C-ITS Lancashire
Navigation and Auditory Display System for Blind People

Summary

Mobility of visually impaired people has always been of significant interest for the researchers. The World Health Organization reported 285 million visually impaired people (partially or full blind) worldwide, with 360,000 in the United Kingdom alone. Visual impairment degrades the quality of life of concerned people in relation to performing common tasks. Navigation of visually impaired people is one of most significant daily activities and plays a fundamental role in enabling them to move around and walk more safely. However, the dynamically changing environment and lack of information about location and orientation with respect to traffic and obstacles on the route make it more difficult. The navigation of visually impaired people has been facilitated by canes, trained guide dogs, and by human guides. Technological advancements such as variety of sensors, Global Positioning Systems (GPS), and machine intelligence have also improved existing systems to assist the visually impaired people in terms of indoor and outdoor activities. However, these methods provide limited facilitation and assistance to automatically sense and avoid diverse types of obstacles, dynamically model the changing environmental states, recognise surrounding objects, and effectively communicate with the visually impaired person. Artificial intelligence methods and machine automaticity can be utilised to further enhance the efficiency and reliability of existing visually impaired and blind person navigation systems by providing sufficient information about surroundings. The proposed method will use sensors (ultrasonic and infrared), map database, and digital cameras to produce heterogeneous information about the surroundings environment. The captured data will be processed by image/video and signal processing methods to sense and recognise any hazards and objects within a fixed area and to model the dynamic environmental states using artificial intelligence approaches. Automatic speech recognition and speech synthesis will be deployed to communicate with the blind person to interpret the information about the surrounding environment in audio visual format. The proposed auditory display system (i.e. the designed headphones) will be portable and self-contained that would be able to produce accurate, precise, and reliable information about the environment (e.g. hazard type, distance from hazard or point of interest, object name, colour, and number of objects) and corresponding instructions to assist and navigate visual impaired people safely with or without the assistance of guides.

Proposed Method

The proposed system is based on sequential and parallel processing of a number of Work Packages (WPs) to achieve the desired goal. Figure 1 demonstrates the detailed workflow for the proposed methodology and associated WPs. Different research areas will be explored mainly focusing on ASR, database system

development, information processing (signal, image) from diverse information resources, deployment of artificial Intelligence methods for dynamic state modelling and situation assessment, and speech synthesis. The WP's tasks will be performed by a number of collaborators with the corresponding expertise. Functionality of the aforementioned WPs can be summarised as follows:

- ✓ WP1 consists of four major tasks that include: a module for determining the traveller's position and orientation; Geographic Information System (GIS) comprising a detailed database of test site (e.g. Preston city centre); Database development for the selected site; route planning and obtaining information from the database.
- ✓ WP2 is based on the development of Automated Speech Recognition (ASR) component to interpret the user voice commands.
- ✓ WP3 is the important component that aims to process the information captured from multiple resources such as: digital Camera Devices (CD) mounted to the designed headphones, street and traffic lights cameras (for a better road-view a blind person is trying to cross), Ultrasound Sensors (US) and Infrared Sensors (IS) mounted to headphones and cane stick, and other available information (e.g. traffic centre). The image processing, video data analysis and signal processing methods will be deployed for the objects recognition, classification, and obstacles detection using the acquired information from aforementioned resources.
- ✓ WP4 consists of artificial intelligence approaches to model the environmental states dynamically and make the situation assessment based on processed information, beliefs from multiple information resources, and associated weights. Deep research will be conducted on diverse areas that include data fusion, evidence combination, probabilistic and fuzzy inference methods to model the uncertain and dynamic situations.
- ✓ WP5 will use the combined evidence from WP4 and incorporated in it to the speech synthesis module to interpret the current surrounding state information into audio-visual instructions using the static instructional database. The output warnings/instructions will be forwarded to the blind person through the designed headphones.
- ✓ Finally, WP6 will integrate all WPs to produce the operational system. A final technical report will be produced to be supplemented with a number of articles which will be prepared throughout the project timeline and published at related conferences and in high impact journals linking both the technological and highway aspects of the project.

Deliverables and Milestones

A detailed description of milestones and deliverables for each WP is presented in Table 1.

Table 1: Milestone & Deliverables

WPs	Milestones	Timeline	Deliverables
WP1	**M_1**: Determining the traveller position and orientation using GIS comprising a detailed database of test site	T_0+02 months	**D_1:** Preparation of database system for the selected site
	M_2: Database development for the selected site	T_0+03 months	**D_2:** Model for the blind person's orientation, location, and optimal route
	M_3: Route planning and obtaining information from the database.	T_0+03 months	
	M_4: Unit testing	T_0+03 months	
WP2	**M_5**: Development of the Automated Speech Recognition (ASR) system to interpret the user voice commands	T_0+04 months	**D_1:** Speech recognition module for automatic interpretation of user commands
	M_6: Unit testing	T_0+04 months	
WP3	**M_7**: Obstacle and hazard detection using signal processing on US sensors data	T_0+06 months	**D_1:** Object recognition and obstacle detection to model the surrounding hazards using signal and image processing
	M_8: Obstacle and hazard detection using signal processing on IR sensors data	T_0+06 months	
	M_9: Objects recognition and hazard detection by video data analysis & image processing	T_0+08 months	
	M_{10}: Unit testing	T_0+08 months	
WP4	**M_{11}**: Dynamic state modelling	T_0+09 months	**D_1:** A dynamic state model
	M_{12}: Situation assessment	T_0+09 months	**D_2:** Situation assessment based on combined evidence
	M_{13}: Independent testing	T_0+09 months	
WP5	**M_{14}**: Capturing required instructions in a textual format	T_0+10 months	**D_1:** Audio visual instructions and warning generation
	M_{15}: Speech synthesis and audio visual instructions	T_0+10 months	
	M_{16}: Unit testing	T_0+10 months	
WP6	**M_{17}**: Integration of all WPs	T_0+11 months	**D_1:** Demonstration & Test Report **D_2:** Conference paper and journal article submission
	M_{18}: Integration testing in Lab	T_0+11 months	
	M_{19}: Prototype testing in real site	T_0+11 months	
	M_{20}: Updates & Changes	T_0+12 months	
	M_{21}: Demonstration & Report	T_0+12 months	
	M_{22}: Technical report writing, articles preparation & submission to conference and journal	T_0+12 months	

Table 2: Timeline for milestones and deliverables in the proposed project

WPs	**Months**											
	1	2	3	4	5	6	7	8	9	10	11	12
WP_1		M_1	M_{2-4}									
WP_2				$M_{5,6}$								
WP_3					M_7	M_8	M_9	M_{10}				
WP_4								M_{11}	$M_{12,13}$			
WP_5										M_{14-16}		
WP_6										M_{22}	M_{17-19}	M_{20-22}