Proposed Wind Robot Arm Design in Order to Move Sensitive Devices for Industrial Applications

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Abstract

The Wind Robot Arm (WRA) instead of a gripper type for grabbing devices is proposed in this paper. It utilizes a plastic arm, wind blowing and suction system to move devices. A plastic hollow cylinder is connected to the plastic hollow ring. These elements consist of a plastic arm. At first, the air is blown into plastic arm. Then, the device is placed inside proposed arm. Finally, the air is sucked in order to create vacuum. This causes that the moved device is captured by compacted plastic ring and is placed on the proposed place.

Keywords: Robot arm, Rotational arm, Wind arm, PUMA, SCARA

Introduction

In 1922 Czech playwright Karel Capek wrote R.U.R., or Rosum’s Universal Robots, and the 1923 translation brought the word “robot” into the English language from the Czech word for worker. Although the history of robots can be linked to the automata of the 18th century just as computers are linked to Babbage's Difference Engine, the first modern industrial robot dates from 1954 when George DeVol filed a patent for a general-purpose manipulator.

The industrial robot shown in Fig.1 is used to move various devices in various factories. It is done with the movement of fulcrum, arms, wrists and terminal operators.

Two robotics movements consist of: Movement of fulcrum, arm and wrist, Movement of terminal operator. The robot utilizes movement of fulcrum, arm and wrist for achieving the desired place and desired operation is done through the using the terminal operator. There is a degree freedom for every axis of the robot. Structural classification of robots divided into four categories consists of: Cartesian, cylindrical, spherical and joints structures.
**Cartesian Structure**

In this type of structure shown in Fig. 2, three orthogonal linear axes create cube-shaped space for robot. Movement route of this robot is linear.

![Figure 2. Cartesian Structure](image)

**Cylindrical Structure**

In this type of structure shown in Fig. 3, two linear axes are horizontal and vertical and one rotational axis in horizon. These axes provide the cylindrical space for robot.

![Figure 3. Cylindrical Structure](image)

**Spherical Structure**

In this type of structure shown in Fig. 4, there are two rotational axes in horizontal and vertical and one linear axis. These axes combined and create sphere-shaped space. On top of the base is cone-shaped because it is not possible to access some parts.

![Figure 4. Spherical Structure](image)

**Joints Structure**

In this type of structure shown in Fig. 5, there are three rotational axes. Body, arm and wrist of robot connected by two hinge joint and both of them are rotated on a basis.
Puma Industrial Robot Arm

At the first time, Programmable Universal Manipulation Arm or Programmable Universal Machine for Assembly (PUMA) shown in Fig.6, was made and completed at Universal Robotics Company in 1978. The first customer of this robot was General Motors Corporation. PUMA was only produced by Universal Company till 1986. Then PUMA was produced by Kawasaki. PUMA Model 560 was the largest customer. The organization Control, Robotics and Welding of General Motors gave the first prototype of the PUMA robot to the Smithsonian Institution’s National Museum of America In 2002. Every industrial arm has the RRR (three rotational joints) structure called PUMA. The second and third joint axes were parallel and both of them were vertical with first joint. PUMA arm with three axes has three degrees of freedom for each position. The end of PUMA arm connected spherical wrist. The PUMA robot wrist makes three degrees of freedom. The PUMA robot (rotating arm with a spherical wrist) has six degrees of freedom and can move to any point and put devices in any direction.

PUMA end-effector and ball movement are expressed in a world cartesian reference frame. PUMA end-effector position varies along a straight path from the initial PUMA end-effector resting position to the ball catching position.

Figure 5. Joints Structure

Figure 6. PUMA
SCARA Industrial Robot Arm

In 1981, Sankyo Seiki, Pentel and NEC presented a completely new concept for assembly robots. The robot was developed under the guidance of Hiroshi Makino, a professor at the University of Yamanashi. The robot was called SCARA (Selective Compliance Assembly Robot Arm). Its arm was rigid in the Z-axis and pliable in the XY-axes, which allowed it to adapt to holes in the XY-axes. By virtue of the SCARA's parallel-axis joint layout, the arm is slightly compliant in the X-Y direction but rigid in the 'Z' direction, hence the term: Selective Compliant. This is advantageous for many types of assembly operations, i.e., inserting a round pin in a round hole without binding. The second attribute of the SCARA is the jointed two-link arm layout similar to our human arms, hence the often-used term, Articulated. This feature allows the arm to extend into confined areas and then retract or “fold up” out of the way. This is advantageous for transferring parts from one cell to another or for loading/unloading process stations that are enclosed. The SCARA configuration shown in Fig.7, has three parallel revolute joints which allow to position the tool in a plane and a translational joint ensuring motion normal to the plane. SCARA is an open loop-type manipulator that is used for assembly in production industries successfully.

![Figure 7. SCARA with three parallel revolute joints](image)

The industrial robot arm shown in Fig.8, there are two cylinders on the both sides of the robot. There are two anti-gravity spring at the cylinders. These anti-gravity springs help the robot to carry heavy loads. The anti-gravity springs play the role of the balance mass against gravity.

![Figure 8. SCARA](image)

Proposed Industrial Wind Robot Arm

In this proposed arm shown in Fig.9, instead of a gripper type for grabbing devices a plastic arm with wind blowing and suction system is utilized to move devices. Design of gripper arms is very complex and expensive. So, wind compressor used to provide required force for moving arm. A plastic hollow cylinder is connected to the plastic hollow ring. These elements consist of a plastic arm. At first, the air is blown into plastic arm. Then, the device is placed inside proposed arm. Finally, the air is sucked and vacuum is created in the plastic arm. This causes that the moved devices are captured by compacted plastic ring and are moved them on the desire place. The WRA can move sensitive devices. It utilizes four sensors to recognize devices the air of hollow plastic arm is sucked. There is a direct respect between duration of wind compressor motor movements for air suction to create vacuum and computed duration by factory for the first time. After creating vacuum, wind compressor motor is stopped and device is prepared for moving.
For blowing wind and suction must change direction of motor or use two motors. First motor is used for wind blowing and second motor is utilized for air suction. These are done by relay or key between wind blowing motor and air suction motor.

There are two servomotors for moving mechanic arm. Mechanic arm of robot has two duties. One task is to guide of plastic arm for arriving desired place. Another task is to help the plastic arm for making balance when it carries out the heavy devices. The shield of plastic arm is connected on the top of the mechanic arm for protection the plastic arm. WRA can achieve to every place in any point though movement of two servomotors. Both of servomotors create horizontal and vertical rotational axes.

Microcontroller controls the WRA. An AVR (Alf-Egil Bogen and Vegard Wollan RISC) microcontroller is used for controlling the plant instead of computer. Thus, the price of WRA is lower than some of models.

**Plastic Arm**

Fire-retardant PVC (Polyvinylchloride) is used for manufacturing the plastic arm of the WRA. Plastic arm shown in Fig.10, consist of a plastic hollow cylinder, is connected to the plastic hollow ring. End of plastic arm connected to the wind compressor for providing required wind for blowing hollow plastic arm.

**Mechanic Arm**

The body of industrial arm is created from composite of carbon and metal combination. Metal are very expensive. Therefore, the fiberglass or polycarbonate is used for designing mechanic arm. Strength, resistant, light, beauty and cheap are properties of fiberglass. Also, manufacturing of fiberglass is very easy and simple. The base of robot includes a fiberglass or polycarbonate or heavy metal.
Movement

Motion can be created by DC (Direct Current) motors, AC (Alternating Current) motors and servomotors, SMA (Shape Memory Alloy) and solenoid. The WRA structure is RR (two rotational axes). The first servomotor creates rotational axis in vertical direction and the second servomotor creates rotational axis in horizontal direction. There are two movements for grabbing and moving devices consist of: Movement in Y axis for grabbing devices by plastic ring, movement in X axis for transferring devices.

Electronic and Control Circuit

Microcontroller

It utilizes an AVR microcontroller for controlling the WRA. Tasks of AVR are: Receiving information from sensors, command to relay, command to servomotors, command for wind blowing and suction systems.

- Receiving information from sensors: There are four sensors inside the hollow plastic ring. Wind is sucked when these sensors recognize the device. It used IR LED (Infrared Light Emitting Diode) or needle sensor for recognizing devices.

- Command to relay: The messages received from sensors are used as inputs for microcontroller. The AVR microcontroller commanded to relay for changing direction of wind compressor motor or switching to another motor to move against the direction of first motor. Then, wind is sucked.

- Command to servomotors: The AVR commanded to each servomotor for on or off. After wind blowing, the first servomotor is on (the second servomotor is off) and works in Y axis to grabs devices. After air suction, the second servomotor is on (the first servomotor is off) and works in X axis for transferring devices from one place to another one. Both of servomotors make orthogonal rotational axes. Each servomotor creates a degree of freedom. So, the WRA have two degree of freedom for moving devices in every position.

- Command for wind blowing and air suction systems: The duration of blown and sucked air is specified by factory. At first, the air is blown into plastic arm. Then, the device is placed inside proposed arm. Finally, AVR command to compressor for air suction. This causes that the moved device is captured by compacted plastic ring and move them on the desired place.

Sensors

The WRA uses sensors for recognizing device inside the hollow plastic ring and air suction. After sensing the device inside the plastic ring, the AVR is commanded to compressor for moving in order to air suction. The sensors recognize volume of devices and suction will be done on this basis. Thus, it is not necessary for small devices to be sucked all of the air into the plastic arm but for large devices to be sucked all of the wind into the plastic arm. The time of wind suction is determined by sensors shown in Fig.11.

![Figure 11. Sensors](image)

Relay

The WRA utilizes electronic relay for switching motors of wind compressor. The first motor is used for wind blowing and another is utilized for air suction. Its task is done when AVR microcontroller commanded to relay. An electronic timer is used for time adjusting between less than a second and several seconds.

Servomotor driver

There are servomotor driver boards to inception of servomotors. These boards consist of potentiometer for servomotor phase adjusting.

Wind compressor

Two motors can be used for wind blowing and air suction or use one motor can be utilized for working in two directions.
Table 1. Comparison of the WRA with PUMA

<table>
<thead>
<tr>
<th>Type of industrial robot arm</th>
<th>The proposed WRA</th>
<th>PUMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of structure</td>
<td>RR</td>
<td>RRR</td>
</tr>
<tr>
<td>The number of motors</td>
<td>Three motors including:</td>
<td>Six servomotors for creating motion.</td>
</tr>
<tr>
<td></td>
<td>• one AC motor for wind compressor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• two servomotors for mechanic arm.</td>
<td></td>
</tr>
<tr>
<td>The number of arms without considering the base</td>
<td>Two arms including:</td>
<td>Arm, wrist and terminal operator.</td>
</tr>
<tr>
<td></td>
<td>• Plastic arm.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Mechanic arm.</td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>Faster than similar models because the WRA used fewer arms and fewer motors.</td>
<td>Lower than the WRA because it has more arm and motors in comparison with the WRA.</td>
</tr>
<tr>
<td>Control</td>
<td>The WRA is controlled with the AVR. So, design of the WRA is simpler than other models.</td>
<td>The PUMA is controlled by computer and complex circuit.</td>
</tr>
<tr>
<td>Cost</td>
<td>Less than other models because it is control by the AVR and used fewer components.</td>
<td>Has several motors and is controlled by computer. So, it is expensive than the WRA.</td>
</tr>
<tr>
<td>Degree of sensitivity</td>
<td>Can move sensitive devices like an egg.</td>
<td>Have sensors at inside of the gripper for monitoring of pressure</td>
</tr>
</tbody>
</table>

Table 2. Comparison of the WRA with SCARA

<table>
<thead>
<tr>
<th>Type of industrial robot arm</th>
<th>The proposed WRA</th>
<th>SCARA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of structure</td>
<td>RR</td>
<td>RRP</td>
</tr>
<tr>
<td>The number of motors</td>
<td>Three motors including:</td>
<td>between three and six servomotors in various application</td>
</tr>
<tr>
<td></td>
<td>• one AC motor for wind compressor.</td>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td>The number of arms without considering the base</td>
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<tr>
<td>Speed</td>
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<td>Lower than the WRA because it has more arm and motors in comparison with the WRA.</td>
</tr>
<tr>
<td>Control</td>
<td>The WRA is controlled with the AVR. So, design of the WRA is simpler than other models.</td>
<td>The SCARA is controlled by computer and very complex circuit.</td>
</tr>
<tr>
<td>Cost</td>
<td>Less than other models because it is control by the AVR and used fewer components.</td>
<td>The most expensive.</td>
</tr>
<tr>
<td>Degree of sensitivity</td>
<td>Can move sensitive devices like an egg.</td>
<td>Have sensors for pressure monitoring.</td>
</tr>
</tbody>
</table>

Conclusion

A wind robot arm was proposed and design for industrial applications in this paper. The suggested WRA has the following advantages:

- In comparison with similar models, the WRA is cheap and simpler in design.
- For grabbing devices, the WRA doesn’t use any motor and it is done based on wind blowing and suction. Also, a wind compressor can be used for several WRA. Therefore, energy consumption is reduced.
Sensitive devices such as eggs can be moved by the WRA.
Installation of a WRA is very easy.
Comparison between the WRA and other robot arms such as PUMA and SCARA are fulfilled at Table 1 and Table 2.

References

PUMA series 500 industrial robot arm, A compacted-controlled robot for medium-to-highweight assembly, welding, materials handling, packaging and inspection applications, A Westinghouse Company, pp. 2-6.