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Proposing a Smart and Intelligent System to Assist the Blind Community Based on Advance Technologies

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Abstract: Blind community or visually impaired persons have limited access and capabilities to participate in the society equally thus resulting in isolation of the blind community. The problem of blindness is more prominent under desert climatic conditions due to sand storms, dry and harsh environment. In Saudi Arabia, the problem of blindness is more common among the nomads living under open temporary houses. This study proposed a smart and intelligent system based on multi advance technologies such as Wireless Sensor Network (WSN), Radio Frequency Identification tags (RFID), Global Positioning System (GPS), speech guidance and map navigation to help and assist the blind community under controlled conditions such as within campus or community. The proposed smart and intelligence system will help blind community to engage into community by providing the feel and fun of participating with real routine life. The average speed for NPT, BPT, VIB and VIA was 0.58, 0.22, 0.29 and 0.39, respectively for both inside and outside building locations. The proposed AMAT system improved the access time for VIA and VIB groups by only 33 and 17%, respectively. The proposed system showed a significant performance by the visually impaired persons for efficiently reaching to targeted locations by avoiding obstacles smoothly.

Key words: Wireless sensor network, global positioning system, radio frequency identification, reliability, satellite

INTRODUCTION

Humanity has always high importance and the blind community is an essential part of the humanity. All the innovations and technologies are developed to make the human life easier and comfortable with each aspect. However, the blind community visionary disability would reduce their chance of using such innovated products. Therefore, blind community considered themselves as a burden for the society and they do not engage in basic routine activities which results in isolating the blind people from the society.

Visual impairment can result at any stage of life. For example, it can result by birth borne blind naturally. The visually impaired community can be specified in three different groups as follows:

Visually impairment people by birth (VIB): Generally, this group of community is less enthusiastic to participate in additional normal life activities. The VIB community mainly faces severe problem to navigate the surrounding environment easily. As this group is not familiar with the architectural structure of paths, roads, buildings and different kinds of obstacles, it is hard for this group to recognize the intensity of loss caused by any accident with obstacles. They are only aware of obstacles within their building by their counted steps. This is achieved by feeling those obstacles which are touchable and elevated on ground. A comprehensive smart and intelligent system support is required to enable appropriate navigation for this community group.

Visually impairment people caused by accident (VIA): This group of community is highly enthusiastic to participate in normal and additional life activities. The VIA community group can navigate the surrounding environment. Because, this group is familiar with the architectural structure of paths, roads, buildings and different kinds of obstacles. A simple smart and intelligent system support is required to enable appropriate navigation for this group.

Partially visually impairment people (PVI): This community group has very low or weak vision capabilities by birth or caused of any accident. This group of community is also enthusiastic to participate in normal and additional life activities with a smart support. The PVI community group can easily be engaged in the

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surrounding environment with less guidance. This group is familiar with the architectural structure of paths, roads, buildings and different kinds of obstacles. Therefore, it is easy for this group to recognize the intensity of harm caused by any obstacles in the case of an accident. A simple and smart system support is required to enable appropriate navigation for this group.

Some people are born naturally handicapped. Others have unfortunate life with some forms of disabilities caused by accidents, diseases or other factors (WHO, 2011). Due to difficulties to mixed with the society comfortably, these groups of people have segregated their life at an end corner without good understanding and support from the society. The worst scenario is that when equal opportunity is not provided to them to do the same as that of the normal people, or the opportunity itself may have been taken away from them. As a result of this, their desire has been limited to freely mix around with the society. Besides, their capability to participate in physical activities is also limited due to their dependence on others.

Currently, the vision of many blind associations is to resolve the segregation issue and the limited capability experienced by visually impaired people. For instance, the deep belief in the rights of the blind to merge in the society and to show up their capabilities and their great hidden potentials was the base for attempts carried by many parties to resolve the issues (Qatar Social and Cultural Center for the Blind, 2011). The assistive technology, both the software (DAISY, a JAVA/XML open-source content management system) and the hardware (Braille/white cane), has always contributed in improving the literacy and independence of blind people. However, the available solution so far was based on limited audio description (Rogers and Braun, 2007) with no capability of the system to get a user immersed and engaged into a situation properly. Furthermore, the solution was limited to only applications of movie and video game. The few other supportive systems are also proposed by literature review to help them by keeping active and engaged (Vincenty, 1975). The proposed systems include the followings:

- **Drishti:** An Integrated Navigation System for blind and disabled community is based on wireless pedestrian navigation system. It integrates many technologies including wearable computers, voice recognition and synthesis, wireless networks, Geographic Information System (GIS) and Global positioning system (GPS) according to Telos B Wireless Sensor Node, Moteiv Corporation (2006)
- **Braille Note GPS:** Braille Note GPS is a kind of talking digital map. It uses a cell-phone size GPS receiver sensor to relay the location information from GPS satellites. It can calculates your existence location and can plots the route to your destination you choose with Telos B Wireless Sensor Node according to Moteiv Corporation (2006) and Shelby *et al*., 2003)
- **GPS-GSM mobile navigator:** This system works on the basis of (GPS) and Global System for Mobile (GSM) technology by combining both of them at same time. The navigator is a microcontroller-based system equipped with a GPS receiver and a GSM module. The working principles of the above Location Based Service systems have been utilized in the invention of a route guidance system for the Visually Impaired (Shelby *et al*., 2003; Ansari *et al*., 2007; Yun and Kim, 2007)
- **Secure and Safe Mobility Network (SESAMONET):** This system used Radio Frequency Identification Tags (RFID) technology for user location and tracking (D'Atri *et al*., 2007). The SESAMONET works in the format of a grid where RFID tags are buried up to a certain level, while a reader is attached to cane to read the values when it moves on the tags. The data then sent to the Personal Digital Assistant (PDA) for calculating the required location
- **iCane:** This system also works similar to SESAMONET and uses the same technology for person localization (Chang *et al*., 2005). The above proposed systems have limitations to provide hassle free movement to blind community and in some cases few proposed system are heavy in weight and creates trouble in carrying them during move

The theme of this study was to bring the blinds and visually impaired people to their routine life by maximizing their participation with the routine life activities. To achieve this, a merger of multi advance technologies is required to overcome this issue appropriately. The main objectives of this study were 1: To propose an Adopted Multiple Advance Technologies (e.g., WSN, GPS, RFID) to help the blind community to participate in the normal society on equal basis by providing assistance and guidance, 2: To develop an assisting tool or navigation system which makes free move possible for blind community and to provide an equal chance and opportunity for the visually impaired people to live their routine lives.

PROPOSED APPROACH

The blind community needs help and attention to actively participate with routine life rather to live isolated life. The study proposed an Adopted Multi Advance

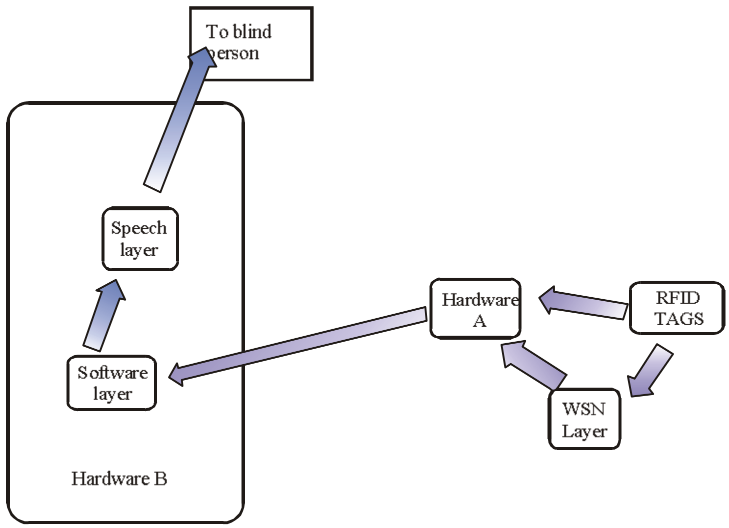

Fig. 1: Overview of the adopted multi advance technologies system

Technologies (AMAT) such as GPS, RFID, WSN, Speech Recognition and maps technology. The AMAT can work in two scenarios for blind community. First scenario is based on using the daily life routine use locations. These destinations include both inside the building and outside locations (e.g., park, walking path). Second scenario is based on introducing new locations where blind people have not visited on their routine. The functioning of proposed AMAT system relies on different components which are divided into layers as shown in Fig. 1.

With the assumption that the blind person is inside a building. The proposed system reads obstacle data through RFID fetched tags. The reading process is achieved when the cane reaches to the range of any obstacle. This data is then forwarded to software layer through hardware A to calculate the location and distance of the obstacle by using predefined GPS maps. Finally, the speech layer converts the obtained data from the software layer into audio form (speech). This speech can guide the blind person inside the building.

On the other hand, with the assumption that the blind person is outside the building. The blind person can also obtain additional information about his path as well as obstacle around him. The RFID tags are either buried on path or fetched with obstacles little far from the blind person. A Wireless Sensor Network (WSN) based on mesh topology is placed in active mode to read the data of surrounding obstacles. This WSN passes the obtained data to the proposed system. The later phases will remain same for this scenario as of first scenario.

Hardware layer: Hardware layer consist of two parts A and B as shown in Fig. 1. Part A of Hardware is attached at end of the cane (stick for blind people) to read RFID tags information when a person is inside or outside a building. However, part A of Hardware can read the data through WSN nodes for obstacles far away from the path when the blind person is outside the building.

Part B of Hardware is placed in the pocket. This hardware has two software such as GPS based software and text to speech conversation software. The GPS based software calculates the exact location and additional information about obstacles (e.g., name, size and type of obstacle). On the other hand, speech layer converts the available information into audio format.

RFID tags: The RFID tags are attached with obstacles inside the buildings. On the other hand, they are buried along the pathway for outside locations. For outside obstacles which are far from the pathway, tags are mounted with such obstacles. These tags contain obstacle information (e.g., name, size and type of obstacle).

WSN layer: As said earlier in the second scenario, WSN nodes are deployed outside buildings. WSN Layer will cover surrounding obstacles which are far away from the blind person path and out of the range of Cane RFID reader. This layer then forwards the surrounding obstacles information to the blind person.

Software layer: Software layer receives the abstracted information obtained by the previous layers. It will then compare such information with the available GPS marked locations for certain selected area. This is achieved by computing and updating the available information regarding obstacles with its exact location and other additional information. After that the software layer passes such information to the speech layer.

Speech layer: Speech layer plays a significant role in the proposed model. It receives all computed and updated information in text format from previous layer and converts such information into audio format. This information in its new format is passed to the blind person.

RESULTS AND DISCUSSION

Tested model used: For testing and validation of the proposed model AMAT, a tested data set was used based on literature review (Amutha and Ponnavaikko, 2009). The model aimed to compare the access time to reach different identified objects for normal and blind people. The model was based on distance measured in meters by counting steps for normal and blind people. For example, it was found that 0.58 m distance required 1 and 2.7 sec for normal person and blind person, respectively. The AMAT system is proposed for testing and validating two different cases i.e., VIB and VIA. The third case PVI is eliminated by considering that partially impaired person requires less help and support.

The proposed system was tested through different simulation tests based on visually impaired people by birth and visually impaired people by accident. The results of access time for both VIB and VIA were compared to the access time required by normal people (NPT) as well as blind people (BPT) who are not using AMAT system. Simulation results were based on two different scenarios. First scenario was based on using the daily life routine locations. These destinations include both inside the building and outside locations (e.g., park, walking path). Second scenario was based on introducing new locations where blind people have not visited on their routine.

Daily life routine use locations: In this scenario, the proposed system AMAT aims to compare the access time required by the four different groups (VIB, VIA, NPT and BPT) to reach certain daily life routine use locations. Such locations include both inside and outside building destinations. The results of access time in this case are presented in Table 1 and 2, respectively. It is noted that the average speed obtained by each group for both inside and outside building locations were exactly the same. For example, the average speed for NPT, BPT, VIB and VIA was 0.58, 0.22, 0.29 and 0.39, respectively for both inside and outside building locations.

Table 1: Performance of the proposed AMAT system based on targeted daily life inside building locations required by the four groups

No.	Distance	NPT	BPT	VIB	VIA
1	9.28	16	43.24	32	24
2	9.28	16	43.24	32	24
3	10.44	18	48.65	36	27
4	15.66	27	72.97	54	40.5
5	16.82	29	78.38	58	43.5
6	17.4	30	81.08	60	45
7	18.56	32	86.48	64	48
8	20.88	36	90.00	72	54
9	22.04	38	102.07	76	57
10	22.6	38	105.31	76	57
11	25.52	44	118.92	88	66
12	26.1	45	121.62	90	67.5
13	26.15	45	121.85	90	67.5
14	26.68	46	124.32	92	69
Average	19.10	32.86	88.48	65.71	49.29
Speed	0.58	0.22	0.29	0.39	

NPT: Normal people, BPT: Blind people, VIB: Visually impaired by birth, VIA: Visually impaired by accident

Table 2: Performance of the proposed AMAT system based on targeted daily life outside building locations required by the four groups

No.	Distance	NPT	BPT	VIB	VIA
1	28.42	49	132.43	98	73.5
2	29	50	135.14	100	75
3	30.7	52.9	143.48	105.8	79.35
4	31.9	55	148.65	110	82.5
5	34.8	60	162.16	120	90
6	38.86	67	181.08	134	100.5
7	40.6	70	189.19	140	105
8	40.6	70	189.19	140	105
9	42.34	73	197.3	146	109.5
10	46.44	80	216.41	160	120
11	69.02	119	321.63	238	178.5
12	69.6	120	324.33	240	180
13	86.42	149	402.71	298	223.5
Average	45.29	78.07	211.05	156.14	117.10
Speed	0.58	0.21	0.29	0.39	

NPT: Normal people, BPT: Blind people, VIB: Visually impaired by birth, VIA: Visually impaired by accident

The results in Table 1 and 2 demonstrate the capability of the proposed system AMAT in reducing the access time required by blind people, particularly in the case of visually impaired people by accident. Application of AMAT system on VIA group improved the access time associated with the blind people who were not getting any help by about 44%. On the other hand, the access time of VIB group decreased through AMAT by about 26% compared to BPT. The proposed system AMAT achieved this by converting the obstacle information (e.g., name, size and type of obstacle) into audio form (speech).

Visiting new locations: This scenario was based on introducing new locations which the blind people have not visited. Table 3 and 4 present the access time results

Table 3: Performance of the proposed AMAT system based on targeted new inside building locations required by the four groups

No.	Distance	NPT	BPT	VIB	VIA
1	9.28	16	55.68	46.4	37.12
2	9.28	16	55.68	46.4	37.12
3	10.44	18	62.64	52.2	41.76
4	15.66	27	93.96	78.3	62.64
5	16.82	29	100.92	84.1	67.28
6	17.4	30	104.4	87	69.6
7	18.56	32	111.36	92.8	74.24
8	20.88	36	125.28	104.4	83.52
9	22.04	38	132.24	110.2	88.16
10	22.6	38	135.6	113	90.4
11	25.52	44	153.12	127.6	102.08
12	26.1	45	156.6	130.5	104.4
13	26.15	45	156.9	130.75	104.6
14	26.68	46	160.08	133.4	106.72
Average	19.10	32.86	114.40	95.50	76.40
Speed	0.58	0.17	0.20	0.25	

NPT: Normal people, BPT: Blind people, VIB: Visually impaired by birth, VIA: Visually impaired by accident

Table 4: Performance of the proposed AMAT system based on targeted new outside building locations required by the four groups

No.	Distance	NPT	BPT	VIB	VIA
1	28.42	49	170.52	142.1	113.68
2	29	50	174	145	116
3	30.7	52.9	184.2	153.5	122.8
4	31.9	55	191.4	159.5	127.6
5	34.8	60	208.8	174	139.2
6	38.86	67	233.16	194.3	155.44
7	40.6	70	243.6	203	162.4
8	40.6	70	243.6	203	162.4
9	42.34	73	254.04	211.7	169.36
10	46.44	80	278.64	232.2	185.76
11	69.02	119	414.12	345.1	276.08
12	69.6	120	417.6	348	278.4
13	86.42	149	518.52	432.1	345.68
Average	45.29	78.06	271.71	226.42	181.14
Speed	0.58	0.17	0.20	0.25	

NPT: Normal people, BPT: Blind people, VIB: Visually impaired by birth, VIA: Visually impaired by accident

for the four different groups. As noted in the previous section that the average speed obtained by each group for both the new inside and outside building locations were exactly the same. For example, the average speed for NPT, BPT, VIB and VIA are 0.58, 0.17, 0.20 and 0.25, respectively for both inside and outside building locations. Another important outcome of the simulation results was observed by considering the results of Daily Life Routine Use Locations together with those of visiting new locations. Based on these results, it is clear that effectiveness of the proposed system AMAT under the second scenario is reduced. For example, the proposed AMAT system improved the access time for VIA and VIB groups by only 33 and 17% , respectively. There was a reduction in second scenario performance obtained by the proposed AMAT system by about 10% as compared to the first scenario. The reason of such performance reduction is due to the fact that dealing with new locations is more challenging for blind people.

CONCLUSION

This study presented a smart and intelligent system based on Adopted Multi Advance Technologies (AMAT). The proposed system was composed of Wireless Sensor Network, Radio Frequency Identification tags, Global Positioning System, speech guidance and map navigation. The simulation results confirmed the usefulness of AMAT system in reducing the access time required by the blind people to reach different locations. It was also observed that there is a reduction in second scenario performance obtained by the proposed AMAT system by about 10% as compared to the first scenario. The reason of such performance reduction is due to the fact that dealing with new locations is more challenging for blind people.

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