

# Smart Help at the Workplace for Persons with Disabilities (SHW-PWD)

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**Abstract**—The Smart Help for persons with disability (PWD) is a part of the project SMARTDISABLE which aims to develop relevant solution for PWD that target to provide an adequate workplace environment for them. It would support PWD needs smartly through smart help to allow them access to relevant information and communicate with other effectively and flexibly, and smart editor that assist them in their daily work. It will assist PWD in knowledge processing and creation as well as being able to be productive at the work place. The technical work of the project involves design of a technological scenario for the Ambient Intelligence (AmI) - based assistive technologies at the workplace consisting of an integrated universal smart solution that suits many different impairment conditions and will be designed to empower the Physically disabled persons (PDP) with the capability to access and effectively utilize the ICTs in order to execute knowledge rich working tasks with minimum efforts and with sufficient comfort level. The proposed technology solution for PWD will support voice recognition along with normal keyboard and mouse to control the smart help and smart editor with dynamic auto display interface that satisfies the requirements for different PWD group. In addition, a smart help will provide intelligent intervention based on the behavior of PWD to guide them and warn them about possible misbehavior. PWD can communicate with others using Voice over IP controlled by voice recognition. Moreover, Auto Emergency Help Response would be supported to assist PWD in case of emergency. This proposed technology solution intended to make PWD very effective at the work environment and flexible using voice to conduct their tasks at the work environment. The proposed solution aims to provide favorable outcomes that assist PWD at the work place, with the opportunity to participate in PWD assistive technology innovation market which is still small and rapidly growing as well as upgrading their quality of life to become similar to the normal people at the workplace. Finally, the proposed smart help solution is applicable in all workplace setting, including offices, manufacturing, hospital, etc.

**Keywords**—Ambient Intelligence, ICT, Persons with disability PWD, Smart application.

## I. INTRODUCTION

ASSISTIVE technology is a device or service, including software that helps a person with a disability in his or her daily activities. Assistive technology can be found in the home, workplace, school, and community. Assistive

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technology helps a person with a disability (PWD) to be socially included and to become or remain independent. Information and communication technologies have the key role to provide accessibility and inclusion of PWD. The ongoing advances in ICT are increasing the scope for IT-deskstop and mobile assistive technologies to facilitate the accessibility, participation, independence, safety, and improved quality of life of the PWD in the workplace. Particularly, the assistive smart software solutions have great potential to socially include the PWDs in the community and necessarily within workplaces.

In fact, It is known that many products, both software and hardware, are not accessible to large sections of the population [10]. Designers mostly consider design for normal users and are either unaware of the special needs of PWD, or do not have the capabilities to accommodate their needs into the design cycle.

However, with the emergence and evolution of the concept and technologies of AmI, smart environment and ubiquitous computing has paved the road toward building smart environments through exploiting the key enabling technologies to improve quality of life and performance and to provide assistance for human at various kinds of environments. Through AmI, people can interact with naturally, smart and intuitive interfaces that are embedded in all kinds of objects. This AmI environment is capable of recognizing and responding to the presence of different persons in an unobtrusive and invisible way. The AmI has specific features, attributes or aspects which include Context awareness that has a predictive behavior based on the knowledge of the environment; Natural interaction with user using gestures, multi-modal interfaces, movement, and images; Adaptation to user and context in an autonomous way; Integration and ubiquity, offering services regardless of where the user is located; and supporting new services, in fields such as security, shop work, safety, health, the work environment, access to information, computing, to improve the quality of life by creating adequate atmosphere and functions. Advances in AmI may help to provide us with the right information at the right time, in appropriate manner and through the most suitable device for each situation. It can also assist greatly in accessing various ICTs devices and networks. A suitable context model is not enough; proactive user interface adaptation is necessary to offer personalized information to the user.

Currently, over a billion people including children (or about 15% of the world's population) are estimated to be living with disability. The lack of support services can make handicapped

people overly dependent on their families, which prevents them from being economically active and socially included. In KSA, it is estimated that 3.73% of the population has a functional disability including (Physical, mental, visual, etc.) [1]. More than 74.2 % of the 3.73 % involves physical, visual or hearing disabilities, which still have potential for participating in knowledge creation. Therefore, developing the proposed scenario will help the PWD at Kingdom of Saudi Arabia (KSA) and at the world to work smoothly like normal people and become productive instead of being idle and frustrated. AmI has been utilized in different kinds of environments, particularly in homes [2]-[4] to serve location to innovative services for elderly and disabled people [5], to assist elderly people [6] and [7], and supporting quality of life for persons with disabilities [8] and [9]. In fact, AmI has a very promising potential to improve the quality of life of PWD. The AmI technologies have been already implemented to assist PWD activities and provide services like remote care, way-finding, safety insurance, etc. The possible AmI key enabling technologies includes Smart software, RFID, Smart card systems, Mobile communication, Wireless networking, Biometric systems, Satellite positioning systems, and Web-based systems.

This project aims to design a technological universal system solution and integrated set of smart software and hardware applications to enable access of PWD to ICTs to carry out their knowledge work effectively and efficiently. It would contain and integrates state-of-the art AmI' key enabling technologies. The proposed scenario will use assistive technology, such as smart software and hardware network solution that are aligned to the track of enabling technology. A smart help and smart editor will be developed using voice recognition to allow PWD to smartly getting help from the server using voice recognition, as well as communicating with others easily using flexible interface that is adaptable to different impairment conditions. In addition, a smart system call will be developed to allow PWD to call other people using voice recognition and Voice over IP technology. Furthermore, an intervention algorithm would track the movement of PWD according to scheduled events and predefined behavior and alert PWD users for misbehaving as well as guide them and remind them for the scheduled events. The solution provided in this paper assist PWD users at the workplace to become productive and enjoying their work through universal smart system that has auto adjustable interface which would be relevant for most of PWD cases to satisfy their needs.

## II. LITERATURE REVIEW

Due to the several factors, including economic and technological advancement, the researches on assistive technologies continually expands. The emergence of ambient intelligence in the last decade, the development in mobile and network technologies and machine learning and intelligent devices, have encouraged more researchers and practitioners to address the issues of developing smart technological solutions for PWD in different environments, mainly homes and hospitals.

In this section, we review the literatures relevant to smart solutions for PWD, with particular focus on the workplace environment. Different assistive applications exist currently in the areas of training, rehabilitations, and support of PWD within different environment. Toward a universality of user interface design, Keates et al. [10] presented a methodological design approach for implementing inclusive interface design for people with different capabilities. They used two case studies to illustrate the use of the model. The first details the design of an interface for an interactive robot. The second looks at the design of an information point for use in a post office workplace. Relevant to this research, Lange et al. [11] considered making use of the advances in computing power, software and hardware technologies, virtual reality (VR), and gaming applications to potentially address challenges for a range disabilities. He discussed an approach for maximizing function and participation for those aging with and into a disability by combining task-specific training with advances in VR and gaming technologies to enable positive behavioral modifications for independence in the home and community.

Concerning the use of assistive systems, A useful research that involves an application of smart technologies in the home environment is [12] who developed an automated smart home-based prompting system for smart interventions in home environments. They developed a fully automated a prompting system without any predefined rule set or user feedback. They used simple off-the-shelf sensors and learn the timing for prompts based on real data collected. They described PUCK (Prompting Users and Control Kiosk), which is a system that automates activity prompts in a smart home environment by identifying the steps at which prompts are required. Also, Chang et al. [13] used a location-based task prompting system to assess the possibility of training two individuals with cognitive impairments in a supported employment program. They concluded that data showed that the two participants significantly increased their target response, thus improving vocational job performance during the intervention phases.

Related to the utilization of assistive technology to aid persons with neuromuscular disabilities, Barrena et al. [14] compared two methods for voice control of household devices through an input-output board driven by an Android application on a smart phone. They used and tested two types of voice recognition software, online Google and offline Pocket sphinx, for accuracy of several commands on a television remote. They enabled the execution of a command through the interface of the smart phone with a television remote. Barrena tested the applications for accuracy depending on distance between person and device as well as level of ambient noise. Mulhern [15] continued the work done in [14], to improve upon previously created offline voice control of household devices through an input-output peripheral interface control processor driven using an application on the Galaxy S Android smart phone. They pointed out that, in trial, the most effective type of voice recognition software for offline communication was Pocket sphinx, and that this offline capability is used and tested for accuracy of several commands on a direct television remote

though the exchange of Bluetooth signals between the phone (input) and transfer station (output). The application was designed to recognize key word commands and send signals to corresponding pins on the input-output board. Hakobyan et al. [16] conducted a research on making mobile phones and other handheld devices accessible via touch and audio sensory channels for the visually impaired persons. They discussed innovative assistive applications designed for the visually impaired that are either delivered via mainstream devices and can be used while in motion or are embedded within an environment that may be in motion (e.g., public transport) or within which the user may be in motion (e.g., smart homes).

Kbar & Aly [17] proposed a technological scenario for the Ambient Intelligence (AmI)- based assistive technologies at the workplace consisting of an integrated and connected set of smart software and hardware technologies to be designed to empower the Physically disabled persons with the capability to access and effectively utilize the ICTs in order to execute knowledge rich working tasks with minimum of effort and with sufficient comfort level. The proposed technology solution for PWD includes smart editor using voice recognition that enable them to edit and document their work smartly through animating of the mouse cursor movement to track the editing without the need to use their hands. It also enables PWD to get help from the network using smart help engine that is based on voice recognition. This proposed technology solution was intended to enable PWD at the work environment using voice to conduct their work tasks as normal persons. Relevant to the utilization of software to empower the PWD in the workplace, Chang et al. [18] assessed the possibility of training three people with cognitive impairments using a computer-based interactive game. They designed a game to provide task prompts in recycling scenarios, identify incorrect task steps on the fly, and help users learn to make corrections. Based on a multiple baseline design, the data showed that the three participants considerably increased their target response, which improved their vocational job skills during the intervention phases and enabled them to maintain the acquired job skills after intervention. Angkananon et al. [19] focused on designing accessible mobile learning interactions involving disabled people using a newly developed Technology Enhanced Interaction Framework. Their framework was developed to help design technological support for communication and interactions between people, technology, and objects particularly when disabled people are involved. Lahav et al. [20] presented the integration of a virtual environment (BlindAid) in an orientation and mobility rehabilitation program as a training aid for people who are blind. They stated that the BlindAid allows the users to interact with different virtual structures and objects through auditory and haptic feedback. They explored the question whether the use of the BlindAid in conjunction with a rehabilitation program can help people who are blind train themselves in familiar and unfamiliar spaces. The study, focused on nine participants who were congenitally, adventitiously, and newly blind. They implemented the research using virtual environment (VE) exploration tasks and

orientation tasks in virtual environments and real spaces. The results demonstrated that the BlindAid training gave participants additional time to explore the virtual environment systematically. Secondly, it helped clarifying several issues concerning the potential strengths of the BlindAid system as a training aid for orientation and mobility for both adults and teenagers who are congenitally, adventitiously, and newly blind.

The above literature reveals that in spite of the so many applications conducted in the area of assistive technologies. A relatively few numbers of research attempts addressed the issue of developing a universal smartly accessible software that satisfy the needs for large group of PWD. Over and above, very few or even rare if not existing the attempts to develop smart software assistive technologies to empower the PWD in effectively and easily conducting his tasks in the workplace. This is actually the main concern and target of the research presented in this paper, where adaptable flexible users interface to support the needs for PWD with different impairments conditions should be addressed as well as providing relevant intervention support to guide PWD users according to expected behavior as well as respond the their emergency need in case loosing focus . The following section will introduced the proposed smart help and communication system to assist the PWD, where smart editor will be covered in future articles.

### III. DESCRIPTION OF THE PROPOSED WORK

In order to assist the PWD at the office so they can be productive and able to interact with other people smoothly, smart system applications is being developed for this purpose as shown in Fig. 1. This includes a smart editor that is based on voice recognition, a smart help that relies on existing network at the work environment. The project is aiming to develop 2 main solutions that will assist disable people at the working environment. First solution is a program that will simulate the mouse movement during the execution of the editing program which is based on voice recognition to determine the right action to be taken by caller according to the context of the sentence/word of the caller. But the scope of this paper is the second solution which is a Smart help that allows PWD users to retrieve relevant guiding information from the help server using voice recognition which will translate the voice into text and then into command to get information from the server.

The smart help is based on network setup using WIFI and flexible interface screen for the PWD person that is based on voice recognition. If PWD person need to access information from the server to assist him/her on retrieving some guidance, they can speak relevant words to open the help program, and then read the selected words that are associated with certain help functionality. The engine of the voice recognition of the smart help will be able to recognize the selected word and execute the relevant command which will communicate with the help server to retrieve the right information and display them on the smart help screen of the PWD person.



Fig. 1 Network System for PWD at Workplace

Smart help aims to design a universal smart help system that covers variety of impairment conditions using flexible interface at the same program, with reach relevant features that makes PWD comfortable and productive at the workplace.

The following describes the objectives and benefits of the Smart Help:

#### A. Flexible Adaptable Interface

The project is aimed to design a smart help system that assists PWD at the work environment by providing a flexible adaptable interface that suits different PWD people with different impairment conditions according to predefined and customized profiles as shown in Fig. 2. The flexible adaptable interface would be driven by PWD users using voice command control as well as keyboard, touch screen and mouse movement. This interface would be adaptable to display different font size, different font color, different window size, different input mic level and different volume level according to the different characteristics of PWD that are stored in his/her profile. The profile of PWD users would be setup automatically at the time he/she log-in in the device by recognizing the user characteristics using RFID or through voice command driven speech. Furthermore, PWD can also customize their default profile to override the predefine one.

#### B. Universal Interface

In addition the SHW-PWD would provide a **universal interface** with all relevant features needed for PWD at the work environment to be able to handle computer terminals smartly and the ability to search for relevant information and communicate with others effectively as shown in Fig. 3. PWD users would be able to interact with environment using a voice command driven event or through touch screen and mouse movement. As shown in Fig. 3, PWD user selected from the help command list employees' names, where the name of employees working at the same building is displayed on the top right corner. PWD user would then select a particular user (using speech and voice recognition or through touch screen) from the employees' list to communicate with. Then from the active executed command list on the left window, PWD selected user call option to communicate with the selected user, where the result would be displayed on right bottom window with options of sending SMS, sending email, chat or call the selected user. The results that will be displayed on the active command list as well as the one displayed on the result right top and bottom windows would be adjusted according PWD user profile group, where relevant font color and size as well as relevant volume and window size that would match the

characteristics of PWD profile.

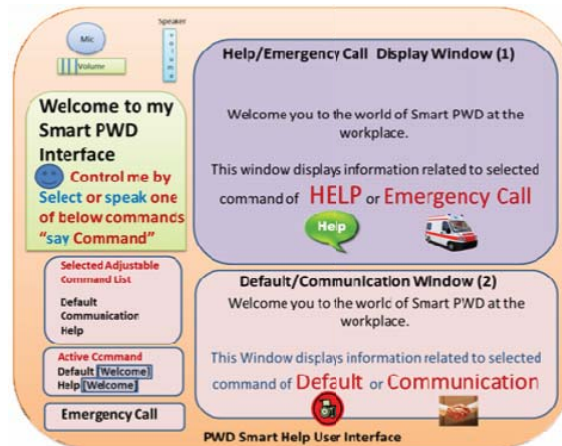


Fig. 2 Smart Help Interface for PWD

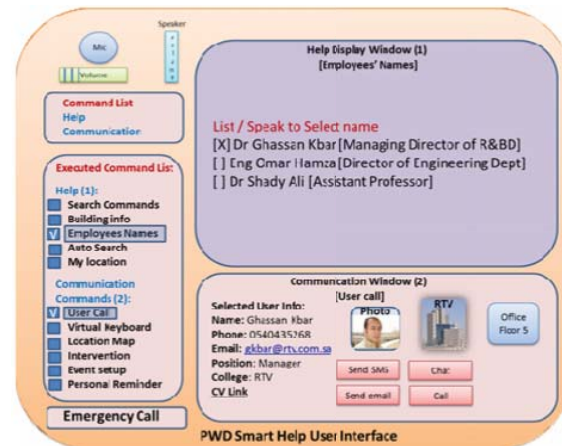


Fig. 3 Example of using help and communication command in the Smart Help Interface

#### C. Help Emergency Response

Furthermore, the solution would provide **help emergency response** that covers difficult situations for PWD to assist them in getting the right help and guidance them to solve their problems. The emergency call will be handled by the Emergency Auto Response (EAR) Program installed on server as illustrated in Fig. 4. The client terminal attached to PWD user will be tracked continuously by the EAR program through WIFI access point that is connected to the EAR server through wired or wireless connection, and the location data will be stored in the MSQl server (sequence 1). If PWD user issues an emergency call through speech or by pressing a button, a signal will be sent to EAR server (sequence 2), where the EAR program would then request the location and map from MSQl server to identify the user ID and its location (sequence 3). Then the EAR server will send a reply to PWD user terminal with few options as indicating the type of help they require further assistant. The message received at requested PWD terminal would be played to PWD and

displayed on the terminal to choose one of the help he/she wants (sequence 5). PWD user will then speak the chosen option which will be sent to EAR server (sequence 6) and to be analyzed by the EAR for further action (sequence 7). If the response coming from PWD is according to the type of help that was sent to him/her then a guidance message will be sent to PWD again (sequence 8 with new message).

*D. Smart Intervention*

Moreover a smart intervention feature would also be supported that allows the system to track PWD movements and guide them to achieve their planned events or in the case of miss guidance and lost. PWD will be tracked on the system to determine its movement on the workplace and in addition to its profile and personal data that have been stored on the system as well as time schedule for meeting, taking medication, break and work, the system will analyze the data

to determine the PWD behavior and update its preference on the system. During the analysis of this data and according to PWD movement at the workplace, it can predict the next action associated with a particular movement and predict any abnormality associated with the movement and issue an alert to PWD terminal for missing or misbehaving as well as issue a warning message to their caregiver about the possible wrong action if it is ranked as serious.

The two solutions (smart editor and smart help) that will be developed by the research team will allow PWD person who can't use their hands to control the necessary applications to interact with the office environment and other people using a smart voice recognition engine. The smart voice recognition engine is the hand of the PWD person, where they will feel like a normal person who can run applications using their hands.

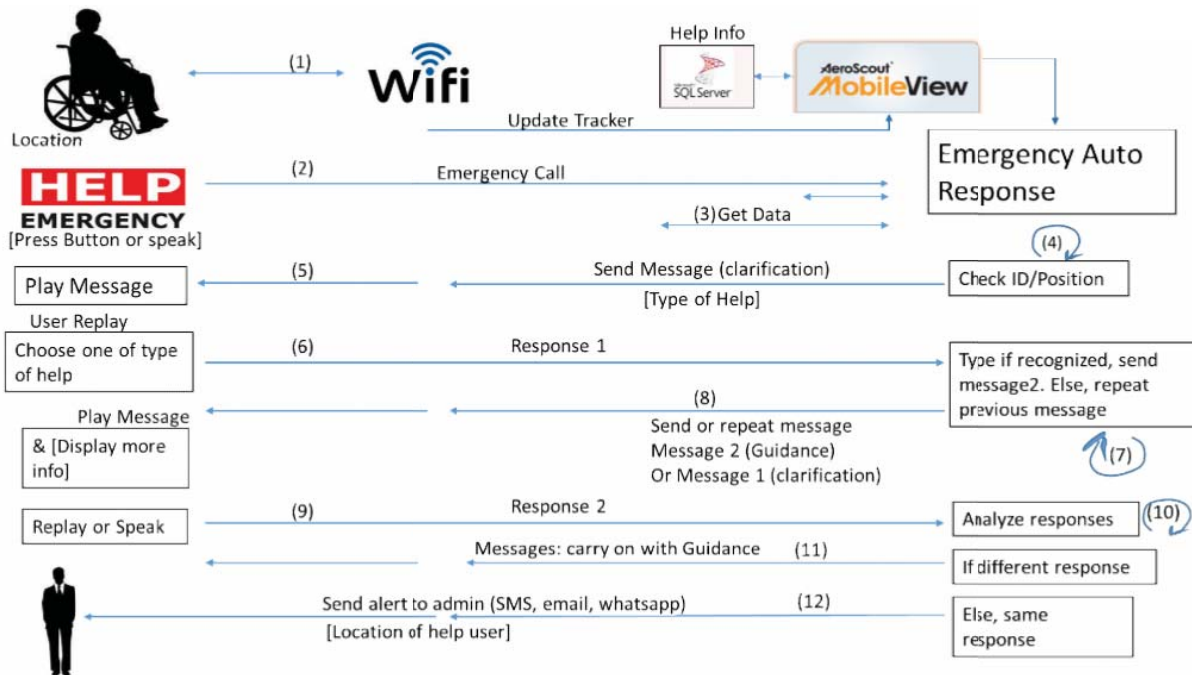


Fig. 4 Sequence diagram of Emergency Auto Response & Help program

IV. ANALYSIS OF SMART HELP FOR PWD

In order to cover the different PWD categories according to impairment conditions of the PWD, we assume that PWD must at least be able to see, or partially see, but they can hear or partially hear, they can move hand or not, and they can speak or not. Hence, Tables I and II identify the different combinations according to different PWD impairments. The flexible interface would be designed to accommodate all conditions of these groups by adjusting the Mic volume, the speaker volume, and the font color, the size of font and the display window size and color.

*A. Intervention Method - Analyze & Predict of PWD Behavior (Mathematical Algorithm)*

Assume a set of *know behaviors* is known as **A**, which include behavior **a**<sub>1</sub> to **a**<sub>n</sub>, where **a** ∈ **A**, and **a** has a set of parameters **x**<sub>1</sub> to **x**<sub>n</sub>, **a** (**x**<sub>1</sub>, **x**<sub>n</sub>).

The *current behavior* is known as **A'** which includes behaviors **a'**<sub>1</sub> to **a'**<sub>n</sub>, where **a'** ∈ **A'** and **a'** has a set of parameters **x'**<sub>1</sub> to **x'**<sub>n</sub>, **a'** (**x'**<sub>1</sub>, **x'**<sub>n</sub>).

To determine if the current behavior is expected or not, first we need to test if the current behavior of PWD is included in the normal behavior, then after that we need to check if the action movement of the current behavior is leading to the correct expected movement direction, where we can decide if

it would be a regular normal correct behavior, else it would be a suspicious behavior.

- To test if the current behavior is included within the set of normal behavior we need to check if all parameters of the current behavior match the parameters of the equivalent normal behavior in the list, where it will be true if:

$$a'(x'_1) = a(x_1) \text{ to } a'(x'_n) = a(x_n)$$

For example the personal note shows that there is a valid scheduled meeting of current behavior ( $a'_1$ ) with the following

parameters: right room number ( $x'_1$ ), right floor ( $x'_2$ ), right room coordinates ( $x'_3$ ), right date ( $x'_4$ ), and right time ( $x'_5$ ).

The set of known behaviors are:

- $a_1$  = going for Meeting
- $a_2$  = accompanying Visiting person
- $a_3$  = Attending event
- $a_4$  = having Break
- $a_5$  = Leaving the workplace
- $a_6$  = Coming to work
- $a_7$  = going to Toilet

Since  $a'(x'_1) = a(x_1)$  to  $a'(x'_n) = a(x_n)$ , then  $a'_1(x'_1, x'_n) = a_1(x_1, x_n) =$  going for Meeting, then  $a'_1$  is a subset of  $A$ .

TABLE I  
GROUP OF IMPAIRMENTS

Requirements	Category	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Must	See	√	√	√	√	√	√	x	x
Must if can't fully see	Partially see	x	x	x	x	x	x	√	√
Optional if see & must if partially see	Hearing	x	x	√	√	x	√	√	√
Must if not moving hand & could be if move hand	Speak	√	x	√	x	√	√	√	x
Must if not speaking & could be if speaking	Move hand	x	√	x	√	√	√	x	√

TABLE II  
GROUP OF IMPAIRMENTS [PARTIALLY HEARING]

Requirements	Category	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14
Must	See	√	√	√	√	√	√
Must if can't fully see	Partially see	x	x	x	x	x	x
Optional if see & must if partially see	Hearing	x	x	√	√	x	√
Must if not moving hand & could be if move hand	Speak	√	x	√	x	√	√
Must if not speaking & could be if speaking	Move hand	x	√	x	√	√	√

*B. Algorithm for Determining the Direction of PWD Movement within the Building*

To check the movement of the current behavior and predict if it leads to correct expected movement direction then we need to check the following:

Assume that PWD is moving to target location (meeting room according to behavior  $a_1$  with room coordinate  $a_1(x_3) = (T_x, T_y)$ , the current PWD user coordinate location is  $(C_x, C_y)$ , and the updated PWD user coordinate after **period of T** is  $(C'_x, C'_y)$ .

There are four possible relative location of PWD in relation to target room  $a_1$  as follow:

- $C_x > T_x$  &  $C_y > T_y$  (Group location A, Current position (Pa) North-East; target (Ta) south-west)
- $C_x > T_x$  &  $C_y < T_y$  (Group location B, Current position (Pb) east-North; target (Tb) west-south)
- $C_x < T_x$  &  $C_y > T_y$  (Group location C, Current position (Pc) South-West; target (Tc) North-East)
- $C_x < T_x$  &  $C_y < T_y$  (Group location D, Current position (Pd) South-West; target (Td) North-East)

The following presents the possible movement direction to determine if it is heading to target location or not:

For Group A: if  $C'_x$  ↓ decreases compare to  $C_x$  &  $C'_x(-T)$ , and  $C'_y$  ↓ decreases compare to  $C_y$  &  $C'_y(-T)$ , then object is moving right direction, else moving in false direction, where  $C'_x$  is the current coordinate location of user,  $C'_x(-T)$  is the

previous coordinate location of user, and  $C_x$  is the original coordinate location of user.

For Group B: if  $C'_x$  ↓ decreases compare to  $C_x$  &  $C'_x(-T)$ , and  $C'_y$  ↑ increases compare to  $C_y$  &  $C'_y(-T)$ , then object is moving right direction, else moving in false direction.

For Group C: if  $C'_x$  ↑ increases compare to  $C_x$  &  $C'_x(-T)$ , and  $C'_y$  ↓ decreases compare to  $C_y$  &  $C'_y(-T)$ , then object is moving right direction, else moving in false direction.

For Group D: if  $C'_x$  ↑ increases compare to  $C_x$  &  $C'_x(-T)$ , and  $C'_y$  ↑ increases compare to  $C_y$  &  $C'_y(-T)$ , then object is moving right direction, else moving in false direction.

V. CONCLUSION

Smart Help (SHW-PWD) solution that is a part of the project SMARTDISABLE has been presented. This covers the design scenario of universal smart system software interface that provides the needed features for PWD at the workplace to assist them in communicating effectively with others using smart flexible dynamic interface that is adaptable to the different impairment conditions associated with different PWD groups. In addition, the solution will provide auto emergency response to cover difficult scenarios facing PWD that makes them not functional due to stress or other harsh conditions. Furthermore, the solution will support smart intervention that keep track the movement of PWD and

determine their behaviors and guide them to right one in case they misbehave or forget their schedule events.

The SHW-PWD would improve the environment conditions for PWD at the workplace and make their life easier and productive with the use of flexible computer interface that is auto dynamic, and interactive according to PWD needs.

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