Smart robot that picks parts from bins

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Abstract

Purpose – To describe how one innovative company has developed software which teamed with a vision system allows an agile robot to be taught how to pick randomly place parts from a multi-layered bin.

Design/methodology/approach – Software, which runs on an industrial PC-based computer platform, has unique algorithms, which can identify randomly placed 3D parts in a bin and calculate the path the robot needs to take to pick each part.

Findings – The software has been successfully applied to picking many different part configurations, including odd-shaped brackets, long slender vehicle axles, round brake rotors and cylindrical shaped pistons and other automotive housings.

Practical implications – Vision-guided robotic picking can now be more efficient and faster than manual part picking in many applications. Users need to rethink part picking.

Originality/value – A long-sought solution to quickly picking parts from bins is now a reality.

Keywords Robotics, Parts

Paper type Case study

Robots have always had the ability to move quickly and remember their assignments but have been limited by having to have a human tell them exactly where to move and how to grab an object. Even the addition of a vision system did not always add the required intelligence necessary to find and pickup randomly arranged items in a bin. Other systems were typically required to exactly orient parts and move them to a precise pick location. For many applications the need for such setup operations negated the potential benefits possible with robotic handling.

What was missing was the ability to see, process object and location information quickly and decide a path of movement to perform random bin picking in a cost efficient manner. The picture changed when Adil Shafi developed his Reliabot® 3D vision package.

Key to the Shafi system is the unique algorithms they have developed and the availability of high-speed computation power in the latest PC-based industrial computer platforms. For fairly simple 3D geometrics, processing times are now in the range of 4 to 6 s to calculate the exact pick path for the robot. That brings object location into a competitive time range with manual picking.

During set up of the system, the operator teaches the robot a home location where the vision system can identify the object and the layer the object has in the bin. The operator also teaches the robot the unload location. The Reliabot software then calculates the pick approach and the path to the unload location based on the part location as determined by the vision system.

The industrial PC communicates with the robot controller via RS 232 or in other cases via an Ethernet protocol. Work is underway to incorporate an industrial PC card right within the robot controller when it is a Windows based system. That would allow a closer communication link over the backplane.

The operator has a HMI display on the industrial computer where he can input information to manage the system and can observe the images of the system camera(s). The number of cameras required for a particular application will depend on the complexity of the part and the presentation.

In some applications where the part configuration and the unload requirements necessitate, the robot will pick the part form the bin and then place on an intermediate location. A second image can be taken and a new pick sequence will be designed to insure that the part is presented to the unload station in the correct orientation. This two-stage cycle is typical when the part has a non-symmetrical shape and is randomly placed in the supply bin. Meaning the part must be flipped over or cannot be gripped correctly the first pick to complete the required unload.

A variety of end of arm effectors are employed. In some cases the end-of-arm device is an electromagnet. This is much more forgiving of the pick location and shortens the total pick cycle time. In other applications, a vacuum cup is the preferred end of arm device. Magnets and vacuum cups are more tolerant of robot location at the point of picking. A forgiving pick location can speed the information processing needed to calculate the robot path.

For some part configurations, the robot may advance to a "first" view location and attempt to identify the part and calculate the pick path. If the system does not "find" a part in this first look, the robot may move to alternative viewing location and try again. The process is much like a bird looking for a worm. If the bird does not see the worm on first look, it cocks its head and tries looking from a different angle.

Frequently, the end-of-arm-device has a sensor to detect if the part pick has been accomplished. For finger type grippers, this may be a proximity sensor. For vacuum cup pick up, it might be a vacuum pressure sensor. If the sensor signals that the part was not acquired, the pick cycle would be repeated.

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Shafi Inc. supplies the vision information processing software and works closely with Cognex for the vision system hardware. For robots, the RELIABOT package has been integrated with a number of makes of robots including Fanuc, Motoman, Adept, Nachi, Kawasaki and ABB.

Examples of successful robotic bin picking

Vehicle axle shafts

A Motoman-Shafi robotic system can unload in about one hour an entire bin of loosely stacked axle shafts without invention by the operator. The Motoman robot is guided by a Cognex two-camera system. The first, fixed location, camera finds the axles in the upper most pick layer. A close-up camera mounted on the robot arm. It sends signals to the Shafi software package to calculate the exact 3D position and pickup angle.

The software is able to differentiate the axle to be picked despite confusing patterns created by the bin full of axles. The software processes all of the image information to direct the robot close enough for a compensating gripper to accurately pickup the axle. The package also computes approach strategies for picking axles located near the bin sides where gripper clearance can be a problem. The software tilts the approaches so the gripper can pick the axle and not interfere with the bin wall (Plate 1).

The gripper is custom designed for the application. It includes a wide u-shaped bracket with compliance which "gives" as the robot engages the axle shaft. When engaged, a piston actuated pair of "fingers" moves to retain the axle for the carry (Plate 2).

Vehicle differential carriers

In a differential assembly application, a robot picks carrier bodies that are randomly placed in a supply bin. A two-camera Cognex vision system provides 3D images, which are processed to decide if the part is right side or wrong side up, the exact location and the angle orientation. The robot is directed to the proper pickup position with adjustment for yaw, pitch and roll (Plate 3).

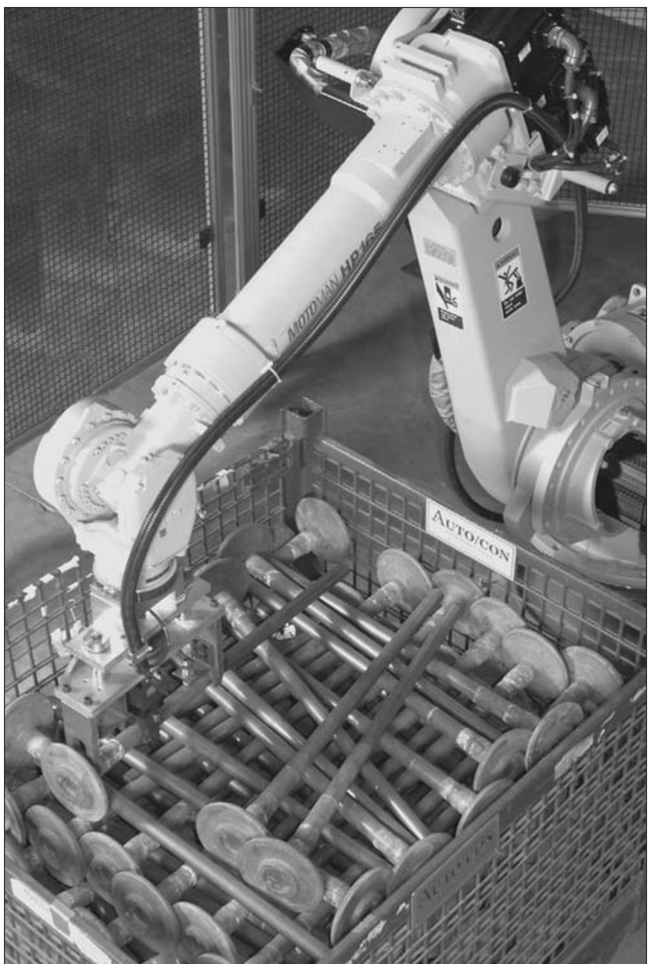
The robot is a Nachi SC50 F with an AX model controller. The vision system uses the MVS-8100D hardware ad the VisionPro 3.4 software package. The system can pick an entire bin of 52 parts without operator intervention.

The Nachi SC50 F is a six-axis AC servo powered robot with an up to a 50-kg payload capability. The arm can move at up to 160° per second.

Brake rotors

A Kawasaki robot and a Shafi system make quick work of a basket type bin of brake rotors. The rotors are randomly stacked

Plate 1 Motoman robot with Shafi Reliabot bin pick software package lifts vehicle axles out of random stacked bin



Note: Two-fingered gripper located at the middle activates when the axle is engaged to retain the axle for the move

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Plate 2 Close-up of the custom end-of-arm device. Outer "U shaped" bracket is spring loaded to be compliant with engaging axle shaft. Two-fingered gripper located at the middle activates when the axle is engaged to retain the axle for the move

without regard to which side is up. The challenge was to decide the orientation and the location as well as the correct pick layer (Plate 4).

The system includes a Kawasaki UX150 robot, a Cognex fixed mounted camera and a pair of arm-mounted cameras. The Shafi software calculates all the direction commands to guide the robot en-of-arm effector to the exact pick location.

The UX150 is a six axis with a horizontal reach of 273 cm and a payload capability of 150 kg. The arm axes can move as fast 100° per second.

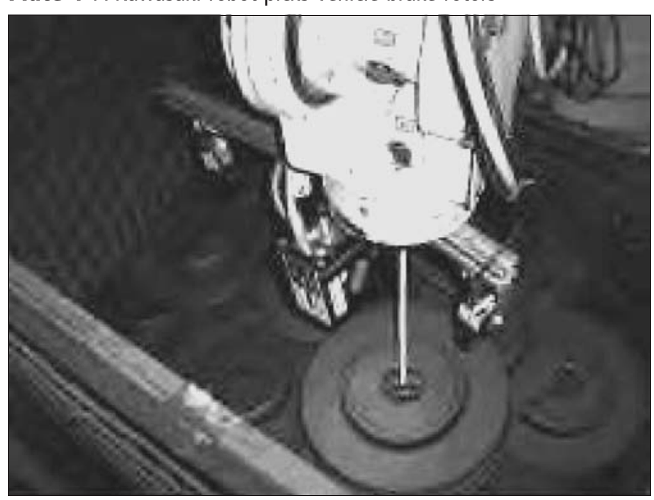
Elbow shaped brackets

Picking up odd shaped brackets frequently requires a two-step procedure. Bins of randomly placed elbow-shaped brackets are first picked from the bin and placed on an intermediate-resting surface. From there the Adept robot is guided to one of the four possible pick orientation of the part on the intermediate surface. The Shafi Reliabot software calculates the necessary moves to then correctly place the part into the assembly process (Plate 5).

The Adept robot with the MV8 controller is paired with a single fixed mounted high-resolution camera. The Cognex/Shafi vision solution provides high depth of field, multi-level 2D guidance.

Plate 3 Differential carriers picked by a Nachi robot

Plate 4 A Kawasaki robot picks vehicle brake rotors



Engine pistons

A Nachi robot with its AX controller picks pistons from a cart/bin rolled into position by the operator. The Cognex/Shafi system guides the robot to pick each piston from it's random bin location. The pistons are just loose stacked in the bin. A single robot arm mounted camera enables the detection of the layered parts and provides the information for calculating the pickup angle and locations of the touching parts (Plate 6).

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Plate 5 Odd shaped brackets can be found and successfully picked

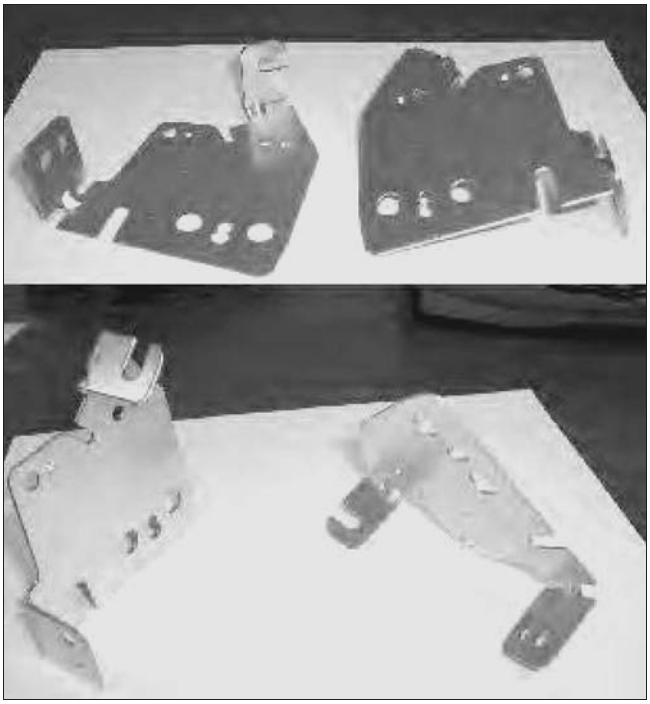

Plate 6 Pistons are located and picked by this Nachi robot with a Cognex vision system and Shafi Reliabot software package

At the start of the cycle the robot hovers the camera/end of arm effector over one corner of the bin. The image software is able to detect each layer. The Cogenx PatMax software is able to find the pistons despite reflections from the highly machined metal surfaces. After the robot has picked the topmost layer, the control indexes down the distance of one layer and the process repeats. A step and repeat system which simplifies the programming.

For more information on the Shafi part picking software visit: www.shafiinc.com