Detecting Potential Falling Objects by Inferring Human Action and Natural Disturbance

Bo Zheng*, Yibiao Zhao* (*equal contribution)
Joey C. Yu, Katsushi Ikeuchi, Song-Chun Zhu
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 reasoning

Disturbance field

3D scene

Stability

Statistics

Risk evaluation

Disturbance observation

Motion disturbance
Risk evaluation
Part I: Physical reasoning
Physical reasoning [CVPR13, Zheng]
Step 1: Segmentation

[CVPR13, Zheng]
Step 2: volumetric completion

Segmentation result

Result of volumetric completion

[CVPR13, Zheng]
Step 3: Stability optimization

[CVPR13, Zheng]

[SWC sampling, A. Babu’ 03]
Part II: Risk evaluation
Physical risk definition

Absorb energy $X_0$

work $W$
disturbance

energy barrier

Risk
Release energy

Potential energy

$\tilde{X}$
Example
Disturbance field by human activities

Primary motion

Secondary motion
Disturbance field by human activities

Input point cloud
Other disturbances

human activity  wind  earthquake
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  • overview

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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!