PERCEPT-V

Electrical and Computer Engineering Department
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Image-Based Indoor Navigation for the Visually Impaired

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MCB — Massachusetts Commission for the Blind

5 Labs — Elevating Human Potential Through Technology

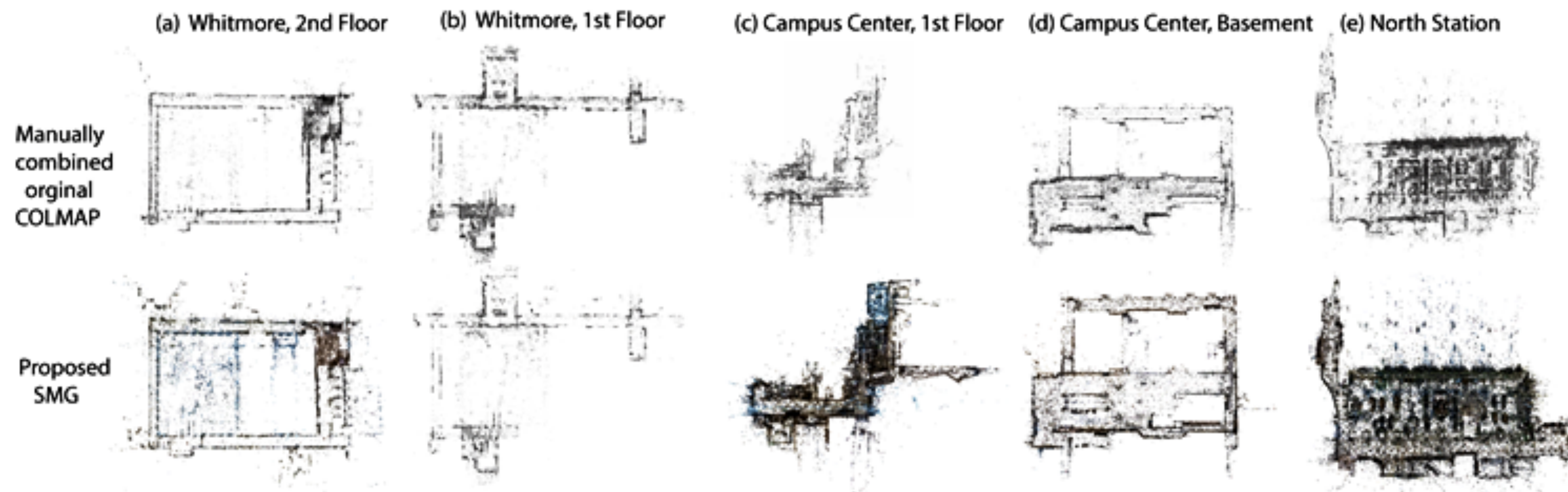**High-Dimensional Signal Processing Group** — University of Massachusetts Amherst

Funded By: NSF

Challenge:

- Percept-V is an indoor navigation system for the blind and the visually impaired (BVI). An image taken by the BVI individual is used to localize them in the environment (both position and orientation). The location and the individual's destination is used to generate navigating instructions based on the spatial point cloud map generated for the environment. The system has been tested using field trials with significant success in providing independent navigation.

- The main challenge we addressed this year deals with the construction of the spatial map of the environment from a set of images of the space: if the correlation between images is small, then a single coherent map of the environment is not constructed, leading to many singular disconnected maps of the space.

Solution:

(a) Whitmore, 2nd Floor (b) Whitmore, 1st Floor (c) Campus Center, 1st Floor (d) Campus Center, Basement (e) North Station

Manually combined orginal COLMAP

Proposed SMG

- Baseline: manually stitch multiple spatial maps, which doesn't mitigate loss of spatial information.

- We developed a custom spatial map generation (SMG) approach that takes into consideration spatial and temporal relationships among images taken by multiple cameras.

- These relationships allow us to establish overlap of feature points more accurately and generate one singular spatial map with high accuracy.

Handheld camera rig and its FOV shown in top-view and side-view

118.2 degrees

69.5 degrees
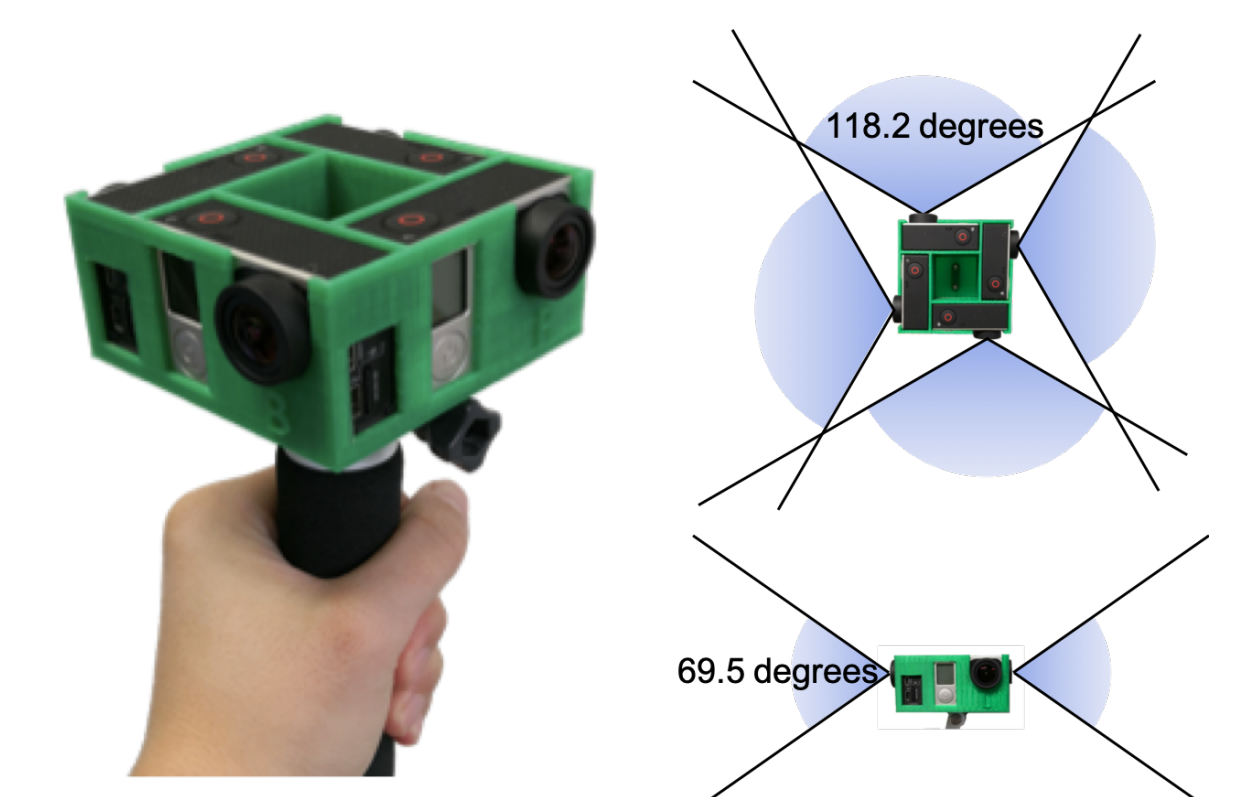
Environment	Number of models generated		Matched images / No. Of images		Total number of points		Spatial map size (Localization), Mb		Spatial map size (Reconstruction), Mb		Area, m²
	Proposed SMG	COLMAP Total	Proposed SMG	COLMAP Total	Proposed SMG	COLMAP Total	Proposed SMG	COLMAP Total	Proposed SMG	COLMAP Total	
Campus Center B1	1	18	3019/3208	2835/3208	191666	244293	23.4	24.6	98.0	95.3	938
Campus Center F1	1	24	2977/3068	2863/3068	262068	283336	31.3	28.3	136.8	135.0	1247
Whitmore F1	1	8	1276/1436	991/1436	80904	66008	8.1	5.9	46.4	36.7	386
Whitmore F2	1	16	1711/1808	1309/1808	128212	10772	12.9	9.6	62.8	50.8	500
North Station	1	11	4020/4100	3999/4100	531195	742076	63.5	72.2	261.1	532.0	2700

Conclusions:

- Usability experiments verify that BVI individuals gain independence by successfully navigating to their destinations.

- SMG increases the number of matched images and decreases the total number of feature points - indicative of successful use of image inputs while retaining only necessary feature points and removing redundant ones.

- Our results can also impact additional applications that require accurate autonomous navigation in indoor environments

- Next steps: calculate numerical accuracy of localization in the environment using ground truth data.