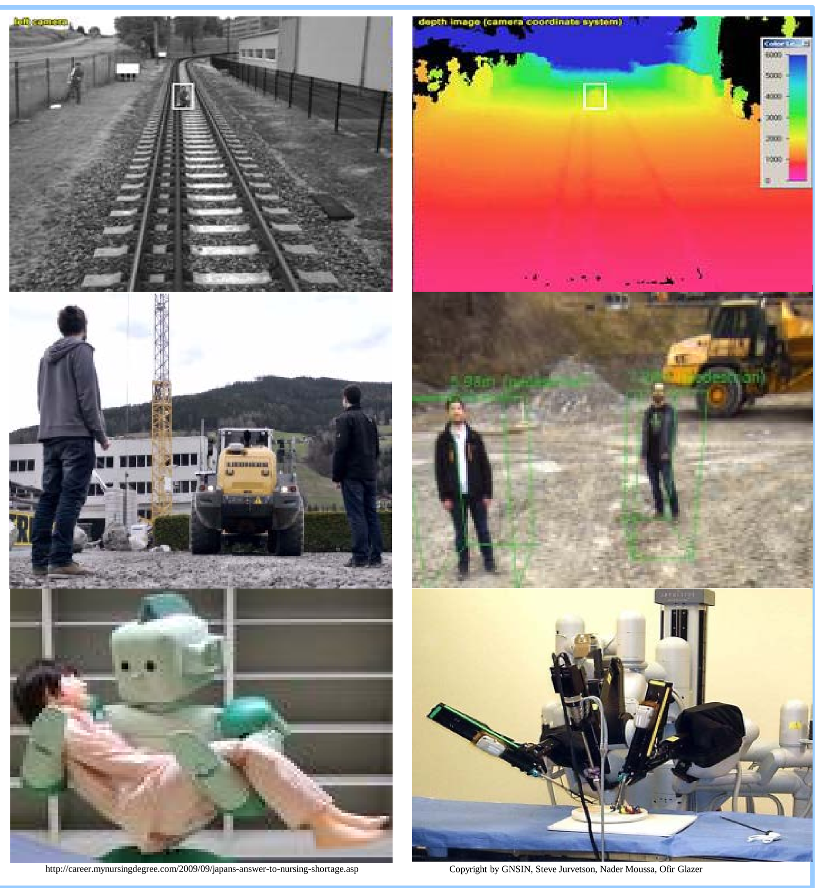
VITRO - Vision Testing for Robustness

Introduction



Computer vision (CV) is a key technology in many upcoming critical applications (e.g. autonomous vehicles, care robots, automated medical systems, and assembly lines). Incorrect situation perception and understanding can result in accidents or even loss of human life. This means that their vision components and vision algorithms have to robustly cope with all potential situations they can encounter during their mission. Assuring this poses a special challenge due to the huge variety in optical details of real-world environments.

Today, CV algorithms are usually tested by applying many real-world test images and comparing the results against a manually established ground truth (GT). This method poses some drawbacks:

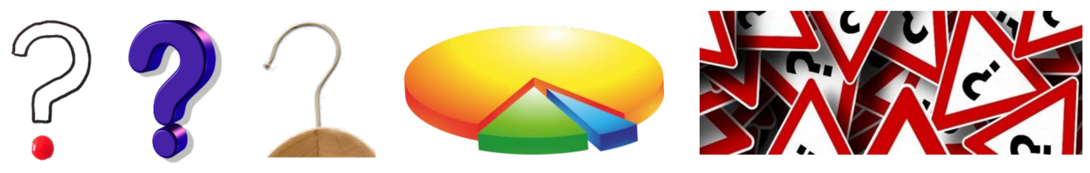
- Requires significant and error-prone human effort for establishing GT
- Limited to realizable situations (e.g. collisions or near misses)
- Lacks computable coverage measures

We need a holistic approach towards vision testing to deal with these drawbacks: VITRO – Vision Testing for Robustness

Motivation

Good test data includes:

- Enough Variation
- Known Coverage
- Low Redundancy

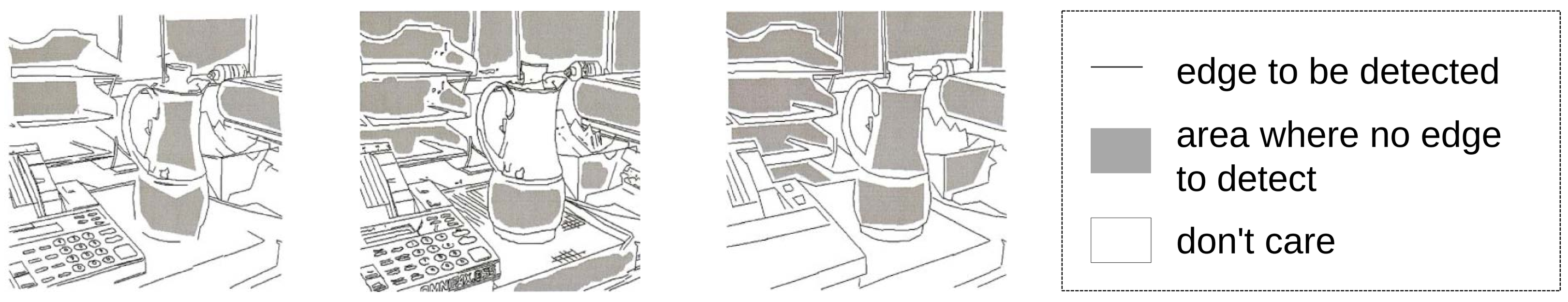


Problem: Dataset bias

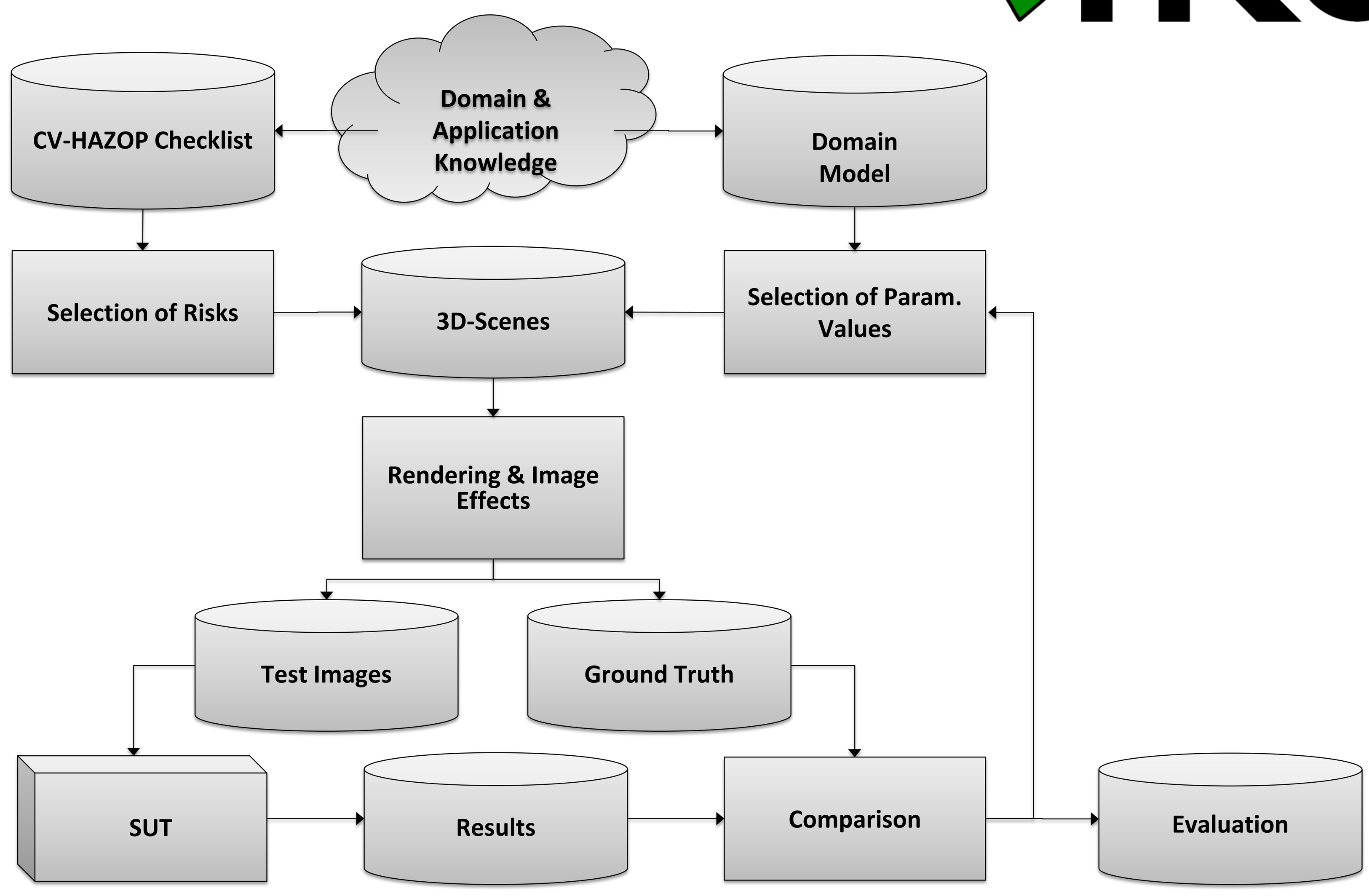
- Ponce et al. [Pon2006]
- Pinto et al. [Pin2008]
- Torralba and Efros [Tor2011]

Images from Caltech 101 [Fei2004]:

Manually established GT can vary depending on the testing person [Bow2001]:



VITRO - Process

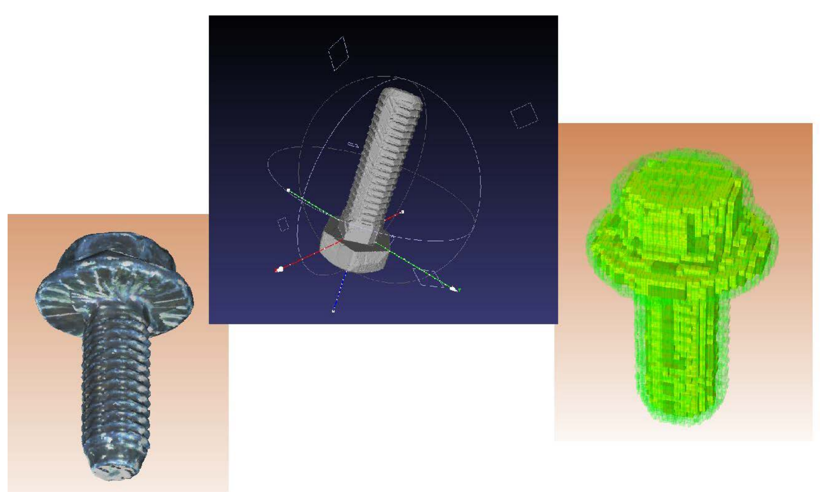


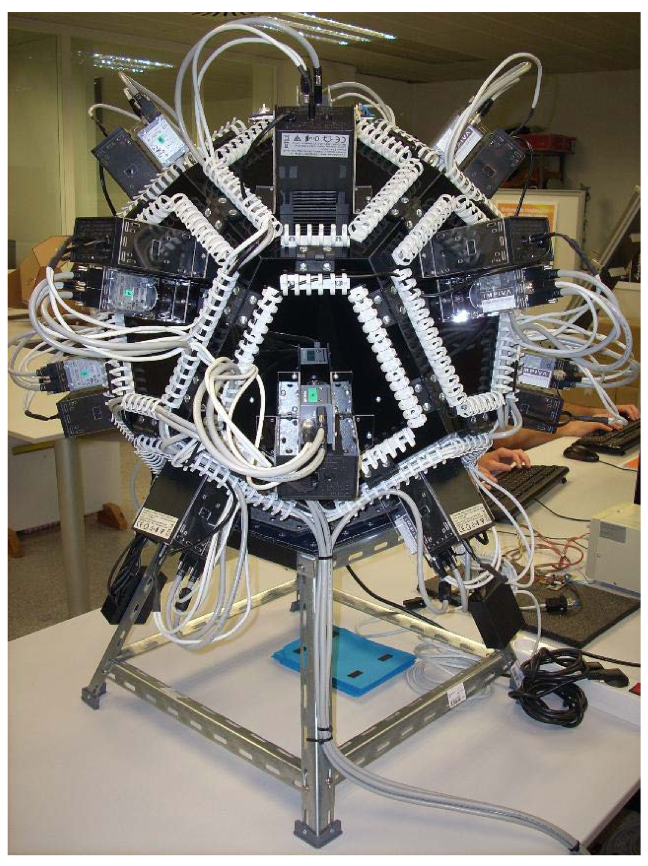
Use Case: ZG3D

The System Under Test (SUT):
Early version of Zero Gravity 3D by Institute of Computer Technology ITI (Valencia) http://www.zerogravity3d.es

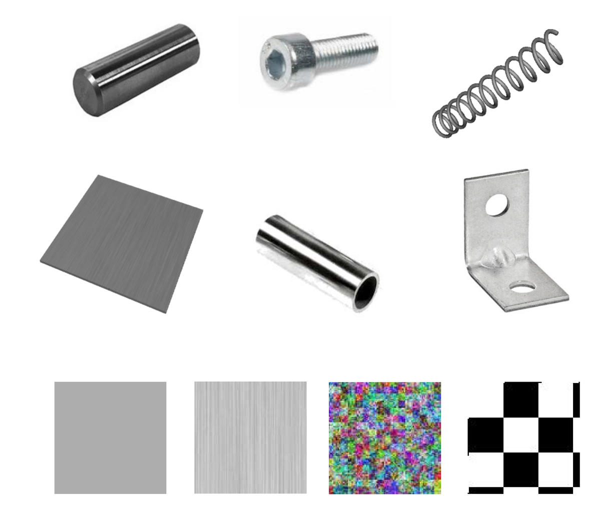
A system to

- inspect geometry of production parts
- by an optimized camera arrangement
- allowing for analysis in freefall





Results

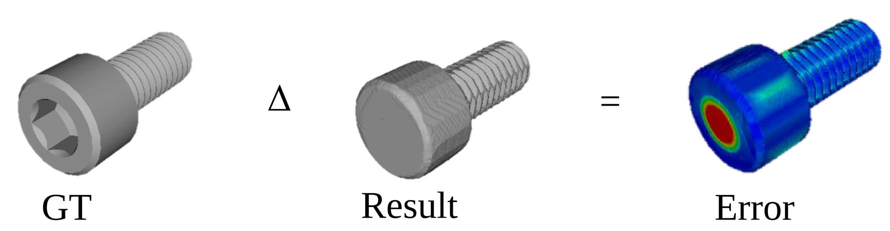


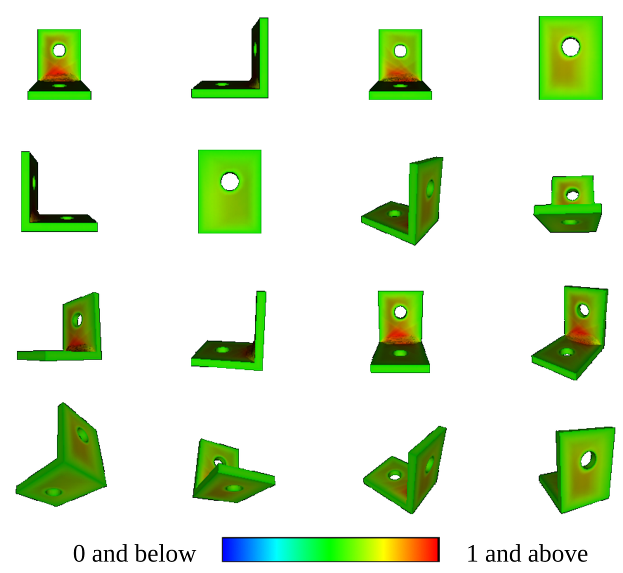
Covered test domain:

- Various Objects with different geometric Properties e.g. convex, visual hull equivalent, Genus > 1
- At various Positions and Orientations
- With various Materials and Textures

Metric:

- Surface Error expressed by Hausdorff Distance





Verdict: Result Quality is

- independent of Reflections and Materials
- decreases at high Object-Complexity

Outlook

Extend functionality

- Domain/application models (generators)
- Rendering capabilities and performance
- GT, evaluation metrics

Integration in closed-loop testing

- Coverage monitoring
- Uncovered situation selection guidance
- Real time!

Follow-up in new ECSEL projects:

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References:
[Bow2001] K. Bowyer, C. Kranenburg, S. Dougherty: Edge Detector Evaluation Using Empirical ROC Curves, Computer Vision and Image Understanding 84, 1–4, (2001)
[Pin2008] N. Pinto, D. D. Cox, and J. J. DiCarlo. Why is real-world visual object recognition hard? PLoS Comput Biol, 4(1), (2008).
[Pon2006] J. Ponce, T. L. Berg, M. Everingham, D. A. Forsyth, M. Hebert, S. Lazebnik, M. Marszalek, C. Schmid, B. C. Russell, A. Torralba, et al. Dataset issues in object recognition, Springer, (2006)
[Tor2011] A. Torralba and A. A. Efros. Unbiased look at dataset bias. In Computer Vision and Pattern Recognition, pages 1521–1528, (2011)

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Contact: oliver.zendel@ait.ac.at