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FRAUNHOFER INSTITUTE FOR MANUFACTURING ENGINEERING AND AUTOMATION IPA

1 *Object detection in position and orientation.*

ADAPTIVE 6D OBJECT RECOGNITION FOR SERVICE ROBOTS

Background

For the autonomous execution of handling tasks in variable everyday environments, a service robot must be capable of detecting objects and computing their pose in 6D (position and orientation).

The great diversity of environments and objects means that the models of all relevant objects can never be available. In the interests of maximum flexibility and expandability, the robot should be able to »learn« new objects independently, thereby continuously adding to its capabilities.

Typical areas of application require not only object recognition in virtual real-time but also robustness to occlusion, deformations and variable light conditions.

Our solution

Fraunhofer IPA has developed a versatile software library for the automatic teaching and recognition of typical everyday objects.

Sensor setup and data fusion

Depth-image cameras or time-of-flight sensors deliver images similarly to colour cameras, the simple difference being that each pixel contains a distance value instead of the usual RGB values. In contrast to a stereo camera system, a depth-image camera computes a distance value for each image point. However, the resulting image is of lower resolution. Coupling a depth-image camera to a stereo camera system makes it possible to exploit the advantages of both systems in order to obtain a depth image that is as dense and also as accurate as possible.

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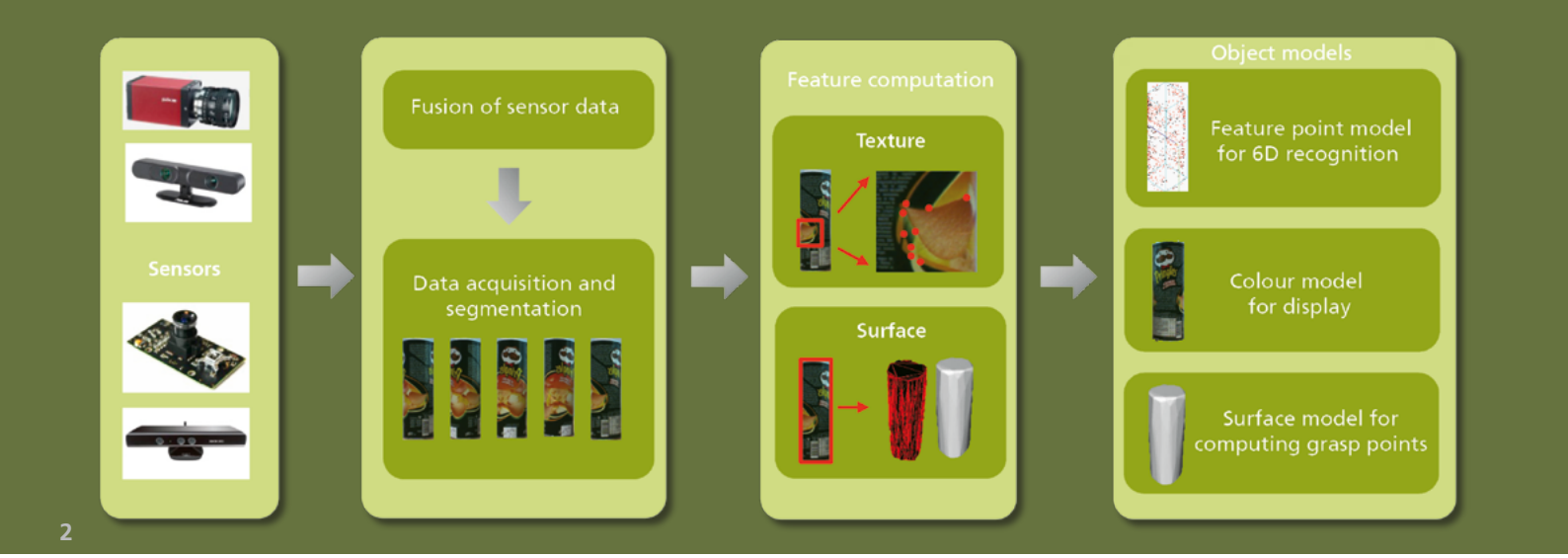

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Object representation

Textured objects are represented by so-called »6D feature point clouds«. These describe a set of distinct points that can be assigned to certain recognizable patterns in the colour and depth images of the object. The object model is defined by the geometrical configuration of all the points with their respective colour patterns in the object.

As textureless objects have no distinctive colour patterns, they are represented by features such as the curvature of the 3D surface or by the shape of the object silhouette.

Automatic learning of new objects

To learn a new object, it is first necessary to generate images of the object from different viewing angles, for example by getting the robot to rotate the new object in its gripper or through the use of a rotary table. The thereby applied process for generating the required object models consists of the following steps:

1. Acquisition of a 3D colour image sequence with different object views
2. Spatial segmentation of the object views on the basis of distance data
3. Computation of stable 6D feature points for all views
4. Fusion of the partial object feature point clouds into an object model

Detection of known objects

To locate an object in a given scene, all of the features detected in the scene must first be captured. Next, those features are scanned for possible correspondences with known object models. An object hypothesis is computed for each correspondence. Statistical functions are applied to evaluate the hypotheses and the one with the highest probability is selected. The use of efficient structures and algorithms means that this detection process takes less than one second.

Object classification

Often in real-world applications, what is required is not to recognize a given, previously learned object, but to assign a hitherto unknown object to a certain object class. Modelling is based on the 3D geometry of the object surface, which is frequently characteristic for similar objects. The information on object class provides pointers for manipulation of the object, its purpose or possible functionalities. It also enables the robot to learn and classify new objects independently.

Reference projects

Acceptable robotiCs COMPanions for AgeiNg Years (Accompany)

The purpose of this project was to further improve the ability of the Care-O-bot® 3 household robot to assist elderly citizens in domestic environments. A key focus was on the manipulation of known and unknown objects for the user.

Item handling for logistics and retail

Mixed mail orders are mostly handled manually in today's warehouse logistics, especially in the mail order business, because of the large variety of items at hand. Detecting all these kinds of items and computing their 3D pose is a prerequisite for automated commissioning of client orders. Similarly, the retail business offers interesting applications like automated continuous stock inventory auditing and searching for misplaced articles.

Detection of cows' udders

For automatic milking or cleaning of cows' udders, it is necessary to accurately detect their position in 3D, more especially the coordinates of the individual teats. Based on the above-mentioned software components, sample images were used to create a generic 3D model of the cow's udder. This made it possible to detect differently shaped udders.

What we offer

Fraunhofer IPA will support you in all phases of development of your customized methods for object detection:

- Selection of suitable sensors and image processing algorithms
- Customization of existing image processing techniques for your specific application
- Design and implementation of new object detection techniques
- Integration of techniques into existing systems and applications

2 *System architecture for the creation of different object models.*