



ICRA2014

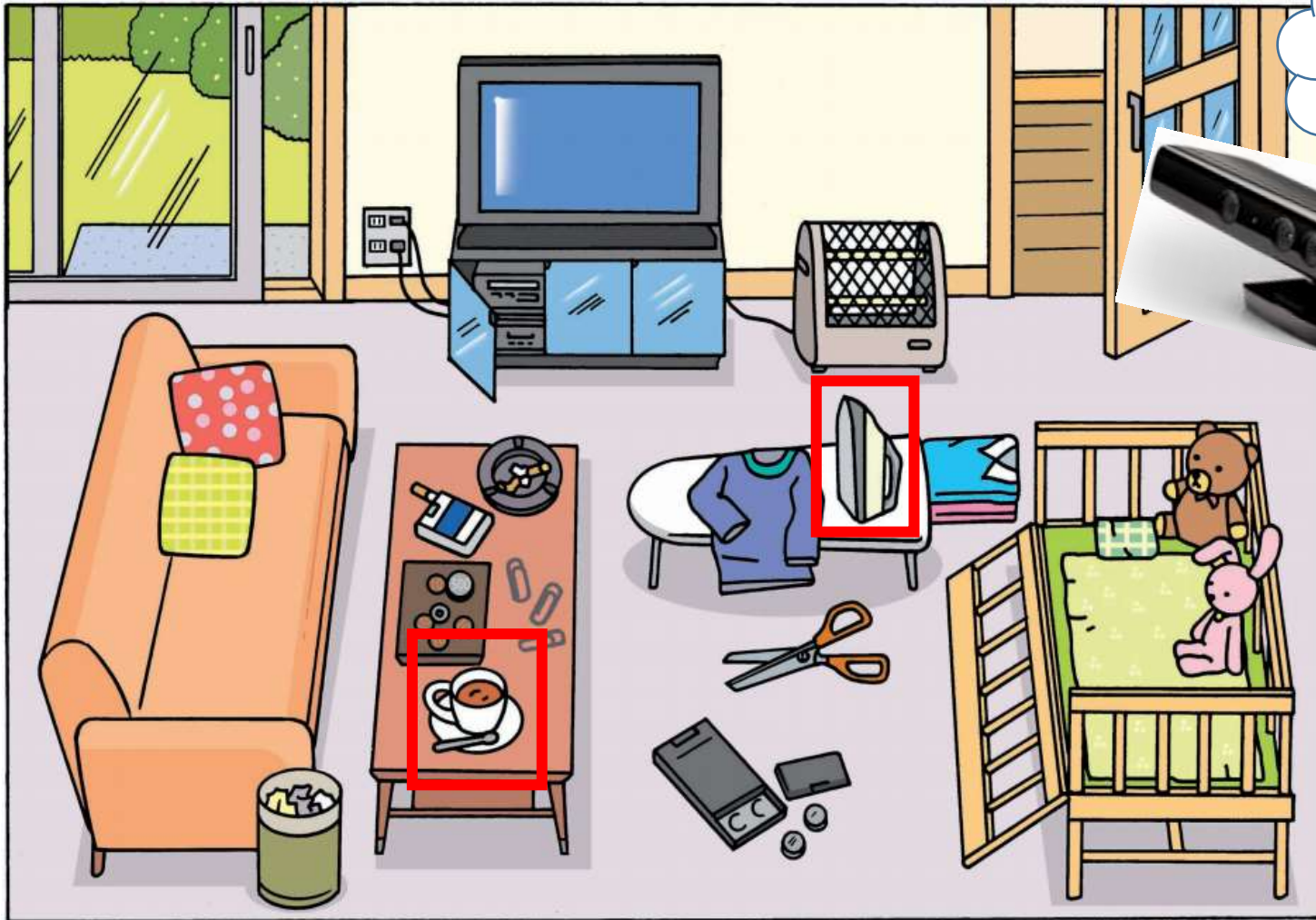
Detecting Potential Falling Objects by Inferring Human Action and Natural Disturbance



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Goal-understand the potential falling objects



“Oh, it’s dangerous!”



Motivations

- safety surveillance system,
- children, elders and people with disabilities
- Robotics -rescue

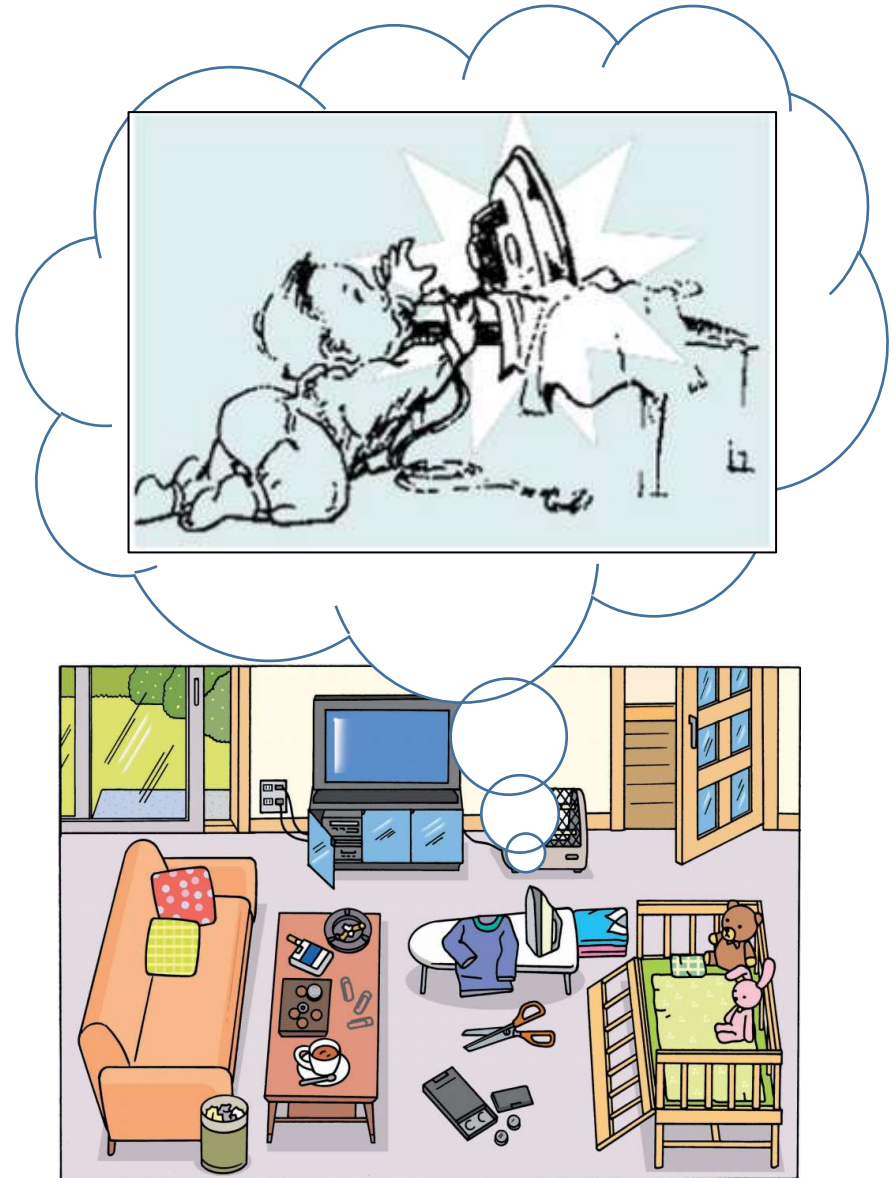


DARPA robotics

Issues

- Human can imagine but machine cannot.
- Doing the serious physical simulation?
 - various collisions
 - large number of objects
 - huge variation in size, shape, material

Time consuming!



Related work

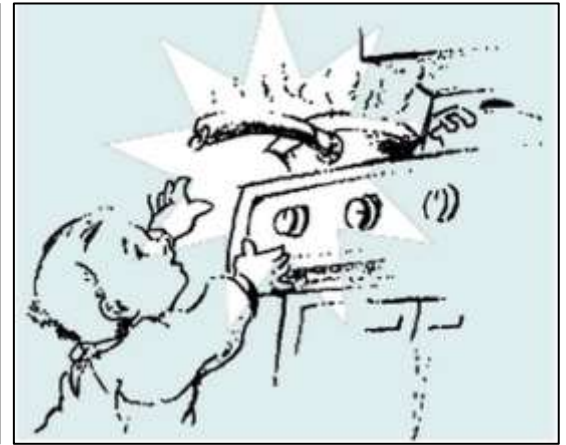
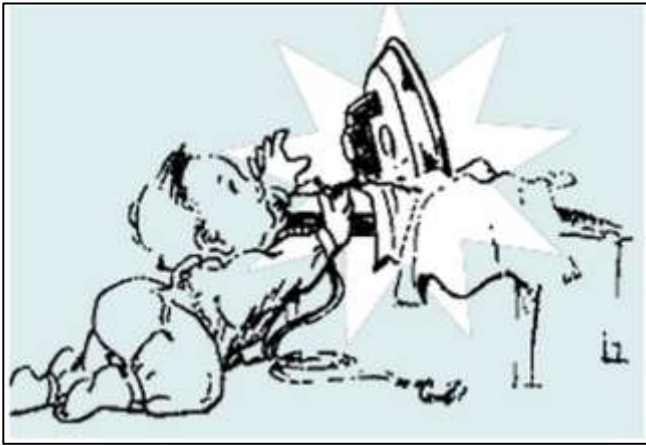
- Physics reasoning – **understand support relations**
 - “Block world revisit” [Gupta, ECCV10]
 - Support relations inference [Silberman, ECCV12]
 - Blocks, Support, and Stability [Jia, CVPR13]
 - Support surface prediction [Hoiem, ICCV13]
- Cognitive science – **Interpret human’s thought**
 - Probabilistic model [Hamrick, CogSc11]
- Robotics – **avoid the obstacles**
 - Safe motion planning [Petti, IROS05]

Outline

- ➔ • Introduction
 - motivation
 - related works
- Method
- Experimental results
- Discussion

Observation – causality of the falling risk

- “Cause” – the physical disturbance (energy absorbed)
- “Result” – much uncontrolled energy released



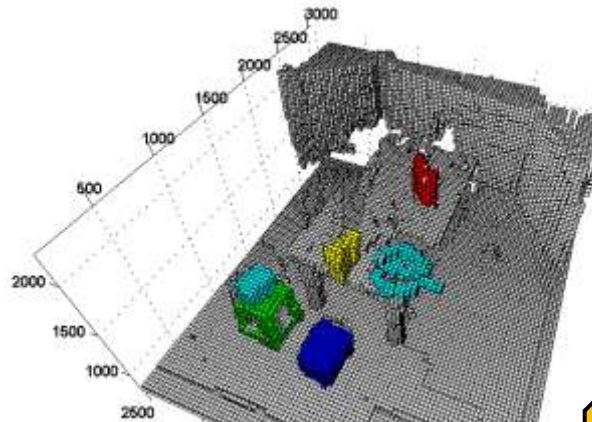
Pipeline

Physical



3D scene

Stability



Physical reasoning

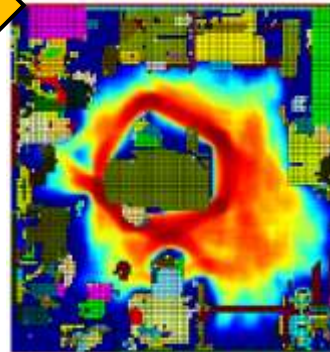
Adapt

Disturbance field

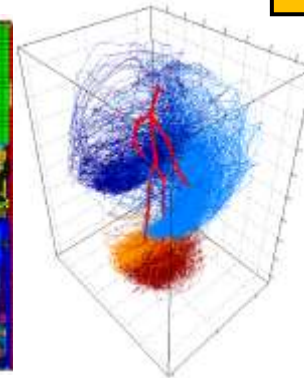


Disturbance observation

Statistics

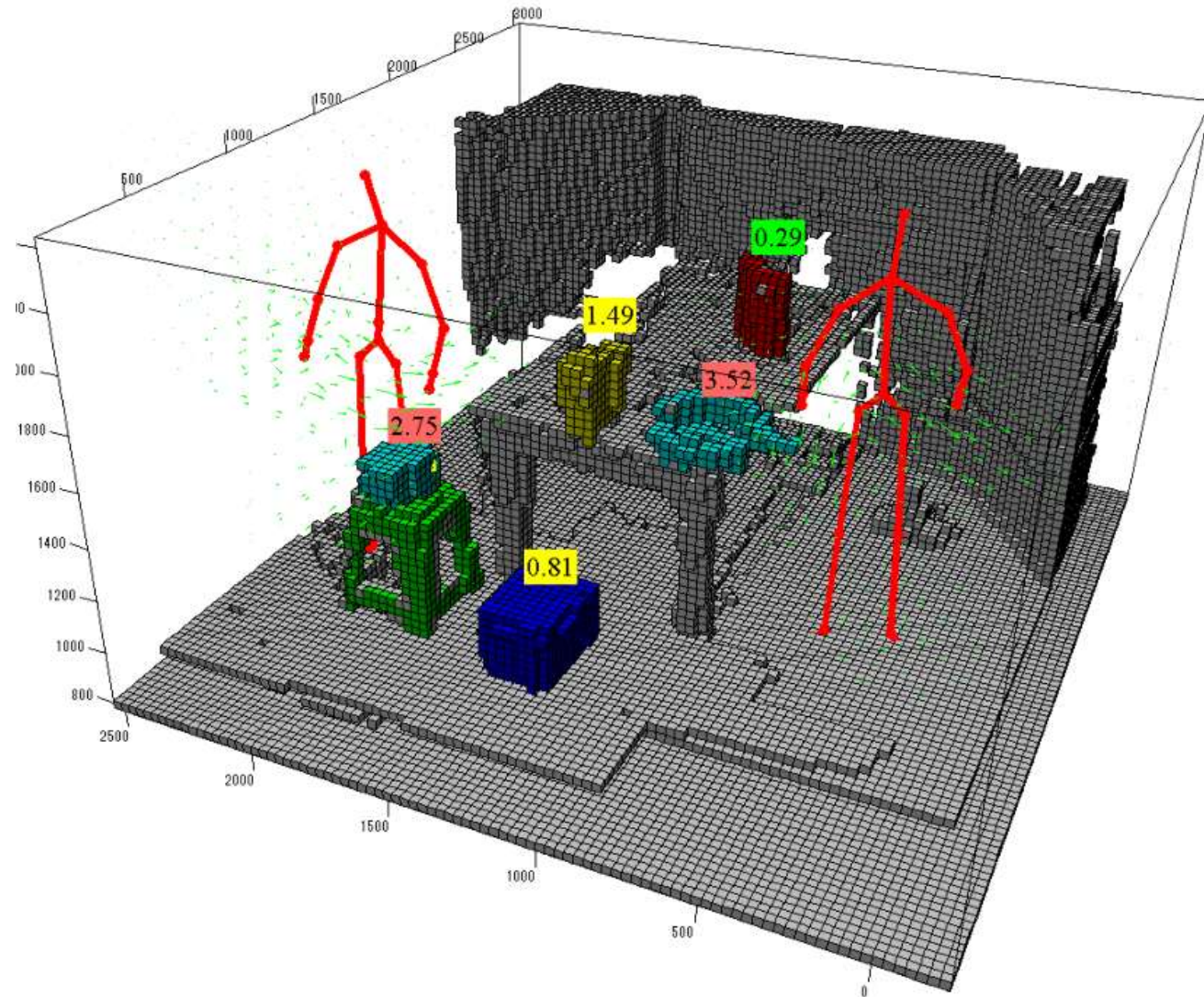


Motion disturbance



Risk
evalu
ation

Risk evaluation

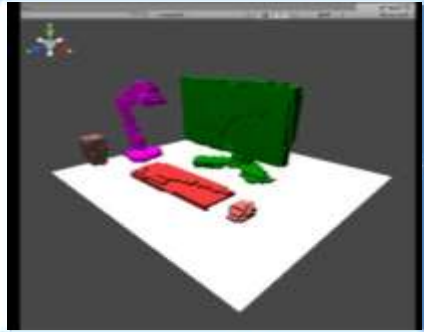
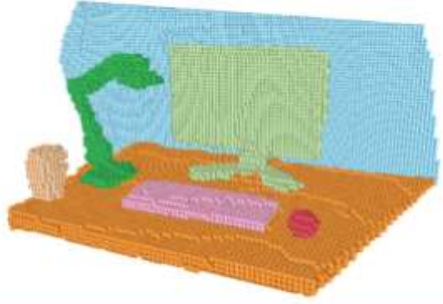
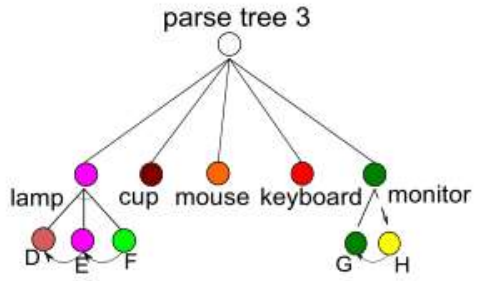


Part I: Physical reasoning

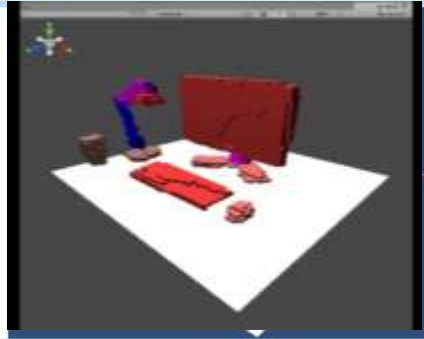
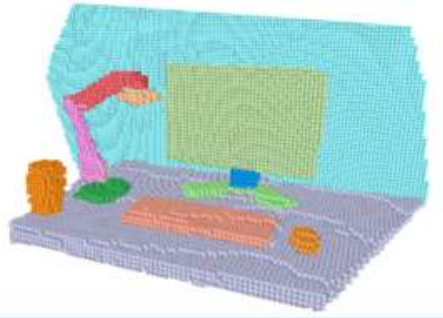
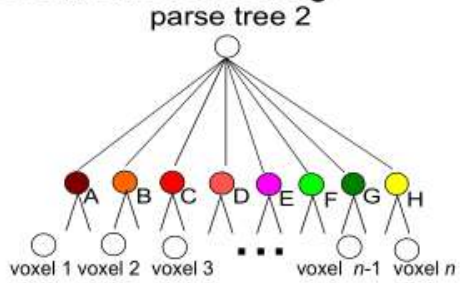


Physical reasoning [CVPR13, Zheng]

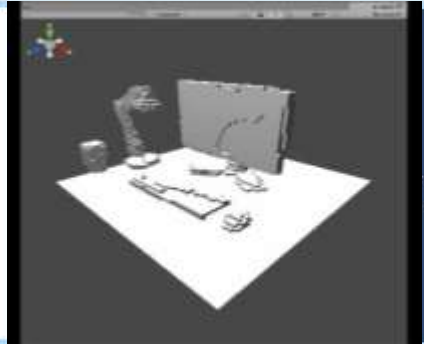
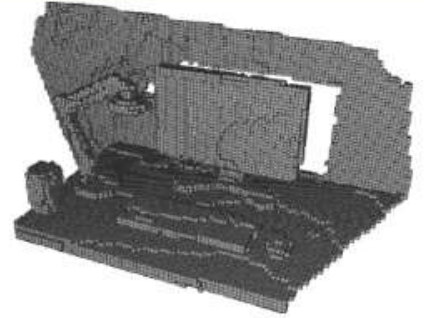
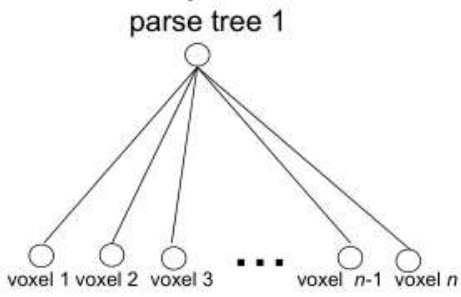
Physical reasoning



Geometric reasoning

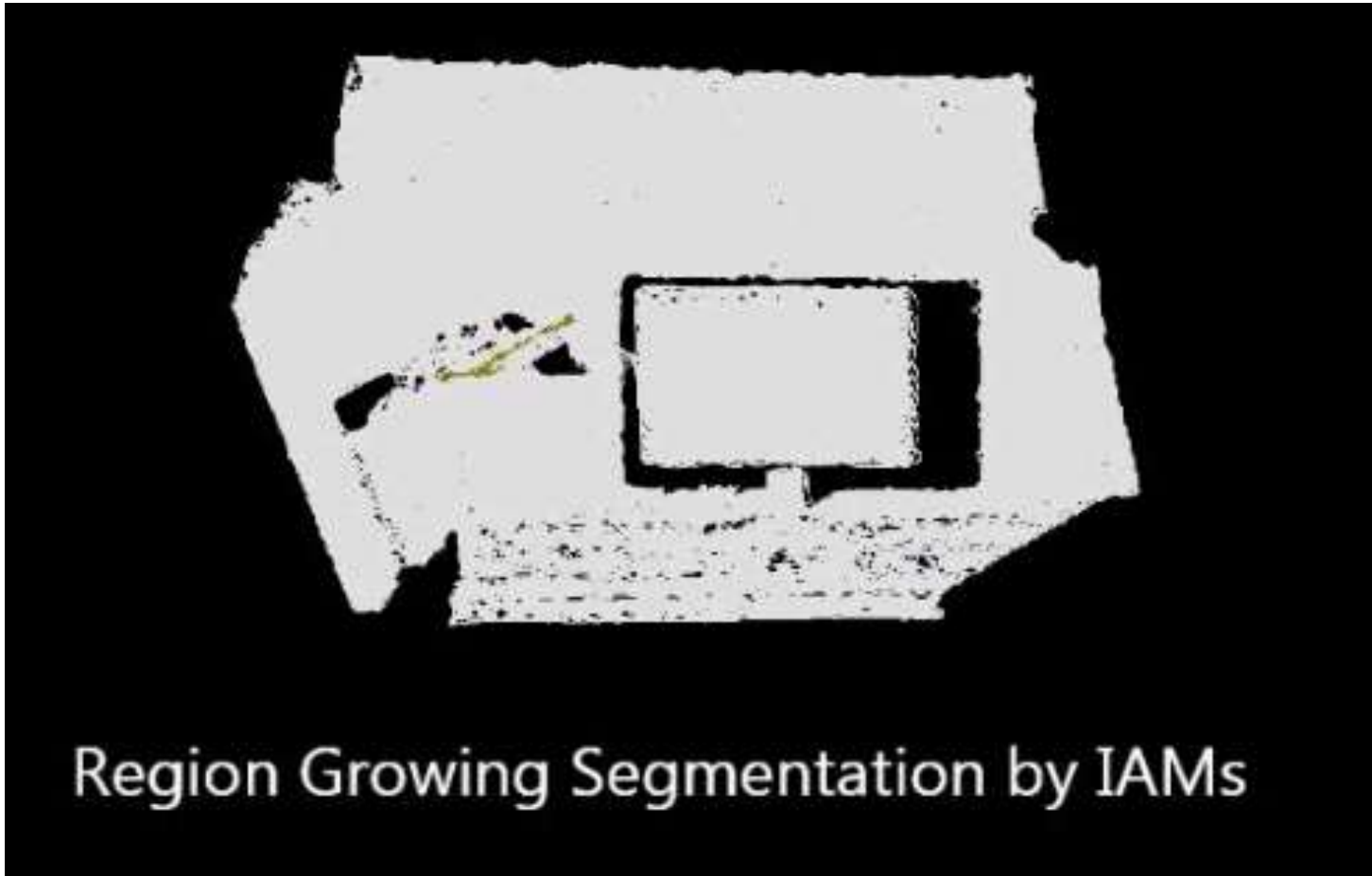


Volumetric representation



Step 1: Segmentation

[CVPR13, Zheng]

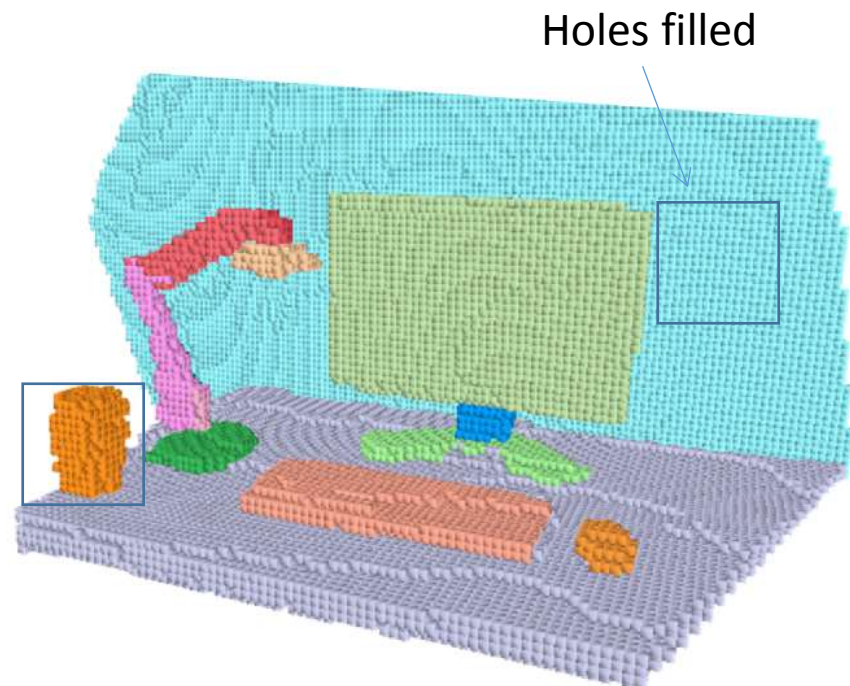


Region Growing Segmentation by IAMs

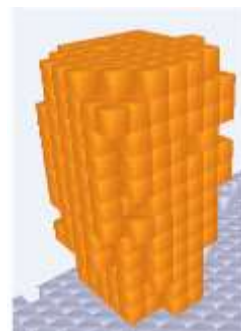
Step 2: volumetric completion



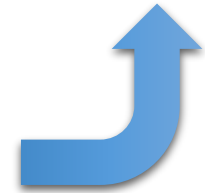
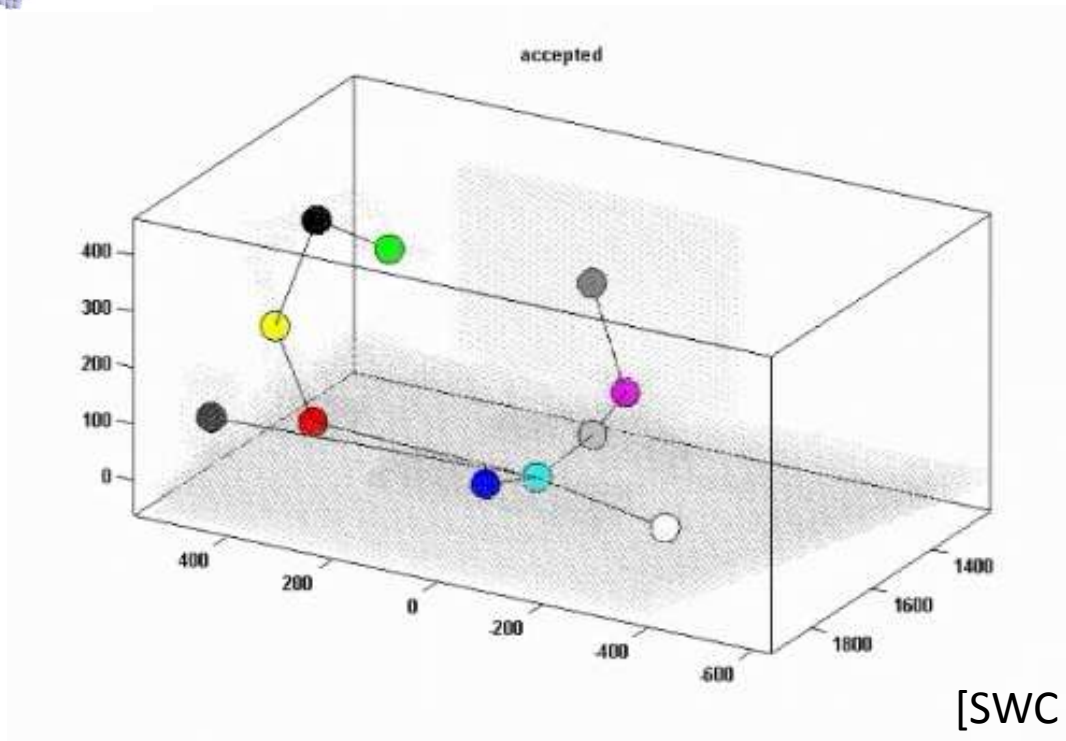
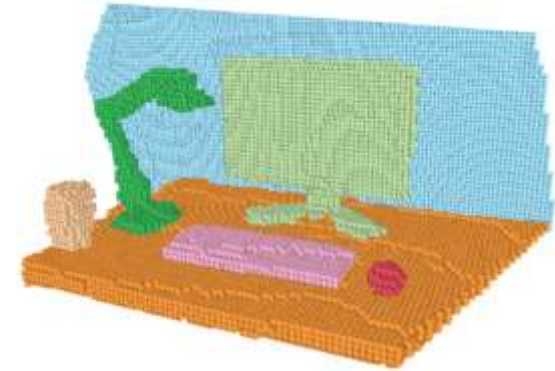
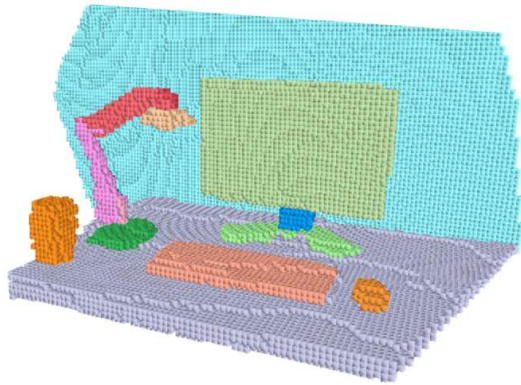
Segmentation result



Result of volumetric completion

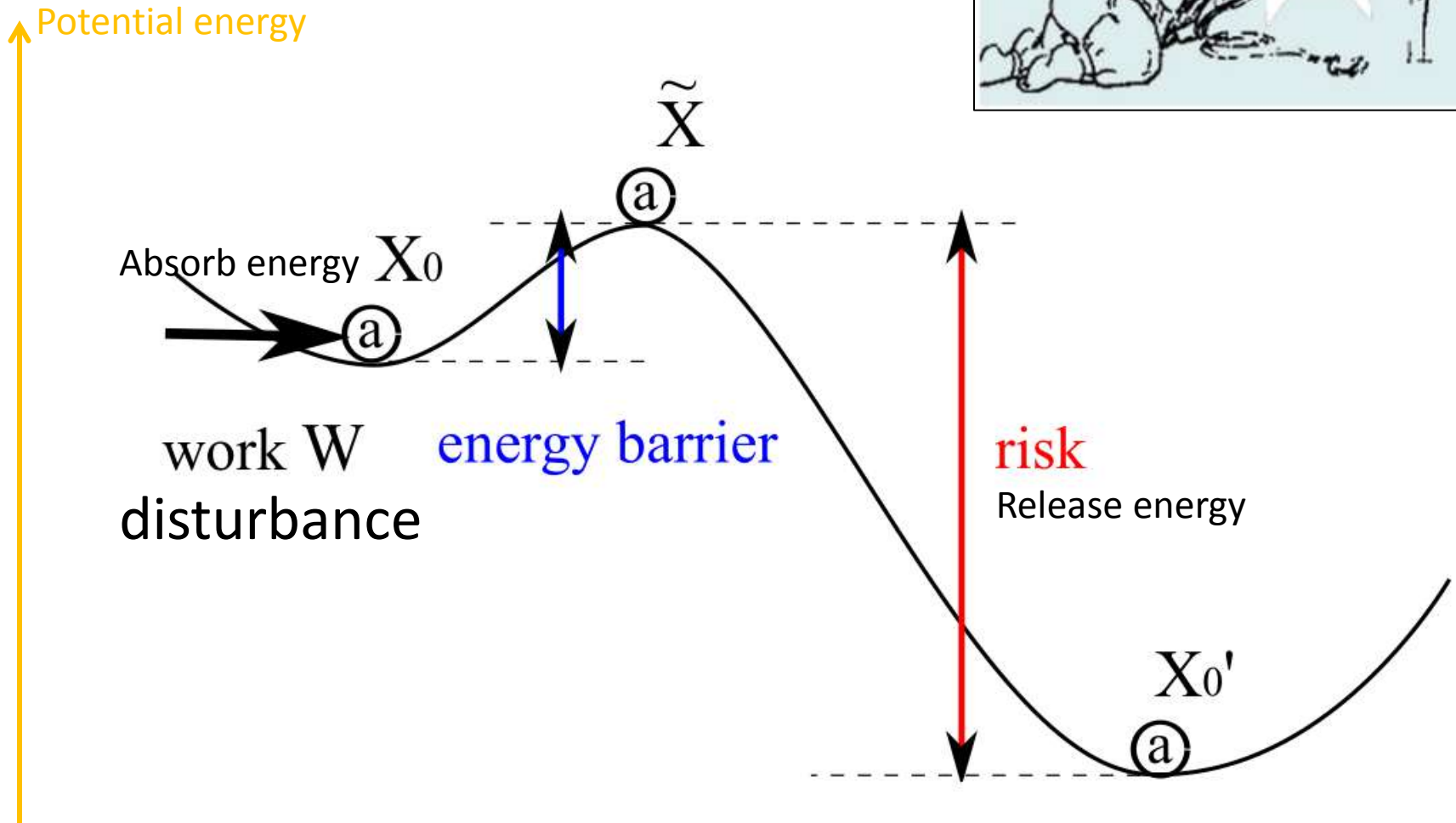
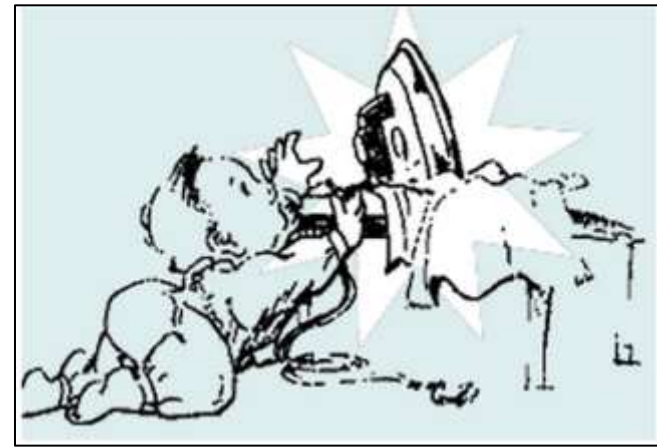


Step 3: Stability optimization

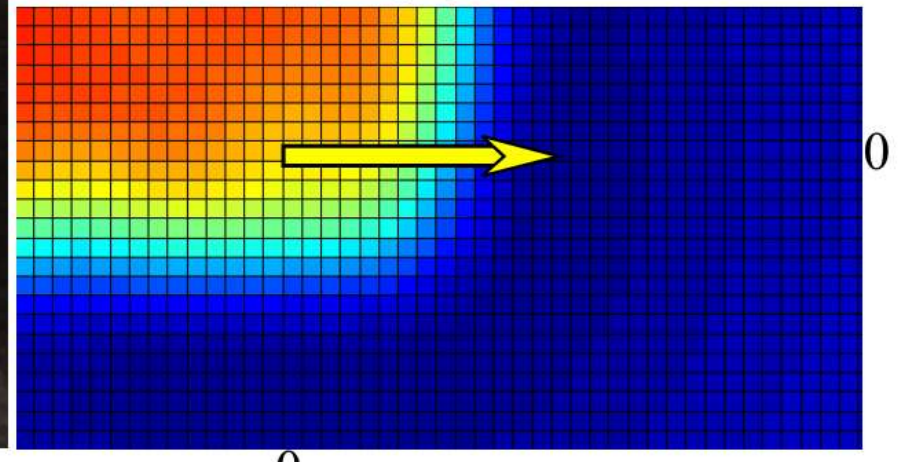
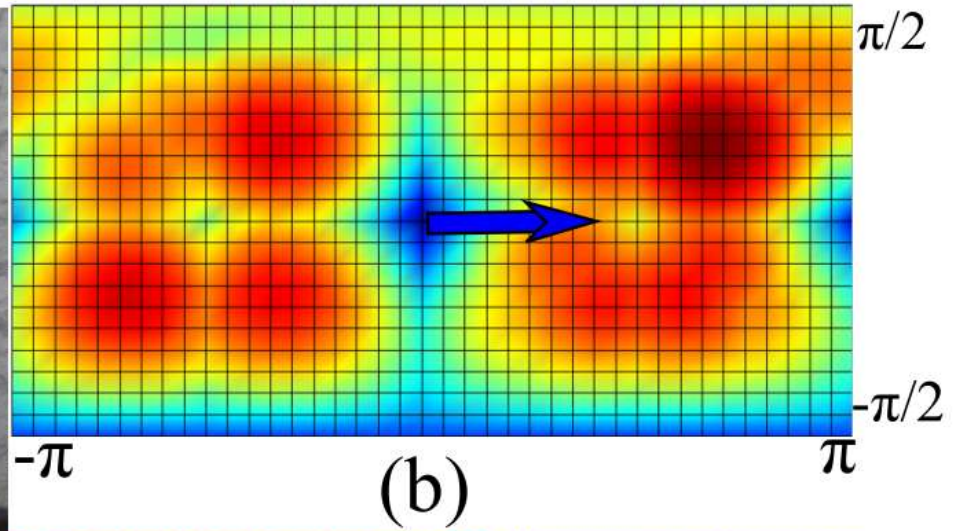
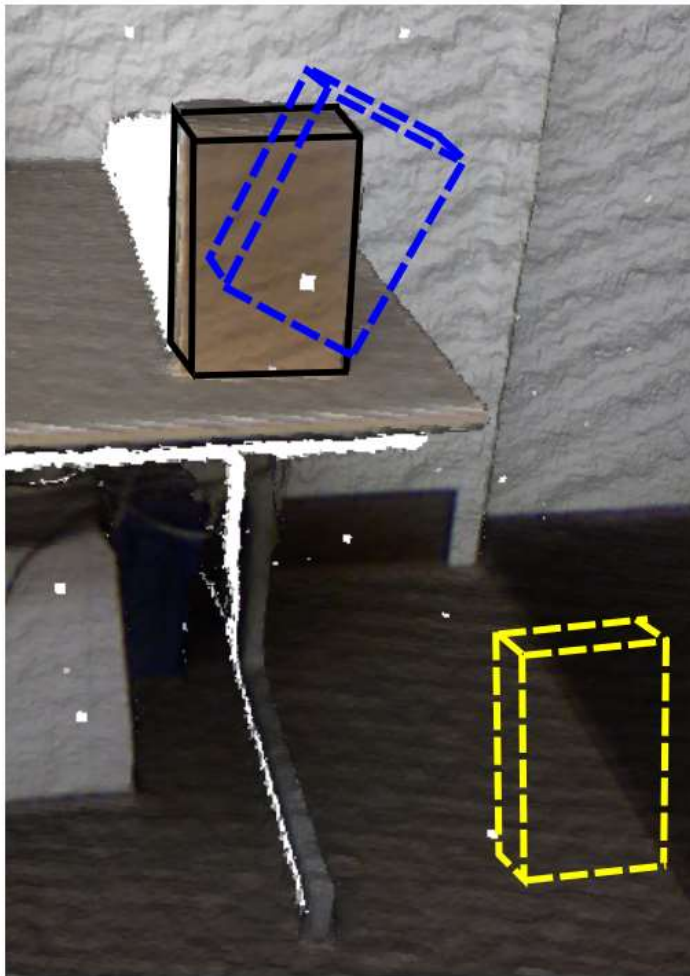


Part II: Risk evaluation

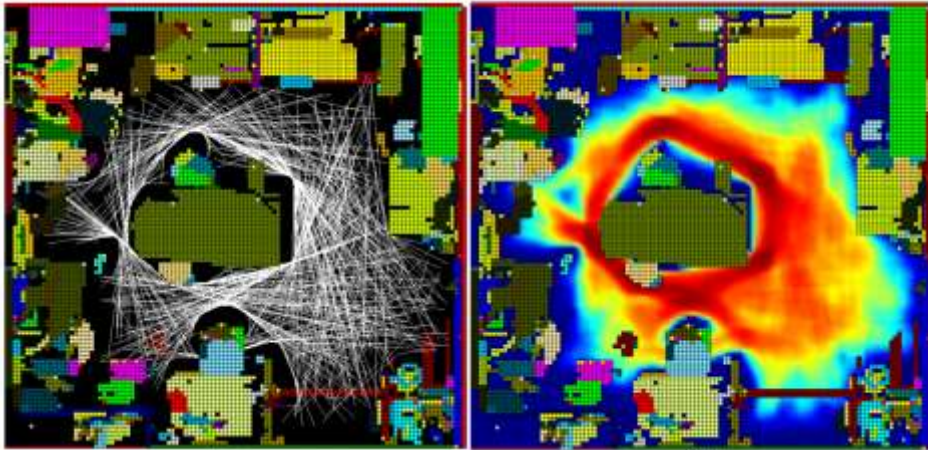
Physical risk definition



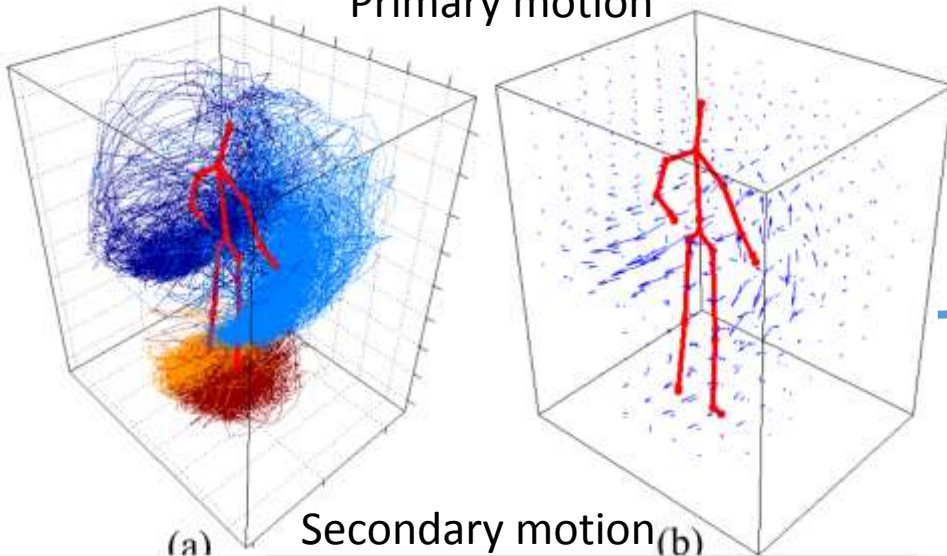
Example



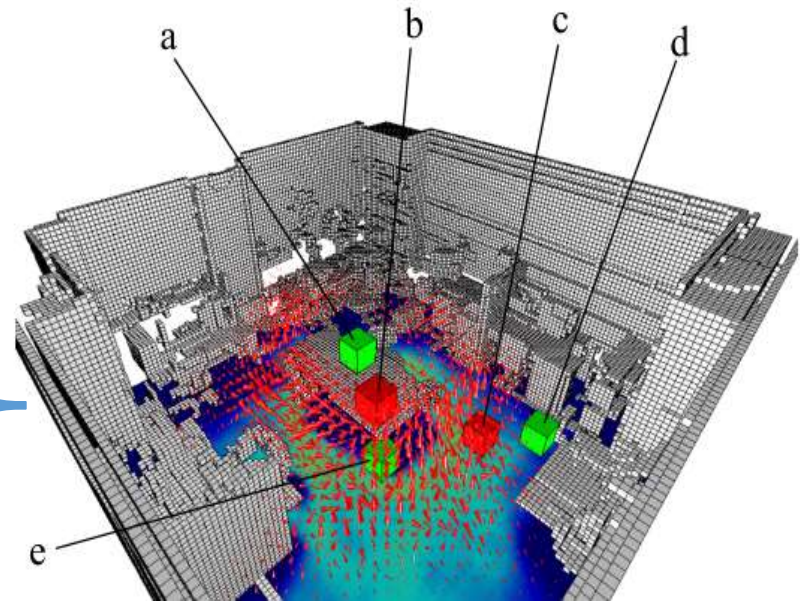
Disturbance field by human activities



Primary motion



Secondary motion (a) (b)

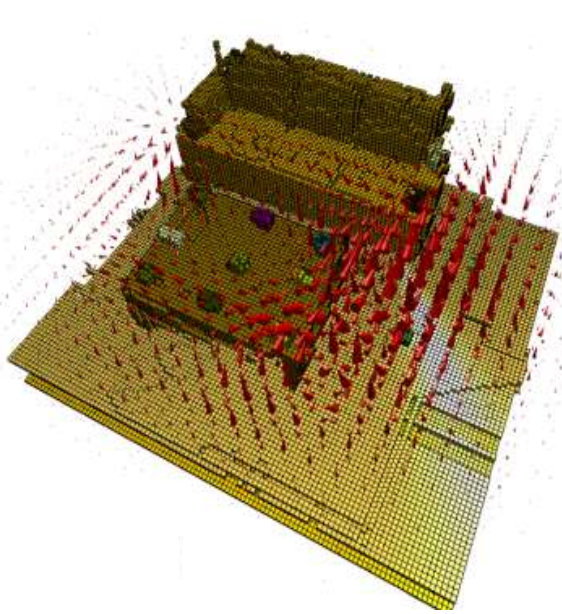


Disturbance field by human activities

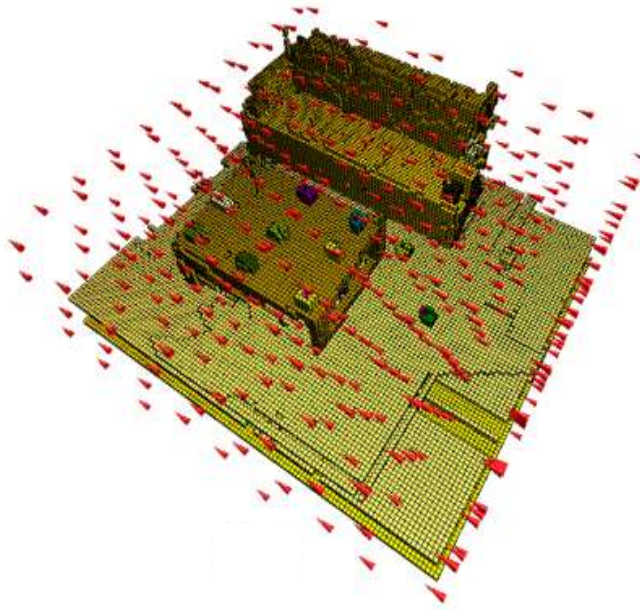


Input point cloud

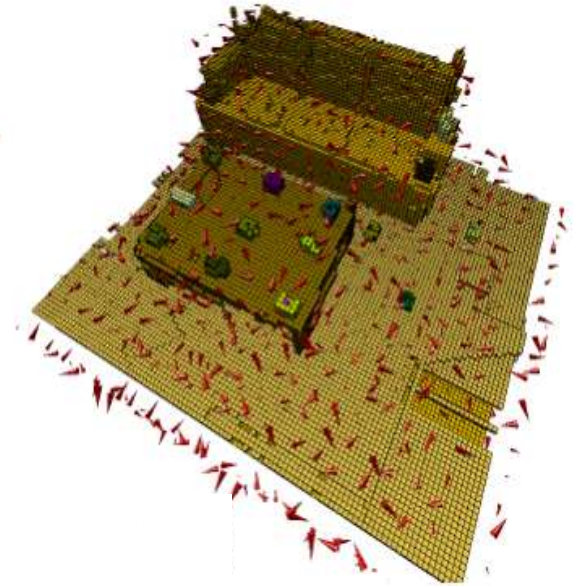
Other disturbances



human activity



wind

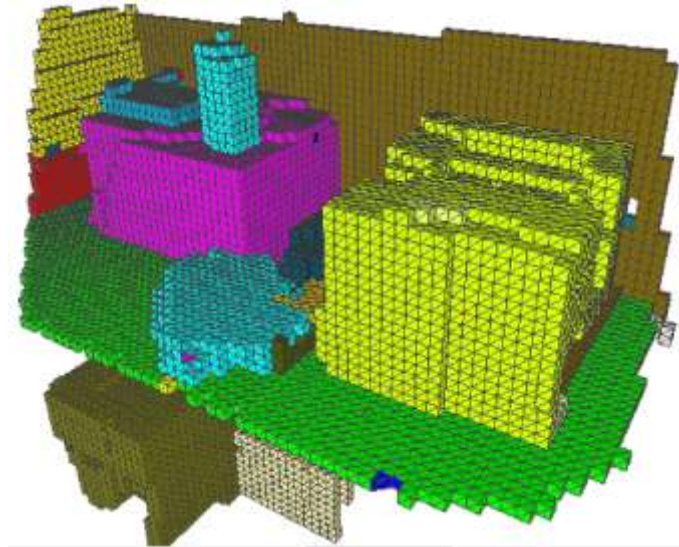
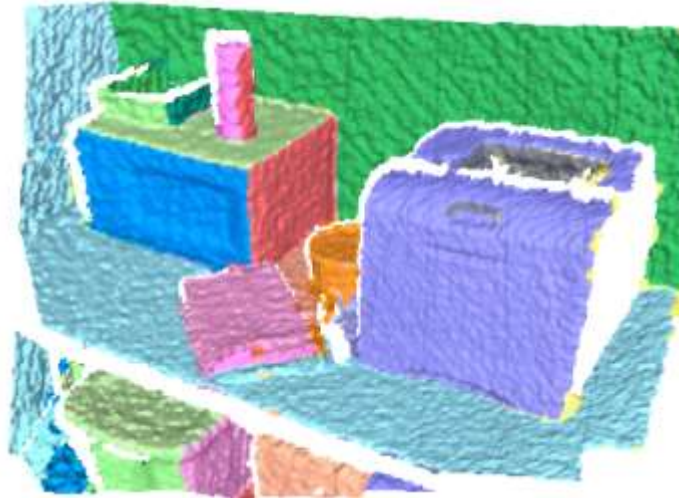
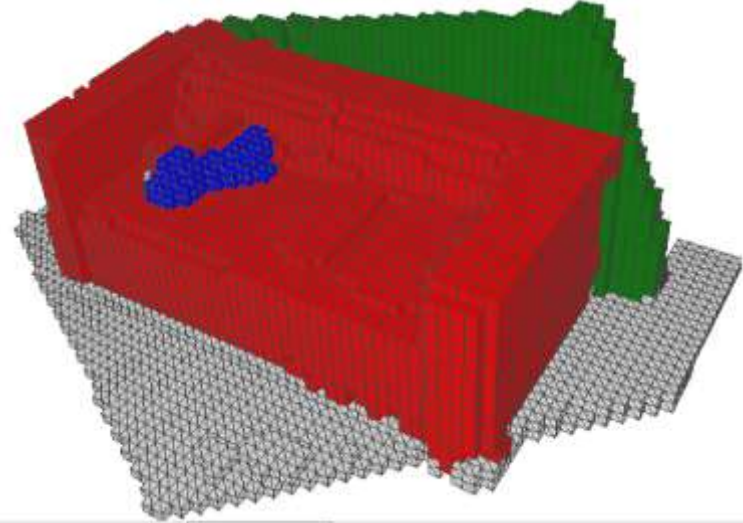
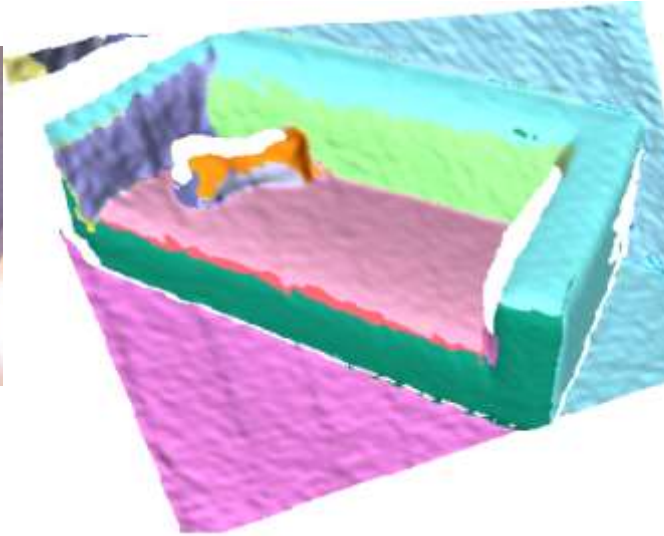


earthquake

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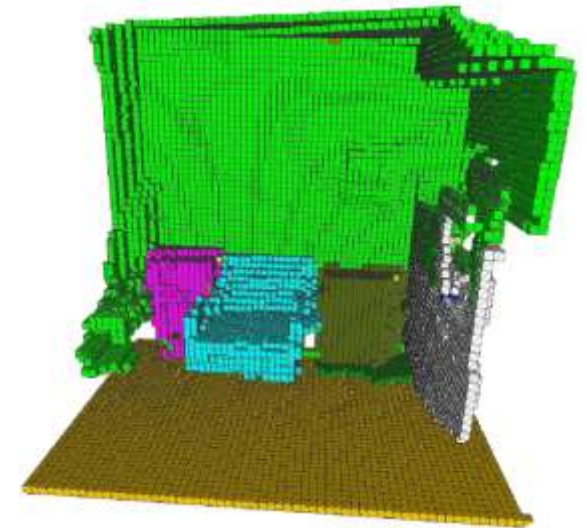
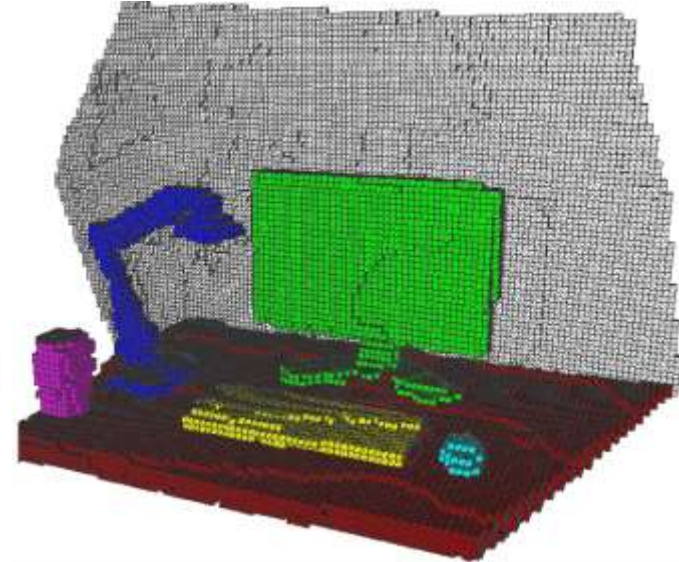
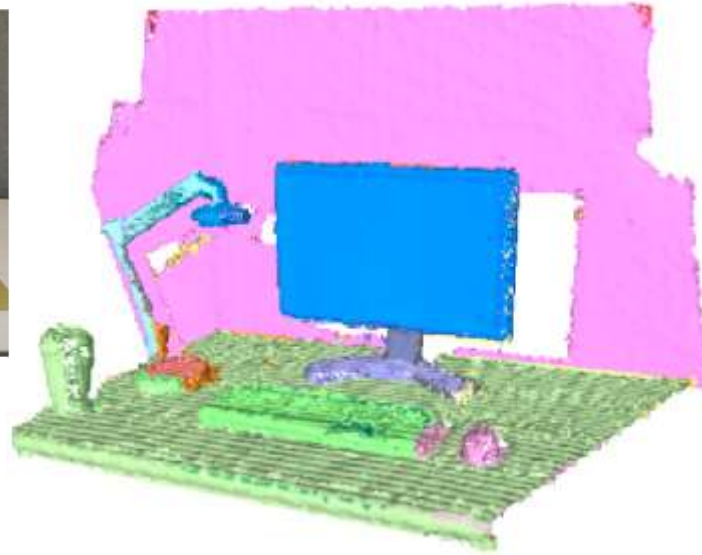
Results of physical reasoning



Point cloud segmentation

Our method

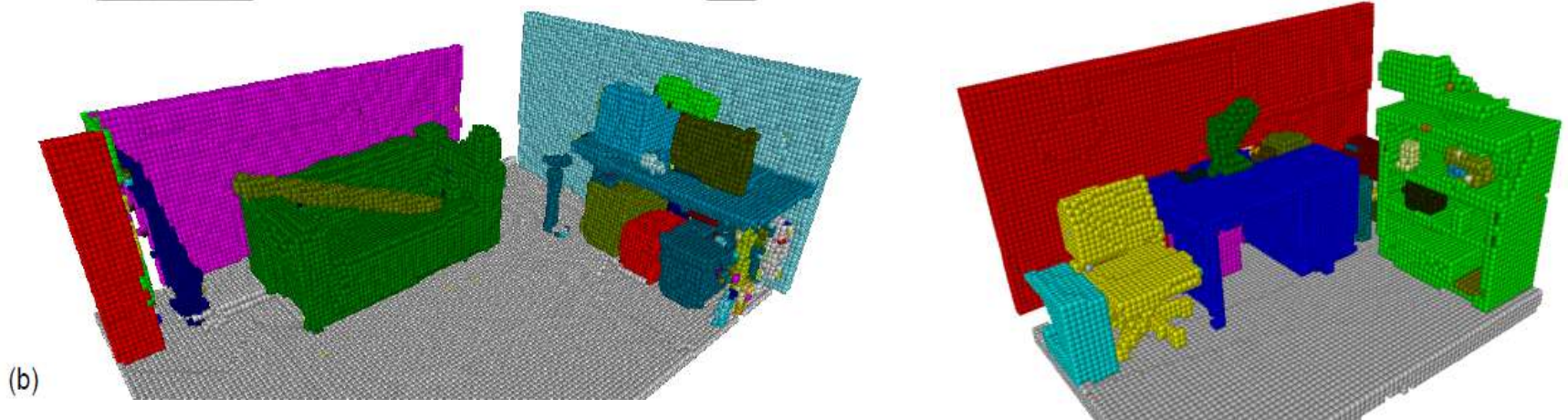
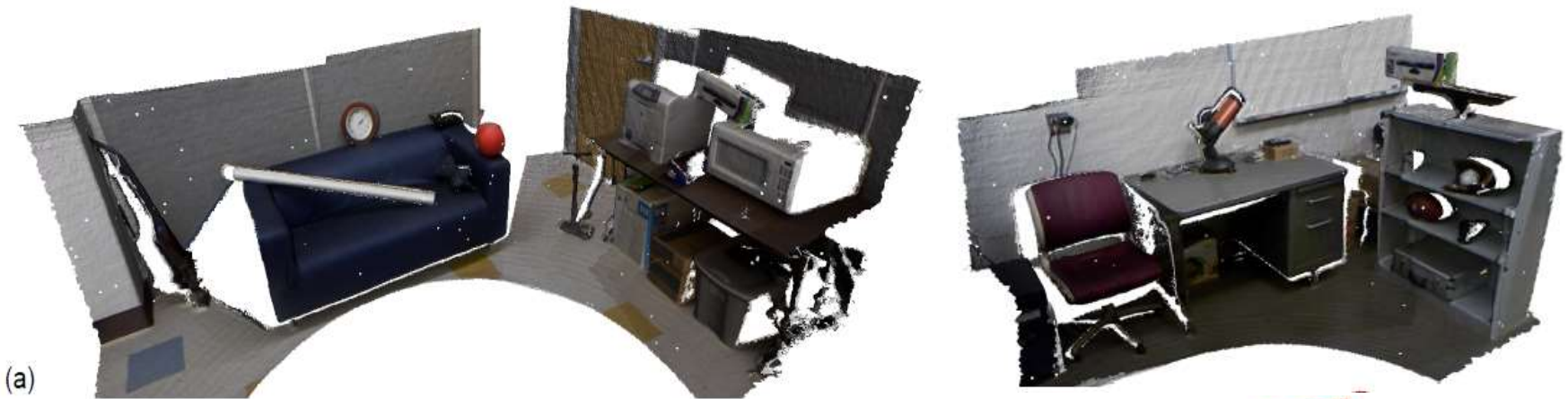
Results of physical reasoning



Point cloud segmentation

Our method

Large scale indoor scene



Risk evaluation

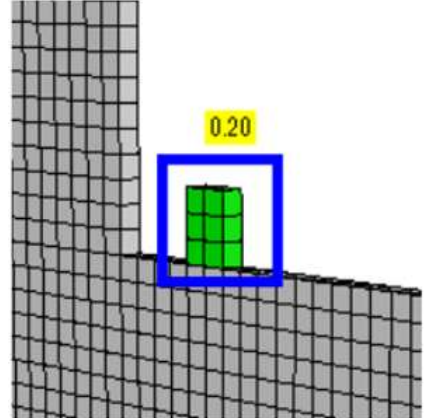
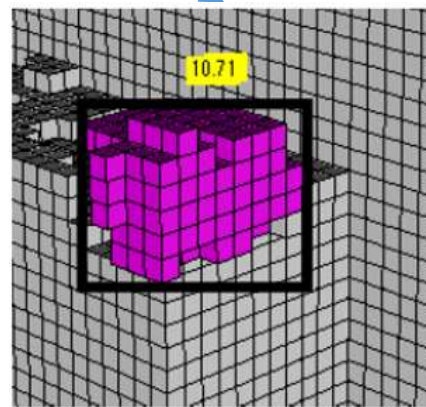
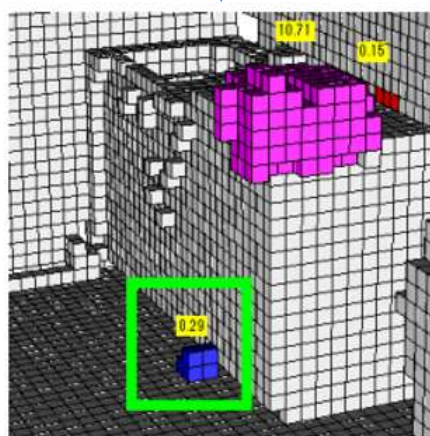
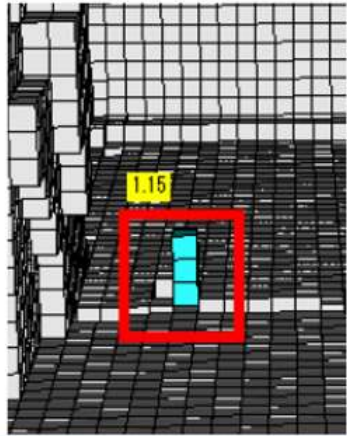
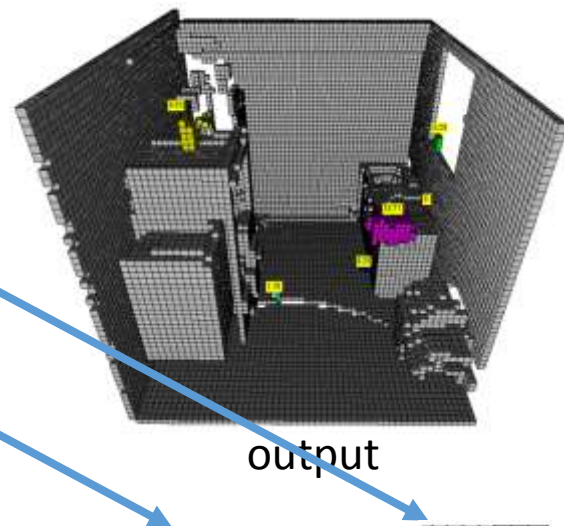
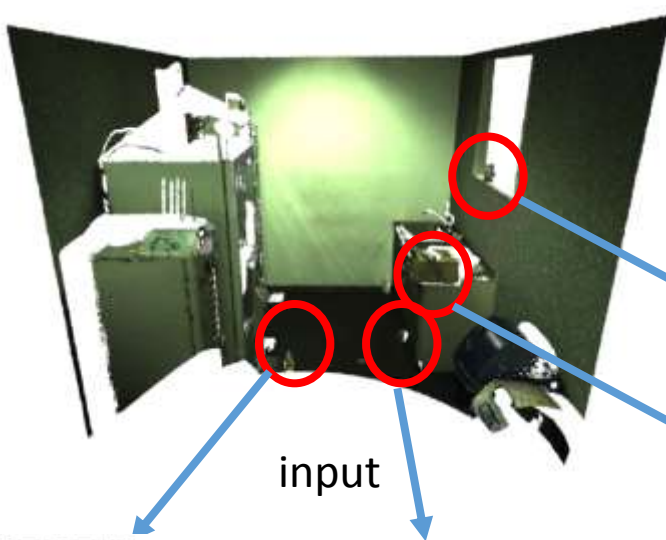
Under different disturbances

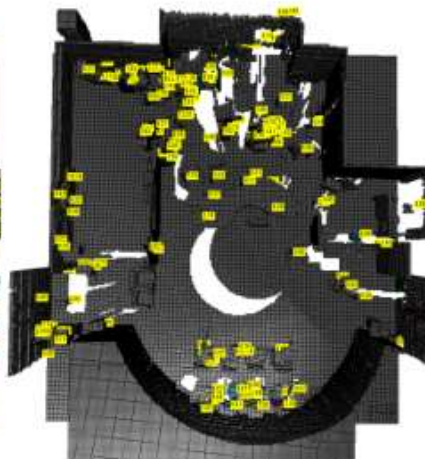
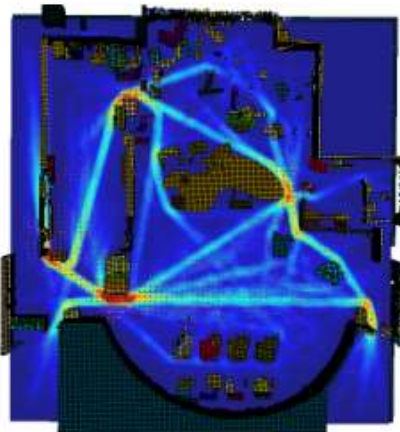
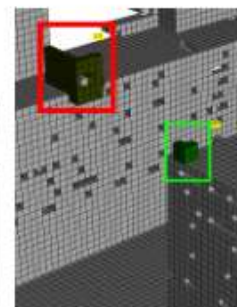
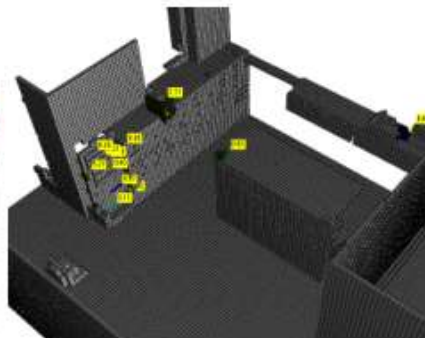
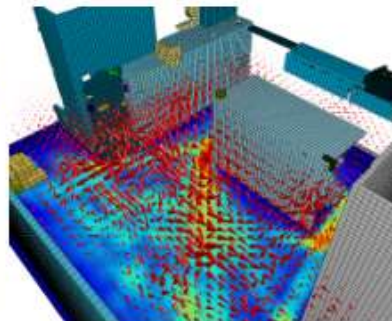
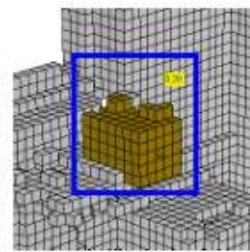
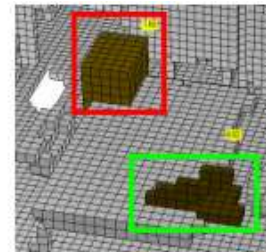
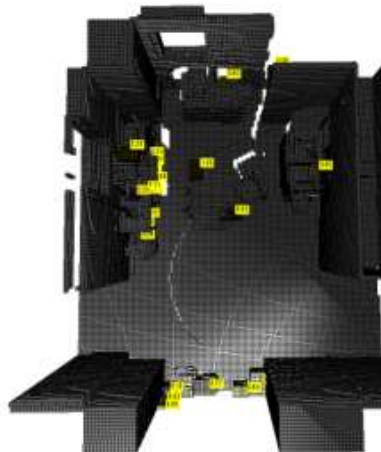
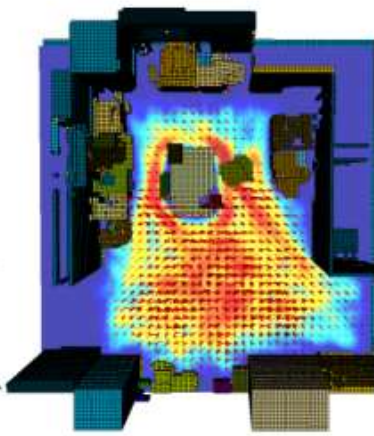
Comparison in different disturbance fields:

1) *human motion*

2) *wind*

3) *earthquake*



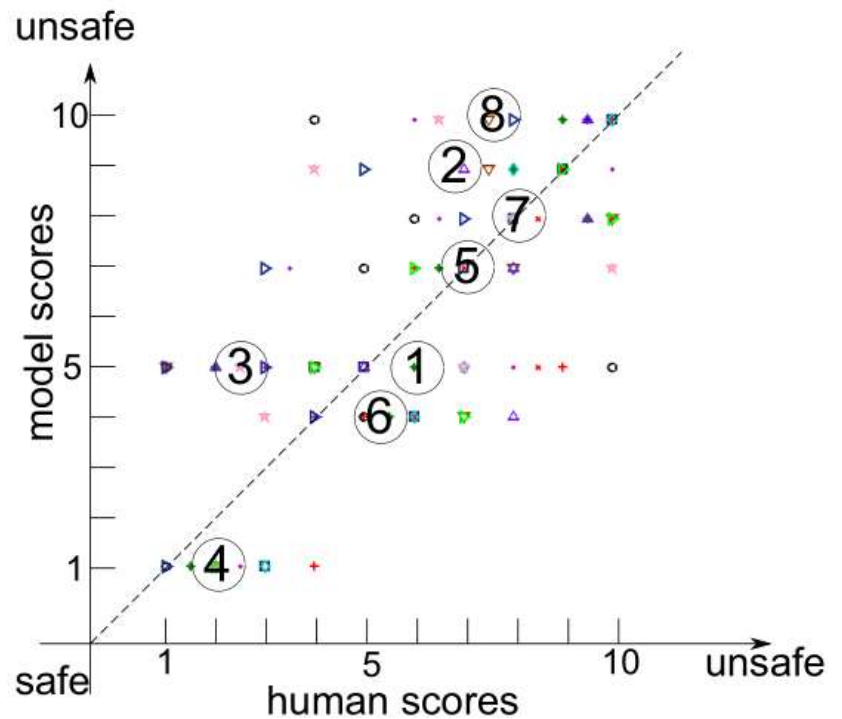
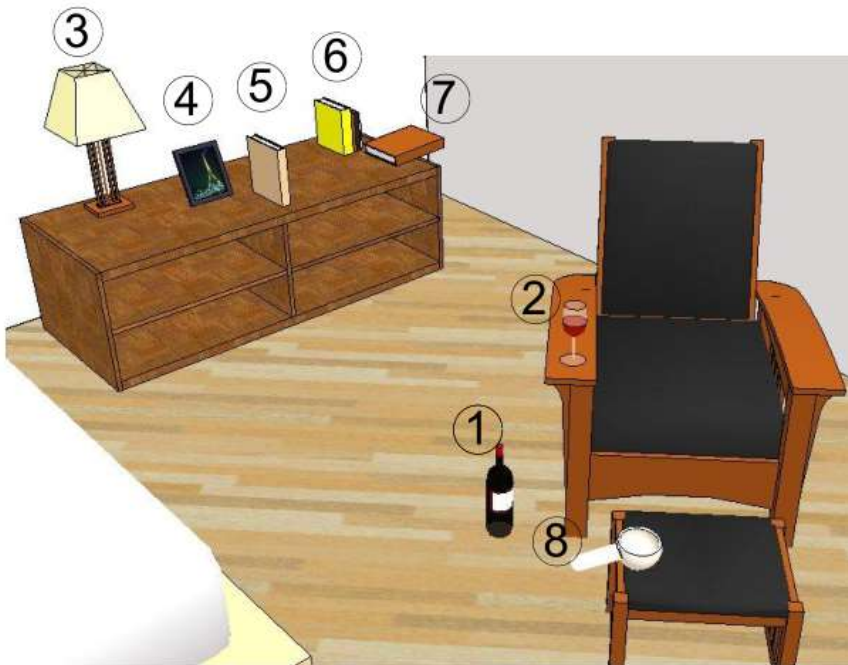


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Discussion: Human v.s. Machine?

- There is no ground truth
- People have big variance on safety understanding



Thank you for your
attention!