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1 *ScanStation for modeling objects.*
2 *Detecting the position and orientation of objects.*
3 *Picking with the aid of 3D object recognition.*

ADAPTIVE 3D OBJECT RECOGNITION FOR SERVICE ROBOTS

Current situation

To perform autonomous handling tasks in a changing everyday environment, a service robot must be able to recognize objects and calculate their exact position and orientation in 3D. Due to the diversity of environments and objects, models of all the relevant objects are never available. To maximize flexibility and expandability, robots should be able to "learn" new objects autonomously and thus continuously extend their capabilities.

Ideally, object recognition takes place almost in real time and compensate for occluded or deformed parts, or for changes in lighting conditions.

Our approach

Fraunhofer IPA has developed a versatile and flexible software library for teaching and recognizing everyday objects automatically. With the aid of depth cameras, an image of the environment is generated in a similar way as with color cameras, but instead of the usual RGB color values, a distance value is stored in each image element. Since the algorithms can use different color and 3D sensor modalities, they are not limited to particular sensors.

Multimodal object representation

The software library makes it possible to characterize objects on the basis of their specific properties. As a result, a wide range of recognition features such as shape, color, texture, inscriptions, logos, function, etc. can be analyzed,

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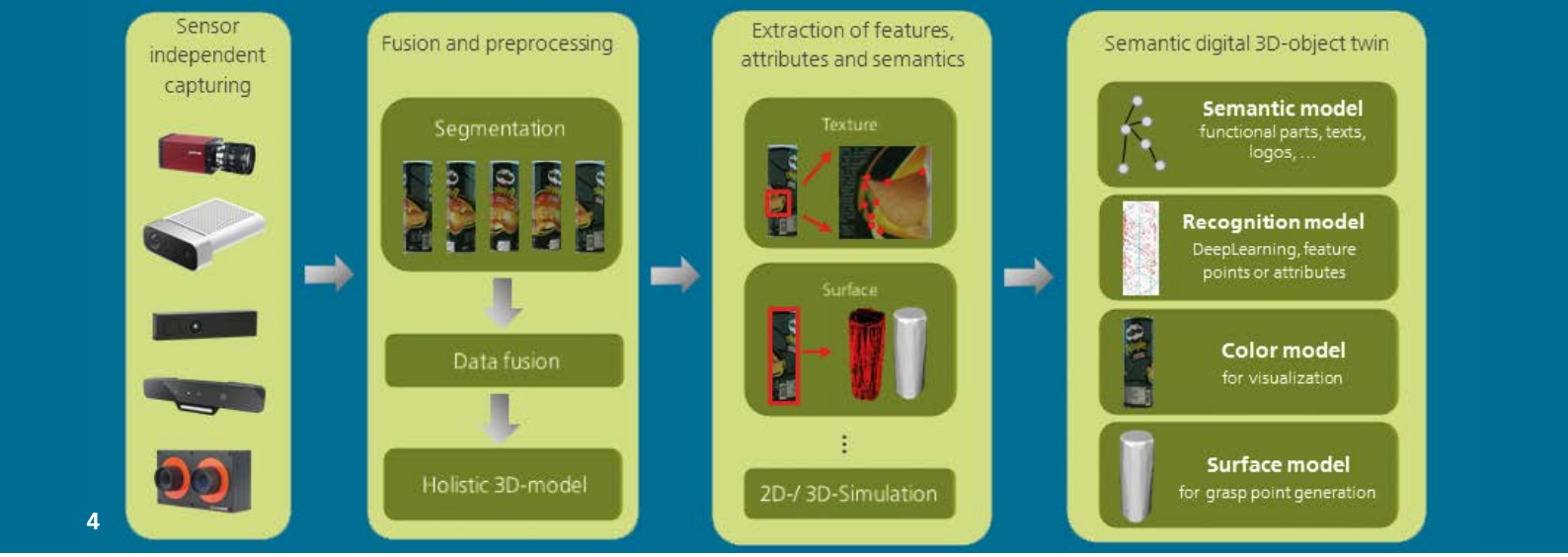

thus enabling objects in unstructured environments to be generically and robustly described. Textured objects are depicted by 3D feature point clouds, for example. The geometrical arrangement of all points with their described patterns in the object defines the object model. Non-textured objects are encoded, for example, based on their curvature or silhouette.

Teaching in objects automatically

In order for a robot to learn a new object, images must be generated from different angles, e.g. by the robot turning the object in its gripper or by using a stationary ScanStation. The procedure comprises four steps:

1. Acquisition of a 3D color image sequence of the object viewed from different angles
2. Spatial segmentation of the object views
3. Generation of a digital 3D object model by fusing the various views
4. Extraction of the respective features, attributes and semantics

Recognizing known objects

To locate objects in a scene, the detected features are utilized to establish correspondences with known object models. For each correspondence, an object hypothesis is calculated, statistically evaluated and the most probable one selected. This process takes less than a second.

Classifying objects

In practice, a previously unknown object often has to be assigned an object class or category. This is achieved by modeling the object via the 3D geometry of its surface, which is frequently characteristic for similar objects. The classification data provides information about how to manipulate the object, as well as about its purpose and functionalities. The robot can also learn and classify new objects autonomously.

Potential fields of application

Retail and warehouse

Service robots use adaptive object recognition to recognize products on the shelves of supermarkets or warehouses, e.g. for the purpose of automatic inventories or automatic picking. This also facilitates the returns management process.

Cleaning

Cleaning robots are designed to detect and effectively remove different types of dirt. The software library makes it possible for a robot to differentiate between dirt and office objects lying on the floor, for example, or to detect rubbish on greenareas along motorways. In addition, elements on surfaces such as handles and fittings can be identified for specific cleaning or disinfection.

Assistance in the home

In the future, in order to actively help people with household tasks, service robots need to be capable of recognizing and locating devices, room features such as doors, and everyday objects, even food, so that they can handle them correctly. A robot can thus be deployed to fetch things or to help out in the kitchen.

Healthcare

An intelligent care trolley uses adaptive object recognition to automatically detect removed care articles and to document their consumption. This can, for example, make restocking more efficient. In the future, a mobile robot could be used to actively hand out care utensils in order to relieve the workload on nursing staff.

Our services

Fraunhofer IPA assists you in all phases relating to the development of your own object recognition methods.

- Selection of suitable sensors and image processing methods
- Modification of existing algorithms to suit your specific application
- Design and implementation of new object recognition methods
- Integration of the methods into existing systems and applications

4 *System architecture for generating different object models.*