AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

VITRO - Vision Testing for Robustness

HOW ROBUST IS YOUR COMPUTER VISION?

CHALLENGE

Computer vision algorithms face many aspects that influence their correctness, e.g. shadows, reflections, low contrasts, or mutual object occlusion. Usually a lot of recorded images are used for testing in order to cover as many of these "criticalities" as possible. This approach causes several problems:

- Even with a very large set of recorded images it is not sure that all relevant criticalities for the target application are covered. Hence, this approach is inappropriate for certification.
- Recording all these images is expensive. Additionally, several situations cannot arranged in reality due to reasons of safety or effort.
- For evaluating test outputs, the expected results (called "ground truth" or GT, some examples are shown below) are needed. Usually they are generated manually, which is expensive and error prone.

Today a number of test data sets are publicly available, but mostly these are not dedicated to a certain application. They allow assessing the tested computer vision solution with respect to the target application only to a limited extent. Altogether, the use of recorded test data does not provide a satisfactory solution.

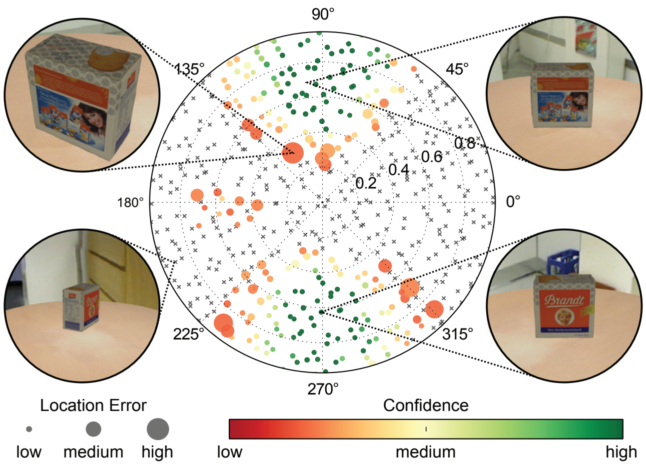
Top row: test image, bottom row: ground truth:

distance optical flow segmentation

SOLUTION

VITRO provides test data sets perfectly tailored to your application with maximum expressiveness about the robustness of your computer vision solution. Generated from models, the data are intrinsically consistent and precisely evaluable.

The "domain model" of a certain application contains its requirements as well as its application-relevant criticalities. The latter are selected from a comprehensive catalogue. Test data generation includes all typical scenes and criticalities, while automatically minimizing redundancies. Additionally, detailed test data sets can be generated for systematic evaluations (see the following example).



Example for a scatter plot: Recognition of an object depending on its orientation and distance (grey dots: no recognition)

HOW DO YOU PROFIT FROM VITRO?

- Verifiable coverage of typical and critical situations
- Automatic test data generation and test evaluation
- Strongly reduced recording effort for real test data
- No manual definition of expected results – cost reduction!
- Testing of dangerous situations without risks
- Applicable already during development
- Support for adaptive/learning computer vision solutions
- Results usable for future certification

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TECHNOLOGY

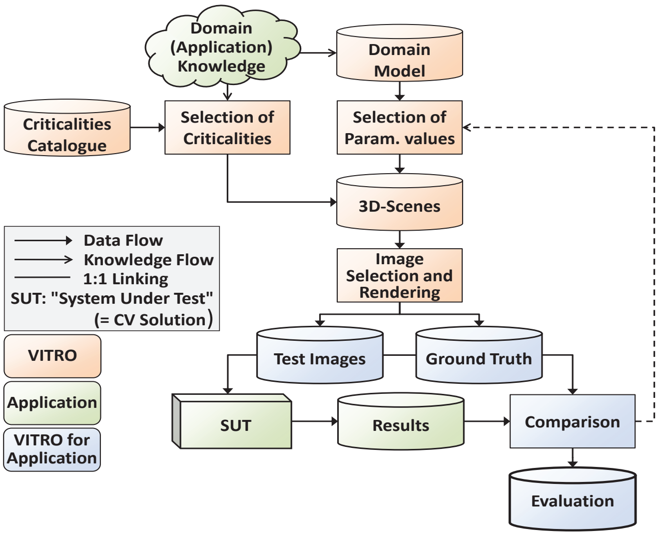
Modelling. The “domain model” describes the objects (geometry, surface appearance etc.), which can occur in rendered scenes, together with relationships between and constraints on them, as given by the application (e.g. on their size and relative positioning). It also contains information about background, illumination, climatic conditions, and cameras, i.e. the used sensors. For certain families of objects like clouds, generators are available. Further object family generators will be developed on demand.

Criticalities. A catalogue with more than a thousand entries is available, which has been created through adaptation of the risk analysis method HAZOP (Hazard and Operability Study) to computer vision (CV). This process has considered light sources, media (e.g. air and climatic phenomena), objects and their interactions (like occlusion and shadow casting), as well as observer effects. The latter includes artifacts of the optics (e.g. aberration), the electr(on)ics (e. g. thermal noise), and the software (e.g. compression artifacts). Only application-relevant entries of this catalogue are selected for the actual testing.

Scene generation. The parameters defined in the domain model, e.g. object positions or intensities of light sources, establish a parameter space. This space is sampled with so-called “low geometric discrepancy” which allows achieving the optimal coverage with few sample points. This results in generating scenes typical for the given application. Criticalities are included either by means of further constraints, or their occurrence is checked in generated scenes automatically. For the generation of characteristic curves (see scatter plot), specific scenarios can be defined.

Test data selection and generation. The previous step can yield redundant test images very similar to others. Therefore, test image candidates are characterized with properties derived from their original scenes, e.g. visual fraction of certain objects. These are used to group candidates and select representatives, which are rendered, and finally GT is generated for them.

Application. Generated test data can be applied to existing CV solutions for assessing their robustness with respect to the modeled application. But VITRO can already be used during development (e.g. test-driven development). In this case, simple scenes are generated first. Once these are processed robustly, increasingly challenging test data follow iteratively. Finally, adaptive and learning approaches can also be trained and tested.



VITRO – schematic application process

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