Feature

PalletPicker-3D, the solution for picking of randomly placed parts

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Abstract

It is now possible to pick randomly placed parts from a bin automatically. SVIA have developed a patented bin-picking system that is general and easy for the operator to teach. It is possible because of the combination of a high precision optical 3D-measuring technique, modern image processing and six-axis robot technology.

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Introduction

It is not difficult to teach a person to pick randomly oriented parts from a box and place them in a fixture. Many researchers and companies have tried to construct and teach technical systems to do the same for many years. The result is not as general as one could wish for: the few systems that exist are limited in the range of parts that can be handled and are difficult to teach to handle new parts.

SVIA have developed a bin-picking system that is general and easy for the operator to teach. The bin could be any type of box or pallet. It is possible because of the combination of a high precision optical 3D-measuring technique, modern image processing and six-axis robot technology. In this article, the system which uses patented technology will be described for the first time.

Description of the system

The patented PalletPicker-3D is a machine with a 3D-optical sensor, a vision system and an industrial robot that picks sorted or unsorted parts directly from a pallet, without any mechanical orientation. The machine is intended to completely replace operators' loading processes and other machinery. With this machine industry will be able to automate processes where human operators could not previously be replaced.

SVIA has a measuring technique that measures the pallet's inner area in 3D with a dimensional accuracy of ± 0.1 mm. With this 3D information the robot can pick parts from the pallet even if the components are unsorted. The sensor that measures the pallet is placed above the pallet, see Plate 1. The bin, box or pallet could be of different type and size.

When the operator has placed the pallet in the machine the sensor measures the pallet-area. Data is processed in a powerful computer with a user-friendly interface for the operator. The computer assesses which parts are on top in the pallet and the co-ordinates and the orientation of the parts are sent to the robot's control system. The robot picks up a part from the bin placing it on a flat area in the machine (Plate 2). A conventional vision system is used for guiding the robot to the final grip of the part. The robot will then move to the final location, for example the process machine. It is also possible to pick parts directly from the pallet to the final location

Plate 1 A historical picture of the first PalletPicker-3D from SVIA (2000). The 3D-sensor in placed in the box on top. The robot is an IRB 2400 from ABB

Plate 2 The robot picks parts for chainsaws with a vacuum gripper. The parts are randomly oriented in the bin

for some, but not all orientations. PalletPicker-3D is built as a standard cell with minimum external dimensions (the "lean principle") for easy installation with existing equipment.

The 3D-sensor will make a new measurement when there are no more parts to pick from the bin. The system also checks if parts have been moved since the last time the measurement was made. This can happen for example when the robot picks one part that has other parts lying partly on top.

The 3D-measuring system

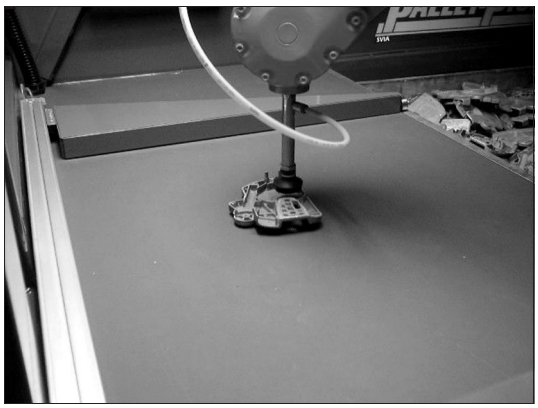
The key to the general functionality is the 3D-sensor. It gives much better information to work with than a normal 2D-vision system when the parts and the gripping positions need to be determined. Parts with differences in colours and surfaces are normally a significant problem for vision systems. Many such problems are avoided when shape information of an object is used instead of the picture of an object illuminated in an uncontrolled way.

The 3D-measuring system uses projected fringes from a video projector and a high-resolution camera. The camera and the projector are placed at different angles and by the stereo principle it is possible to get high precision 3D-information. The result from the 3D-system is (x, y, z) coordinates as well as quality information about how reliable the information is at each camera pixel. This provides a distance measuring result for each pixel with a resolution better than 0.1 mm.

The 2D-vision system

For some parts and in some orientations, it is possible to pick parts directly from the bin to the final position but many pickings need a reorientation of the part in order to be able to grip the part correctly. The robot places the parts on a flat area and a conventional 2D-vision system is then used for guiding the robot to the final gripping position (Plate 3). SVIA has its own vision system that has been developed purely for robot guiding. This has made the system very easy to use and with good functionality. Pattern recognition and some other image processing are used to find the part and its orientation. Vision parameters are by default set to suitable values and the operator does not need to know about vision

Plate 3 After the part has been picked from the bin, it is placed on this flat area. A conventional vision system is placed above and used for guiding the robot to the final gripping position



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technology to deal with most parts that have been used with the systems so far.

In detail, the vision system has to recognise:

(1) the position of the part (if the part is your hand, the system recognises if the fore- or back-hand side is uppermost),
(2) the x and y coordinates of the gripping position, and
(3) the rotation/angular orientation.

Robots and communication

For the application with randomly placed parts in a bin, a six-axis robot is needed. So far only ABB-robots have been used but there are no principal or technical limitations preventing the use of robots from other manufacturers. A master computer handles the communication with the robot and communicates with the 3D-sensor and the vision system.

Limitations

PalletPicker-3D cannot handle all types of parts. For example parts that stick together due to the surface properties or geometry cannot be picked successfully. In practice, if most of the time one gets more than one part when requesting only one, PalletPicker-3D is not the right feeding system. But if more than one part is picked only some times, the system will recognise this with the 2D-vision system. Depending on the application, the system will remove all parts from the flat area under the vision camera or the robot will pick the parts.

The 3D-sensor is limited to diffuse reflecting surfaces. However, almost all surfaces are more or less diffuse. The system works well for ordinary sheet metal or casting parts. But the sensor cannot measure on mirrors, since the sensor will see the mirror picture, not the mirror itself. Parts with big variations in colour and surface patterns can easily be measured and recognised by the system.

The weight and size of parts that can be handled is limited by the robot used. Today, there are robots designed for 500 kg and they can reach up to 3 m. SVIA has not yet found any relevant application that is limited by the size or weight of the parts. For small parts the accuracy of the robot and gripping sets the limitations. The 3D-system and the 2D-vision system can be scaled to whatever size is needed.

The picking is done very precisely, within 0.1 mm or within the limitations of the robot. It is thus possible to pick sensitive parts. But the parts could not be randomly placed in the bin because they could then hit each other while picking up from the bin. However, in practice sensitive parts will always be placed separately from each other, otherwise they will be damaged during transportation.

The robot limits the cycle time. If all parts have to be re-orientated after they have been picked from the bin, the cycle time could be a bit better than 15 s. If the parts can be picked in the final orientation directly from the bin, the cycle time can be reduced to 10 s. These times are for picking from an ordinary European full size pallet ($1,200 \times 800\,\text{mm}^2$). However, it is limited by the robot and these are getting faster all the time.

Applications and costs

The application is machine tending in general. For example feeding castings for machining or metal sheets for assembling or pressing. It is possible to place several pallets around the robot and pick different parts and place them into a fixture for welding or for assembling with the robot. For plate sheets it is possible to use systems without the 3D-sensors if the sheets are in piles. SVIA have other standard machines for shorter cycle times and picking from a conveyer, read more about on the home page www.svia.se. However, this new PalletPicker-3D concept will open many new automation applications and is probably limited only by our imagination and by industry's naturally conservative attitude to new ideas (Plate 4). The cost for a complete system, including the robot, is from 150,000 Euro.

Plate 4 Examples of parts that can be picked by PalletPicker-3D from SVIA