MOTION-COMPENSATED COMPRESSION OF POINT CLOUD VIDEO

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Holoportation at MSR

- Capture a point cloud of the person/object
  - List of occupied voxels: (x,y,z) (r,g,b)
- Transmit point cloud
- Immerse object into scene- render on Hololens

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Second Real Time Voxelization

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Holoportation

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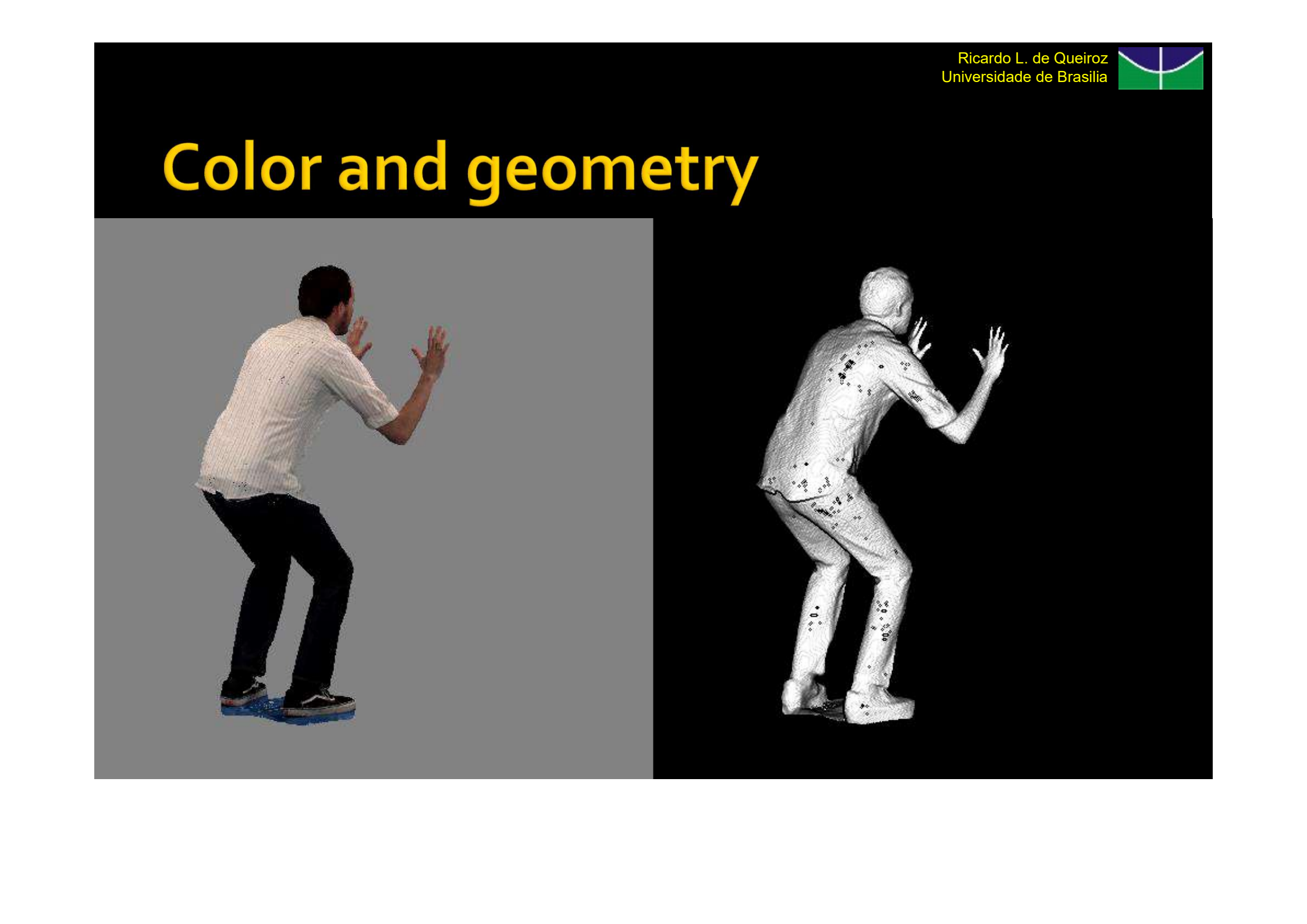

Color and geometry

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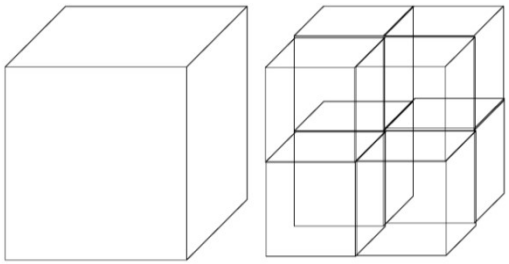
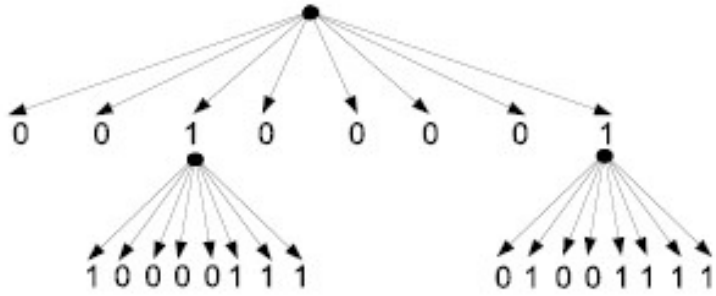
Voxelized point cloud

- Voxelized point cloud (e.g. 512x512x512 grid)
- Voxels $V_i = [x_i, y_i, z_i, R_i, G_i, B_i, A_i \quad]$

  Geometry (position) — Color — Optional attributes

- Color (or attributes) encoded using RAHT
- Geometry encoded using Octtree
  - 2.5-3.3 bpv





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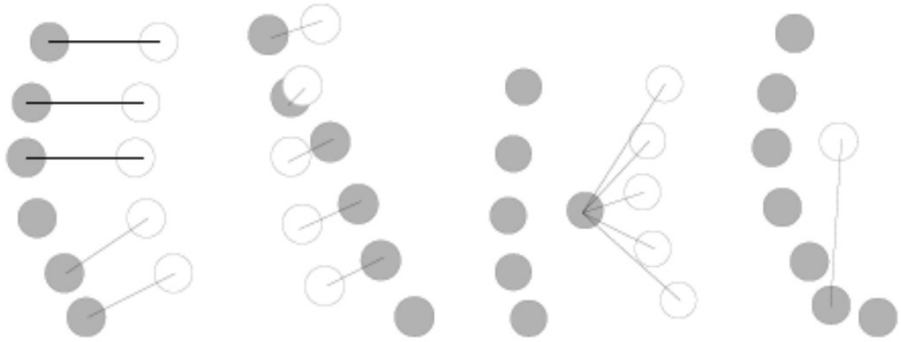
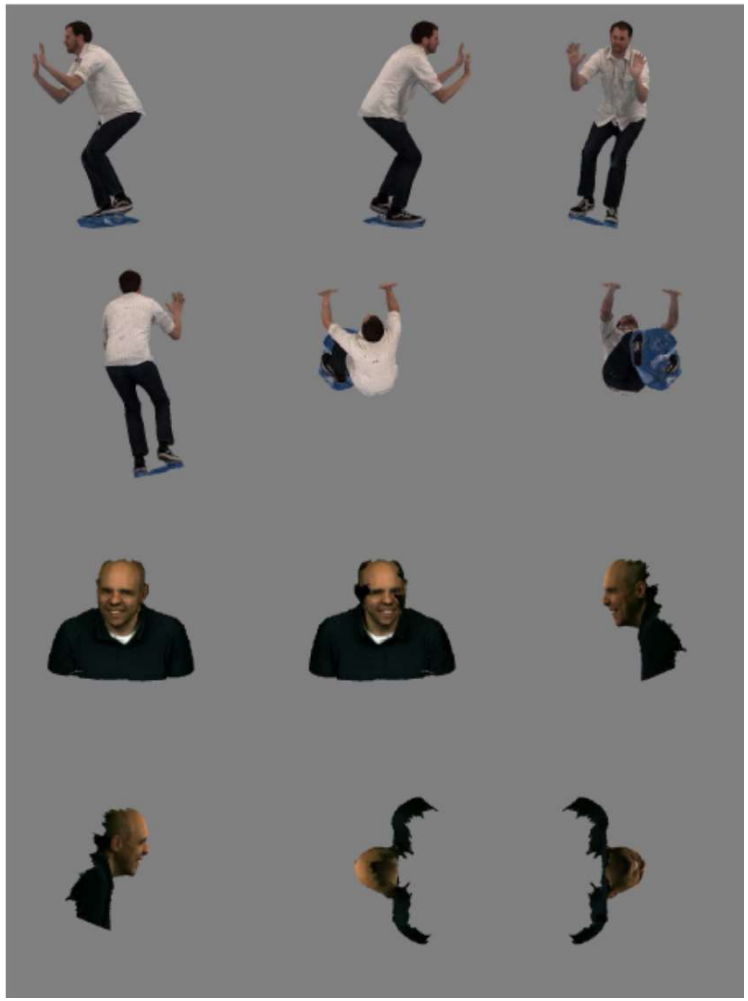
Distortion metrics

Correspondence-based



$$\delta_{Y+G} = \frac{1}{N_\nu}\left(||\mathbf{E}_c||^2 + \beta||\mathbf{E}_g||^2\right)$$

Projections-based (image MSE/PSNR)



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Motion estimation in between point clouds

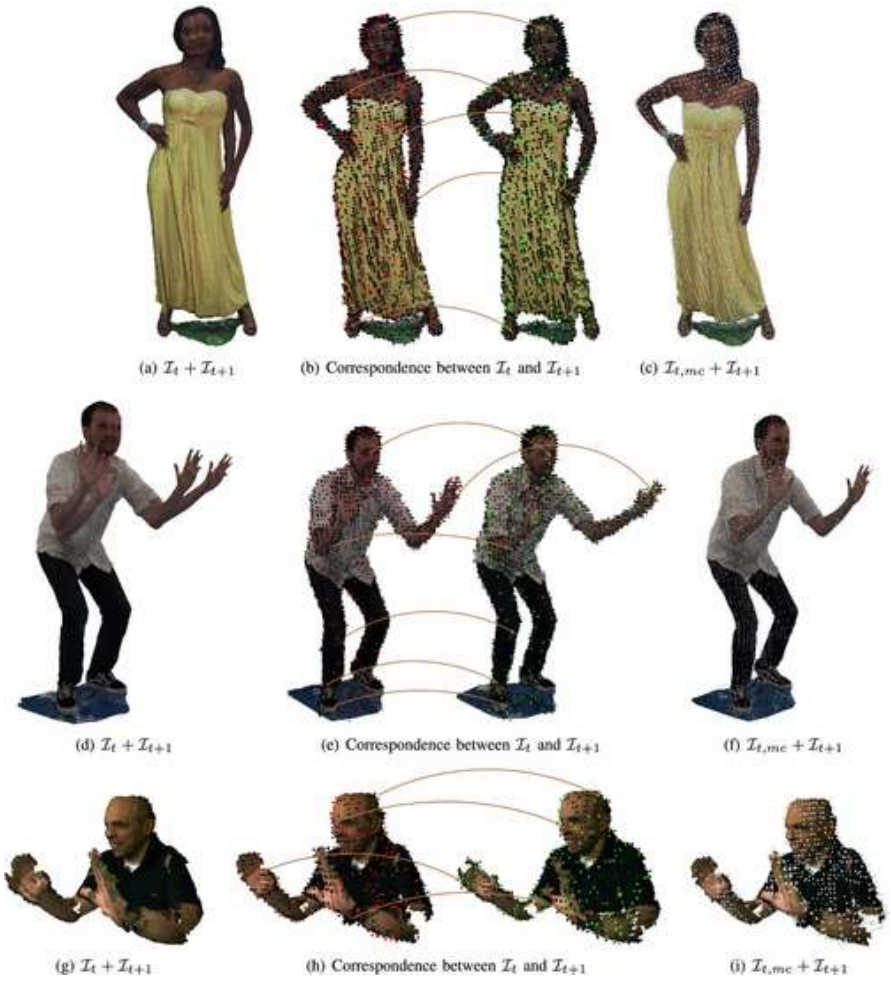

Illustration from:
D. Thanou, P. A. Chou, and P. Frossard, "Graph-based compression of dynamic 3D point cloud sequences," in *IEEE Trans. Image Processing*, vol. 25, no. 4, pp. 1765–1778, Apr. 2016.

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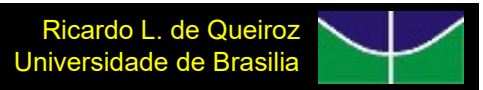
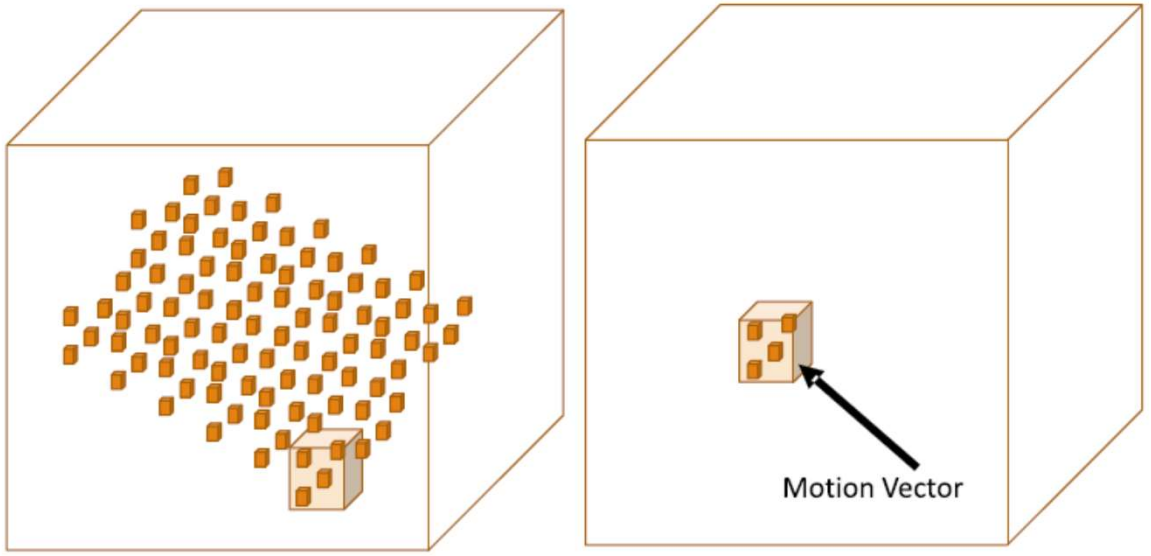


Motion compensation in DPC



Previous Frame

A voxel cube in current frame

$$
\begin{aligned}
b_x N - M_x \le x_{i,t-1} < b_x N + N - M_x, \\
b_y N - M_y \le y_{i,t-1} < b_y N + N - M_y, \\
b_z N - M_z \le z_{i,t-1} < b_z N + N - M_z.
\end{aligned}
$$

$$
\begin{aligned}
b_x N \le x_{it} < b_x N + N, \\
b_y N \le y_{it} < b_y N + N, \\
b_z N \le z_{it} < b_z N + N.
\end{aligned}
$$

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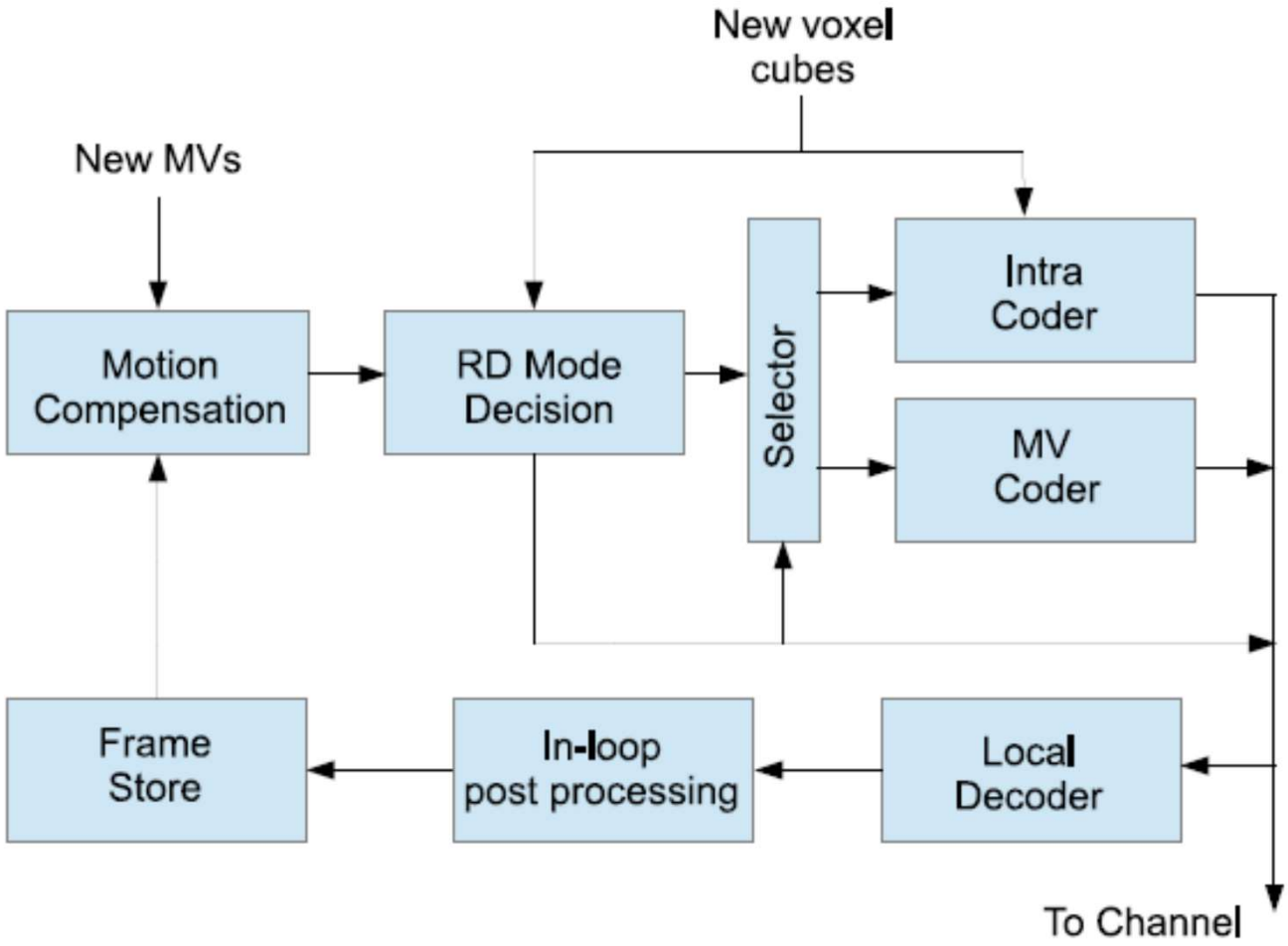
Motion-compensated coder



Intra coder (RAHT): R. L. de Queiroz and P. A. Chou, ``Compression of 3D point clouds using a region-adaptive hierarchical transform," *IEEE Trans. on Image Processing*, Vol. 25, No. 8, pp. 3497-3956, Aug. 2016.

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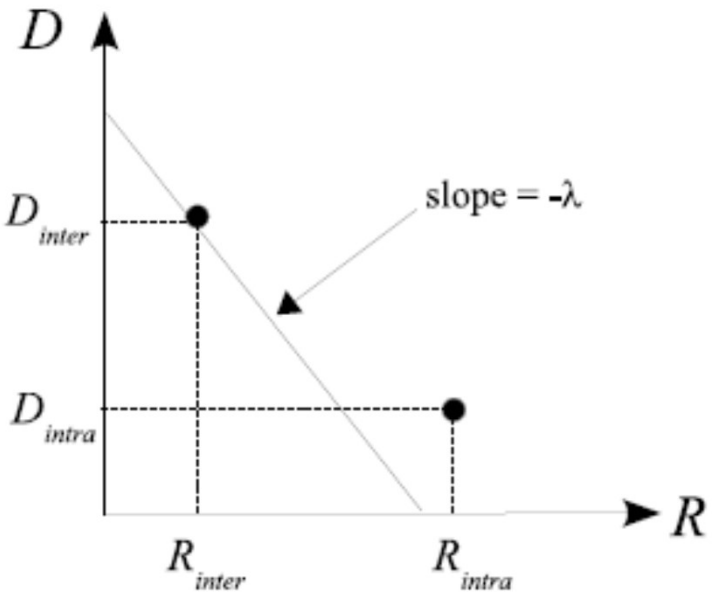
Coding mode decision



-Decision made for every occupied cube (size NxNxN voxels)

$$R_{intra} = R_g^{intra} + R_c^{intra} \approx 2.5||\Omega|| + R_c^{intra}$$

$$R_{inter} = R_g^{inter} + R_c^{inter} = R_{MV}$$

$$D_{intra} = D_g^{intra} + \beta D_c^{intra} = \beta D_c^{intra}$$

$$D_{inter} = D_g^{inter} + \beta D_c^{inter} = \delta,$$

-Choose intra coding if

$$D_{intra} + \lambda R_{intra} < D_{inter} + \lambda R_{inter}$$

-If not just motion compensate (no residual)

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In-loop filtering

- 3d extension of morphological closing applied to geometry
- "Deblocking" filter

$$\hat{x}_i = \frac{\sum_{j,d_{ij}<\eta} x_j \rho^{d_{ij}}}{\sum_{j,d_{ij}<\eta} \rho^{d_{ij}}}$$

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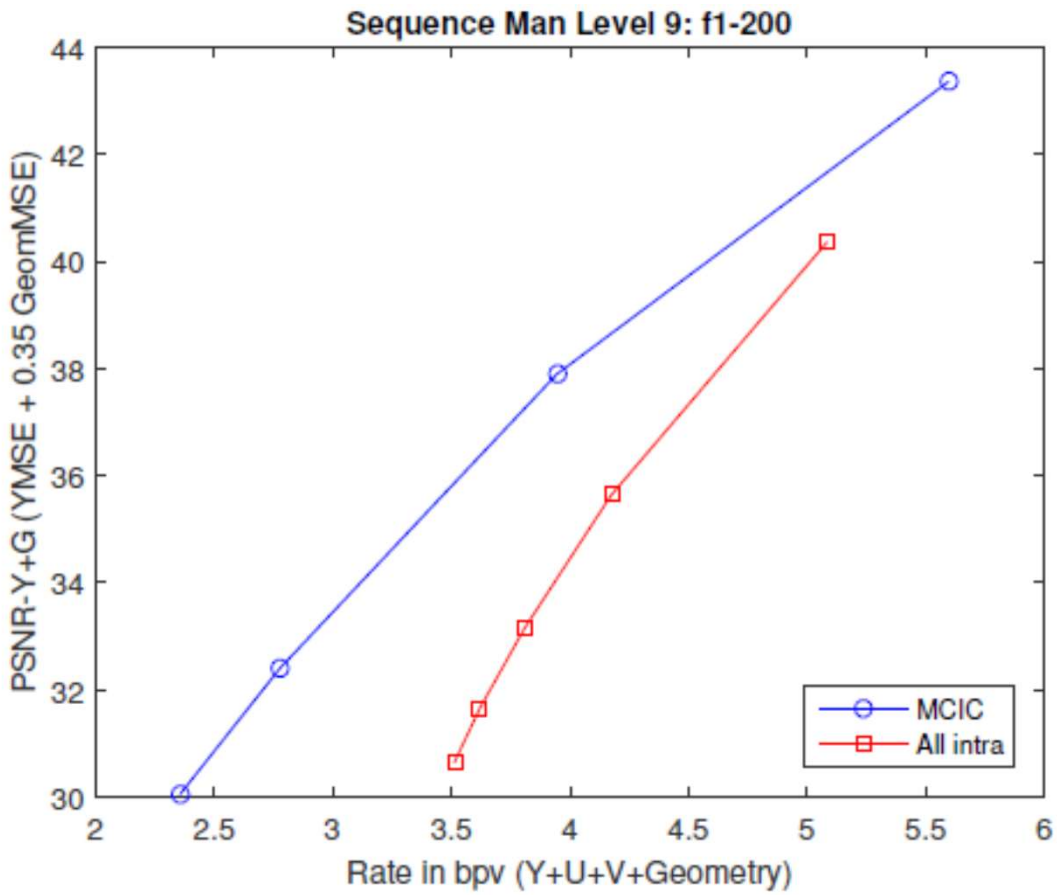
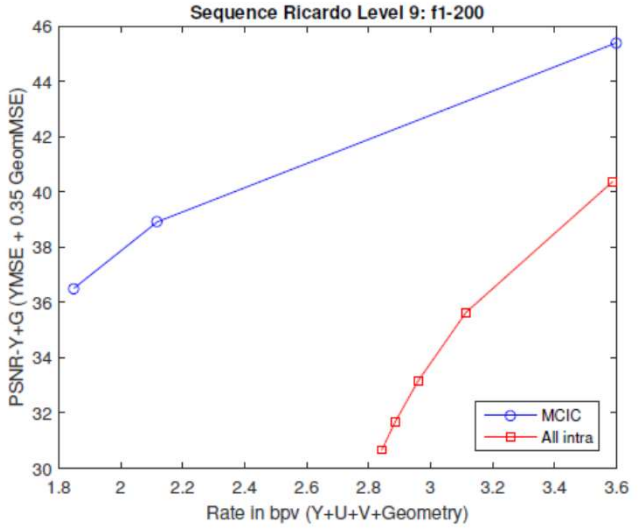
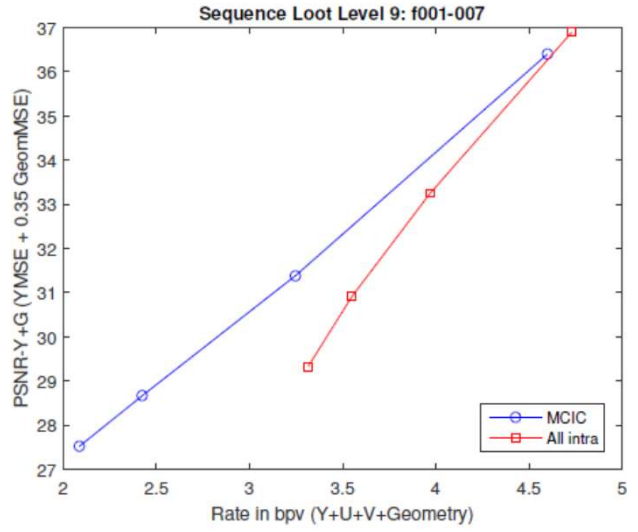
RD curves - correspondence







For distortion based on correspondence which is determined by Euclidean distance

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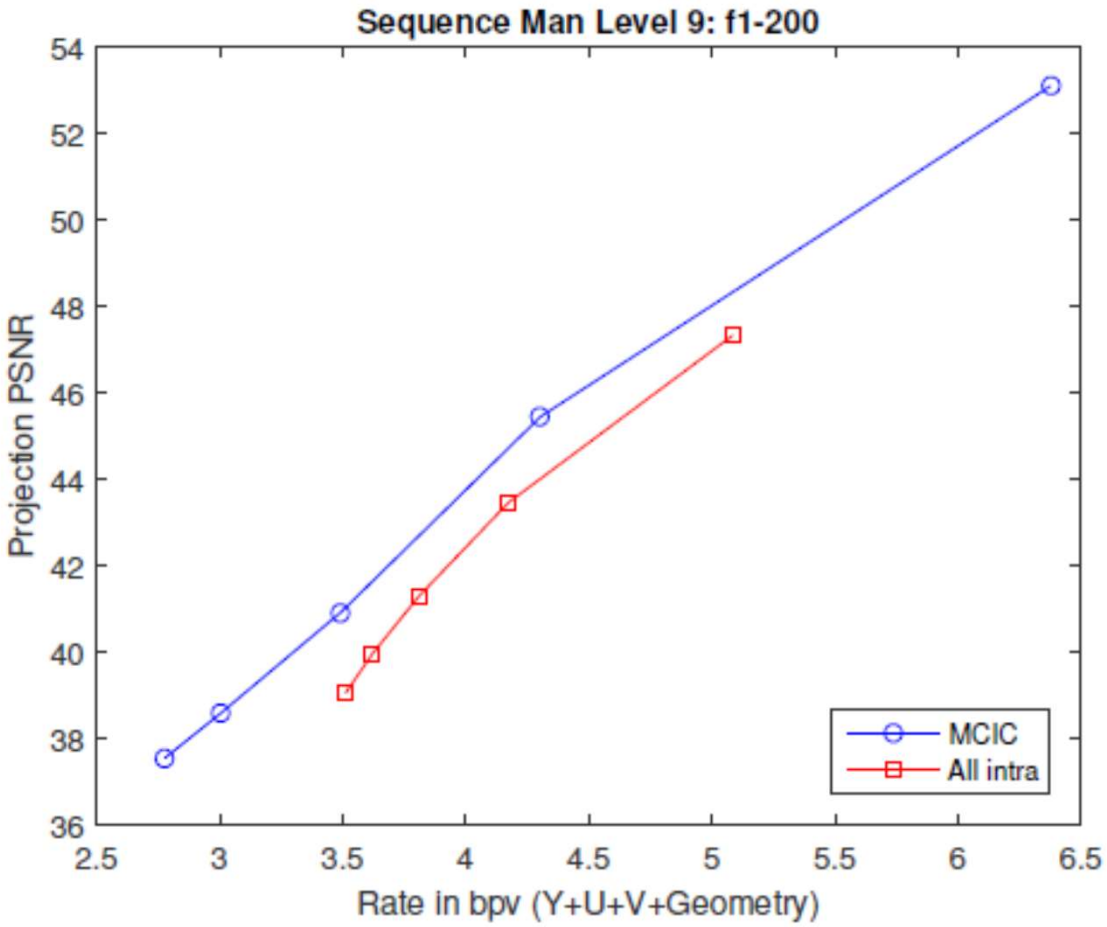
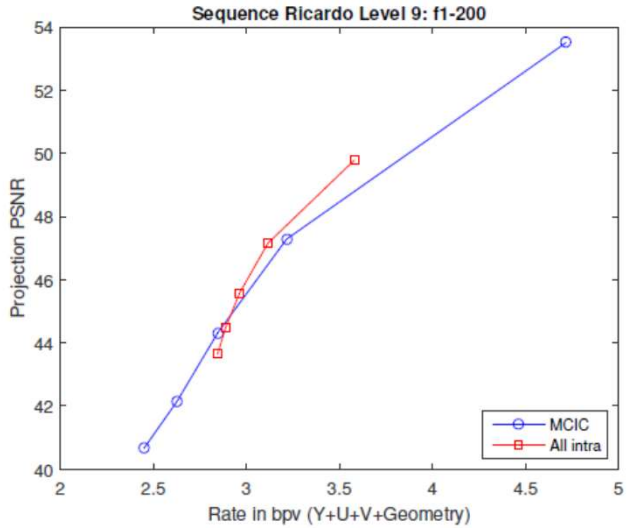
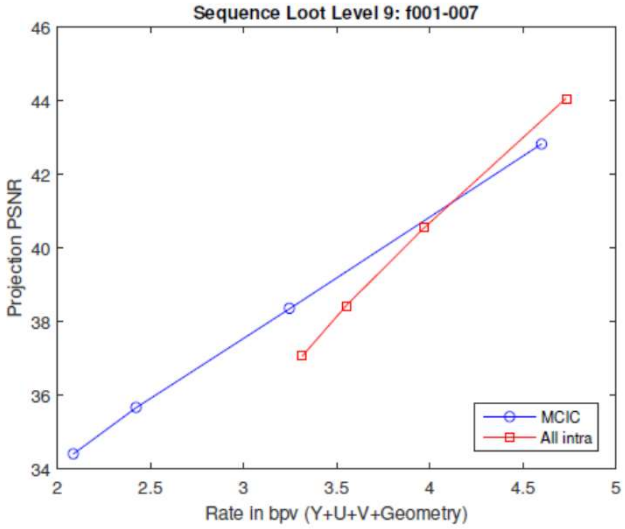
RD curves - projections







For distortion based on projections (6 sided)

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Higher compression of geometry information

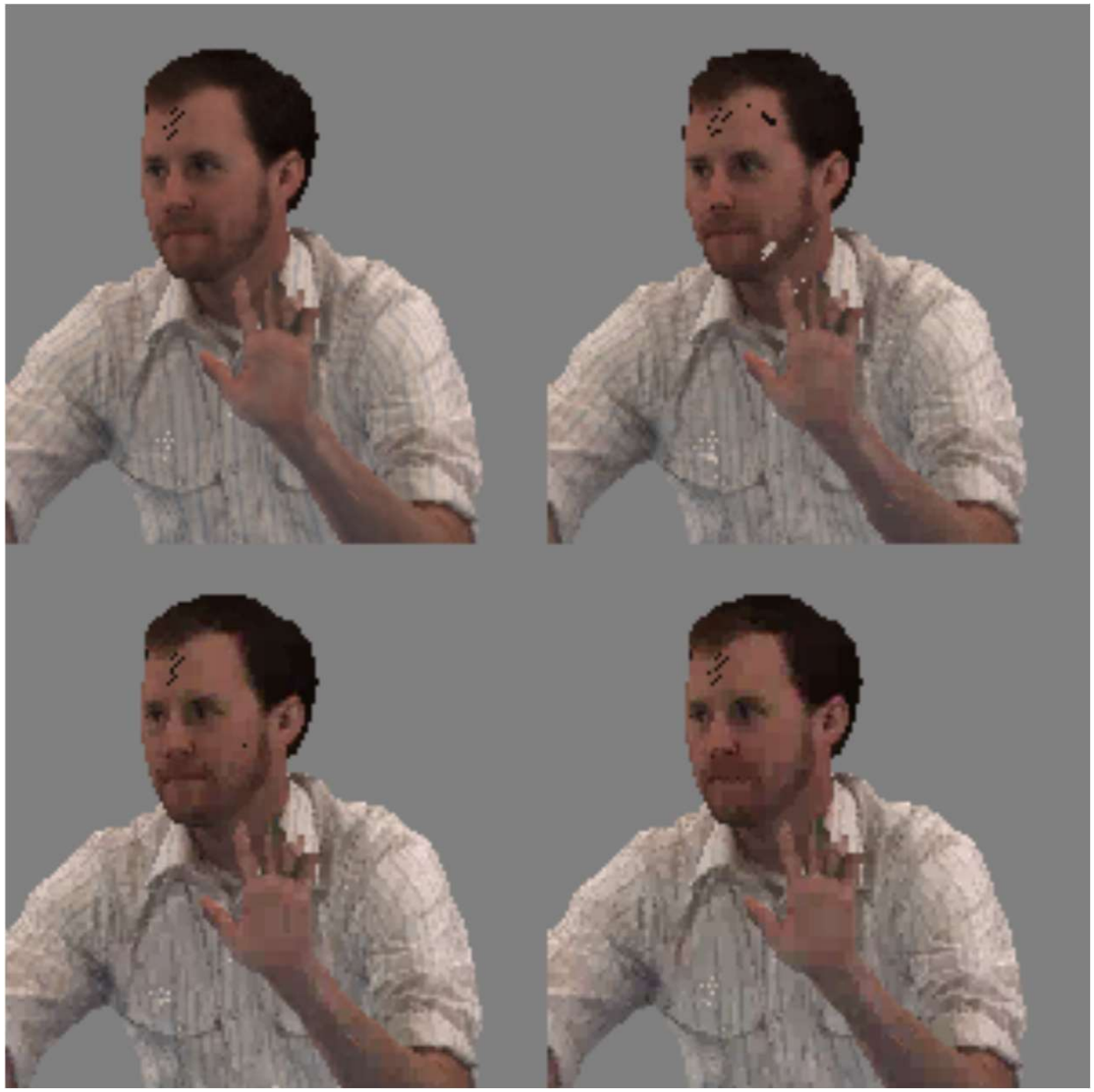
Man: Frame 58

Original

3.7 bpv
RD using a correspondence based distortion metric

3.7 bpv
RD using projection based Distortion metric

3.7 bpv
RAHT (all intra)



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Results

4.4 bpv (original and decompressed)
Man frame 58

RAHT vs. MCIC
Ricardo frame 60

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Conclusions

- Potential for "traditional" motion compensation in compression of point clouds to reduce the bit rate
- Geometry encoding is the largest hurdle now
- We still have very little about encoding residuals (which is what is done in regular motion compensated vídeo coders)
- Lots of work still to be done

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Thank you