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Novel Design of a Social Mobile Robot for the Blind Disabilities

Min-Fan Ricky Lee, Fu Hsin Steven Chiu, Chen Zhuo

***Abstract*— World Health Organization estimated that over 1 billion people are living with some form of disability. Some 110 to 190 million people live with significant disabilities. The number of guide dogs is far lower than the demand and only few visually impaired have access to qualified guidance dogs. This paper present an autonomous mobile robot system aimed for the service to the blind. The system includes a proof-of-concept appearance design as the human machine interface that consists of a stick and main body enveloping the mobile robot platform. The main body contains four modules as sensing, navigation, remote control and social platform. The appearance has a high quality texture demonstrated human factors engineering concepts emphasizing user-friendly interface. The stick has rotation joint design fitting the average human height. The length and angle of the stick is adjustable to user's height and can be used in separate from or combination with the main body. The system combines artificial intelligence, sensing, and navigation system that allows blind people to move in a free state.**

I. Introduction

United Nation projected 22% of the global population will be 60 or older by 2050. This will be the first time to reach an equal population proportion between children (14 or younger) and elderly (60 or older) [1]. This will accelerate the process of global aging and drastically increase health-care facility costs.

World Health Organization estimated that over 1 billion people (or approximately 15 percent of the world's population) are living with some form of disability [2]. Some 110 million to 190 million people (or 2 to 4 percent of the world's population) live with significant disabilities as shown in Figure 1.

Fig. 1. Statistics of blind disabilities in Global.

Min-Fan Ricky Lee is with the Graduate Institute of Automation and Control, National Taiwan University of Science and Technology, Taipei, Taiwan (phone: +886-981-719-066;email: rickylee@mail.ntust.edu.tw)

Fu Hsin Steven Chiu is with the Graduate Institute of Automation and Control, National Taiwan University of Science and Technology, Taipei, Taiwan (email: d9812005@mail.ntust.edu.tw)

Chen Zhuo is with the Department of Mechanical Engineering, University of British Columbia, Vancouver, BC, Canada (email:chrischen@alumni.ubc.ca)

The evidence shows that persons with disabilities are more likely to experience adverse economic and social outcomes. However, the number of guide dogs is lower than the number of demand as the statistics shown in Figure 2.

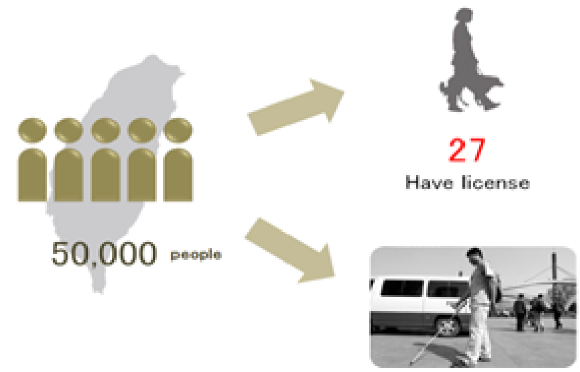

Fig. 2. Statistics of blind disabilities in Taiwan.

An autonomous and intelligent mobile robotic assistant system is proposed in this paper to make it possible for the disabled to live independently, safely and comfortably rather than move to a costly healthcare facility. The system works in a coordinated and efficient manner to carry out the tasks. The intelligent mobile robots navigate autonomously through the home environment and transmit the data through wireless network to the remote control center.

A robot manipulator is developed to assist workers with disabilities [3]. This robot manipulator is designed to carry out the task as PCB circuit testing and inspection of soldering.

An electromyographic (EMG) based semiautonomous human – robot interaction system is presented [4]. It allows the disabilities can send high-level commands to robot for some daily living activities.

A guide dog robot and a stereotyped motion following a person are developed. The guide dog robot consists of a mission planner, digital map, interactive navigator, vision system and undercarriage system [5].

A whole-field target tracking and following mobile robot system is developed based on a pan/tilt/zoom CCD vision system. The vision system scans and locks the pose of the moving target and commands the tracking mobile robot to follow the target while avoiding obstacles [6].

This paper proposed a novel appearance design and fabrication on an existing mobile robot to assist blind people to achieve independent living and communicate through established social networking. The mobile robot control system is presented in two other separate papers as the intelligent control system [7] and visual servo control system [8].

The proposed system in this paper aimed to build a guide robot connected to social network for blind disabilities. The designed HMI (human machine interface) allows a convenient operation. The autonomous navigation provides the optimal and collision free route. It significantly reduces the blind for fear of the unfamiliar environment and achieves intelligent communication with the environment.

II. Method

A robust telemedicine system is proposed [9-10] as shown in Figure 3 to facilitate interactive medical consulting between a patient in an underprivileged and rural village without hospitals and a doctor at a remote hospital. Providing easily-accessible and free medical services to such communities is to improve healthcare, save lives and be cost effective.

The system includes a new low-cost wearable vital sign monitoring outfit and telemedicine in a holistic manner by coupling healthcare and health education. Furthermore, an intelligent medical diagnostic system is developed to aid in more accurate medical decision making.

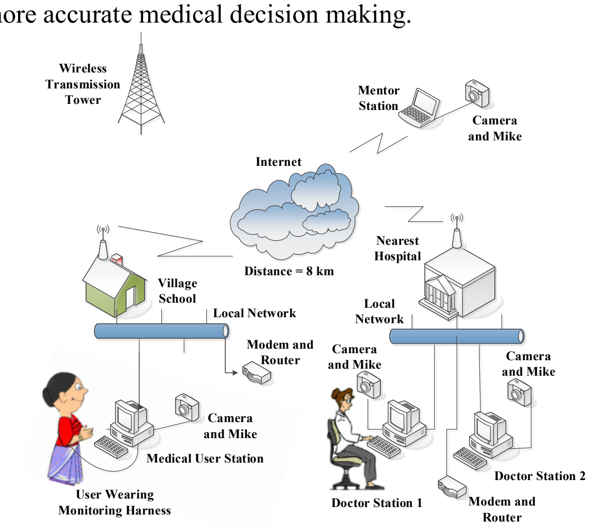

Fig. 3. Tele-medical system architecture [9-10].

Figure 4 indicates the system architecture of tele-medical with detailed explanation. All periphery plants are linked to central server or DAQ. These plants are client terminal, wireless communication hardware and data collecting terminal from which the DAQ receives information.

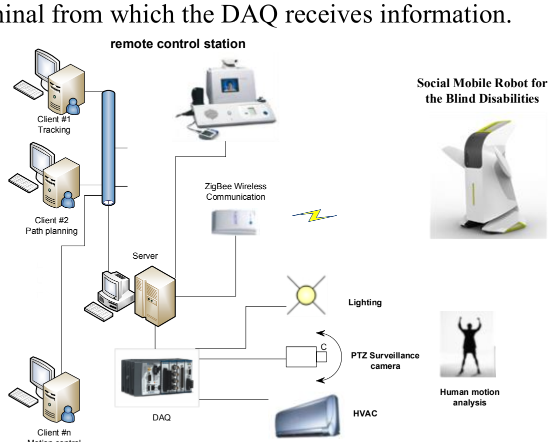

Fig. 4. Tele-medical system architecture.

The design concept shown in Figure 5 is to build a mobile robot as the mobility aids likes a guide dog. The robot detects visual information in the environment and communicates with the blind in real-time.

Fig. 5. Design concept and actual guide dog

The required function in the design is shown in Figure 6 includes mobility to move forward and upward, mechanism of rotation and retraction.

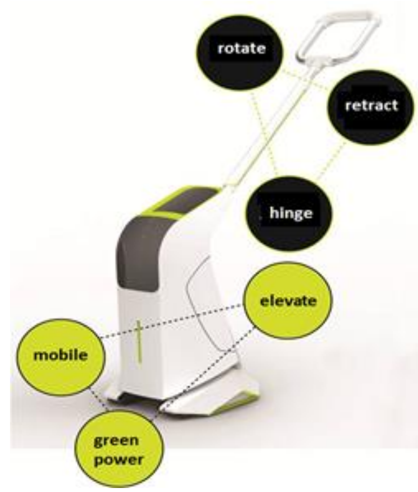

Fig. 6. Design consideration.

The bottom of the robot can convert kinetic energy into electrical energy and just a nudge can start the navigation as shown in Figure 7.

Fig. 7. Design feature: efficient energy.

The tactile sensor is mounted in the handler of the stick for the purpose of authorized access as shown in Figure 8.

Fig. 8. Design feature: personal identification.

The stick and the main body can be separated as shown in Figure 9. The stick can remotely control of the robot.

Fig. 9. Design feature: stick and main body connection.

Various sensors (i.e. sonar, laser, vision, infrared and tactile) are embedded in the robot are shown in Figure 10.

Fig. 10. Function diagram of the robot.

The proposed design aimed as a companion in the life of the blind significantly reduces the blind's fear of the unfamiliar environment. The system integrates artificial intelligence, visual sensing and navigation as shown in Figure 11.

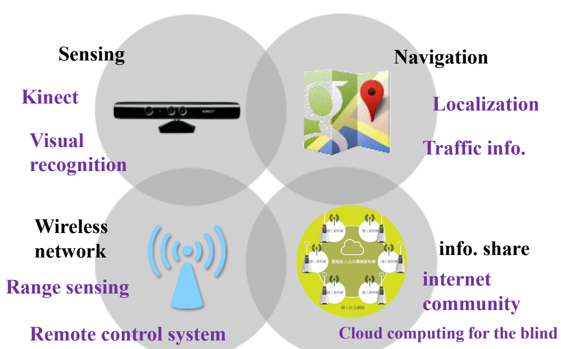

Fig. 11. Design feature.

Sensing system: Kinect sensing technique is applied to enhance sensing capability. The 3D camera provides the real-time video streaming and microphone input. Through image and voice recognition, the mobile robot interactively communicates the visual information to the blinds through the voice form. The advanced sensing technique allows the mobile robot to serve the designated person through artificial neural network learning.

Navigation System: GPS navigation system locates the user and connects the public transportation system through the network. The system recommends the optimal traffic path, and stores the histories in the database for mobile robot to make better and quicker decision according to the similar situation later.

Remote Control System: The robot can operate in different scenario/terrain through the sensors and the wireless network. The mobility, portability and convenience are achieved. The lower part (mobile robot) can be separated with the upper part (handle stick). The user can use the upper part (handle stick) to remotely control the lower part (mobile robot) in charge station.

Social Platform: The user database is constructed through cloud computing technology and is connected with the social network and public database. The users can build up the environment information specific for the travel of the blind group through the mobile robot. That information is used for the trip planning and the environment recognition for the blind.

Biomimetic designs take full advantage of spatial information its functional principle is to be the guardian of the safety of the blind, and relieving the master-slave relationship with the blind. Emphasize the shape of biologically gesture to bring out the kind of pet images consistent with human nature design essentials. Figure 12 shows the human joint like parts could offer perfect manufacture feeling.

Fig. 12. Biomimetic designs.

There are two modes designed in the robot. Mode 1 is stick detached from the body for a separate Usage as shown in Figure 13. When blind into the interior or in a familiar environment, the navigation stick can be used alone. Users can use the navigation stick to call back the navigation base.

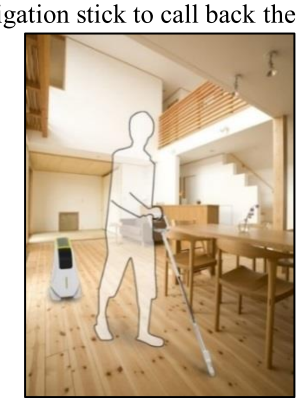

Fig. 13. Mode 1: separated (stick and robot).

Mode 2 is the intelligent human machine navigation (combined usage) as shown in Figure 14. Through wireless networks connection, the navigation stick detects road conditions, and synchronized with the navigator to switch to the appropriate response actions. For long-distance path planning, the autonomous navigation mode is activated. It allow users can easily walk in unfamiliar pavement. The sensor recognize the owner to prevent unauthorized operation of the robot.

Fig. 14. Model 2, combined (stick and robot).

The design of the rotation joint fit the average human height as shown in Figure 15. The length and angle of the stick is adjustable to desired height.

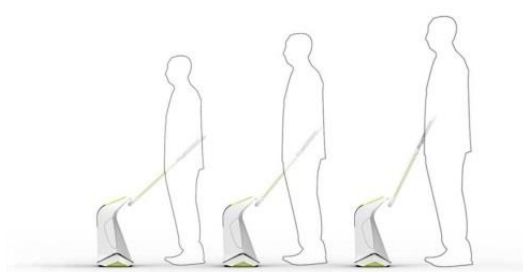

Fig. 15. Adjustable stick.

Two mobile robot platform are adopted in this paper as the prototype locomotion as shown in Figure 16. The specifications are listed in Table I.

Fig. 16. Mobile robot. (Left) P3-DX (Right) Amigo.

TABLE I
MOBILE ROBOT PLATFORM SPECIFICATION

Specs.	Value
P3DX	
Sonars	16
Speed (Max.) mm/s	1600
Size cm	40×45×24.5
Amigo	
Sonars	8
Speed (Max.) mm/s	1000
Size cm	33×28×15

The IPC (Inter Process Communication) is implemented as the communication protocol. It enables data exchange between different processes as shown in Figure 17. The distributed server-client system allows the local robot communicate with the remote control station.

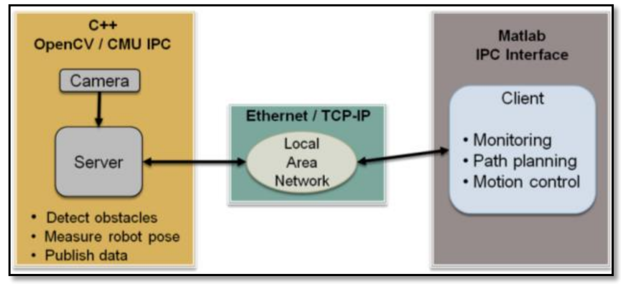

Fig. 17. IPC protocol.

III. RESULT

The prototype design is fabricated as shown in Figure 18 and 19.

Fig. 18. Final production and robot Amigo

Fig. 19. actual model of production

The proof-of-concept is carried out by the mobile robot system as shown in Figure 20 which contains a two wheel differential drive mobile platform (MobileRobots P3DX) embedded with a gripper and a sonar ring contains 16 ultrasound sensors, laser range finder (Hokuyo URG-04LX), pan-tilt-zoom camera (AXIS PTZ 215), a RGB with depth sensor (Microsoft Kinect) and a wireless modem (Lantronix Wibox). The detailed of the control system is presented in separate paper [11].

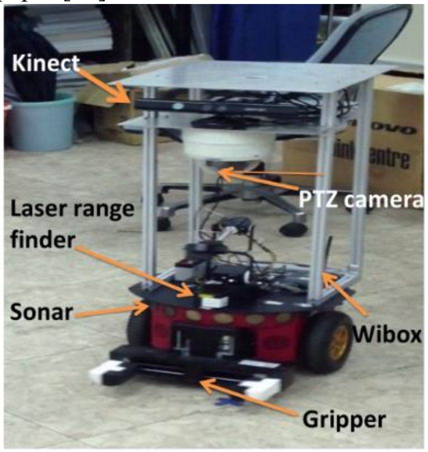

Fig. 20. Mobile robot system.

The proposed system is tested in the indoor scenario [11]. The furniture are all randomly placed in the environment with no prior knowledge. The proposed mobile robot can sense, percept and navigate successfully in the unknown environment in the autonomous fashion. The robot experienced successful patrol on all rooms. Separated room patrol are also tested as shown in Figure 21.

Fig. 21. (Top left) Robot enter the room (Top right) Robot leave the room (Bottom left) Wall following (Bottom right) robot picking up the ball.

The other outdoor scenario for testing the proposed system is shown in Figure 22 [12]. The robot moved between the lanes, uphill and downhill of a slope and avoid obstacles. The robot can traverse trough the outdoor environment (i.e. slope, obstacles and follow the road).

Fig. 22. (Top left) Starting point; (Top right) obstacle avoidance; (Bottom left) slope climbing; (Bottom right) downhill the slope.

IV. Conclusion

The proposed blind mobile social robot connect the physical products to the cloud platform computing. The robot can assist visually impaired people and through the platform to enhance their social interaction. The service robots for specific people will combine products and database platforms, in order to achieve greater efficiency in the use; The established of a database can provide useful data to special education schools, in addition to strengthen service. Therefore a special designed web community platform is created for the blind. The value of this service will rise when more and more user in the network.

The design feature is summarized as follows

- Mobile robot connect to the remote assistance platform
- Can be used in separate or combination
- Users interact each other through the platform to build the social bonding
- Interaction between users through the platform to build the social network and environment database

The future work are summarized as following

- commercial product development of visually impaired guide and social cloud platform infrastructure
- depth interviews and field observations of user requirements
- Add appropriate human factors engineering and human-computer interaction model used in the product process

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