

Structure from Visibility: Finding low-textured and reflective occluders in outdoor scenes using visibility and occlusion

Martijn van der Veen

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Supervisor: Gabriel J. Brostow

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Goal: reconstructing (difficult) objects in outdoor scenes using a set of images



Source: P. Merrell et al. [2007]

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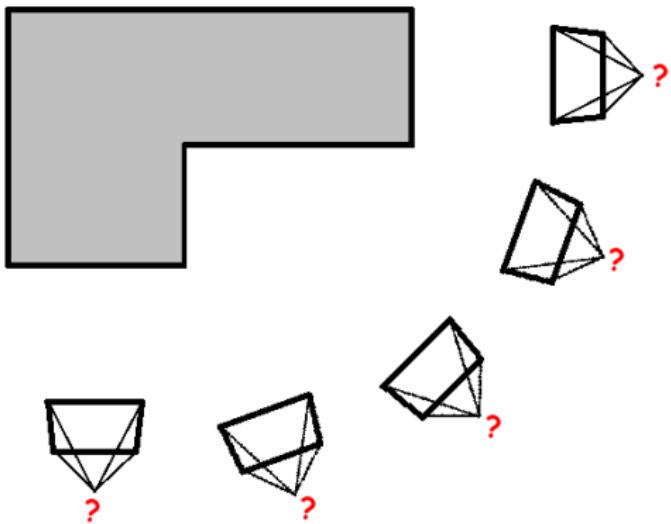
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Resources

- ▶ Structure from Motion (sparse point clouds)
- ▶ Space Carving using Silhouettes
- ▶ Multi-View Stereo (Depth Maps)

Structure from Motion

- ▶ Find and Match interesting points
- ▶ Estimate camera positions
- ▶ Triangulate point locations
- ▶ Make visibility lists



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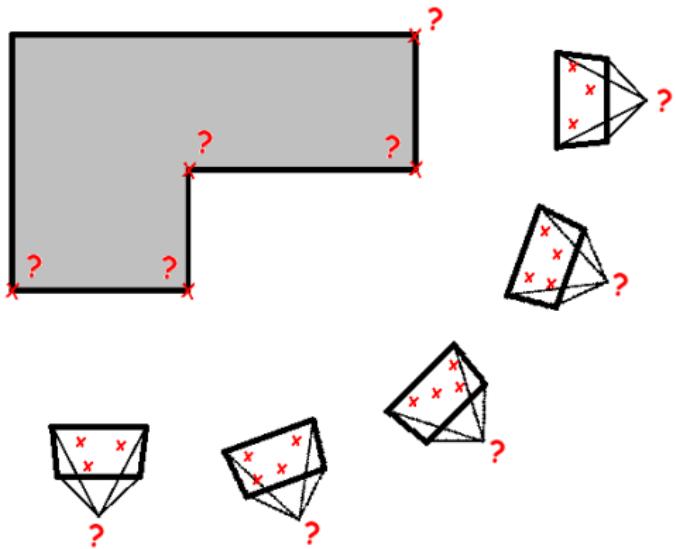
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Structure from Motion

- ▶ **Find and Match interesting points**
- ▶ Estimate camera positions
- ▶ Triangulate point locations
- ▶ Make visibility lists



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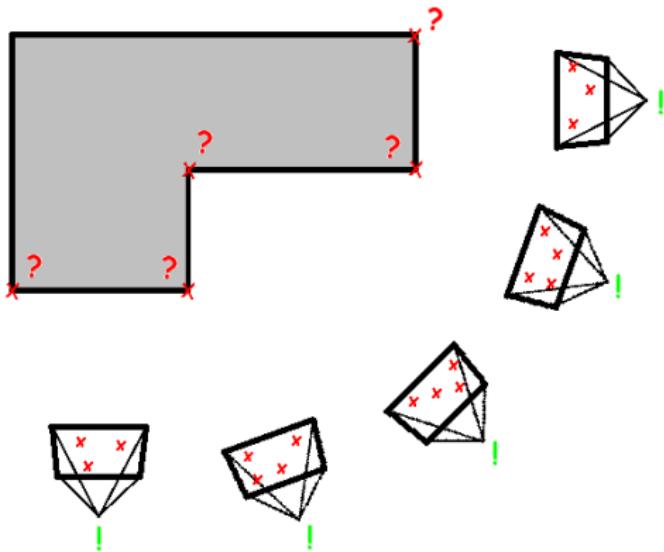
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Structure from Motion

- ▶ Find and Match interesting points
- ▶ **Estimate camera positions**
- ▶ Triangulate point locations
- ▶ Make visibility lists



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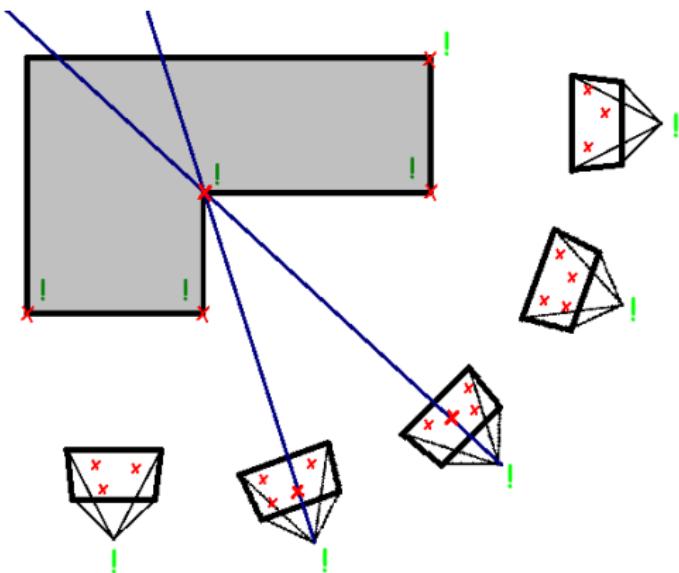
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Structure from Motion

- ▶ Find and Match interesting points
- ▶ Estimate camera positions
- ▶ **Triangulate point locations**
- ▶ Make visibility lists



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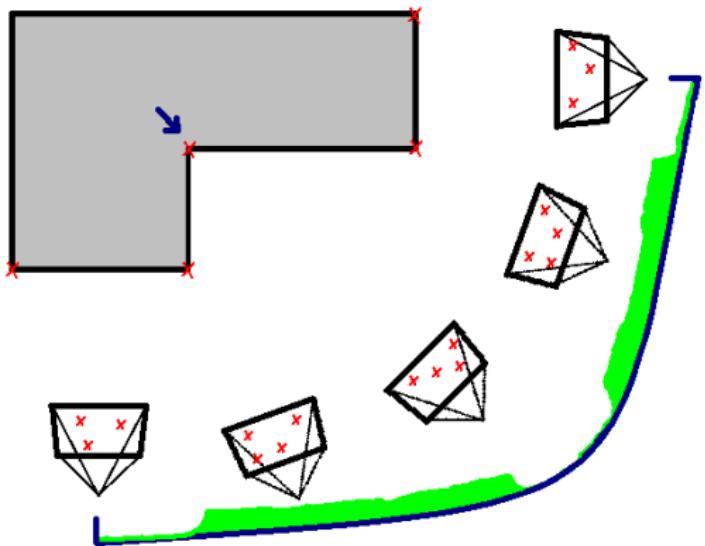
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Structure from Motion

- ▶ Find and Match interesting points
- ▶ Estimate camera positions
- ▶ Triangulate point locations
- ▶ **Make visibility lists**



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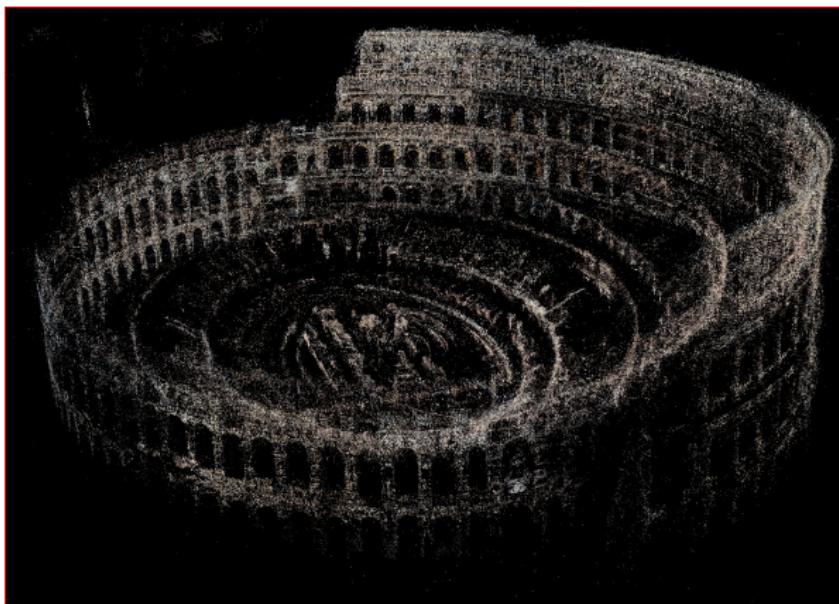
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Structure from Motion

We get:

- ▶ **Sparse Point Cloud**
- ▶ Camera models (poses, etc)
- ▶ Visibility lists



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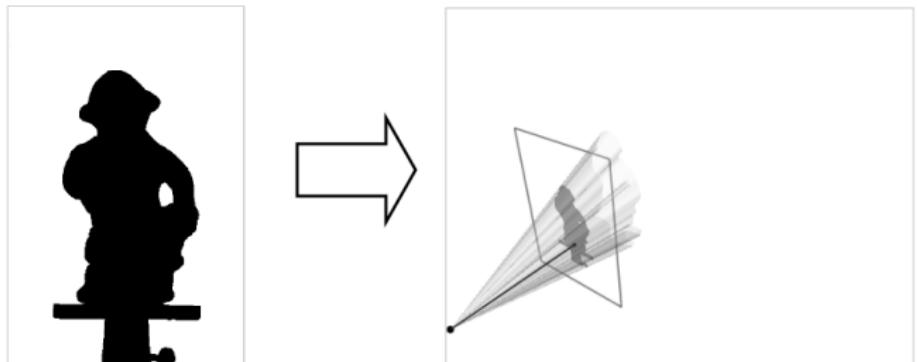
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Source: How to prepare and deliver a presentation, by Roberto Cipolla [ppt]

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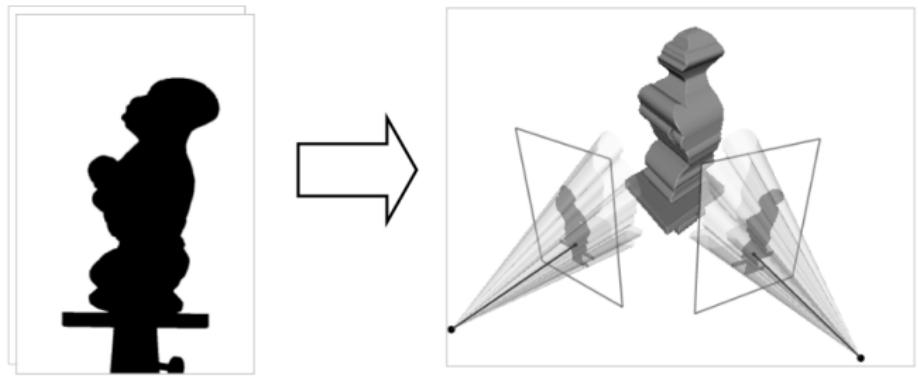
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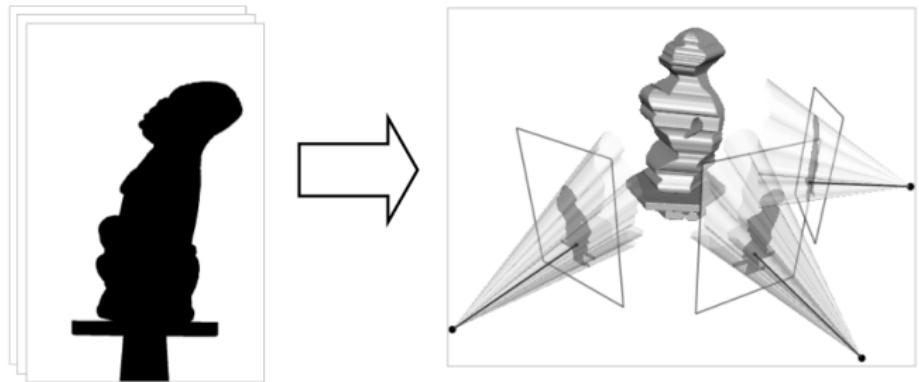
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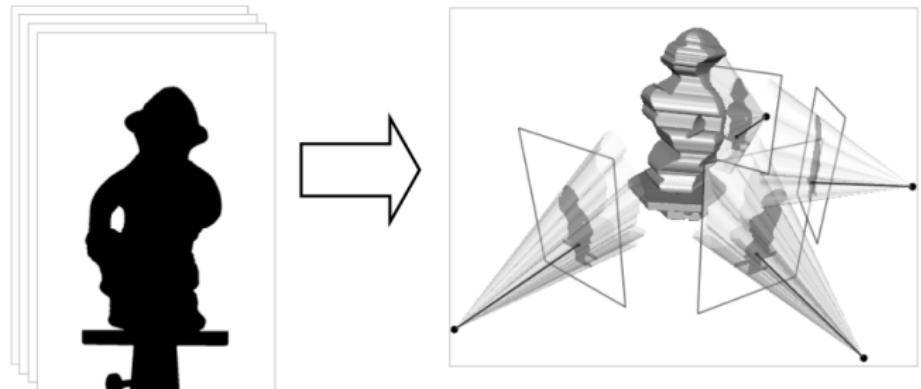
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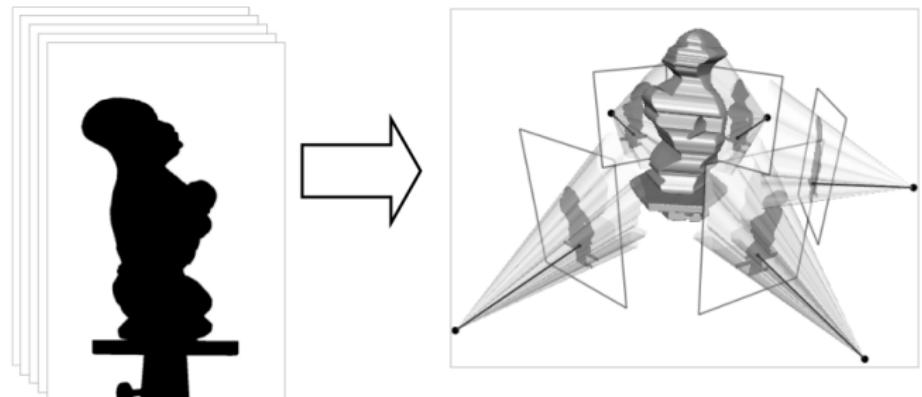
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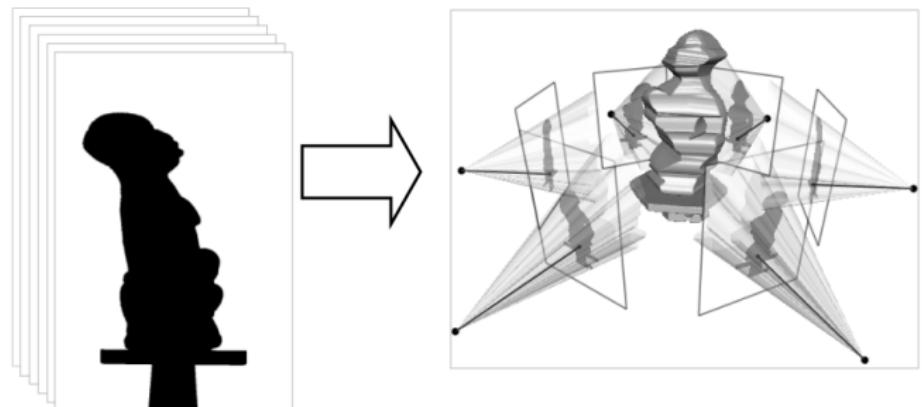
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We get:

- ▶ Convex hull

BUT:

- ▶ Finding silhouettes necessary (can use Green Screen)
- ▶ Often one (simple) object only

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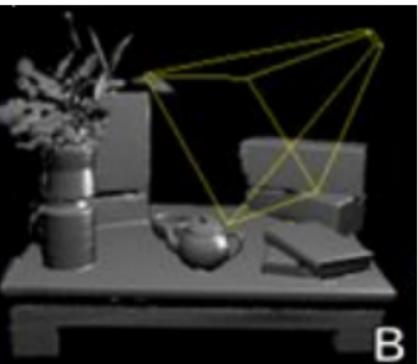
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1. Make depth maps (from image pairs)
2. Merge them

Multi-View Stereo: Active lighting

1. Actively light environment
2. Find back light in image
3. Estimate pixel depth

Example: Kinect (structured light):



Left: <http://www.hackengineer.com/structured-light-vs-microsoft-kinect>

Right: KinectFusion: Real-time 3D Reconstruction and Interaction Using a Moving Depth Camera
(2011)

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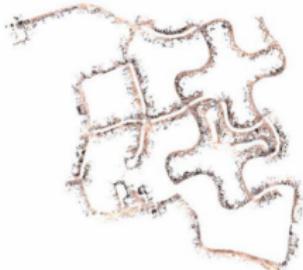
Multi-View Stereo: Photo-Consistency

For every pixel:

1. Find corresponding pixel in second image
2. Estimate pixel depth



Source: Manhattan-world Stereo [2009]



Source: Real-Time Visibility-Based Fusion of Depth Maps [2007]

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Multi-View Stereo: Photo-Consistency

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BUT:

- ▶ Needs photo-consistency measure
(textured + lambertian objects)

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Find objects *indirectly* by visibility and missing visibility
(occlusion)

- ▶ Structure from Motion
- ▶ Space carving
- ▶ (Surface reconstruction + Texture Mapping)

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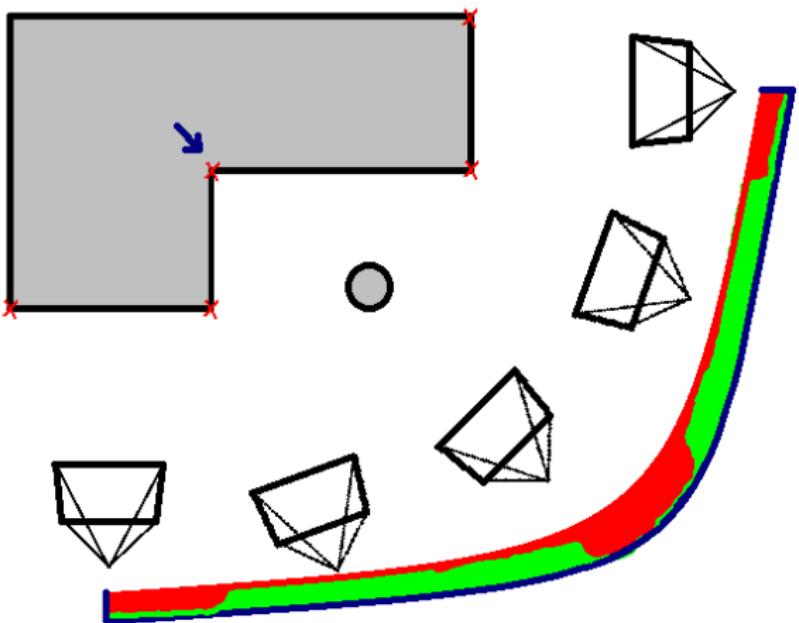
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Method: Space Carving

We get this:



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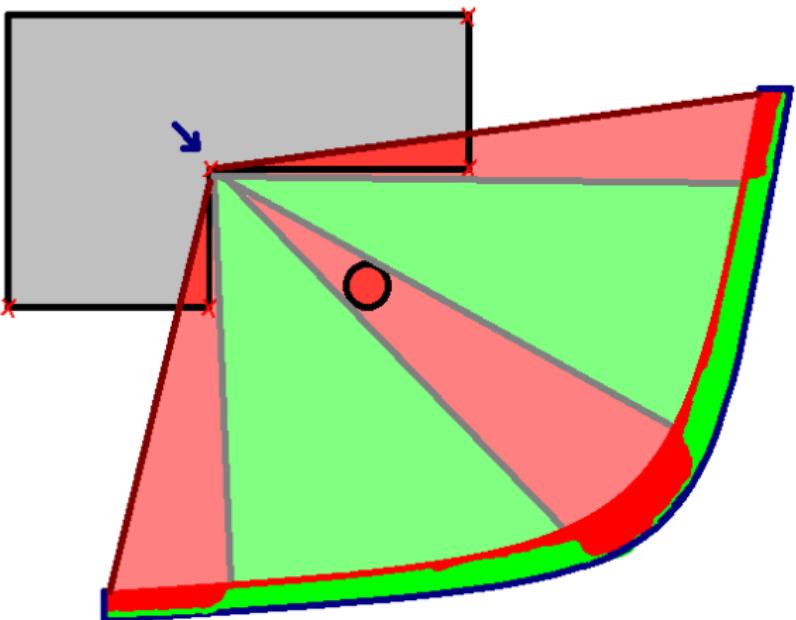
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Method: Space Carving

We do this:



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Shown for 3 examples:

- ▶ Image sequence
- ▶ Sparse point cloud (VisualSfM)
- ▶ Them: Multi-View Stereo CMVS/PMVS (2010)
- ▶ Our: Visibility-Occlusion Space Carving

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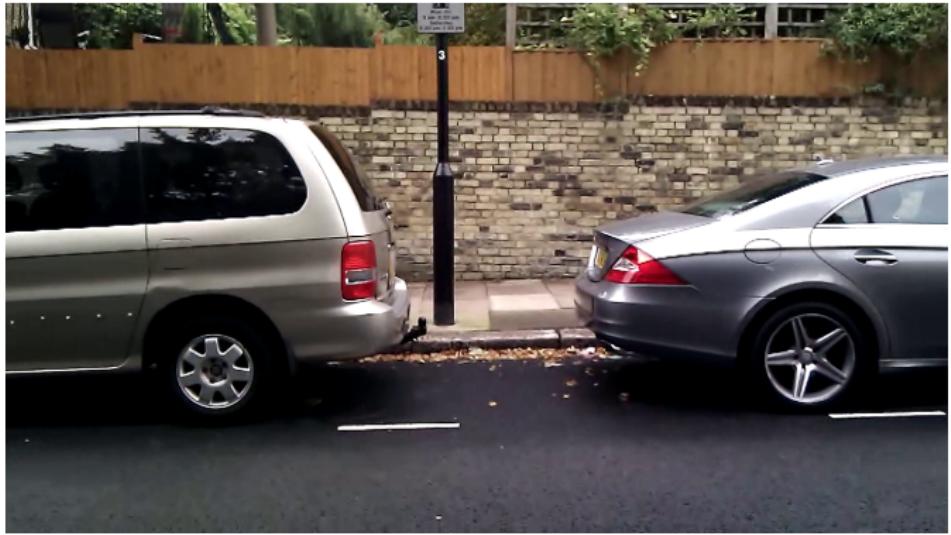
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Result: car_and_wall1



- ▶ **Image sequence**
- ▶ Sparse point cloud
- ▶ Multi-View Stereo (them)
- ▶ Visibility-Occlusion Space Carving (our)

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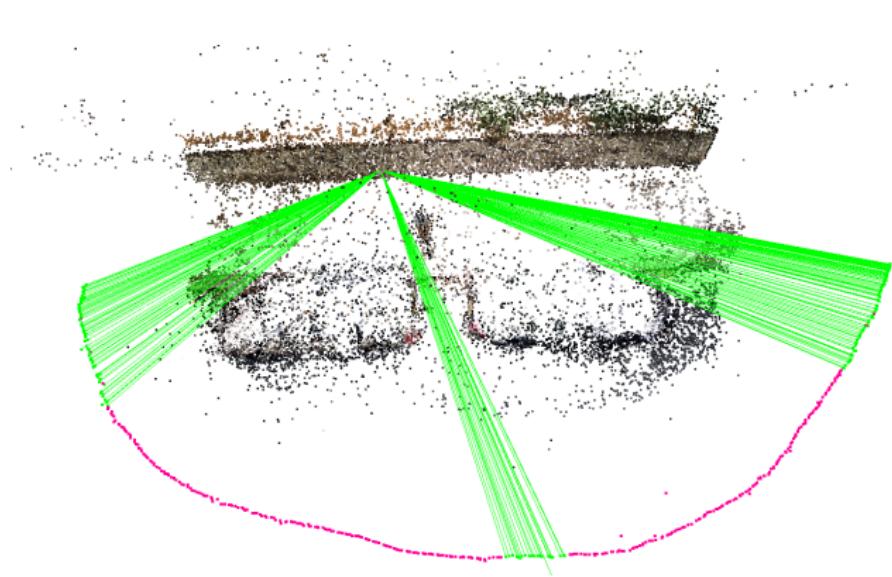
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Result: car_and_wall1



- ▶ Image sequence
- ▶ **Sparse point cloud**
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Result: car_and_wall1



- ▶ Image sequence
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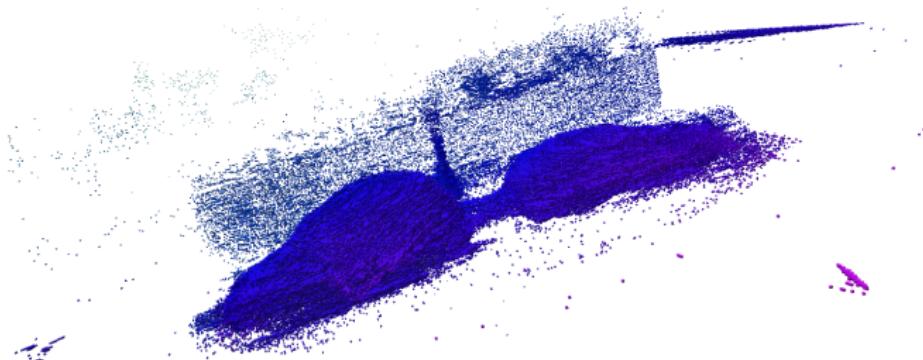
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Result: car_and_wall1



- ▶ Image sequence
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- ▶ **Visibility-Occlusion Space Carving (our)**

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Result: sculpture1



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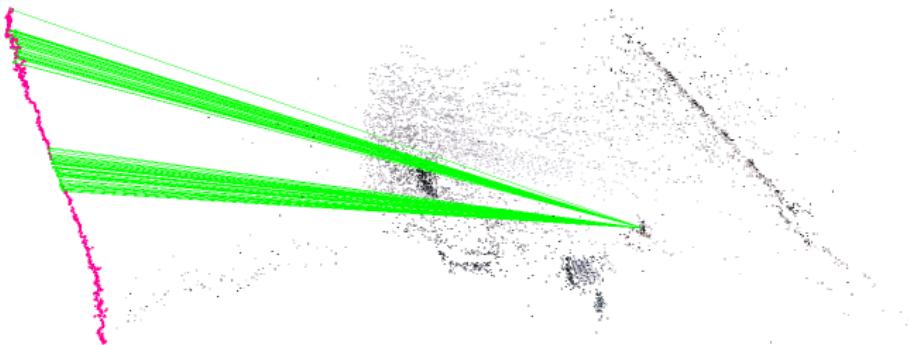
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Result: sculpture1



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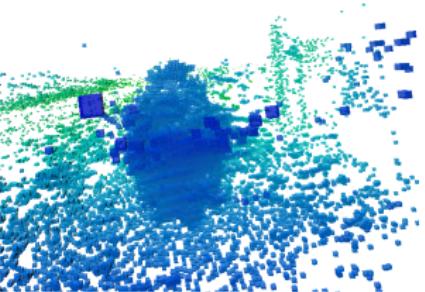
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- ▶ Image sequence
- ▶ Sparse point cloud
- ▶ Multi-View Stereo (them)
- ▶ **Visibility-Occlusion Space Carving (our)**

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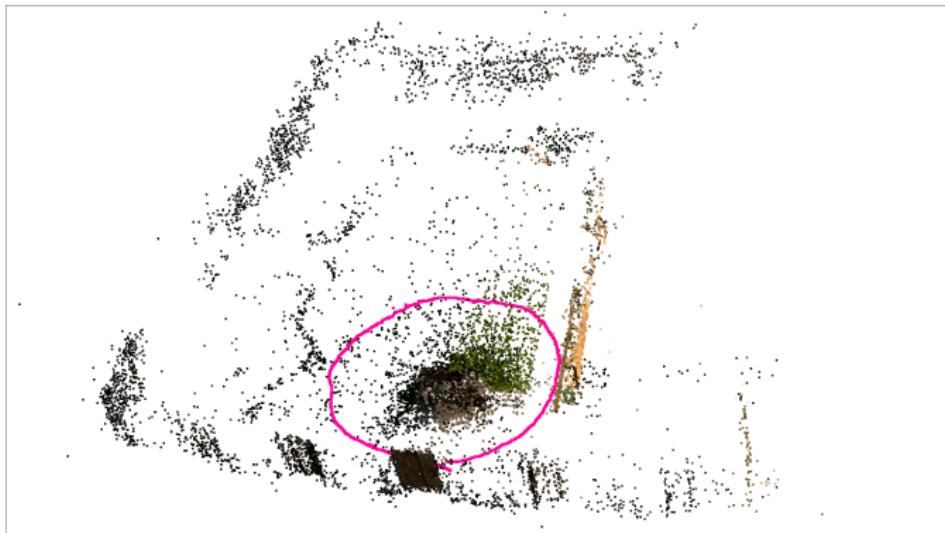
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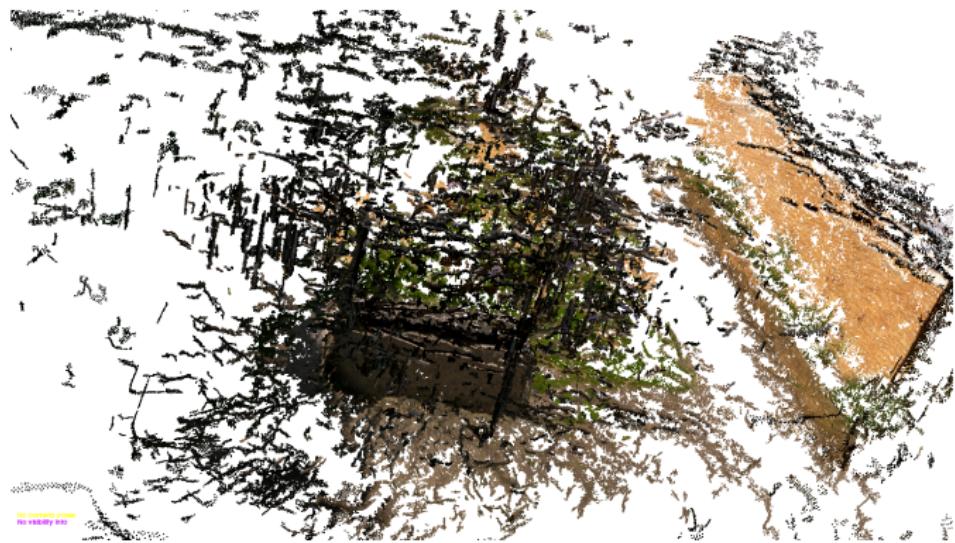
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- ▶ Image sequence
- ▶ **Sparse point cloud**
- ▶ Multi-View Stereo (them)
- ▶ Visibility-Occlusion Space Carving (our)

Result: memorial1



- ▶ Image sequence
- ▶ Sparse point cloud
- ▶ **Multi-View Stereo (them)**
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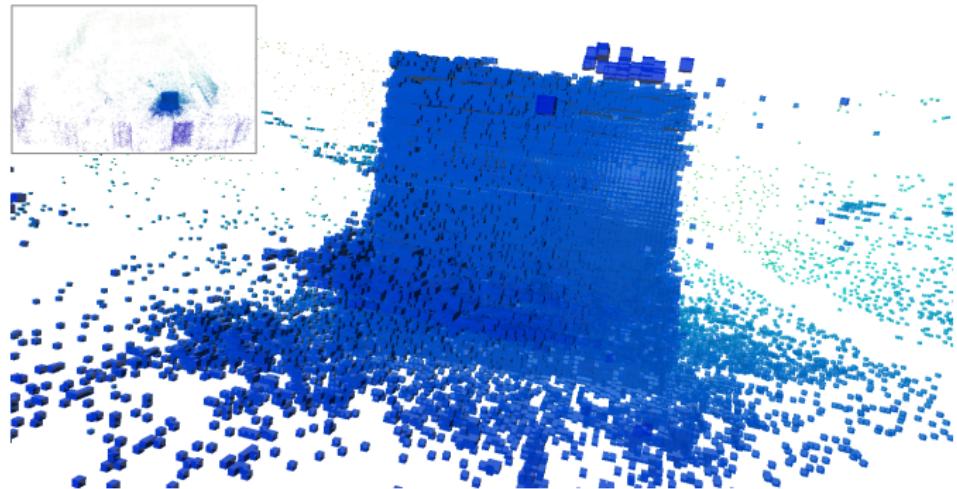
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- ▶ Image sequence
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Conclusion

- ▶ Needs enough data (view points)
- ▶ Needs textured background objects
- ▶ Can outperform state-of-the-art

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Left: <http://www.ikea.com>; right: sparse point cloud

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Texture-rich object



Middlebury Multi-View Temple dataset (2006)

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'Bad' result



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