AN ELECTRONIC TRAVEL AID TO ASSIST BLIND AND VISUALLY IMPAIRED PEOPLE TO AVOID OBSTACLES

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Abstract

When devices and applications provide assistance to people they become part of *assistive technology*. If the assistance is given to impaired people, then it is possible to refer those technologies as *adaptive technologies*. The main aims of these systems are substitution of physical assistants and the improvement of typical tools already available for impaired people. In this paper some benefits and examples of adaptive technology applications will be discussed. Moreover we present an adaptive technology framework to avoid obstacles to be exploited by visually impaired and blind people. The proposed assistive technology has been designed to perform vision substitution; specifically it provides *Electronic Travel Aid (ETA)* capabilities through the processing of information acquired with a depth sensor such that the user can avoid obstacles during the environment exploration. In the proposed system we require to know just the height of the sensor with respect to the ground floor to calibrate the ETA system. Experiments are performed to asses the proposed system.

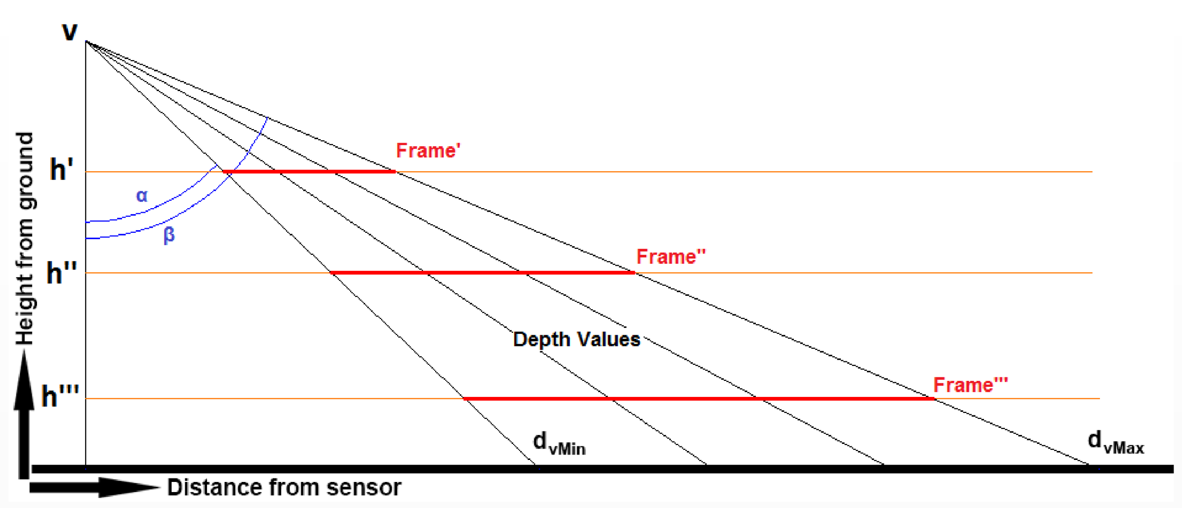
Proposed Method

The main aim of this work is the development of an *Electronic Travel Aid (ETA)* system for visually impaired which is able to detect obstacles and help the user to avoid them. Our framework consists of a Kinect ($v1.0$) device to acquire the depth of the scene and a control unit to process the acquired data, that also sends feedback to user about obstacle detected. The output modality used is the audio channel, with different levels of sound intensity corresponding to different distances of detected obstacles. The scene acquired with the Kinect is divided in a 3×3 cells, and for each cell a risk index R is estimated. This index measures the risk degree of clashing with an obstacle and is directly proportional on the average distance of detected obstacles in each cell. The system works by analyzing the *depth-maps* acquired by Kinect where each voxel in the 3D space represents the distance from sensor.

Proposed Algorithm

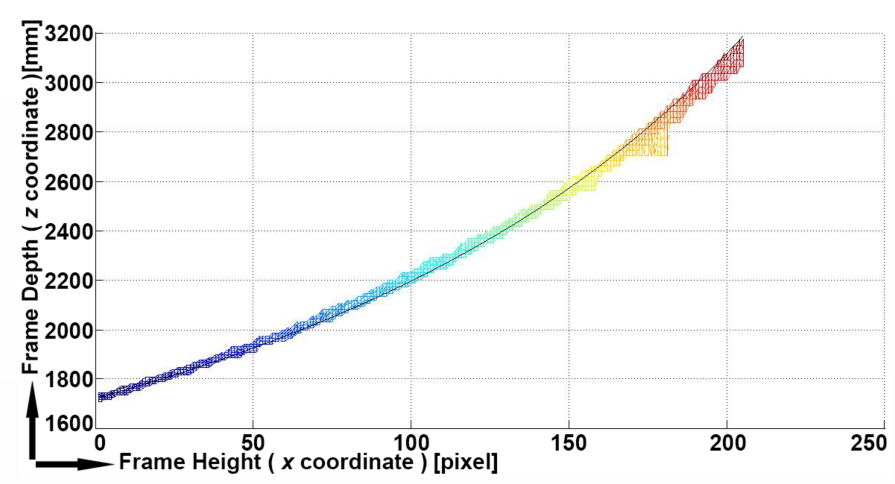
1. System calibration
2. Noise reduction & ROI definition
3. Ideal plane estimation
4. Predictor–Corrector of error
5. Thresholding
6. Masking & Distance computation
7. Risk indexes computation
8. Feedback to user

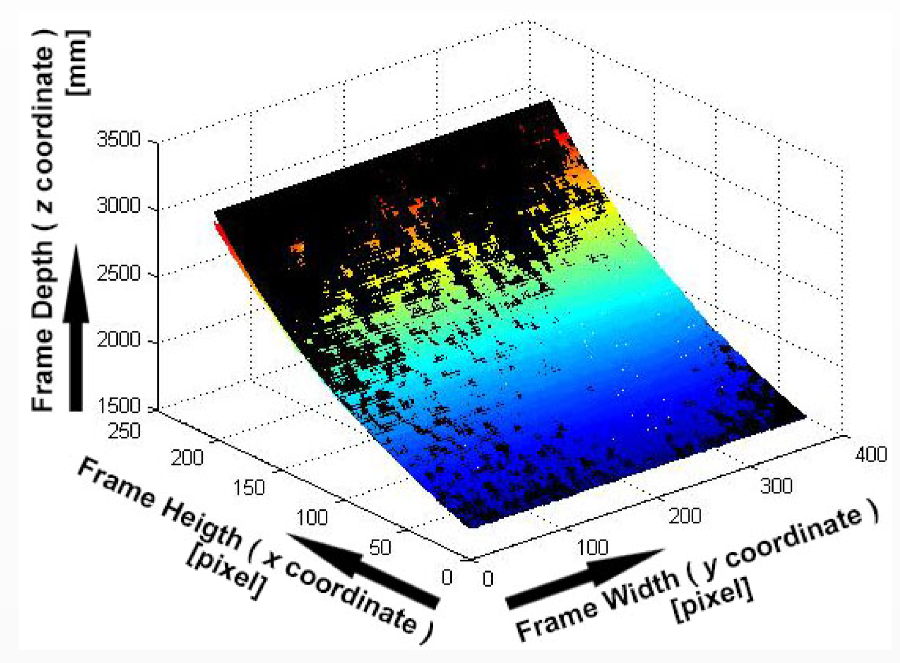
System Calibration



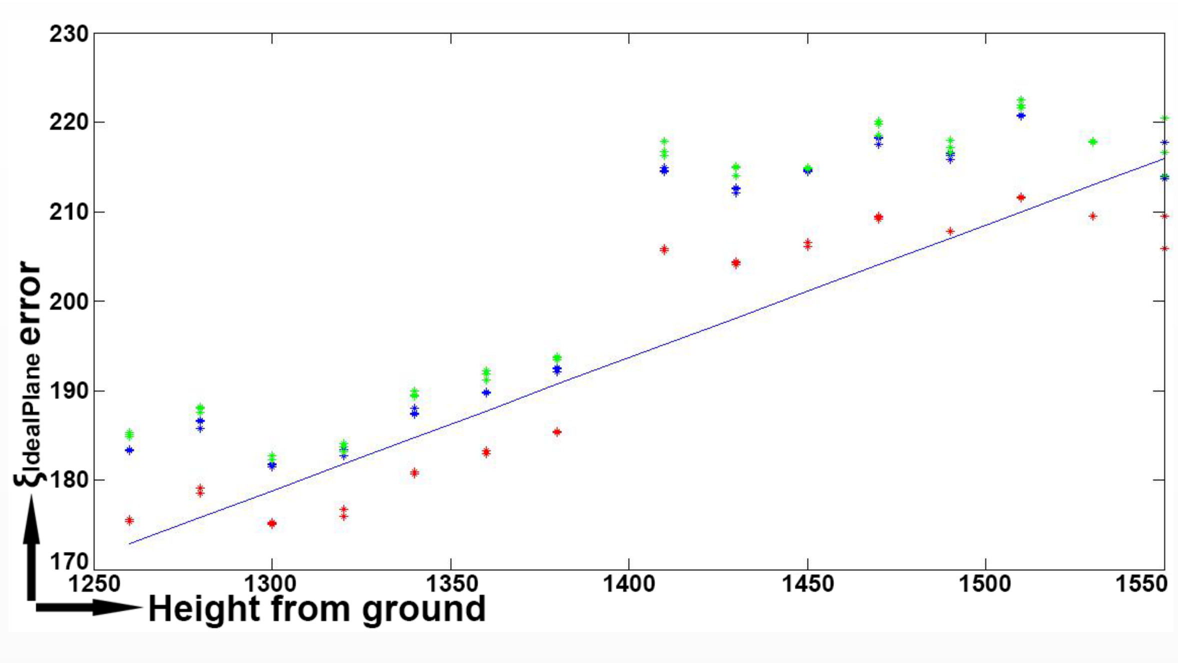
Noise Reduction and ROI

Plane Estimation

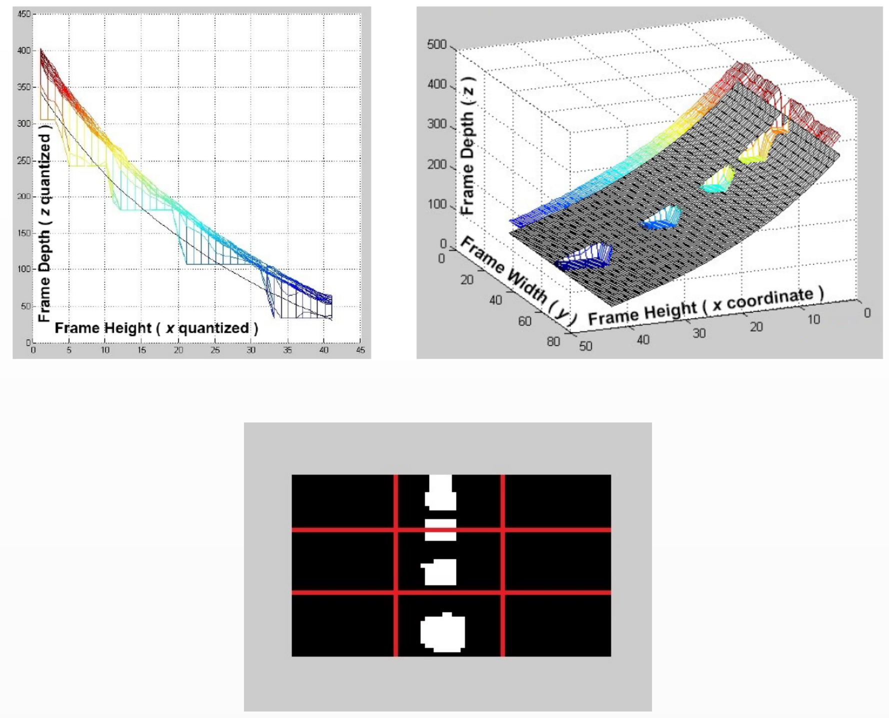




Predictor–Corrector



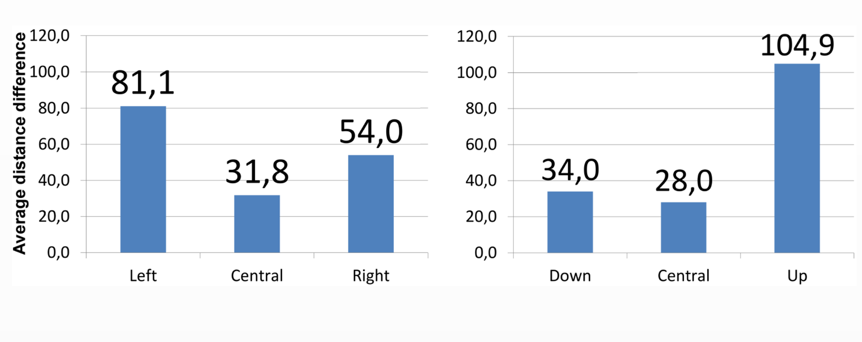
Thresholding and Masking



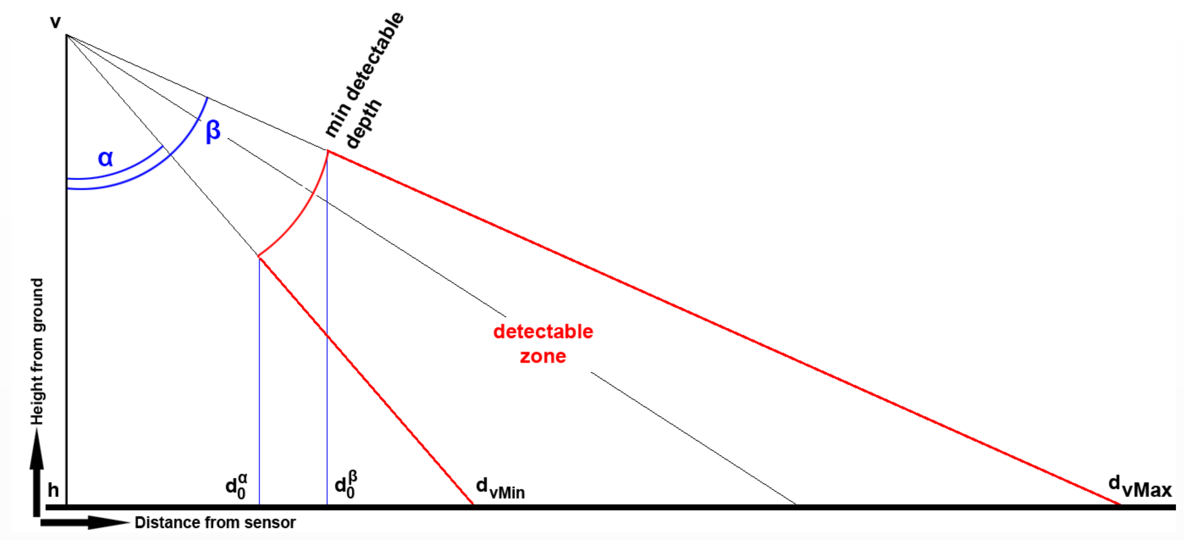
Experimental Results

GT	M	D	GT	M	D	GT	M	D		
1660	1563	**97**	*1485*	1489	**4**	*1560*	1509	**51**	**104,9**	Avg. (1st row)
1675	1443	**232**	*1645*	1551	**94**	*1690*	1564	**126**	**70,1**	RMSE (1st row)
1740	1532	**208**	*1660*	1613	**47**	*1790*	1705	**85**		
1240	1230	**10**	*1265*	1273	**8**	*1290*	1325	**35**	**28,0**	Avg. (2nd row)
1260	1180	**80**	*1300*	1310	**10**	*1340*	1323	**17**	**24,4**	RMSE (2nd row)
1310	1258	**52**	*1365*	1366	**1**	*1355*	1394	**39**		
950	962	**12**	*970*	1007	**37**	*950*	978	**28**	**34,0**	Avg. (3rd row)
1000	1020	**20**	*1010*	1052	**42**	*1010*	1058	**48**	**14,2**	RMSE (3rd row)
1050	1031	**19**	*1020*	1063	**43**	*1030*	1087	**57**		
Avg. (1st col.)		**81,1**	Avg. (2nd col.)		**31,8**	Avg. (3rd col.)		**54,0**	**55,6**	Avg. (tot)
RMSE (1st col.)		**79,9**	RMSE (2nd col.)		**28,1**	RMSE (3rd col.)		**31,3**	**55,9**	RMSE (tot)

Averaged Results



Detectable Heigth



$$h_D \in \begin{cases} [(d_{vMin} - d) * \cot\alpha \ ; \ (d^\gamma - d) * \cot\gamma] & \text{if } d_0^\alpha < d \le d_0^\beta \\ [(d_{vMin} - d) * \cot\alpha \ ; \ (d_{vMax} - d) * \cot\beta] & \text{if } d_0^\beta < d \le d_{vMin} \\ [0 \ ; \ (d_{vMax} - d) * \cot\beta] & \text{if } d_{vMin} < d \le d_{vMax} \end{cases}$$