Virtual Vision Is Better: New Approaches in Image Processing

What makes a good inspection system for the industrial production process? First and foremost, the lighting and camera setup, because depending on how the light beam falls on a surface, defects such as dents or scratches become more apparent. Of course, the properties of the material to be inspected also play a role. Plastic has a different optical behavior than metal.

Here you can clearly see that certain areas in the image are overexposed. Reliable defect detection is not possible there.

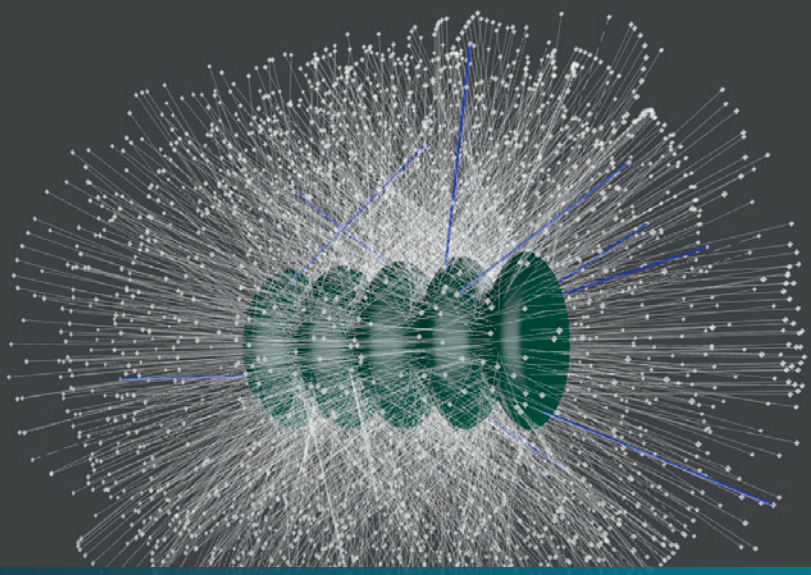
As long as the geometry of the test object is simple, such as rubber seals, tablets or metal plates, the setup can be adapted in just a few steps. The situation is quite different with complex geometries: If one takes, for example, a commercially available bulbous thermos made of aluminum with a handle made of plastic, it is almost impossible to develop a machine for fully automated inspection. If a robot is used to precisely maintain the angle between the surface and the illumination, this fails at the handle at the latest. In addition, aluminum and plastic exhibit different reflective behaviors. The angle of the illumination and camera must therefore be changed during the inspection.

Image processing, computer graphics, robotics: Together to the goal

So what to do? One solution would be to construct the entire inspection in the computer and physically simulate it – in other words, virtual image processing. Interdisciplinary work is being done on this at the Department of Computer Science at the TU Kaiserslautern and at Fraunhofer ITWM: Using existing computer graphics methods such as ray tracing, material models, CAD, and camera models, the team generates synthetic images and tests image processing algorithms on them. In addition, it implements methods to determine the optimal positions of the camera and lighting.

The first research result is an algorithm that calculates which surface areas can be safely inspected at all. For this purpose, it uses a 3D model of the test specimen and takes into account camera positions and illumination angles. This also resulted in a demonstrator consisting of a robot with camera and illumination.

However, simulating an entire inspection system and then modeling its effectiveness is a much more complex task. That is why the researchers asked themselves: How do you calculate optimal camera or illumination positions in relation to the inspection object? And they were able to answer it in part – with another algorithm. This method uses the 3D model to scan the entire surface and uses the local curvature to calculate which surface points are



Based on the geometry of the inspected object, our software creates a list of viewpoint candidates (white) and reduces them to a set of viewpoints needed to cover the most important areas (blue). A viewpoint marks a physical point in space, relative to the object, where the camera must be positioned during the inspection.

> **"In addition to computer graphics and visualization, we also need modeling based on physical principles for a viable simulation. With the V-POI planning tool, we are taking a big step in this direction"**
>
> **Prof. Hans Hagen**
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potentially important and thus must be in the camera's field of view. These positions are used for path planning of the robot or even fixed camera positions.

Learning system: Viewpoint of interest V-POI

The V-POI planning tool developed by the project team already copes well with component geometry and surface properties and has also learned to recognize potential problem areas during analysis. In order for the inspection system to know what a good part should look like, it is first "fed" the CAD data of a workpiece. The software is designed to calculate individual scan paths for objects placed on a turntable, for example, based on the specific product.

Goal: Manufacturer-independent system

The research objective is a software infrastructure that simulates the complete inspection environment, i.e. both the properties of the test specimen and the properties of all hardware components (illumination, camera, optics, etc.). The architecture of the software is to be designed in such a way that commercial suppliers of sensors, lighting, etc. can enter their product-specific properties, e.g. camera parameters, without having to disclose sensitive know-how. The system will therefore be manufacturer-independent.

Further information at
www.itwm.fraunhofer.de/virtual-inspection-planning

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