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Design of Pick and Place Robot

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Abstract: *The popular concept of a robot is of a machine that looks and works like a human being. The industry is moving from current state of automation to Robotization, to increase productivity and to deliver uniform quality. The industrial robots of today may not look the least bit like a human being although all the research is directed to provide more and more anthropomorphic and humanlike features and super-human capabilities in these. One type of robot commonly used in industry is a robotic manipulator or simply a robotic arm. It is an open or closed kinematic chain of rigid links interconnected by movable joints. In some configurations, links can be considered to correspond to human anatomy as waist, upper arm and forearm with joint at shoulder and elbow. At end of arm a wrist joint connects an end effect which may be a tool and its fixture or a gripper or any other device to work.*

Keywords: Robot.

I. Introduction

Robotics is the branch of engineering science & Technology related to robots, and their design, manufacture, application, and structural disposition. Robotics is related to electronics, mechanics, and software. Robotics research today is focused on developing systems that exhibit modularity, flexibility, redundancy, fault-tolerance, a general and extensible software environment and seamless connectivity to other machines, some researchers focus on completely automating a manufacturing process or a task, by providing sensor based intelligence to the robot arm, while others try to solidify the analytical foundations on which many of the basic concepts in robotics are built.

In this highly developing society time and man power are critical constrains for completion of task in large scales. The automation is playing important role to save human efforts in most of the regular and frequently carried works. One of the major and most commonly performed works is picking and placing of jobs from source to destination.

Present day industry is increasingly turning towards computer-based automation mainly due to the need for increased productivity and delivery of end products with uniform quality. The inflexibility and generally high cost of hard-automation systems, which have been used for automated manufacturing tasks in the past, have led to a broad based interest in the use of robots capable of performing a variety of manufacturing functions in a flexible environment and at lower costs. The use of Industrial Robots characterizes some of contemporary trends in automation of the manufacturing process. However, present day industrial robots also exhibit a monolithic mechanical structure and closed-system software architecture. They are concentrated on simple repetitive tasks, which tend not to require high precision.

The pick and place robot is a microcontroller based mechatronic system that detects the object, picks that object from source location and places at desired location. For detection of object, infrared sensors are used which detect presence of object as the transmitter to receiver path for infrared sensor is interrupted by placed object.

II. Literature Survey

Robot is a word that is both a coinage by an individual person and a borrowing. It has been in English since 1923 when the Czech writer Karel Capek's play R.U.R. was translated into English and presented in London and New York. R.U.R., published in 1921, is an abbreviation of Rossum's Universal Robots, robot itself comes from Czech robota, "servitude, forced labor," from rab, "slave." The Slavic root behind robota is orb-, from the Indo-European root orbh, referring to separation from one's group or passing out of one sphere of ownership into another. Czech robota is also similar to another German derivative of this root, namely Arbeit, "work". Arbeit may be descended from a word that meant "slave labor," and later generalized to just "labor."

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III. Components Of Robot

3.1 Structure

The structure of a robot is usually mostly mechanical and can be called a kinematic chain. The chain is formed of links, actuators, and joints which can allow one or more degrees of freedom. Most contemporary robots use open serial chains in which each link connects the one before to the one after it. These robots are called serial robots and often resemble the human arm. Robots used as manipulators have an end effector mounted on the last link. This end effector can be anything from a welding device to a mechanical hand used to manipulate the environment.

3.2 Power Source

At present mostly (lead-acid) batteries are used, but potential power sources could be:

- Pneumatic (compressed gases)
- Hydraulics (compressed liquids)
- Flywheel energy storage
- Organic garbage (through anaerobic digestion)
- Still untested energy sources (e.g. Nuclear Fusion reactors)

3.3 Actuation

Actuators are like the "muscles" of a robot, the parts which convert stored energy into movement. By far the most popular actuators are electric motors that spin a wheel or gear, and linear actuators that control industrial robots in factors. But there are some recent advances in alternative types of actuators, powered by electricity, chemicals, or compressed air.

3.4 Touch

Current robotic and prosthetic hands receive far less tactile information than the human hand. Recent research has developed a tactile sensor array that mimics the mechanical properties and touch receptors of human fingertips. The sensor array is constructed as a rigid core surrounded by conductive fluid contained by an elastomeric skin. Electrodes are mounted on the surface of the rigid core and are connected to an impedance-measuring device within the core. When the artificial skin touches an object the fluid path around the electrodes is deformed, producing impedance changes that map the forces received from the object.

3.5 Vision

Computer vision is the science and technology of machines that see. As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences and views from cameras. In most practical computer vision applications, the computers are pre-programmed to solve a particular task, but methods based on learning are now becoming increasingly common. Computer vision systems rely on image sensors which detect electromagnetic radiation which is typically in the form of either visible light or infra-red light.

The sensors are designed using solid-state physics. The process by which light propagates and reflects off surfaces is explained using optics. Sophisticated image sensors even require quantum mechanics to provide a complete understanding of the image formation process.

IV. Manipulation

Robots which must work in the real world require some way to manipulate objects; pick up, modify, destroy, or otherwise have an effect. Thus the 'hands' of a robot are often referred to as end effectors, while the arm is referred to as a manipulator. Most robot arms have replaceable effectors, each allowing them to perform some small range of tasks. Some have a fixed manipulator which cannot be replaced, while a few have one very general-purpose manipulator, for example a humanoid hand.

Mechanical Grippers: One of the most common effectors are the gripper. In its simplest manifestation it consists of just two fingers which can open and close to pick up and let go of a range of small objects. Fingers can for example be made of a chain with a metal wire run through it.

Vacuum Grippers: Pick and place robots for electronic components and for large objects like car windscreens, will often use very simple vacuum grippers. These are very simple astrictive devices, but can hold very large loads provided the pretension surface is smooth enough to ensure suction.

V. Classification Of Robots

Industrial robots are found in a variety of locations including the automobile and manufacturing industries. Robots cut and shape fabricated parts, assemble machinery and inspect manufactured parts. Some types of jobs robots do: load bricks, die cast, drill, fasten, forge, make glass, grind, heat treat, load/unload machines, machine parts, handle parts, measure, monitor radiation, run nuts, sort parts, clean parts, profile objects, perform quality control, rivet, sand blast, change tools and weld.

Outside the manufacturing world robots perform other important jobs. They can be found in hazardous duty service, CAD/CAM design and prototyping, maintenance jobs, fighting fires, medical applications, military warfare and on the farm.

5.1 Types of Robots as per Applications

Nowadays, robots do a lot of different tasks in many fields. And this number of jobs entrusted to robots is growing steadily. That's why one of the best ways how to divide robots into types is a division by their application.

Industrial Robots: Robots today are being utilized in a wide variety of industrial applications.

Any job that involves repetitiveness, accuracy, endurance, speed, and reliability can be done much better by robots, which is why many industrial jobs that used to be done by humans are increasingly being done by robots.

Mobile Robots: Also known as Automated Guided Vehicles, or AGVs, these are used for transporting material over large sized places like hospitals, container ports, and warehouses, using wires or markers placed in the floor, or lasers, or vision, to sense the environment they operate in. An advanced form of the AGV is the SGV, or the Self-Guided Vehicle, like Patriot Gofer, Tug, and Specie-Minder, which can be taught to autonomously navigate within a space.

Agriculture Robots: Although the idea of robots planting seeds, ploughing fields, and gathering the harvest may seem straight out of a futuristic science fiction book, nevertheless there are several robots in the experimental stages of being used for agricultural purposes, such as robots that can pick apples.

Tele Robots: These robots are used in places that are hazardous to humans, or are inaccessible or far away. A human operator located at a distance from a telerobot controls its action, which was accomplished with the arm of the space shuttle.

Telerobots are also useful in nuclear power plants where they, instead of humans, can handle hazardous material or undertake operations potentially harmful for humans.

Service Robots: The Japanese are in the forefront in these types of robots. Essentially, this category comprises of any robot that is used outside an industrial facility, although they can be sub-divided into two main types of robots: one, robots used for professional jobs, and the second, robots used for personal use. Amongst the former type are the above mentioned robots used for military use, and then there are robots that are used for underwater jobs, or robots used for cleaning hazardous waste, and the like.

5.2 Types of Robots by Locomotion & Kinematics

As you can understand, robot's application alone does not provide enough information when talking about a specific robot. For example an industrial robot - usually, when talking about industrial robots we think of stationary robots in a work cell that do a specific task.

Cartesian robot /Gantry robot: Used for pick and place work, application of sealant, assembly operations, handling machine tools and arc welding. It's a robot whose arm has three prismatic joints, whose axes are coincident with a Cartesian coordinator.

Cylindrical robot: Used for assembly operations, handling at machine tools, spot welding, and handling at die-casting machines. It's a robot whose axes form a cylindrical coordinate system.

Spherical/Polar robot: Used for handling at machine tools, spot welding, die-casting, fettling machines, gas welding and arc welding. It's a robot whose axes form a polar coordinate system.

SCARA robot: Used for pick and place work, application of sealant, assembly operations and handling machine tools. It's a robot which has two parallel rotary joints to provide compliance in a plane.

Articulated robot: Used for assembly operations, die-casting, fettling machines, gas welding, arc welding and spray painting. It's a robot whose arm has at least three rotary joints.

Parallel robot: One use is a mobile platform handling cockpit flight simulators. It's a robot whose arms have concurrent prismatic or rotary joints.

5.3 Selection of Task

Tasks

The various tasks which a pick and place robot can perform are as follows:-

Robot pick-and-place

The use of robots for placing products in cartons and transfer of cartons and products between different stations in the packaging lines is very common in all industries. High speed pick-and-place robots for placing small items like candy and cookies in packages are often combined with a visual observation system for identifying products.

Handling of flexible packages

Flexible packaging material is the generic term for soft packages made of film, foil or paper sheeting. Popular forms are stand-up pouches, bags, sachets and envelopes. These packages are often formed, filled and sealed in a vertical or horizontal form-fill-seal machine. The package is then finally put into a case by top loading.

Cartooning machines

Cartooning machines erect boxes from flat sheets of corrugated material. The erected boxes are then filled with products or individual cartons and are then prepared for the palletizing process. As with most packaging machines, vacuum cups, vacuum pumps and other pneumatic components are an essential part of the cartooning.

Rotary Cartoners

Rotary cartoner is one of the most popular types of cartooning machines. These machines use a series of vacuum bars equipped with suction cups that move in a continuous rotary motion. Rotary cartoners utilize a "pick-and-carry" motion to move cartons.

Palletizing and Depalletizing

Palletizing is the process of placing packages on a pallet alternatively removing them from a pallet (depalletizing). Palletizing machines use vacuum pumps, suction cups and other pneumatic components. These machines typically pick up multiple boxes at a time and place them on a stack (or remove them from a stack).

Automated Pick & Place Robots

The use of specialized machines for high speed pick-and-place of small items with suction cups is very common in the electronics and consumer industries. This application is typically characterized by short cycle times, high acceleration forces and large variations on the parts to be handled.

Seal Machines

During the pouch/bag forming phase vacuum is often applied to transport belts that help provide a grip on both sides of the pouch/bag material. The vacuum belt moves the pouch material from a web roll into position to receive the product from the filler. Holes in the belt allow vacuum to hold the pouch while the belt is rotating and the pouch is been removed.

Bag Opening

Vacuum and suction cups are used to pick and open paper and plastic bags. Suction cups with stiffer bellows and a soft sealing lip are preferred in these quite often high-speed applications.

Selection of Task

- From the various tasks which can be done using the pick and place robots we have particularly meshed the two process of picking & placing along with pallezting process.
- We have decided to pick an Automobile Battery (Dimensions 45x45x65mm. Weight 250 grams) from the conveyor.
- Then placing it at the packing center, also picking a packed battery from the packing station and moving towards the Box-packing center.
- Placing of Battery at Box-packing center and again movement to the conveyor to pick an unpacked battery.
- So both the picking & placing along with the packing procedure can be accompanied using this pick and place robot.

Why Pick & Place Robots

We have selected the pick and place robots for this particular process due to the following reasons:-

- Using of Human labour for the loading and unloading of the Batteries and also for packing purpose will consume more time.
- Even though Number of laborers is required more, the loading and unloading time should include allowances if laborers are considered.
- Moreover the work can be done easily using a single pick and place robot, which is used for both loading and unloading and pallezting purpose.

Defining Work Station

The work station for this operation of pick & place and pallezting is been designed in such a way that:-

- The unpacked battery coming from the belt conveyor is been sensed by a sensor and the moment of the conveyor is been controlled by the sensor.
- As one by one the battery comes, the Robot picks one battery and moves towards the packing station, keeps the battery on the conveyor there.

- Then picks the Packed Battery from there and moves towards the Box-packing center and places the Battery for Box-packaging.
- Further Robot movement continuous towards the return journey takes a Battery from conveyor and again the above procedure is been carried out.

VI. Design Procedure

Factors to be Considered

The various factors to be considered while designing of pick and place robots are been discussed as follows. The factors are all important while designing procedure of the robot.

Controls

The mechanical structure of a robot must be controlled to perform tasks. The control of a robot involves three distinct phases - perception, processing, and action. Sensors give information about the environment or the robot itself (e.g. the position of its joints or its end effector). This information is then processed to calculate the appropriate signals to the actuators (motors) which move the mechanical.

The processing phase can range in complexity. At a reactive level, it may translate raw sensor information directly into actuator commands. Sensor fusion may first be used to estimate parameters of interest (e.g. the position of the robot's gripper) from noisy sensor data. An immediate task (such as moving the gripper in a certain direction) is inferred from these estimates. Techniques from control theory convert the task into commands that drive the actuators.

At longer time scales or with more sophisticated tasks, the robot may need to build and reason with a "cognitive" model. Cognitive models try to represent the robot, the world, and how they interact. Pattern recognition and computer vision can be used to track objects. Mapping techniques can be used to build maps of the world. Finally, motion planning and other artificial intelligence techniques may be used to figure out how to act. For example, a planner may figure out how to achieve a task without hitting obstacles, falling over, etc.

Autonomy Levels

Control systems may also have varying levels of autonomy. Direct interaction is used for hap tic or taleoperated devices, and the human has nearly complete control over the robot's motion. Operator-assist modes have the operator commanding medium-to-high-level tasks, with the robot automatically figuring out how to achieve them. An autonomous robot may go for extended periods of time without human interaction. Higher levels of autonomy do not necessarily require more complex cognitive capabilities. For example, robots in assembly plants are completely autonomous, but operate in a fixed pattern. Another classification takes into account the interaction between human control and the machine motions.

1. Teleportation: - A human controls each movement; each machine actuator change is specified by the operator.
2. Supervisory: - A human specifies general moves or position changes and the machine decides specific movements of its actuators.
3. Task-level autonomy: - The operator specifies only the task and the robot manages itself to complete it.
4. Full autonomy: - The machine will create and complete all its tasks without human interaction.

Basic Methods of Programming Robots

There are three basic methods for programming Industrial robots but currently over 90% are programmed using the teach method.

A. Teach Method

The logic for the program can be generated either using a menu based system or simply using a text editor but the main characteristic of this method is the means by which the Robot is taught the positional data. A teach pendant with Controls to drive the robot in a number of different co-ordinate systems is used to manually drive the robot to the desired locations. These locations are then stored with names that can be used within the robot program. The coordinate systems available on a standard jointed arm robot are:-

B. Lead Through

This system of programming was initially popular but has now almost disappeared. It is still however used by many paint spraying robots. The robot is programmed by being physically moved through the task by an operator. This is exceedingly difficult where large robots are being used and sometimes a smaller version of the robot is used for this purpose. Any hesitations or inaccuracies that are introduced into the program cannot be edited out easily without reprogramming the whole task. The robot controller simply records the joint positions at a fixed time interval and then plays this back.

C. Off-Line Programming

Similar to the way in which CAD systems are being used to generate NC programs for milling machines it is also possible to program robots from CAD data. The CAD models of the components are used along with models of the robots being used and the fixturing required. The program structure is built up in much the same way as for teach programming but intelligent tools are available which allow the CAD data to be used to generate sequences of location and process information. At present there are only a few companies using this Technology as it is still in its infancy but its use is increasing each year. The benefits of this form of programming are:-

- Reduced down time for programming.
- Programming tools make programming easier.
- Enables concurrent engineering and reduces product lead time.

Programming Languages A KAREL

Karel is an educational programming language, created by Richard E. Pattis in his book "Karel the Robot: A Gentle Introduction to the Art of Programming". This language was first used in courses at Stanford University. The language is named after Karel Capek,

Principles

A program in Karel is used to control a simple robot that lives in an environment consisting of a grid of streets and avenues. Karel understands five basic instructions:

1. move (Karel moves by one square in the direction he is facing),
2. turn left (Karel turns 90 ° left),
3. put beeper (Karel puts a beeper on the square he is standing at),
4. pick beeper (Karel lifts a beeper off the square he is standing at),
5. Turnoff (Karel switches himself off, the program ends).

Safety Requirements

The various safety requirements which were considered while designing the robot are decided as follows:

1. The Robot should not be programmed such that it should damage the Battery while holding it in its gripper.
2. Correct holding position should be set as if it not set then while movement of the Robot it may drop the Lead Batteries which can arise a Hazardous situation in the industry.
3. The Robot should be interfaced properly with the sensors been placed near the Belt conveyor so as to know when the belt conveyor is to be stopped or to be started to move the batteries ahead.
4. Load carrying capacity should be maintained as it should be always more than the default load which is to be shifted.

VII. Steps of Design

Selection of Product

From the number of products available we selected the Battery of automobiles for been used in our project. We had number of options for the selection of product, as per our requirement the Battery was matching the conditions. The other products which we considered were as follows: -

- Bearing: - Due to radial cross section of the bearing, it would be little bit difficult for the robot gripper to hold the bearing in it and transport from one place to another holding it. so, we rejected this product.
- Bags of Iron Ore: - The fines bagging system was pre-decided but due to the weight limit we switched over the other products.
- Cell Phone Packing: - As due to the light and sensitive parts of the cell phones we also skipped it as there are chances of causing damage to the cell phones while holding in the grippers of the robots.
- Bottle Packing: - The radial shape of the bottles was not able to grip inside the grippers of the robots. though pick and place robots are used in bottle packing industries but they are been designed very precisely and are costly so as the grippers are to be such that it can hold the bottles and move towards the decided target.

Designing of Workspace

The designing of work space have been done by keeping following points in mind: -

1. It should utilize Minimum time for doing the job.
2. No obstructions should be there in between the workspace envelope.
3. Idle time should be reduced as much as possible.
4. Efficient and safe transportation of the Batteries should be under gone.

The design of work space includes a Belt conveyor which brings the charged batteries from the plant and it is been transferred to the Packing center Using the Robotic arm. There is moment of 90 degrees; the robot picks a packed Battery from the packed centre after placing the unpacked Battery. Then the robots proceed towards the Box packing centre where it unloads the Battery and further moves towards the Belt conveyor to repeat the same procedure.

Selection of Parts

Various components of appropriate specifications should be selected so as to complete the fabrication and assembly of the Robot. If the selection is not done properly then the proper working of the robot cannot be obtained. It includes the parts like selection of actuators, motors, sensors etc. Thus the selection procedure of various components is also an important issue for the project work.

Completion of Model

Future work is to fabricate and manufacture the complete body structure of the robot, then the assembly of all the manufactured parts are to be done so that the required load is lifted and been transported to the targeted place.

Programming

Programming of the Pick and place Robot is to be done using a suitable Programming Language. The Robot is to been interfaced with the computer by the programmed software, which will guide the robot to do its job for which it is been programmed. There are numbers of various programming languages available now a days in the market, so the appropriate programming language is to be selected for the programming purpose and the programming is to be done.

Interfacing with the Computer

In the industrial design field of human-machine interaction, the user interface is where interaction between humans and machines occurs. The goal of interaction between a human and a machine at the user interface is effective operation and control of the machine, and feedback from the machine which aids the operator in making operational decisions.

A user interface is the system by which people (users) interact with a machine. The user interface includes hardware (physical) and software (logical) components. User interfaces exist for various systems, and provide a means of:

- Input, allowing the users to manipulate a system,
- Output, allowing the system to indicate the effects of the users' manipulation

After completion of the model of the pick and place robot and selection of programming language both should be interfaced. The interfacing of robot and computer using the software is the most important thing in the project. It should be interfaced using trial and error method, and then final movement should be set using the software's. The movement of robot should be precisely managed causing no harm to the operator, and also the batteries which are to be moved from one station to another.

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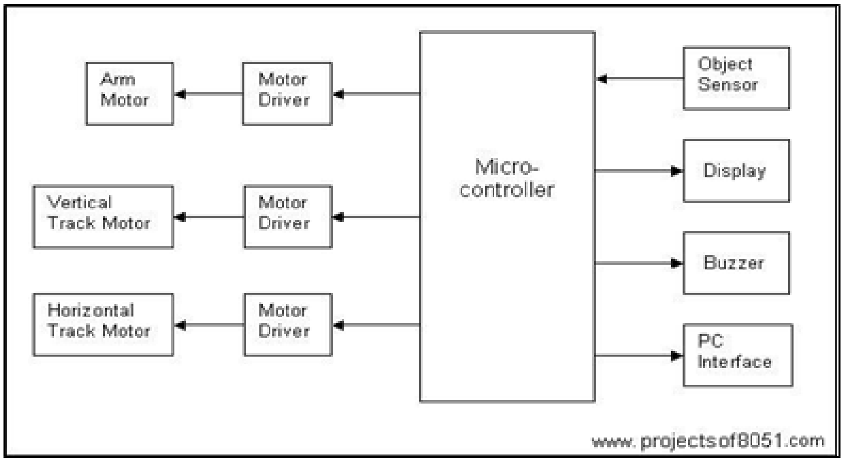
Works to be Done



VIII. CONCLUSION

Robot pick and place automation speeds up the process of picking parts up and placing them in new locations, while also increasing production rates. These pick and place robots are more accurate and do not fatigue while doing back-breaking or hard to maneuver movements that may be difficult for humans. The consistency, quality and repeatability of a pick and place robot system is unmatched. These systems are also versatile and can be reprogrammed and tooled to provide multiple applications for consumers.

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