Rolling Shutter Camera as High Frequency Tracker

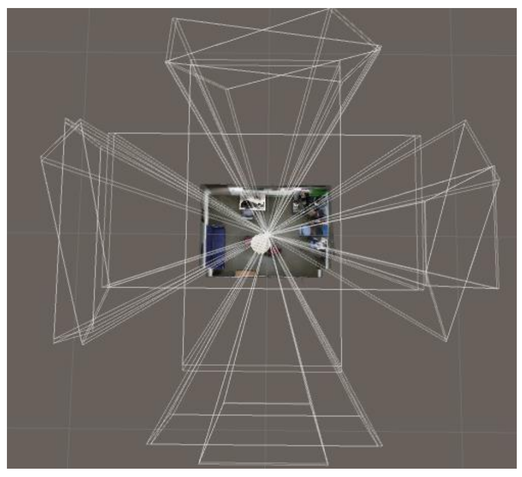
Akash Bapat, Enrique Dunn, Jan-Michael Frahm

Problem

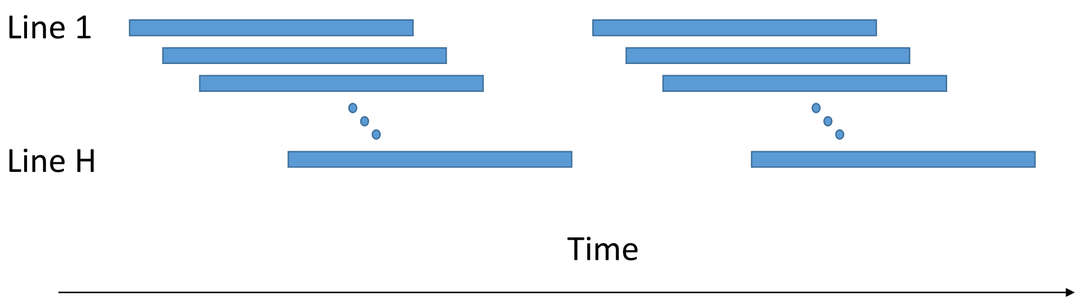
High frequency tracking of head pose for augmented reality applications

Solution

Use a cluster of high fps rolling shutter (RS) cameras assuming a static indoor environment.
Use 10 stereo-pairs of RS cameras pointing in all directions.



Rolling shutter camera as 1-D sensor

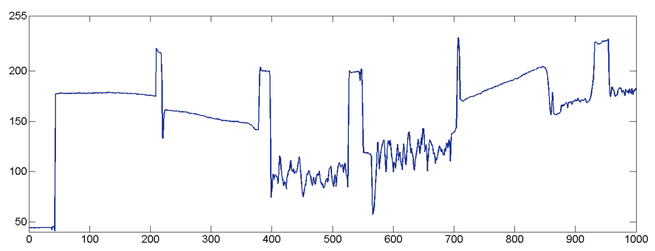


Rolling shutter image integration

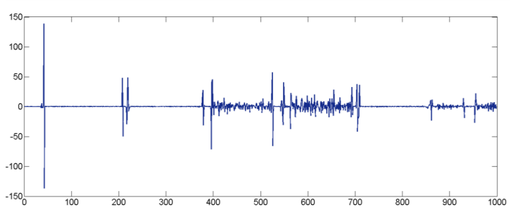
Each row can be considered as 1-D image of W pixel width. RS camera captures such row samples at fps*H frequency. Hamming distance can be used for matching if descriptor is binary.

Row image descriptor

Image



Visualization of one row (200th)



Double derivative of row

1	0	1	0	1	1	1	1	0	0

Binary descriptor

Small Motion Assumption

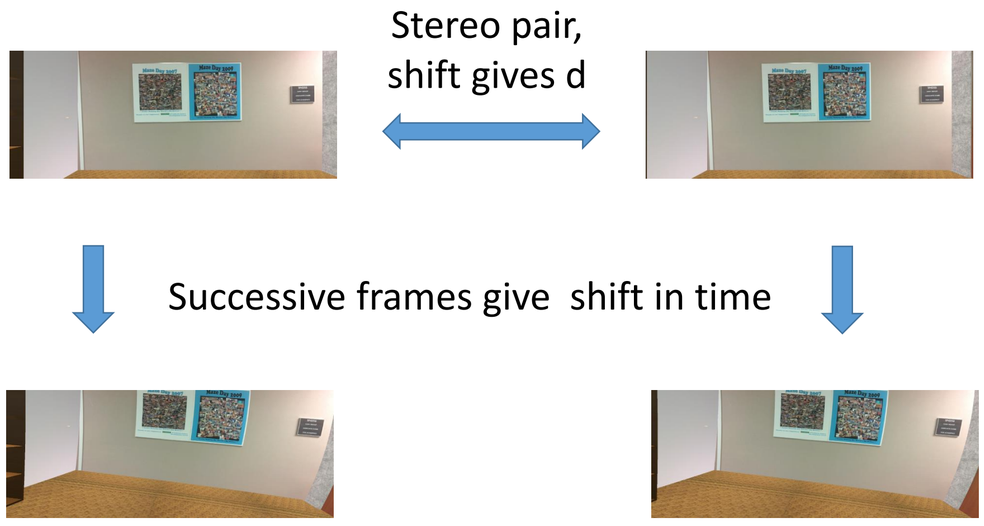
Assuming small motion gives us a simplified model which reduces computation time. This in turn lets us work at higher frequencies justifying the small motion assumption. These two reinforce each other.

Linear Model

$$X_{cam}^{t+1} = V\ dM\ * M_{prev}\ V^{-1} X^{t}{}_{cam}$$

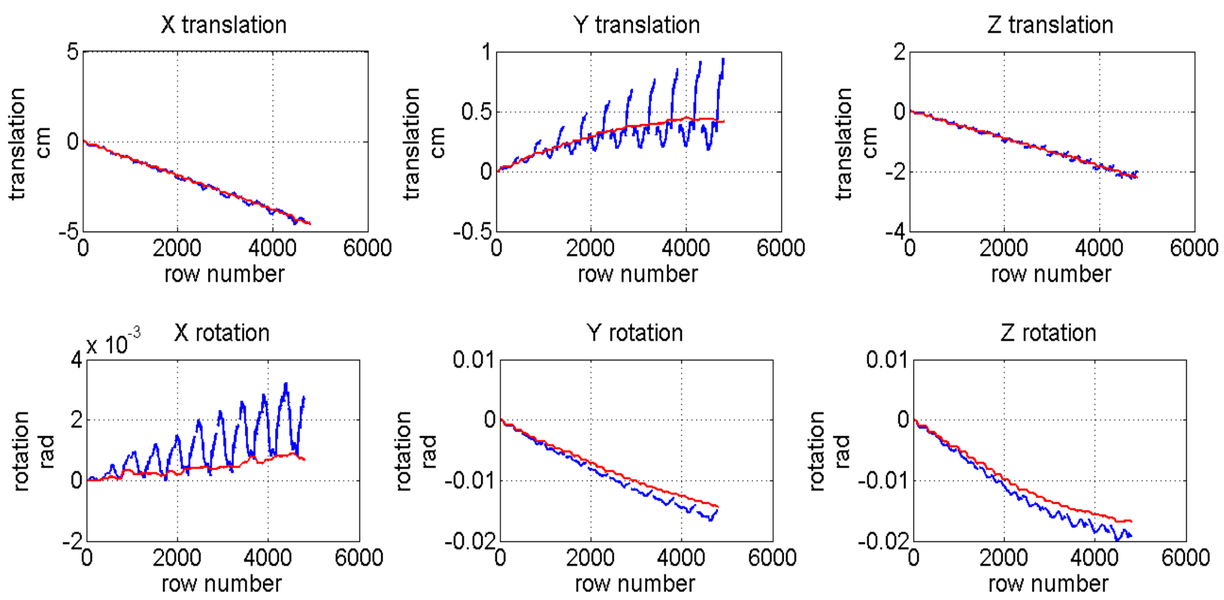
Estimate dM: Each camera gives one equation giving a system of linear equations. Weighted least squares is constructed which factors in the confidence in each camera.

V : [R|t] of camera X^{t}_{cam} : [0, y, d,1]^{T}
M_{prev} : motion till previous row
X^{t+1}_{cam} : [s , ☒, ☒, W]^{T}



Simulation Results

Hi-Ball real motion data in synthetic room



Supported by NSF award #5037304 II-New: Seeing the Future: Ubiquitous Computing in EyeGlasses

CV²R Consortium for Vision and Virtual Reality
UNC DEPARTMENT OF COMPUTER SCIENCE