Robotics in Textile Industry: A Global Scenario

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Abstract

For Many years, the application of automation has resulted in significant benefits to industrial world. High levels of consistency and precision in work pieces and high levels of repeatability and accuracy in manufacturing equipment have been required. Economic Justification can be shown only for large quantities of production. To achieve this, we need adaptive manipulation systems having some “Artificial Intelligence”. Keeping the concept in mind, an employee in 1970s of the Japanese Yasukawa Company developed a mechatronic system named “Industrial Robots”.

Today Mechatronics is often to be synonymous with Robotics. Since computer plays a key role in robotics, the word “robot” has a specific meaning and it has an emphasis in industry specially related to textiles.

Classification of Industrial Robots

Industrial Robots may be categorized by their geometries or by their capabilities. The degree of flexibility of control like most other capabilities of robots is directly related to the sophistication of the software within the controlling computer.

It is classified into three categories-

I. Mechanical Stop Control Robots
II. Servo Controlled Robots
III. Continuous Path Control Robots

(i) Mechanical Stop Control Robots :

Here an actuator moves a joint until the joint runs up against a mechanical stop. Programming of such robots is typically done with a screw driver although some flexibility may be built in by using several selectable stops on each axis.

A Typical example is the older programmable sewing machine where the motor slowly rotates the complex cam into the machine and the eccentricity of the cam displaced the needle the appropriate amount.

(ii) Servo Controlled Robots :

It is a point to point programming in which the actuator may be controlled in such a way that it can stop at any point along its path. It is commonly used in industrial environments in which the working volume is relatively empty and in which the co-ordination with external moving objects such as conveyors is not required.

(iii) Continuous Path Control Robots :

Here the robot may be required to interact continuously with its environment in more complex work environment. Some typical examples are welding, spray painting and performing operations along a moving conveyor.

Components of a Robot System:

It can be explained either from a physical point of view or from system point of view. It is important to note that the same physical component may perform many different information processing operations. Likewise, two physically separate components may perform identical information operations.

(a) Actuator - A robot system contains six actuators. Since six are required for full control of position and orientation.

(b) Sensor - To give information regarding the position and possibility, the velocity of the actuator, to control on it.
**Computation Objects** - It requires a micro-computer to perform work place analysis, servo, kinematics and dynamic operations. In addition it should perform supervisory operations such as path planning and operator interaction.

**Tactile Sensing for Robots**

Touch information is obtained through physical contact of the sensor with a target object. The sensor includes all the major components of a tactile sensor system. They are-

1. Touch Surface
2. Transduction medium
3. Structure

**Characteristics of Tactile Sensor:**

Mode Points to the direction of sensor response relative to the touch surface. Basic modes are normal and shear.

Further meaning of mode establishes whether the response is Primary or Gray Scale. Some sensors measure the combined effects of all the forces and torques imposed on the touch surface. Information is delivered in terms of force and moment components related to the six degrees of freedom for a particular coordinate system. Such sensors can be called as Force- Torque Sensor or a Vector Sensor.

Resolution relates to several aspects of the sensor.

- First is the spatial resolution
- Second is at the individual site and
- The Third is in the time domain

The total range depends upon the dimensions and configuration of the touch surface as well as the performance of the control and interface electronics.

**Tactile Sensor Styles:**

The tactile sensor styles are determined by the manner in which the sensor is used and also by the sensitive fields. There are several general classes of style -

1. Gripper mounted
2. Work surface mounted
3. Large field and Small field

The large field and small field designations are two subclasses that would fit either within the gripper or work surface mounted styles. Large field sensors are likely to be work- surface mounted.

**Use of Robotics in Textile Manufacturing:**

The significant factor which distinguishes the textile industry from the others is the basic nature of the “Work piece”. The textile materials are either woven or felted and not homogeneous and anisotropic as like metals are. This unique aspects of textiles lend interpretations to the items listed initially which are quite different in species but generically the same when compared with other industries.

**Recent Application of Robotics in Textiles:**

1) **Production of highly Deformable**

Since flexible materials are found in almost every industrial Product, automated handling of such materials becomes significant from an industrial and economic point of view, too. Two examples can demonstrate this importance: The complete textile industry deals with the processing of highly deformable objects. The price for cloths is mainly depends on the costs of handling and processing the textiles. Though many common tasks like the lapping, (UN) folding and positioning have been addressed in many robotic research works and a large variety of prototype systems has been set up, the large-scaled application of robotic handling systems has not yet been achieved.
2) **Robotics to fabric testing**

Garments are produced by a making-up process which involves sewing fabric panels into a three-dimensional assembly, using sewing machines. As early as 1960, Lindberg considered the relationship between fabric properties and problems encountered in garment construction. Stylios developed an expert system for predicting fabric sewability and setting of optimum sewing machine parameters, based on fabric properties. The concept of automatic overfeed control, using fabric properties in sewing machines was reported by Kawabata. Fabrics, being limp materials, pose considerable problems in automated handling. Gunner and Taylor identified bending rigidity and coefficient of friction as two important fabric properties which control fabric behaviour during handling by a robot or any automated handling device. Computer simulation of fabric behaviour during automated handling, based on mechanical properties, has been reported by various researchers. These simulations can be used for trajectory control of fabric handling devices.

The KES and FAST test systems were developed primarily for objective hand evaluation. They work on relatively rigid test procedures ideally suited to hand evaluation. However, these tests do not adequately represent the stresses applied to a fabric panel during handling and making-up. A fully automated fabric test system, involving a robot, has been developed by the present investigators. The main feature of this system is its flexibility to change the test conditions.

![Flow Diagram of fabric low-stress properties in relation to Garment Assembly](image)

3) **Robotics for melt-blowing to form shaped/molded fabric structures**

The production of nonwoven and tailored 3D structures for protective garments (such as those worn by fire fighters) using robotics and melt blown technology is under development by the researchers. In particular, the integration of robotics and a small-scale melt-blowing unit is also possible. The researchers are developing the framework and general motivation of the model which shows the novel 3D-fiber application system developed using a seven-degree of freedom system. This system will be used with control algorithms developed at the NCRC to improve uniformity of the shaped fabric structure.

4) **Robotics used in Weaving Coordinate System**

The approach point is a point indicated by a step immediately before the step where weaving starts.

- Wall direction: Z direction of the robot axis
- Horizontal direction: The direction of approach point from the wall
- Advance direction: The direction which moves from the weaving start point to end point.

![Figure of the Robot employed in weaving coordinate system](image)
5) Robot technology for Metal spinning

Metal spinning is a plasticity forming process that forms a metal sheet or tube by forcing the metal onto a rotating mandrel using a roller or a paddle tool. It is widely used for producing round hollow metal parts and products, e.g. tableware, kitchenware. Metal spinning appears to be a suitable task for an industrial robot for several reasons. In manual metal spinning, the various senses of the worker, particularly force feeling via the tool, play an important role. Metal spinning needs much smaller forming force than other plasticity forming techniques, on the order of kilograms instead of tons, because it is based on local deformation. It involves many control parameters and needs dexterous motion with multiple degrees of freedom. It is suitable for limited production of a wide variety and is a process of high added value, which we can see from the fact that even manual production can be viable as a manufacturing business. Thus it is expected that the profitability of a force controlled industrial robot can be high. Here the metal spinning is more flexible and intelligent, by introducing robot control technologies, such as force control, into the forming process. The forming conditions are modified in real time based on feedback of the forming status to avoid forming defects and to obtain high-quality products.

Conventional robot tasks are mainly composed of moving an object. In contrast, this research encounters the novel aspects of transforming an object. We expect that challenging research subjects may develop from this research while utilizing the potentials of robot technologies developed so far.

Experimental Setup

Forming Process

Conclusion:

In recent years, studies on industrial robots for manufacturing applications tend to be less and less active while most academic researchers are inclined towards non-manufacturing applications. In consequence, applications for industrial robots have not varied much from the conventional handling, assembly, welding and painting. Some researchers even consider industrial robots as mature or old-fashioned technology since they only take notice of such applications.

Current industrial robots are generally used for simple repetitive tasks of low added value, which substitute for unskilled factory workers. Such robots have value only if they are less expensive and used in mass production to achieve higher speed and yield. However, mass production is not the only form of operation in manufacturing industries. There are various types of manufacturing crafts that only experienced artisans can perform. Such crafts are usually of small quantity but can create high value added products. A new market for robot technologies might develop if robotics researchers were attracted to such areas, utilizing the potentials of accumulated techniques, e.g. sensory feedback control, to achieve valuable application tasks for which even expensive intelligent robots can be worthwhile.
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