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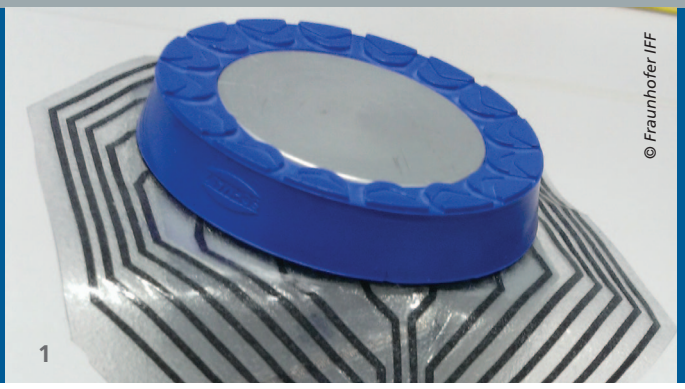

1 *Object pose as determined by a magnet gripper with a tactile sensor.*

MULTI-MODAL BIN-PICKING FOR NEW INDUSTRIAL TASKS-PICKIT

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PICKIT

State-of-the-Art and Motivation

Bins with randomly stored materials are currently one of the most cost-effective and flexible supply forms, especially in the field of intra-logistics. Extracting particular parts out of a bin can be automated by using so-called bin-picking systems which combine vision sensors, grippers and image processing algorithms to enable a robot to grip parts automatically.

However, all commercially-available systems still face the same challenges, namely the verification if a part was gripped properly and whether problems occur during the handling process. In the ECHORD++ project pickit, a tactile sensor was designed which can be attached to different types of industrial grippers. For our experiments we used a tool-mounted camera system of Scape Technologies A/S.

Tactile Sensor Technology

The tactile sensor has a highly flexible structure with a spatial resolution of up to 2mm and can be easily mounted to differently shaped grippers, even on non-rigid structures. Our tactile sensors were designed specifically for a magnet gripper, a suction cup and a simple two-finger gripper.

Capabilities

Combining tactile sensation with visual sensors can significantly increase the performance of a bin-picking system. For instance, continuous evaluation of the tactile sensor data can detect collisions between the gripper and surrounding structures. Furthermore, movements of the gripped part can be detected and used to conduct intermediate handling steps to place

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the part accurately. Additionally, the tactile modality can also be used to determine if the part was gripped as intended. In some cases, even the object pose can be modelled (picture 1). Finally, the correct placement of the part can be verified, using the tactile feedback.

Reducing Cycle Times

The multi-modal bin-picking system applies two different approaches in order to verify a part grip. The first approach is based on the comparison of a predefined tactile pattern with the current sensor information. In some cases, if both patterns are matching to a certain extent, the part can directly be placed at the deposit station without conducting intermediate gripping steps. Thus, the cycle time could be decreased by 18% for an exemplary application featuring a suction cup gripper.

The second approach featured the exact placement of a washer using a magnetic gripper. Here the object pose can be determined from the tactile information. In several experiments, this approach reduced the total cycle time by up to 36%.

Particularities of the flexible suction cup

Since the suction cup adapts to different object surfaces very well, we utilized this particular feature to determine the local object shape by extracting depth information on the part (picture 2).

This method can also be applied to the characterization of objects when conducting many touches in a row e.g. for detection of transparent objects.

Particularities of the rigid magnet gripper

Furthermore, our experiments have shown an improvement in the recognition accuracy of the bin-picking systems through use of tactile feedback. This was demonstrated for object features like slight curvatures (picture 3). As a consequence, the parts can be sorted according to their curvature.

Acknowledgement

The multi-modal bin-picking system was developed and tested in the pickit experiment by the Fraunhofer IFF in cooperation with Scape Technologies A/S. The pickit experiment is part of the ECHORD++ project funded by the European Commission under frame-work 7 (grant agreement no. 601116).

2 *Object shape as determined by tactile suction cup.*

3 *Washer consisting of small object features.*