Haoyu Wang's Research in SENSEI project

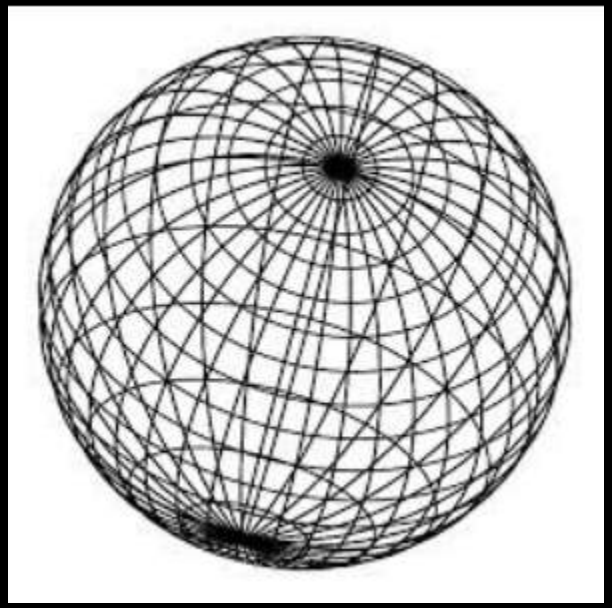
Haoyu Wang

Electronic Visualization Laboratory
University of Illinois at Chicago

What is SENSEI project?

- Short for Sensor Environment Imaging (SENSEI) Instrument Project
- Goal: a scientific camera & display system for fully surrounding stereo cinema for scientific visual and depth data acquisition

- SENSEI Team: faculties and students from different universities and institutions
- Software group in EVL



SENSEI project

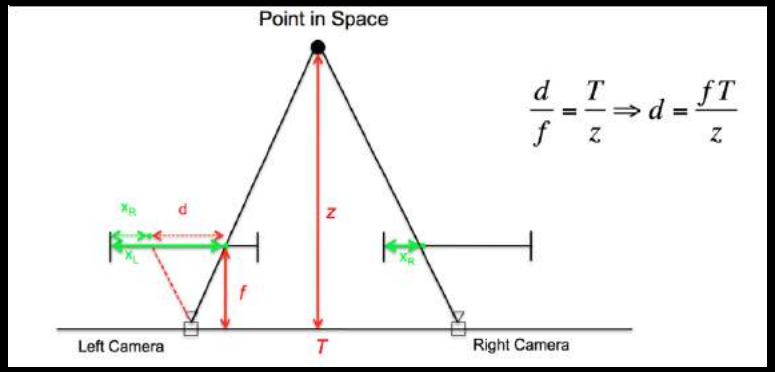
- Capture dynamic visual omnidirectional data
  - By CAVEcam or the camera prototype later
- Create VR-like experience with image based material
  - 360 by 180 panorama construction for both left and right eye
    - Point Cloud Reprojection
    - 2D image stitching（my task）
  - 360 by 180 stereo video from panorama sequences
- Develop display transmission and storage systems to support scientific explorations

Point Cloud Reprojection

- Points Cloud Reprojection using depth maps
  - a PhD thesis project by Jason Juang
  - Now being worked on by Ji Dai & Jurgen Schultz
- Brief description
  - Compute dense disparity maps from each pair of images
  - Based on knowledge of camera position and camera movement, reconstruct the Point Clouds for whole 3D space
  - Project the point clouds onto the two spheres from virtual eye positions

Steps in Point Cloud Reprojection

Disparity to depth



Disparity map from image pair

Point cloud from disparity map

Result of Point Cloud Reprojection

- Panorama of synthesized data

left

right

Result of Point Cloud Reprojection

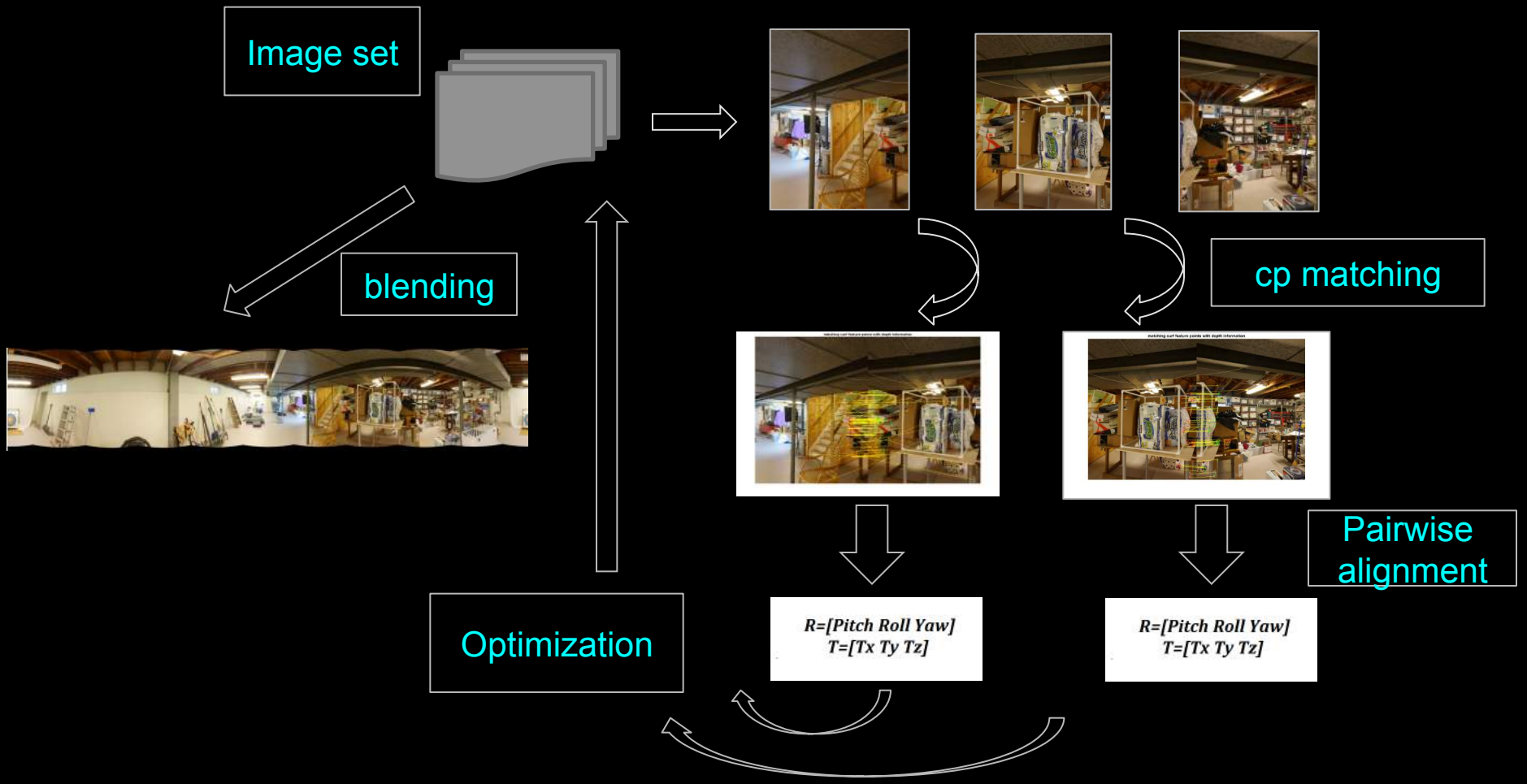
- Panorama of real data (basement image set)

Conclusions of Point Cloud method

- Pros
  - Geometrically correct
  - No vertical misalignment and no parallax error
  - With correct dense point clouds, can provide view from any position around camera rather than its shooting spot
- Cons
  - Need accurate dense disparity maps for perfect reconstruction of point clouds, which is probably time-consuming task
  - Need to fill the black holes after reconstruction

2D-stitching method for panorama

- How 2D stitching method generate panorama

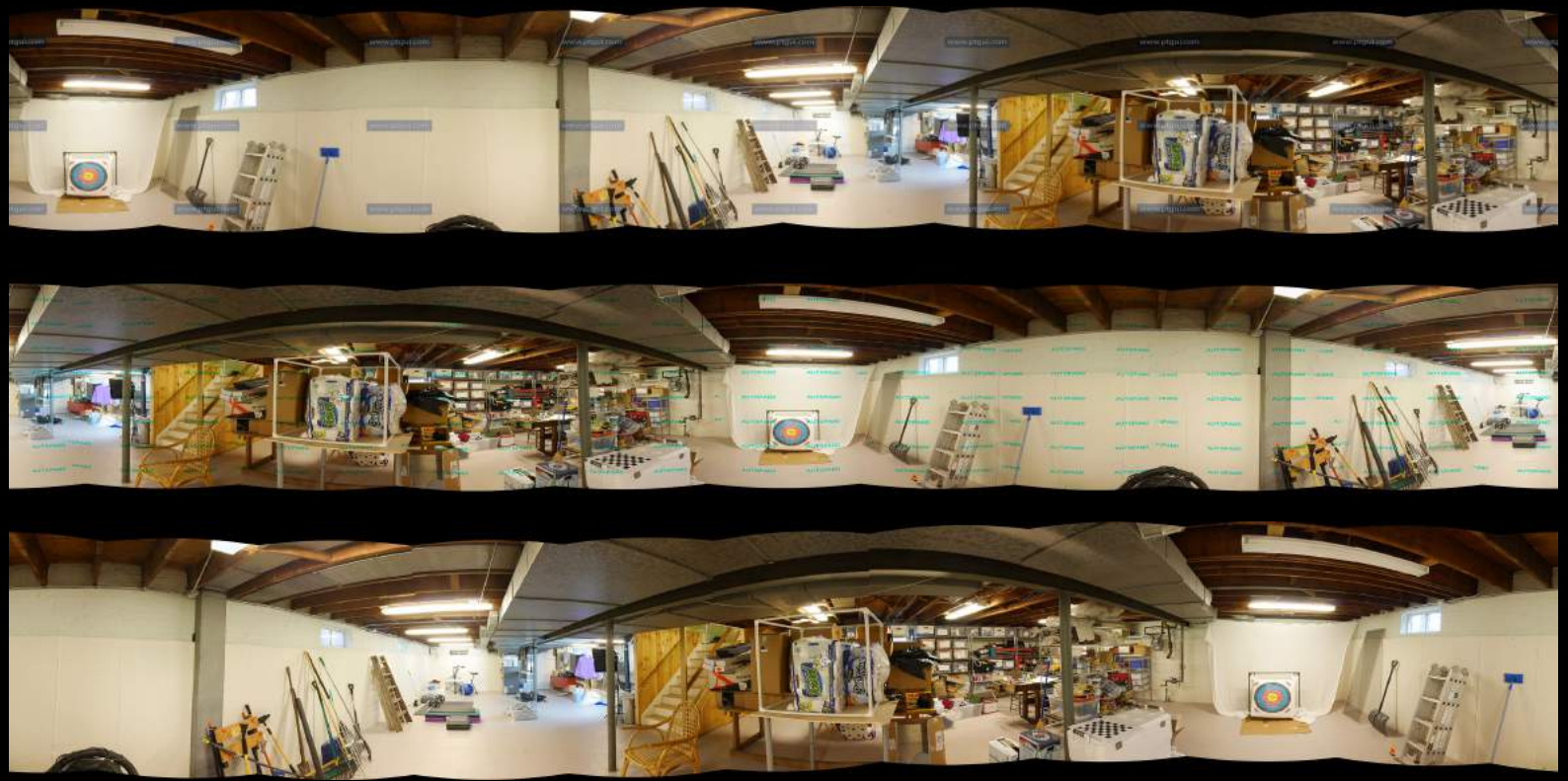


Conclusions of 2D stitching method

- Pros
  - Don’t need disparity maps
  - No black holes in the final panorama
- Cons
  - Actually suffer from vertical misalignment and parallax error
  - Can only provide scene from the position of the camera

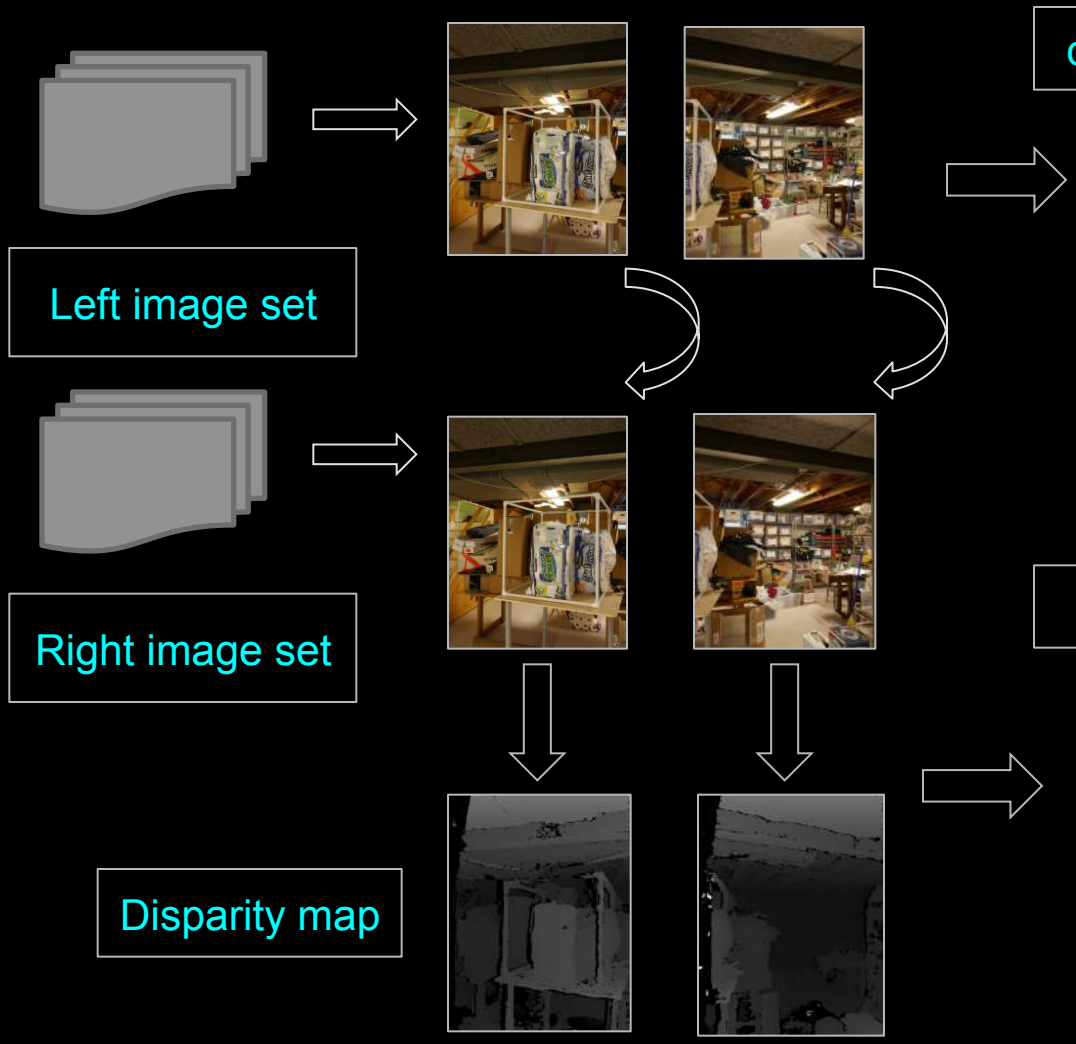
software for image stitching

- Many software can do the image-stitching:
  - PTGUI, Autopano, ICE



- Why not use them?

Improvement to the stitching with depth



cp matching without depth information

cp matching with depth information

Pairwise stitching result before and after depth matching

- Pairwise stitching result before depth-matching

- Pairwise stitching result after depth-matching

Another problem for stereo panorama: vertical disparity

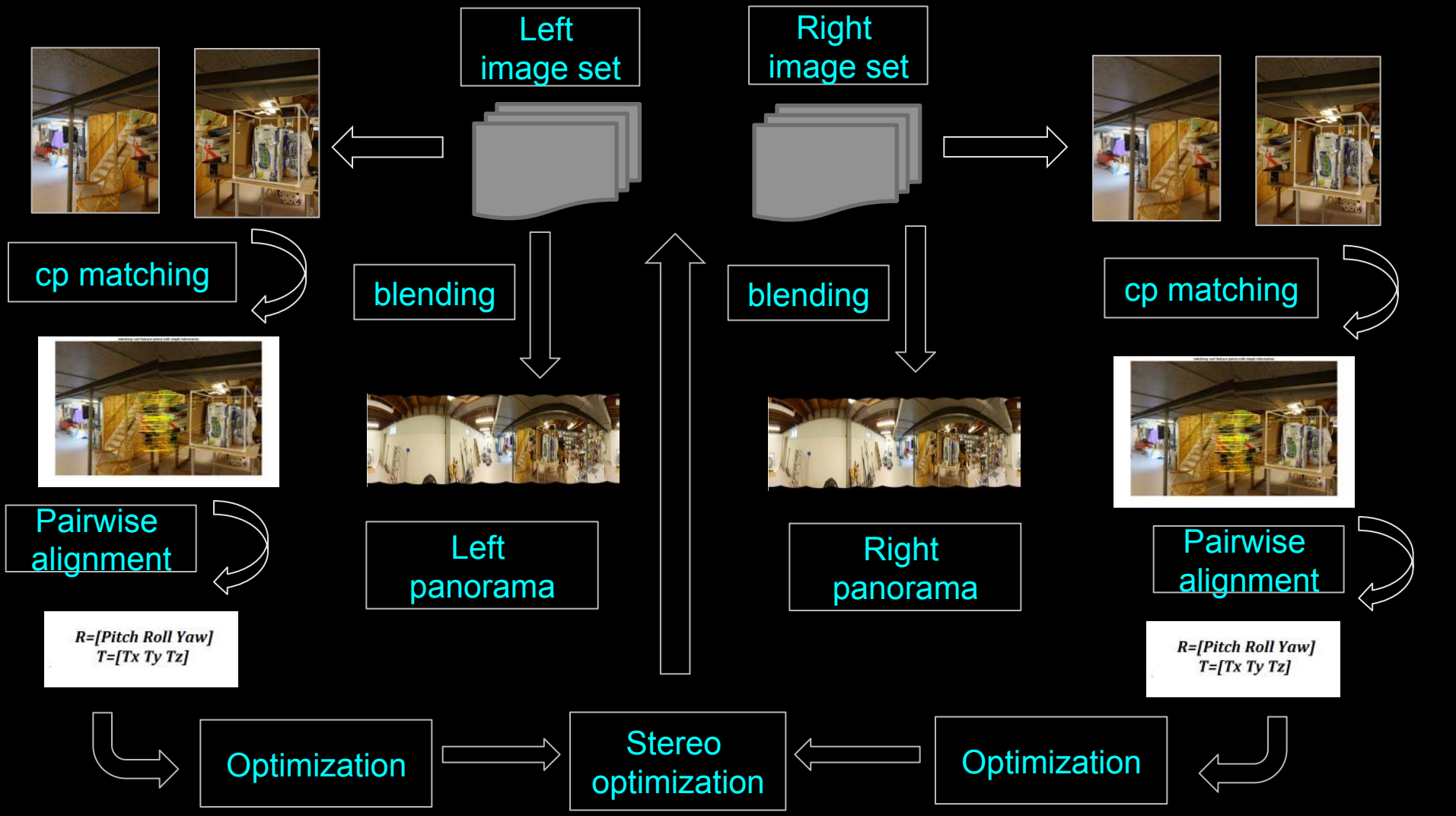
Left panorama

Right panorama

Left panorama for basement

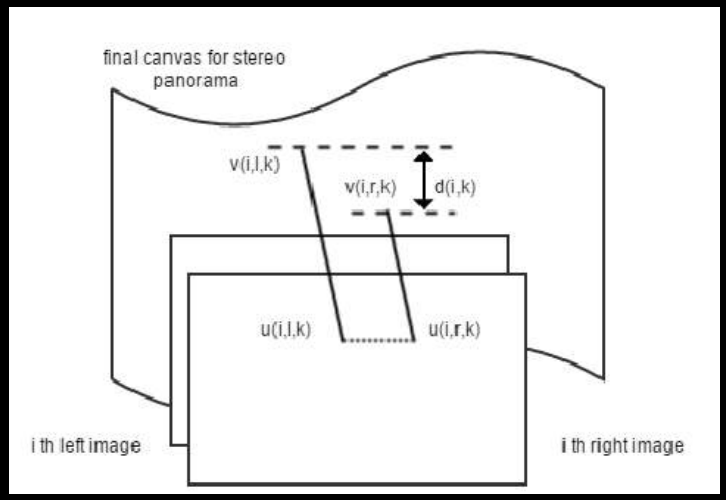
Right panorama for basement

solution to vertical disparity problem



solution to vertical disparity: stereo optimization

- $I\downarrow i\uparrow l$ and $I\downarrow i\uparrow r$ are m pairs of images, $i \in \{1,2,3\ldots,m\}$
- $M(i)$ is the set of features which could be found in both of the i th left and right images
- $U\downarrow i,l,k$ and $U\downarrow i,r,k$ are position of k th matched features in the i th left and right



$$(R,T)=argmin\}$$

$$v=R*u+T$$

$$R=\{R\downarrow 1\uparrow l,$$

$$T=\{T\downarrow 1\uparrow l,T\downarrow 2\uparrow l,$$

$$R\downarrow 2\uparrow l,\ldots,$$

$$T\downarrow m\uparrow l,1\uparrow$$

Result of panorama of 72 images : left

Result of panorama of 72 images : right

Six cube faces

The end

- Q & A :