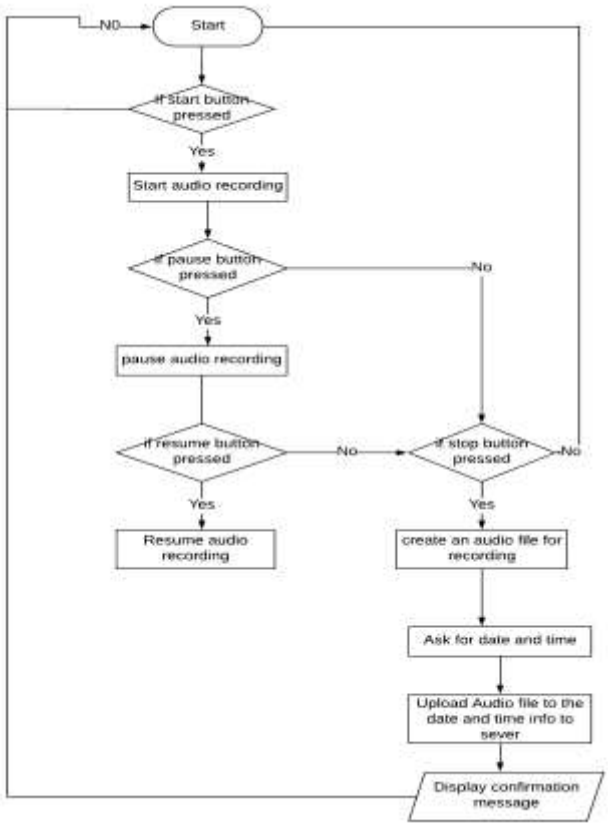

Figure 10. Implementation diagram for Audio Uploads

J. Back-End Implementation

Different tables are used in backend implementation of smart mirror system. They are detailed in the following:

User table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	user_id	int(11)			No	None			Change Drop More
2	user_name	text	utf8_general_ci		No	None			Change Drop More
3	user_type	varchar(50)	utf8_general_ci		No	None			Change Drop More
4	pno	bigint(20)			No	None			Change Drop More
5	user_interest	varchar(100)	utf8_general_ci		No	None			Change Drop More
6	pwd	text	utf8_general_ci		No	None			Change Drop More

Schedule table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	user_id	int(11)			No	None			Change Drop More
2	tm	varchar(100)	utf8_general_ci		No	None			Change Drop More
3	dt	text	utf8_general_ci		No	None			Change Drop More
4	sched	text	utf8_general_ci		No	None			Change Drop More

Elder table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	user_id	int(11)			No	None			Change Drop More
2	tm	varchar(50)	utf8_general_ci		No	None			Change Drop More
3	dt	varchar(100)	utf8_general_ci		No	None			Change Drop More
4	prescription	text	utf8_general_ci		No	None			Change Drop More

Child table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	user_id	int(11)			No	None			Change Drop More
2	tm	varchar(100)	utf8_general_ci		No	None			Change Drop More
3	dt	varchar(100)	utf8_general_ci		No	None			Change Drop More
4	activity	text	utf8_general_ci		No	None			Change Drop More

Personal table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	user_id	int(11)			No	None			Change Drop More
2	tm	varchar(100)	utf8_general_ci		No	None			Change Drop More
3	dt	varchar(100)	utf8_general_ci		No	None			Change Drop More
4	activity	text	utf8_general_ci		No	None			Change Drop More

Authentication table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	uid	varchar(100)	utf8_general_ci		No	None			Change Drop More
2	pwd	text	utf8_general_ci		No	None			Change Drop More
3	user_id	varchar(100)	utf8_general_ci		No	None			Change Drop More

Audio table structure

#	Name	Type	Collation	Attributes	Null	Default	Comments	Extra	Action
1	user_id	int(11)			No	None			Change Drop More
2	tm	varchar(100)	utf8_general_ci		No	None			Change Drop More
3	dt	varchar(200)	utf8_general_ci		No	None			Change Drop More
4	audio	text	utf8_general_ci		No	None			Change Drop More

The Smart mirror system has been implemented using Python, PHP and Android. The face recognition, detection, user registration and display interface for smart mirror is implemented using APIs available in Python. The server-side scripting is done using PHP. It also performs interaction with backend MySQL database. The front end interface to control smart mirror is provided be developing a Native Android App

V. RESULTS AND DISCUSSION

A. *Experimental Setup*

The experimental setup is shown in Figure 11. It gives the connectivity of the smart mirror. It includes the 2-way acrylic mirror for reflecting user's face, Speaker for playing announcements, Raspberry Pi that has smart mirror software and interfaces with other hardware, Camera module to acquire the face of the user. This smart mirror system displays the details of the user in front of the based on user type and also displays news based on interest of the user.

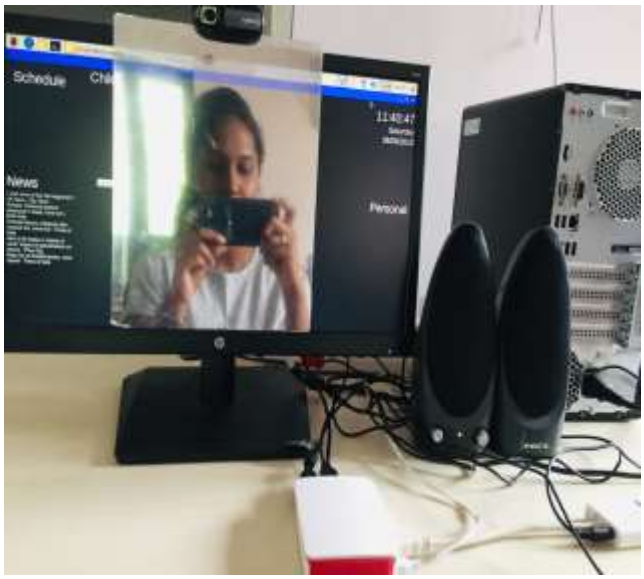

Figure 11. Experimental setup

B. *Test plan*

A Test plan is prepared for testing the implemented Smart Mirror system and is represented in Table 1. It has multitude of the test cases and output expected uniquely for different test case with the remarks of either success or failure.

Table 1. Test Plan for Intelligent Mirror System

Sl. No.	Test case	Expected output	Remarks
1.	Face Registration	Face details in DB	Success-stores faces Failure-not stored
2.	Validation in face registration	Validates face registration in db	Success-face detected Failure-not detected
3.	Face Recognition	Name of the intended user and respective interests are displayed	Success-face detected Failure-not detected

4.	Type=Elderly	Medication details	Success-details stored Failure-not stored
5.	Type=Child	Activity details	Success-details stored Failure-not stored
6.	Type=Personal Assistant	Updates and reminders	Success-details stored Failure-not stored
7.	Front end user setting	Allows user to update the user information	Success-updated info Failure-data not updated
8.	Front end=upload schedule	Allows user to upload activities	Success-activity data updated Failure-not stored
9.	Front end=upload audio	Allows user to upload audio output	Success-audio inserted to database Failure-not stored to db

C. Face Recognition

The face recognition module recognizes the user who are already registered and trained .If the user is not registered it displays as none. One such successful case is presented in Figure 12.

Figure 12. Recognition of Registered User

D. Smart Mirror Actions

Displays user scheduled actions and personal actions on time inserted by the user to alert the schedule or personal actions of user. A schedule entered for a elderly person is shown in Figure 13.

Figure 13. Elderly Person Schedule

E. Front End GUI

A user friendly Android App has been developed for front end interface to Smart Mirror system. This app authenticates the user and once authenticated has options to edit his/her details, update/insert a schedule and upload Audio file. The authenticated user has option to navigate to different activities and is shown in Figure 14. One of them is editing the details like user name, phone numer, type of user and his/her interest. Another activity is updating/inserting activity of the user based on the type. Next Activity is listing of existing activities and last activity is the uploading of Audio files.

Figure 14.Android App Navigation Interface

The application provides the option of entering the activities along with date time. User can either enter both date and time or only time. If both date and time is entered, it will be for specific date and time (one time). However, if only time is entered it will be for each day. User Activity upload screen is shown in Figure 15.

Figure 15. Alert Raising Interface

A front end interface for an authenticated user to record audio and upload to server is given in Figure 16. User can record, pause and resume and once completed can stop recording. The recording can be played and if satisfied can upload along with date and time to play. If only time is input, the audio will play each day at the same time

Figure 16. Recording User Interface

F. Discussions

Results of the proposed Intelligent Mirror system that addresses three different objectives was discussed in this section. It helps elderly person to become self-dependent by getting to know prescriptions/schedules when they stand infront of mirror. Effective parenting can be accomplished by making children to carry activity reported on the mirror. Users can also use smart mirrors as their personal agents suggesting or acting as reminders for schedules. The smart mirrors can be easily and effectively controlled using Android APP. The speakers are also integrated to convey messages displayed as text. The accuracy of face recognition is due to the application of Convolution Neural networks. The improvement in accuracy of face recognition is due to pre-encoding of all faces and saving them in a file.

G. Analysis

This work has been tested exhaustively and analyzed for its performance. The primary requirement of such mirror systems is the performance expressed in terms of parameters such as response time and identification accuracy.

Response time is measured as time required to intelligently identify category for which user standing infront of mirror belongs. We have made a testing of 100 such users including a combination of elderly, child and personal agents. Response time for categories is depicted in Figure 17. It is clearly evident from the plot that response time is very low (in terms of milliseconds) making it amenable to be implemented in real time. Further the response time do not depend on category of the user.

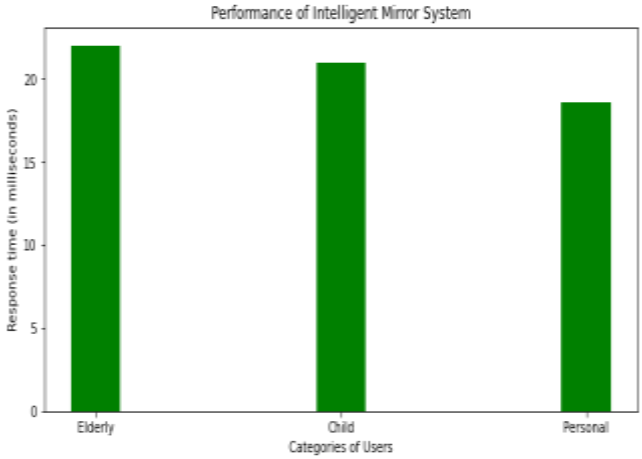

Figure 17. Response time measurement for various categories of users

Identification Accuracy (IDA) is expressed as accuracy in predicting correct category of users. It can be written as:

$$IDA = \frac{\text{Number of samples correctly identified} * 10}{\text{Total number of samples}} \quad (1)$$

A graph of IDA against various sample size is plot in Figure 18. It can be implied from the plot that a high value of IDA is achieved irrespective of sample size.

Figure 18. Identification Accuracy for various size of sample of users.

VI. CONCLUSION AND FUTURE SCOPE

The intelligent mirror aims to reduce time needed in a user's daily routine and provide a merger of user and technology that becomes an enhancement, not a new burden. The functionality must meet these descriptions in the design. By making use of multiple displays, the user can stay updated on the time, weather, and news headlines while preparing for the day in with the fully functional Smart mirror. Although there are other smart mirror technologies that are available, the smart mirror created in this project stresses saving cost and flexible usage. Through an easy to use interface, the mirror can be easily setup to display data that conforms with their interest. The mirror is able to connect to the internet and pass the proper data to display. The smart mirror made in this project meets all the design goals of recognizing user, type of user and accordingly control notifications, alerts and play audio recordings. The easy to use Android APP helps in easier control of smart mirror.

The smart mirror implemented can speak and can show. However it cannot listen like Alexa or other voice recognition systems. The future thought would be to extend this magical mirror with voice recognition capabilities and accept user input by using smarter touch screen based mirror sheets.

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