Data Challenges with 3D Computer Vision

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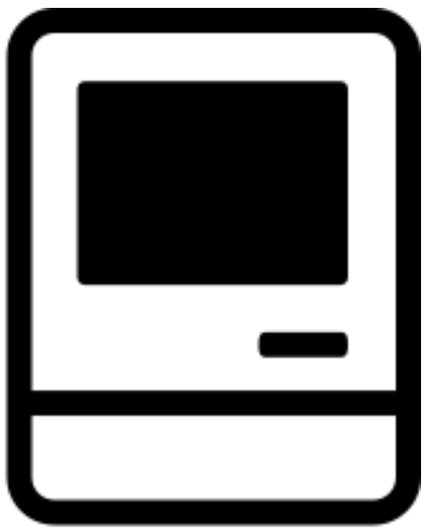
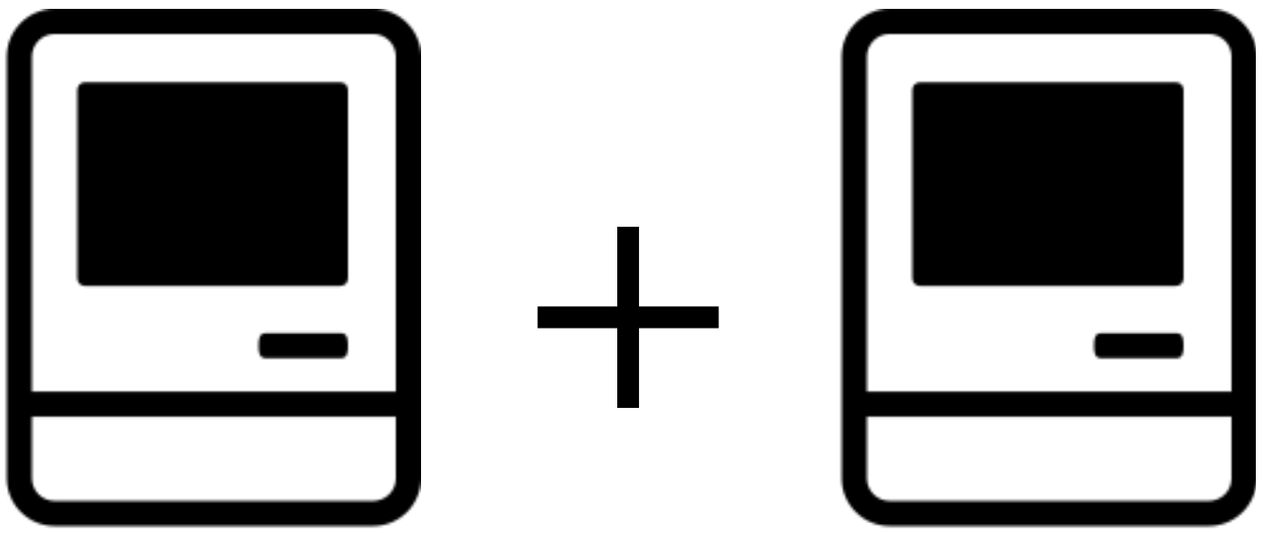
3D Computer Vision Challenges

- Data Capture / 3D Perception
- Size of 3D Data
- Making Sense of 3D Data
- Visualizing 3D Data
- But: *3D CV is a qualitative shift*





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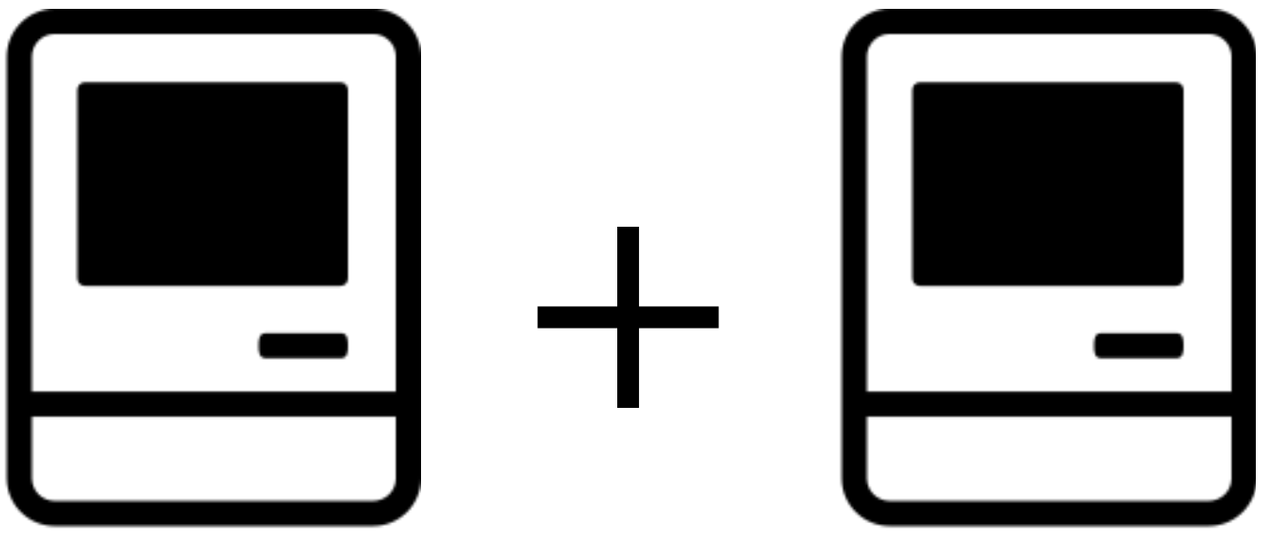

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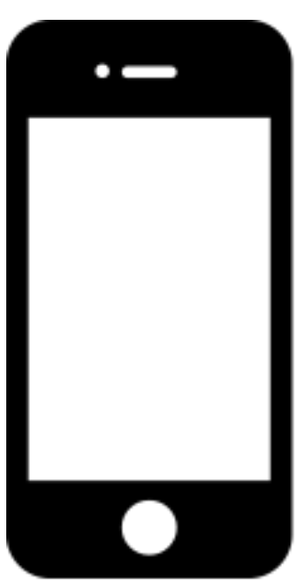
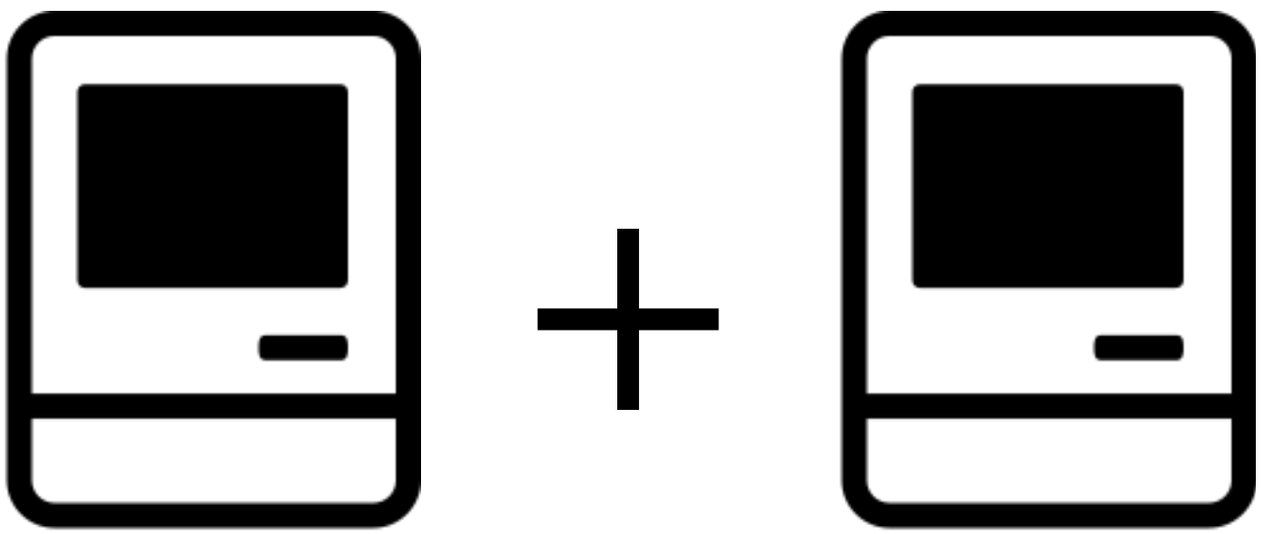




= WWW

= ?

What for?

Autonomous logistics

Kiva systems

Autonomous driving

Local Motors

Inspection and Maintenance

FAE Drones

Mining

3D Perception

Microsoft Kinect (2010):

- 3 MP Camera
- Depth Sensor
- Indoor only

Google’s Project Tango (2015)

- 4 MP Camera
- Depth Sensor
- Indoor only

3D Perception

Indoor & Outdoor

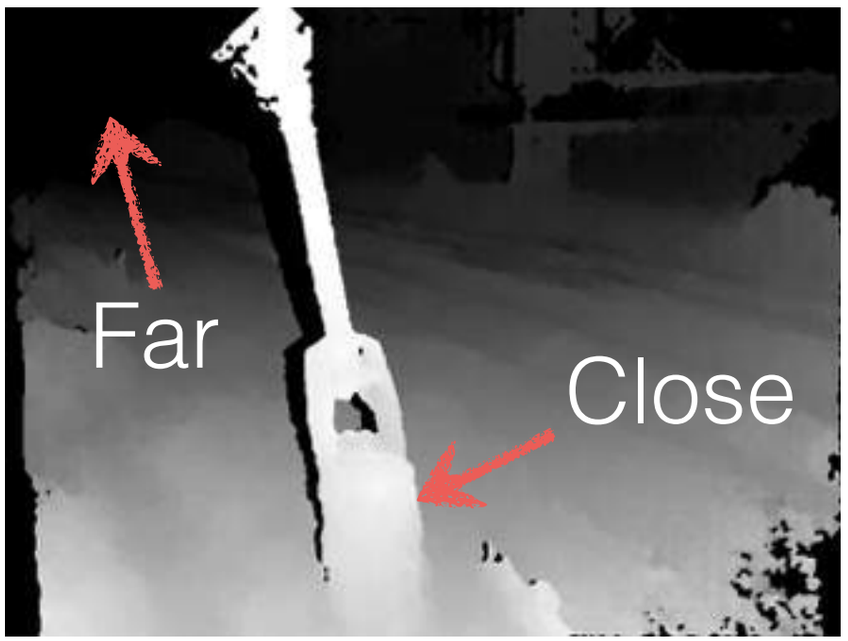
DLR's Integrated Positioning System (2014):
3D Navigation and inspection helmet.

- Stereo + Navigation
- Indoor & Outdoor

Digital Perception:
From 2D to a 3D Modell

Original Image

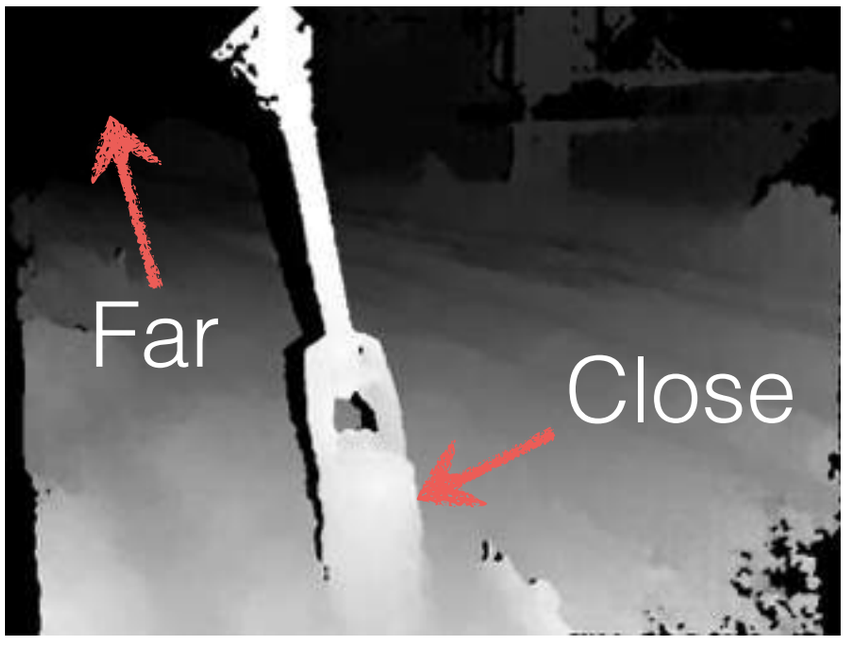
Digital Perception:
From 2D to a 3D Modell

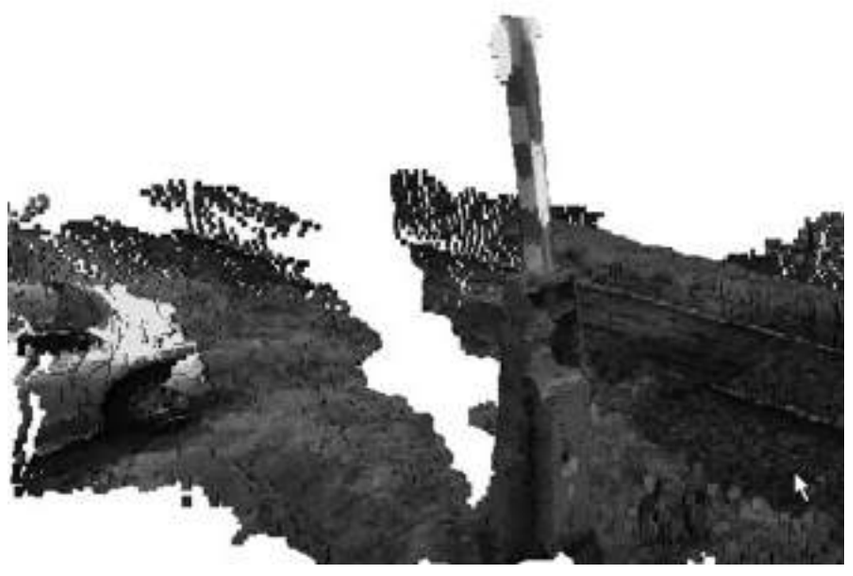


Original Image

Depth Map

Digital Perception:
From 2D to a 3D Modell





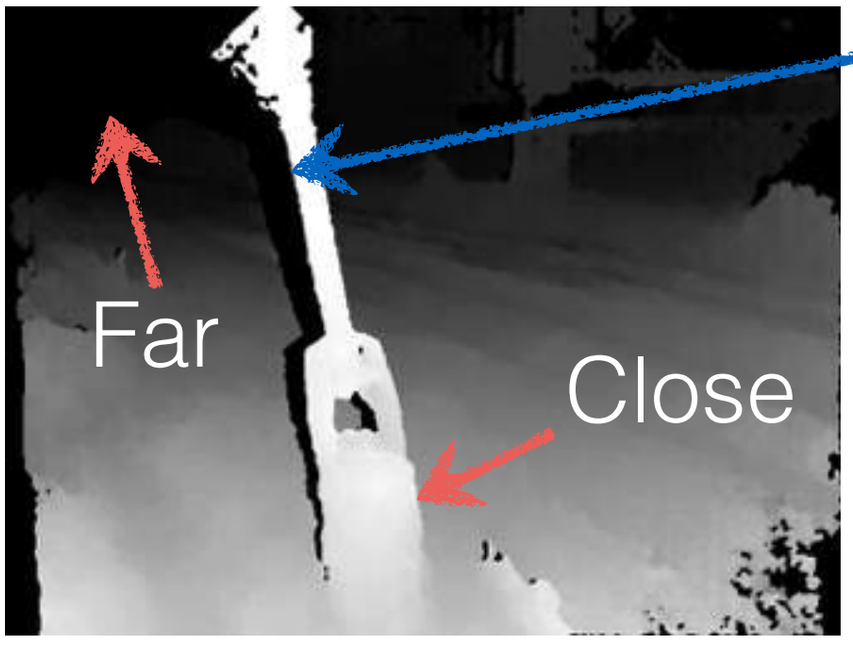
Original Image

Depth Map

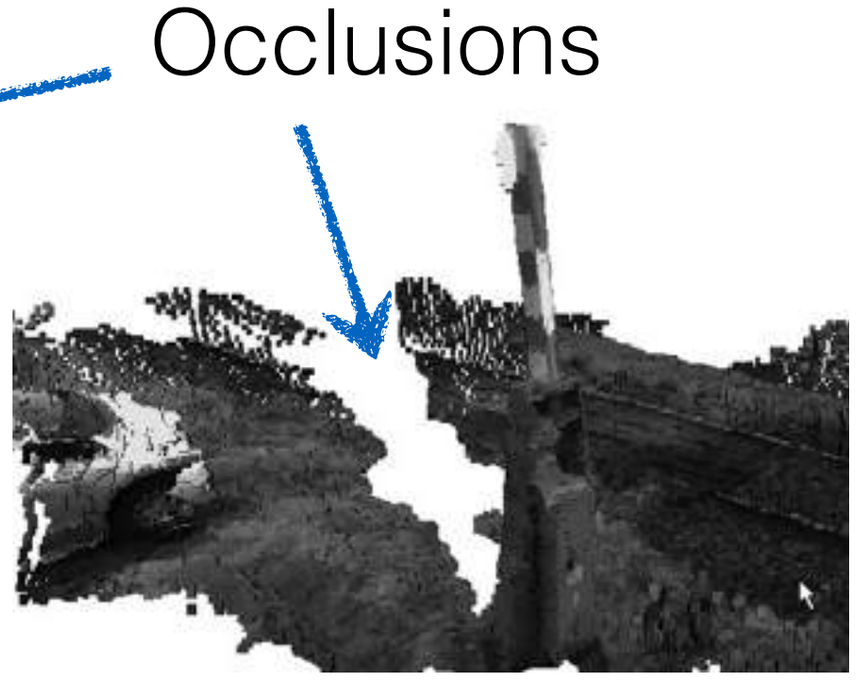
3D point Cloud

Digital Perception:
From 2D to a 3D Modell

Original Image



Depth Map

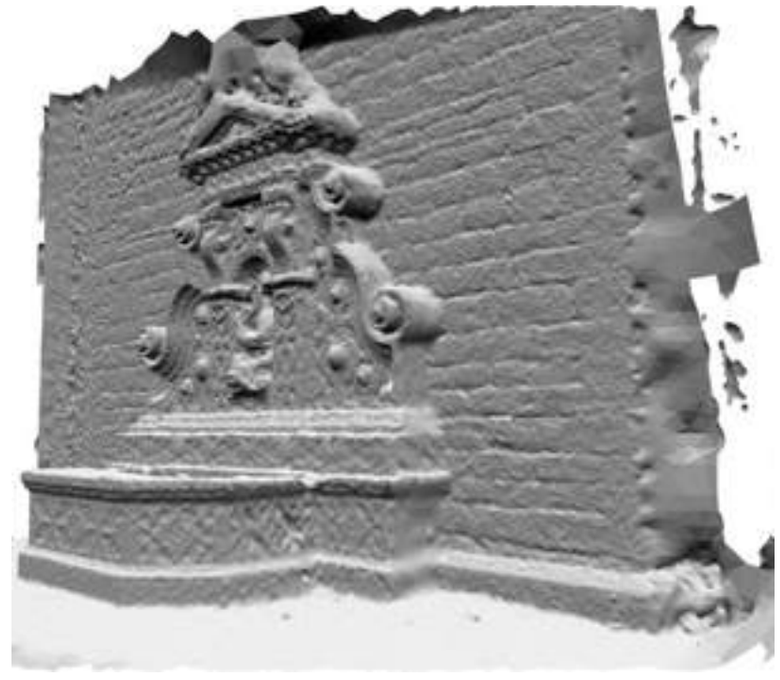


3D point Cloud

3D Perception

From single-shot to full 3D model

Input images



Computed
3D model

Algorithms compute a 3D model from unknown camera positions. **Benefit**: Automated modelling possible.

Digital Perception: Data Challenges

- a 9MP 8bit color image + 16bit depth: **43 MB** each

- 9 MP 8bit color image stereo setting @ 10 fps: **514 MB / s**

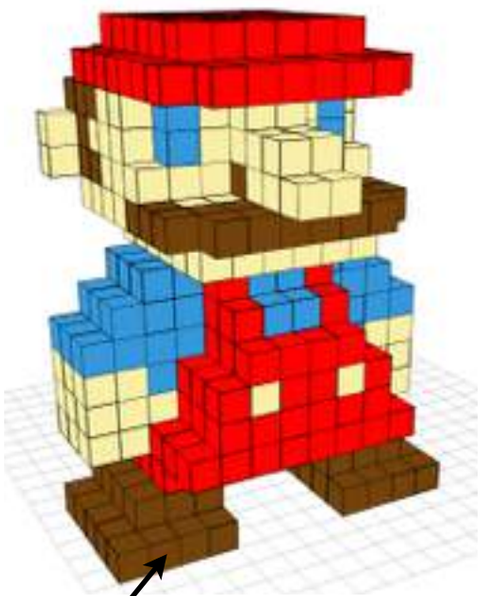
- 1 day worth of data capturing: **36TB**

How can we…

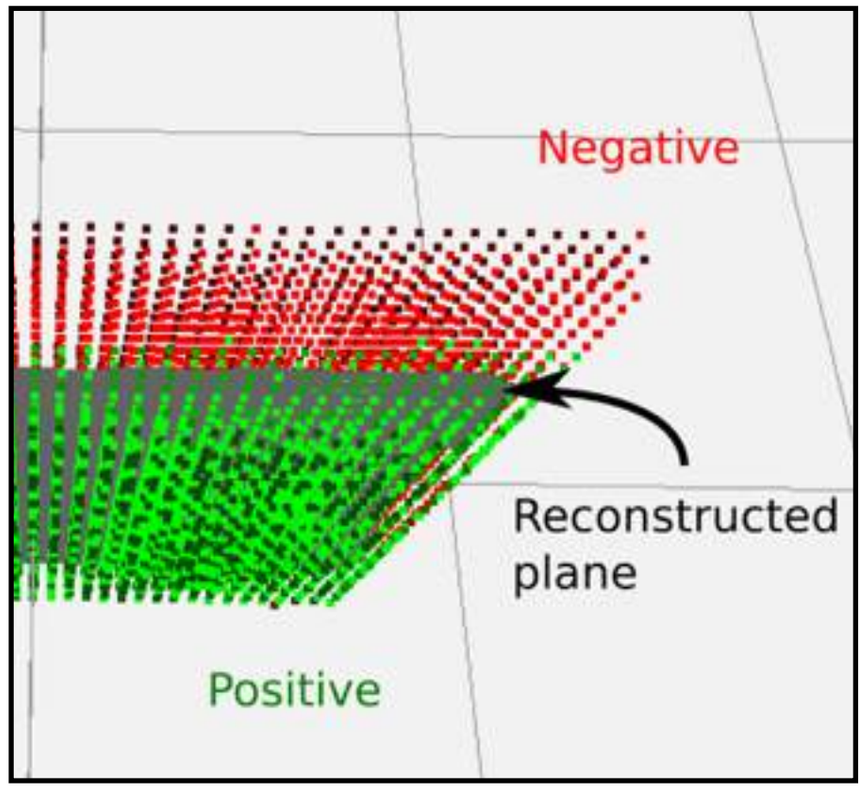
- store such huge amounts of 3D data?
- derive information from 3D data?
- make 3D data searchable?

Storage for 3D Modelling

Representing the 3D world as voxels



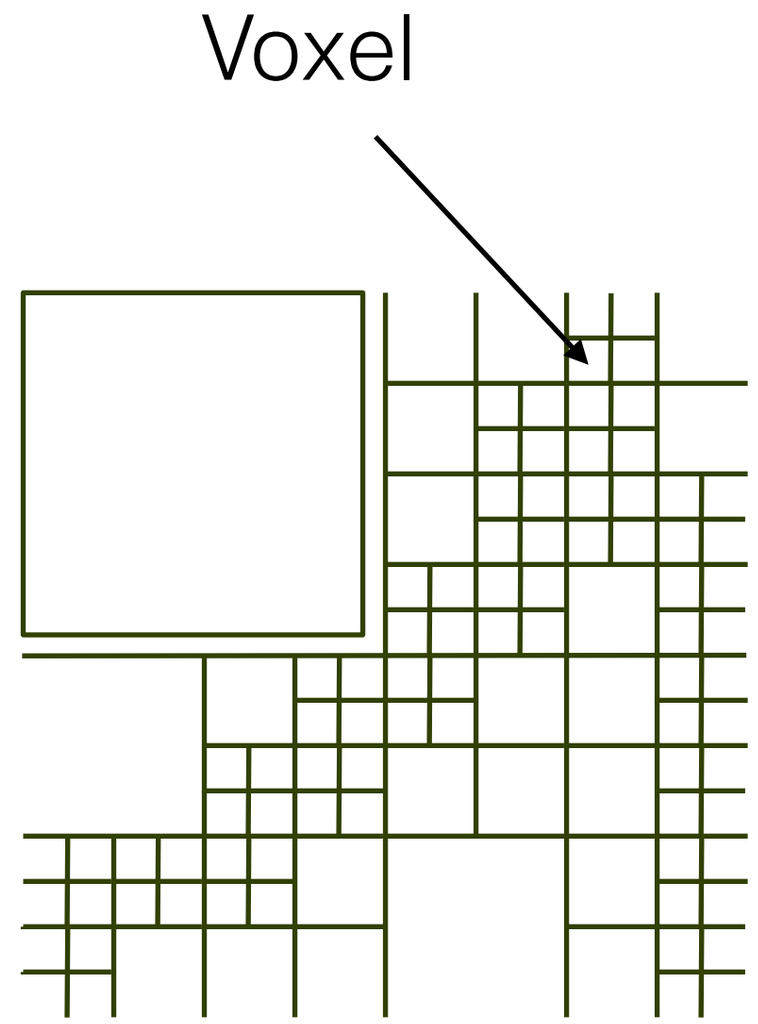
a 3D pixel (voxel)



"Implicit voxels": represent the surface by values <0 or >0.

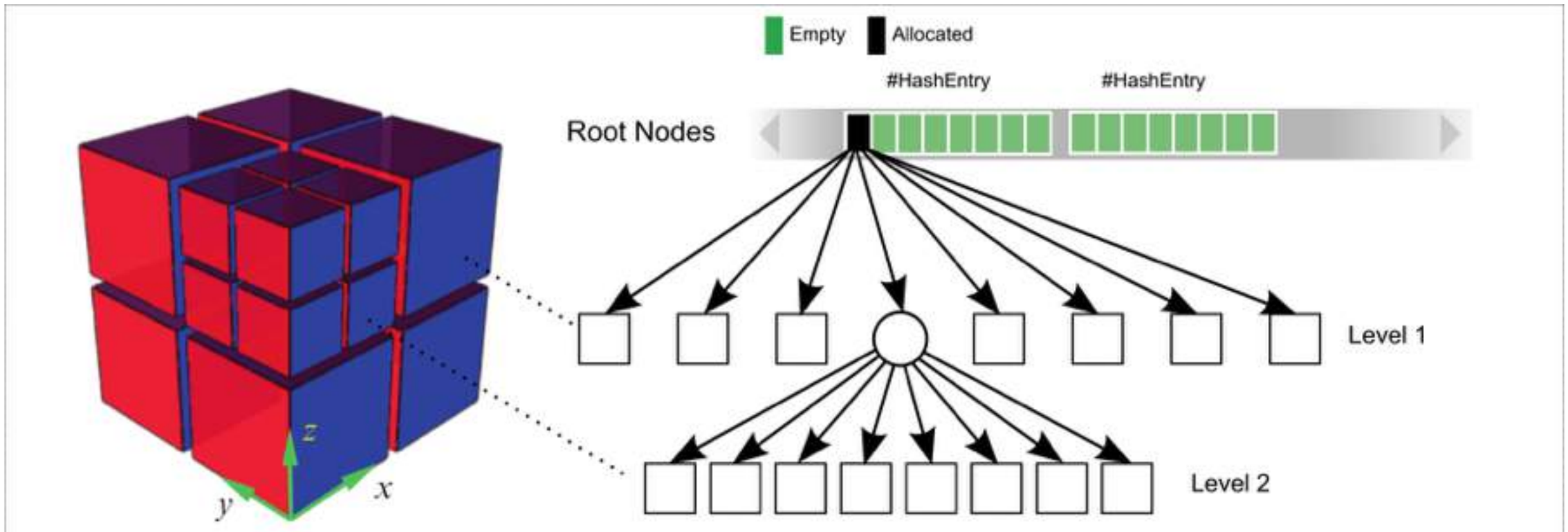
Storage for 3D Modelling

- Tree-based Data Structure
- O(m) memory
  m being # leaf nodes
- One child pointer per voxel
- Siblings stored in consecutive addresses



Storage for 3D Modelling

Octree Indexing

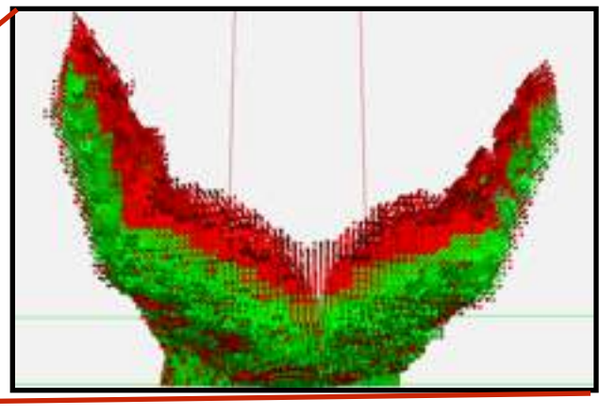


Hash-table based design

- O(1) search and updates

Storage for 3D Modelling

Demos



So what?

- Current Voxel Access takes 0.45µs
    - 2 Frames / second w/ 640x480 resolution depth images images can be processed on a CPU.
    - 0.04µs is required for real time modelling
    - Generating meshes for visualization is an open issue yet (automatic Level of Detail).
    - Object recognition: TBD, depends on the application.
- Storage requirements: A plane of 100x100m@3cm resolution requries approx 70MB

Conclusion

- Current research in 3D Computer Vision enables to reconstruct physical environments in real time
- Modelling and storing large environments is extremely challenging
- Infrastructure for storage and visualization is totally missing. No standards, no providers, only a few internal solutions
- 3D Digitalization today is like the web of the 1990s.

Thank you!

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