ROBOTIQ

BIN PICKING APPLICATIONS AND TECHNOLOGIES

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INTRODUCTION

Either for machine tending or part transfer, material handling is worth automating since it is monotonous and a non-value added job. Robots are already used in manufacturing to do these tasks. However, there still room for improvement. The first step of any manufacturing application is related to bin picking, since the robot has to pick up the part prior to doing its job. As often mentioned, automated bin picking applications are the "Holy Grail" of robotics since they have many challenges to overcome.

There are different types of bin picking with different levels of difficulty. The main features that define the complexity of bin picking applications are:

1. The geometry of the part.
2. The severity of randomness of parts in the bin.

This document will provide you with information about what you should know and consider in order to automate your bin picking applications. First, let's take a look at the different kinds of material handling. Then, we will talk about the whole bin picking process from cameras and software to selection and gripping. After reading this document, you should be able to define your bin picking process and have all the necessary information to find the best packaged system to suit your needs.

TYPES OF MATERIAL HANDLING

STRUCTURED MATERIAL HANDLING

In this type of manipulation, the rigid part that needs to be gripped has a predetermined location and orientation easily reachable by a robot and its end effector. It either needs jigs or it arrives at your manufacturing plant in a structured bin.

SEMI-STRUCTURED MATERIAL HANDLING

Here the part is constrained on a planar surface with no assigned location or orientation. This is defined as a 2 degrees-of-freedom (DOF) pose. There is no overlapping of parts. This kind of handling is easily done with the help of a vision system under controlled lighting.

BIN PICKING

Bin picking consists of a single type of object randomly piled in a box. The system needs to resolve the pose of each object with 6 DOF. A lot of overlapping parts may be encountered. Here again, actual vision technologies have proven that they can solve this kind of puzzle, but controlled lightning is still needed.

WHOLE BIN PICKING PROCESS

Bin picking requires the synchronization of three components:

1. **Vision Systems: the hardware component**
   Basically, a robot has to locate and grasp objects that have been placed randomly in a container. To do so, a vision system is used to take pictures of the bin.

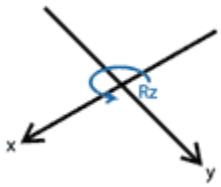
2. **Vision Systems: the software processing**
   This part is all about the data analysis scanned or detected by the hardware component. The images scanned are processed by the software to recognize a part in the bin to be picked up. Then, the software needs to talk with the robot controller to plan the best path to pick the selected part up avoiding any collision.

3. **The end effectors**
   Finally, the robot moves to grasp the object by using its end effector and brings it to the next manufacturing cell.

1. VISION SYSTEM: HARDWARE

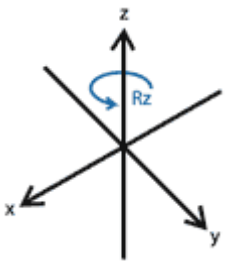
Different vision technologies now exist on the market. Vision systems don't only include the cameras; the computation of the information received by them is also part of the system. Once images are taken, the software needs to process the data in order to recognize the part to pick. Their methods can differ from one manufacturer to another, but the vision system itself can be categorized.

2D ROBOT VISION



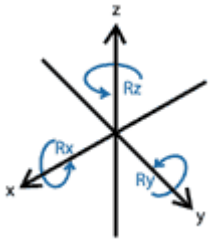
This kind of vision system can be used for identification and position recognition of a part on a 2D plane. It usually can detect the X, Y variation and the rotation of the part around the Z axis. There is usually only one camera located at a constant distance from the part.

2.5D ROBOT VISION



The 2.5D vision can also detect the part's height using a single camera. The camera takes different pictures of the part or it can also use a time-of-flight laser to determine its height. This kind of laser will calculate the time needed for the laser light to hit the part and come back. In order to take its different poses, the camera of this vision system needs to move. The information received from the images can define the position of the part in X, Y, Z and its rotation around the vertical axis. This kind of vision is a lean system equivalent to the ability of a 3D camera and is often used for de-palletizing.

3D ROBOT VISION



3D vision can detect variations in X, Y and Z direction. Moreover, it can detect rotation around the three axes giving 6 Degrees-Of-Freedom (DOFs) part location. It is the preferred technology for bin picking applications. 3D systems can use either one moving camera or two with a shape-matching (model). A TOF laser with surface-matching can also be used (point cloud). The camera distances can change.

FIXED-CAMERA VS END-OF-ARM MOUNT

The way the cameras are mounted can present some advantages or disadvantages.

A fixed-Camera will allow the robot to keep going with its work while the picture is taken and processed. However, the camera needs to be far from the moving arm to avoid any interference. So, the pictures are often less accurate and not always in the right orientation. To capture more than one angle of the part, another camera is usually needed.

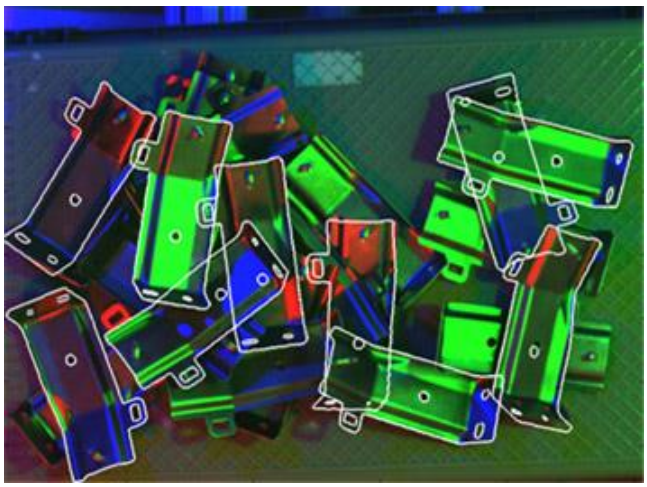
When the camera is mounted on the robot arm, the accuracy of the picture is improved. Moreover, the orientation can be adjusted to get the best images possible. One camera can be used to get pictures of the part from different angles. However, the camera needs to have high-flex cabling because it is moving with the robot arm. If the camera is in harm's way, then it might be damaged if a collision occurs. Another thing to consider is that the arm needs to stop in order to take a picture, so the cycle time can be longer if it is mounted on the robot arm.

2. VISION SYSTEM: SOFTWARE

The computational aspect of the vision system consists of two tasks: object recognition and path planning.

a. The Object Recognition

Object recognition uses the local geometric features of the part to be able to accurately calculate the position and orientation of the object. Moreover, objects that contain a lot of unique features can be detected from a partial view. The vision system, usually a 2D or 3D camera, takes pictures of the bin, then processes the images in order to recognize a part in the bin. Different methods are used such as comparisons with CAD models, 3D point cloud, geometric pattern matching (GPM), etc. Object recognition not only gives information on the detected object, but also on the undetected ones. This is called environmental information. By using this information, collisions can be avoided while calculating the path.



b. The Path Planning

This leads us to the path planning role of the vision system. When an object's position and orientation is determined, the path of the robot for reaching this object is calculated. As stated before, collisions have to be avoided, so the vision system helps by providing information on the other parts in the bin, as well as for the localization of the bin's walls. This is a safety feature that all bin picking systems should be using.

END EFFECTORS

When all the calculations are done, the robot arm can move and pick the piece detected. However, to grab this object, the right end effector has to be chosen. And here again there are some challenges to consider:

- **Complexity of robot gripper design**
  Specific robot grippers can be specially designed for the object to be handled in the bin. But, since the parts are randomly located in the bin with different orientations, designing the right gripper can be a complex task.

- **End effector flexibility**
  Also designing a specific device brings flexibility problems, because different grippers need to be used for different pieces. Furthermore, what if the bin contains various types of objects?

- **Having the right type of end effector according to the parts to be handled**
  Common grippers can be used to perform bin picking. However each one has its pros and cons. For example, suction cups may be effective for small and flat parts having a regular finish. However, if you have an irregular part with a porous finish, things could be different. Same thing with pneumatic grippers: having parts in a structured or semi-structured

environment with enough space between them could be a good solution. However if the end effector has to reach into a confined space and deal with overlapping parts, pneumatic grippers may not be the perfect fit due to the difficulty of doing partial opening and closing.

- **Precision required once the part is picked**
  Depending on the applications and the process, picking the part might be only one part of the challenge. The accuracy needed for the next step in the production process can also have an impact on the choice of end effector. Indeed if the part has to be inserted in a CNC machine, put on a conveyor or brought to a particular assembly position the precision required will have an impact on what you need in terms of handling equipment.

Industrial bin picking applications seem to represent a good fit with flexible electric grippers. These kinds of robot gripper provide more flexibility by, among other things, performing partial opening and closing to reach tight areas.

BASIC METRICS TO MEASURE THE QUALITY OF A SOLUTION

The potential metrics that could be used to evaluate a solution for bin picking applications are the following:

Speed
Which is defined as the time required to pick an object in the bin or the number of objects which can be picked in a given amount of time.

Efficiency
Which is a mixture of time efficiency (time required to locate the object vs cycle time), grasping quality and percentage of success.

Accuracy
Which is the measurement of error in object recognition and part pose estimation.

Since there are a lot of factors influencing these metrics, the best way to evaluate a solution is to test it. A bin picking system is not only about the cameras or the end effector; it is the combination of every component in the cell. This is why it is difficult to determine the quality of a solution considering the components individually.

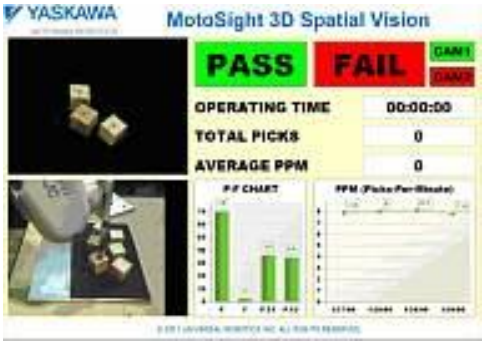
PACKAGED SYSTEMS FOR BIN PICKING

MAJOR BRANDS

FANUC

Fanuc offers a complete solution for bin picking applications. All the hardware and software is 100% from Fanuc. This solution is called iRVision 3DL and it is integrated with the R-30iA Controller. The system can work with either one or more cameras. No additional hardware is necessary such as a PC. You just have to plug the cameras to the controller. There is a light exposure mode to compensate for light fluctuation. The software has a lot of options such as inspection module, GPM tool locator to detect a previously trained image pattern, BLOB tool to detect the part even if it has irregularities, curve tool locator and more. Moreover, the iRCalibration Suite offers calibration modules for various systems such as vision shift, TCP set, vision frame set and more. For more information, visit their website:
http://www.fanucrobotics.se/en/products/vision-systems/irvision

YASKAWA – MOTOMAN



Motoman has partnered with world-leading vision product providers to offer a packaged solution for bin picking applications. Their new software MotoSight 3D offers real 3D vision to their robot arms. This vision software supports 6 DOFs with one, two or three cameras. If the single camera option is chosen, it has to be mounted on the robot. If multiple cameras are used, they can either be mounted on the robot or fixed to another location. This gives better flexibility and can accommodate irregular parts. It can be integrated with off-the-shelf cameras and it is supported by their DX100 and NX100 controllers. The software will compare what it sees to a standard CAD file of your part. In term of performance, the whole system can handle 6 to 10 part per minute. For more information, here is their website:
http://www.motoman.com/products/vision/#sthash.zx9TKcVS.OYIdBnIP.dpbs

ABB

The vision system integrated for ABB robots is named TrueView. It is compatible with the IRC5 controller and all IRB robot arms. The patented single camera 3D technology can locate a part with 6 DOFs. The camera is mounted on the robot arm and is supplied with super flex cables for a long service life. The set-up is fast as well as the calibration. The camera used can be an analog Sony CCD, JAI or Baumer both of which are GigE digital cameras. The system has 2 red LED light bars to improve the quality of the pictures taken. The vision processing time is about 1 to 3 seconds. For more information, follow this link to get the datasheet:
http://www05.abb.com/global/scot/scot241.nsf/veritydisplay/599b2f4b48524fe8c1257b130057a117/$file/TrueView%205.12%20revB.pdf

INDEPENDENTS

SHAPESCAN

3D SHAPEscan is a solution, developed by ISRA Vision, to precisely locate the position of a part which is randomly arranged in a bin. This system includes 2 cameras and special laser lighting. The system can be installed in a fixed position, as well as on a robot arm. It can be adjust for any size of container by adjusting the distance between the two cameras. The 3D sensor scans the bin and the software develops a so called 3D point cloud. With this newly developed evaluation method, SHAPEscan can identify basic geometric shapes in the bin. It assures robust recognition of a part's geometry. The depth is determined by laser projection. The stereo view, allowed by the two cameras, makes it capable to see in 3D just as a human does. For more information on this solution, get the datasheet via this link: http://www.isravision.com/en/products/robot-vision/3D-shape-scan

SCAPE TECHNOLOGIES

Scape Technologies offers a standardized solution for any bin picking application. Based in Denmark, this company enables robot arms to see in order to grip unsorted objects in a bin. The installation is very simple: Install the software on a standard PC, mount the Scape Tool Unit on the robot, use the standard Scape software, upload the files of your parts to the PC and, by making some adjustments, the system is ready to start running. The Bin Picking Suite offers a range of recognition and gripping options. This standardized solution also offers an optimal return on investment. To get more information, visit their website: http://www.scapetechnologies.com/

These packaged systems are just a few of the solutions available on the market. Many different independent vision integrators are providing great solutions for bin picking applications. Therefore, to make the right choice, it is not only important to ask about their products, but also about their services, since vision technology is still about testing and adjustments.

CONCLUSION

For the past two decades, robot manufacturers have been working hard to put in place efficient robotic bin picking systems. It still is one of the most difficult applications for robotics. But now with the technical progress of 3D vision systems, computation and flexible end-effectors, this application seems to be a reality for today's industrial day-to-day production line. Many solutions have been proven to work with success, so it is now time to convince the industrial world that solutions for bin picking are available.

ABOUT ROBOTIQ

Robotiq designs and manufactures flexible robotic tools for agile automation. We aim to give to industrial manufacturing – from large businesses to SMEs – robotic tools solutions to optimize automated processes. We work with robot manufacturers, system integrators and end-users to enable new applications and improve productivity. Contact us for more information at info@robotiq.com. Or visit our website at www.robotiq.com