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AUTONOMOUS GARBAGE COLLECTOR – ROBODUMPSTER

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ABSTRACT

A robotic arm has anatomy similar to the human arm. They are becoming very popular as research platforms. This technology is well suited for real time applications, due to the ease with which humans perform different tasks in different environments. Progress of robotic arm is, however, inhibited due to a shortage of affordable platforms with wide capabilities. In this work, we present infrared based autonomous robotic arm. This robotic arm has been developed with sufficient power and capabilities so as to be employed for various applications. It has autonomous capabilities and can effectively work in different environment by employing a infra based servo motor module. The function which we have implemented is of an autonomous garbage collector. It measures breadth of the object and correspondingly grab or avoid it.

Keywords: Robotic arm, garbage collector, infrared, actuators, wireless

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1. INTRODUCTION

Autonomous garbage collector is a mobile robot that locates garbage cans using an IR sensor system, empties them into its truck bed and dumps the garbage into the designated garbage collection area. It also uses IR sensors for obstacle avoidance. Inspired by honorable Prime Minister Narendra Damodardas Modi's inspirational initiative-" Swachh Bharat Abhiyan", which was a call to all Indian citizens to start keeping the streets of the villages and cities clean in their own small ways. We decided to answer that call and it struck us to design the "RoboDumpster". Moreover, it will be a step to spread robotics and its applications in India. A number of countries have similar systems in place, namely – The Dust Bot in Italy, The Marine Drone in France. The Dust Bot serves in the hilly towns of Italy collecting dust from the streets where as The Marine Drone filters the plastic pollution in the seas of France.

In the worldwide attention garbage collection becomes a major problem. College campuses, stadiums and function halls are plagued by the issue of trash after the parties, after which there are lot of plastics, papers and glass items available. This creates lot of hazards and cleaning up requires lot of people and it is also time consuming. The manpower needed can be significantly reduced by developing an autonomous robot which can locate, sort and separate the different garbage items. With this idea, the autonomous garbage collecting robot being described in this paper was designed. There are many experiment has been done in order to find the solution for picking mechanism and requires knowledge to differentiate between the materials.

A robot was designed to solve this problem with necessary requirements such as sorting mechanism, pickup mechanism, multiple sensors and intelligent control algorithms [1]. Even steps have been taken to clean up the beach and a garbage collection robot was designed for the collection of garbage in the beach which has been operated and controlled conveniently [2].Energy efficient two legged robots with natural looking are designed for Passive dynamic walking [3]. Several approaches are developed for the design of bipedal robots with human walk that requires little effort for control [4]. A robot is developed with actuation and control authority [5]. The smooth and versatile form of bipedal robots with humanlike forms has been developed and presented [6].

The robotic arm which we have created is a method explained in this paper which is using 7 dynamixel actuators. Main purpose of using these actuators is that these actuators can produce a torque which will be more when comparing it with other robotic arms. Moreover, these actuators can be connected in parallel as well as in series connection. Parallel connections can be complex and will not provide a clean circuit. On the contrary, the series connections provide simple and easy connections. Therefore, these actuators are used. Other reasons include the modes of the operation which can be easily changed according to the operation i.e. DC Continuation Mode which is used in 4 actuators for basic movement of robot in all the directions and Fixed Rotation Mode is used in the remaining 3 actuators for lifting and carrying objects.

The remainder of the paper is organised as follows. In section 2 experimental robots are described. An overview of mechanical design is discussed in section 3 and conclusion in section 4.

2. EXPERIMENTAL ROBOT

An autonomous mobile robot that locates garbage cans using its IR sensor detection system, empties them into its truck bed and dumps the garbage into the designated garbage collection area. It uses IR sensors for obstacle avoidance. The robot is placed in an arena where garbage cans containing the garbage are kept. The robot has an IR sensor detection system, which locates the garbage cans and aligns itself to it. It then lifts the garbage can with the help of its grasper, which is a 2 DOF robotic arm, and empties its contents into its truck bed. It then moves to the dumping area and empties its contents.

The robot avoids collision with any of the walls with the help of IR sensors. The detection system differentiates the garbage cans from any obstacle based on its breath. An IR sensor comprises of an LED and a photodiode. The LED emits light which is received by the photodiode when reflected by the obstacle. The range of the sensor can be adjusted using a potentiometer.

a) If the object width>specified width, avoid the object
b) If the object width<specified width, pick the object

2.1. Planning and control

In planning and control, the essential difference between robotic arm and other kinds of robots (like industrial ones) is that the movement of the robotic arm has to be human-like, using arm locomotion, especially biped gait. The ideal planning for arm movements during normal operation should result in minimum energy consumption, like it does in the human body. For this reason, studies on dynamics and control of these kinds of structures become more and more important.To maintain dynamic balance during the walk, a robot needs information about contact force and it's current and desired motion. The solution to this problem relies on a major concept, the Zero Moment Point (ZMP).

2.2. Constraints and limitations

The realistic constraints are

1. Environmental: RoboDumpster helps to keep a clean environment.
2. Economic: This project can help to eliminate the human labor. The cost of making may be high for a single unit but the work done in long term will definitely save resources and money.

Another characteristic of autonomous robotic arm is that they move, gather information (using sensors) on the "real world" and interact with it. They don't stay still like factory manipulators and other robots that work in highly structured environments. To allow humanoids to move in complex environments, planning and control must focus on self-collision detection, path planning and obstacle avoidance.

Robotic arm don't yet have some features of the human body. They include structures with variable flexibility, which provide safety (to the robot itself and to the people), and redundancy of movements, i.e. more degrees of freedom and therefore wide task availability.

3. OVERVIEW OF MECHANICAL DESIGN

The research platform proposed in this paper is the autonomous robotic arm, which is depicted in Fig. 1. It is a type of various kinds of robotic arms. It has a height of 16 cm, and a weight of approximately 2.2 kgs. It has 7 servo motors including one IR based motor. The basic idea of this innovative project is that it has 4 servo motors namely as dynamixel AX-12 which acts as a 4 wheels of this robotic arm. 2 motors are connected with IR based motor namely as dynamixel AX-S1, it also has a distance measurement sensor. We used a lipo battery for its power supply. The detailed specifications of the robot developed are summarized in Table 1.

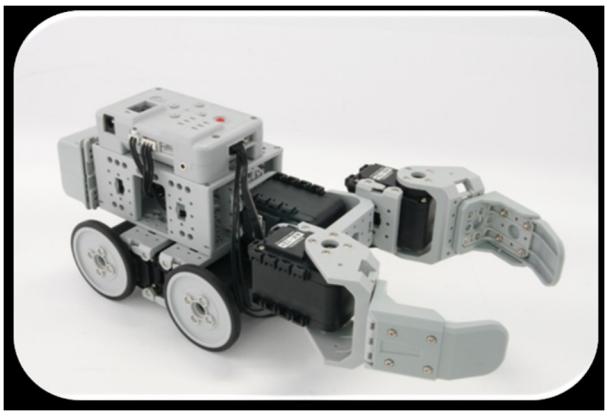

Figure.1 Autonomous Garbage Collector

Table 1 Specification of Robot

PARAMETERS	SPECIFICATION
HEIGHT/WEIGHT/DOF	16cms/2.2kg/7 DOF
ACTUATORS	Dynamixel AX-12, AX-S1
SENSORS	IR sensor, Absolute distance sensor, DMS sensor
PROCESSOR BOARD	CM-530
OPERATING SYSTEM	WINDOWS
INTERFACES	TTL, RS485
POWER	11.1v rechargeable LIPO battery 1000ma/PCM, SMPS for external power

3.1 Actuator

Actuators are the motors responsible for motion in the robot. Robotic arm is constructed in such a way that they mimic the human body, so they use actuators that perform like muscles and joints, though with a different structure. To achieve the same effect as human motion, robotic arm use mainly rotary actuators. They can be either electric, pneumatic, hydraulic, piezoelectric or ultrasonic.

Hydraulic and electric actuators have a very rigid behaviour and can only be made to act in a compliant manner through the use of relatively complex feedback control strategies. While electric coreless motor actuators are better suited for high speed and low load applications, hydraulic ones operate well at low speed and high load applications. Pneumatic actuators operate on the basis of gas compressibility. As they are inflated, they expand along the axis, and as they deflate, they contract. If one end is fixed, the other will move in a linear trajectory. These actuators are intended for low speed and low/medium load applications. Between pneumatic actuators there are: cylinders, bellows, pneumatic engines, pneumatic stepper motors and pneumatic artificial muscles.

We use here dynamixel AX-12 motor which rotates at 0 to 300 degree. Also it has a position feedback option. If we go beyond the limit of this type of motor it will shut off automatically without damaging itself. It has also high torque as compared to other motors.

Another motor which we used is dynamixel AX-S1 motor. It is a special kind of motor because of its infra-red technology. It has various functions:

a) IR Obstacle Detect Compare Value
b) Light Detect Compare Value
c) IR Distance Sensor Value (Left/Centre/Right)
d) Light Brightness Sensor Value (Left/Centre/Right)
e) IR Obstacle Detected

We use also a microcontroller called CM-530. It consists of ATMEGA 2561. It has 6 input and output ports. 5 dynamixel are connected with this microcontroller and it operates at 11.1V. It is a versatile device. Distance measurement sensor is also used. It can be used to detect walls or objects within a certain range and is not affected by color as much as IR sensors and can measure exact distance.

3.2. Fabrication

Each individual bracket is designed using AutoDesk Inventor, and then assembles in the software to form a complete robot. Feasibility of design is checked, and if design is feasible, development process proceeds to manufacturing.

The fabrication process requires different tools, namely:-

1. CNC machine
2. Band Saw
3. Dremel
4. Vise
5. Bending Break

The most important piece of equipment is the CNC machine which is used to cut all the parts out of the stock material.

Figure 2. CNC machine set up

The majority of the parts for this project were fabricated from 5052 aluminium. This alloy was selected for its formability and strength. The fabrication process is divided into five sections: milling, part removal, deburring, tapping, and bending. The milling process includes any processes that must be completed using a CNC machine. Once the parts are cut from the sheet, the part removal process will require a band saw to sever the checks (the small connectors holding the milled parts to the original sheet). However, the freed parts will not be in the final form until they are deburred and bent to the final shape for assembly. A bending break is recommended to perform the bending operation. In addition, certain parts have holes that will need to be tapped. For this process, a tap handle and the appropriate tap bit will be necessary for creating all threaded holes.

3.3. CNC milling

CNC machines use a programming language called G-Code which is a list of commands that tells the machine what actions to perform and where to go. A complete set of G-Code commands is called a tool path. Tool paths can be generated manually or by using a CAM (Computer Aided Manufacturing) package.It is desirable to perform the milling operation in the following order: facing, scoring, drilling, pocketing, and final cut-out. At the end of the milling operation, the part should still be held in place by checks. Checks are thin tabs that prevent the part from being unconstrained. To reduce the amount of finishing work, the checks should be cut as close to the actual part as possible without cutting into the actual part.

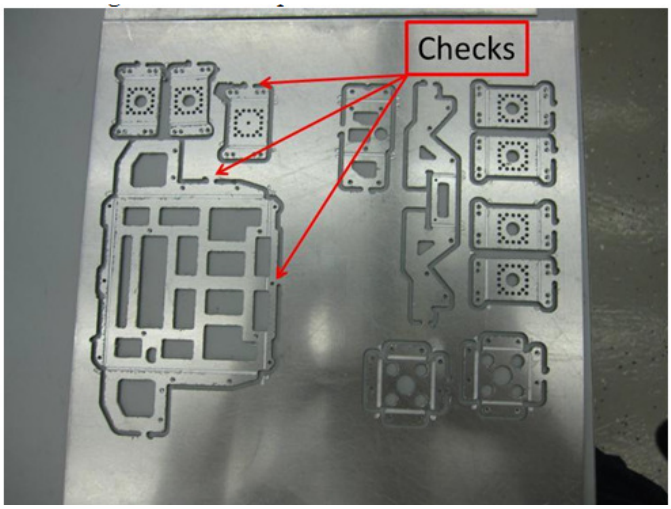

Figure 3 Sample parts with checks used to constrain the parts of the aluminium sheet

3.4. Deburring

Deburring is a finishing method used to remove burrs created during the machining operations. This is an important part of the fabrication process because small metal fragments can harm electronic components and sharp edges can cut wires and are a safety hazard. By the end of this process the piece should look clean on all of the edges and the edges should feel smooth.

3.5. Tapping

Tapping is a process that forms threads in a smaller pre-drilled hole. The diameter of the pre-drilled holes for bolts used in this project is 1.6 mm and 2.5 mm respectively.

3.6. Bending

Many of the brackets on the robot use bent geometry. Four methods were used: Simple Bend with a Break, Difficult Bend with a Break, Bend with a Vise, and Custom Bend.

3.7. Assembly Process

After the brackets have been manufactured, deburred and bent, all parts and actuator are assembled using bolts to build a humanoid robot. The two most common bolts used for the assembly for the robot are M2 and M2.5 bolts. The diameter for the pre-drilled holes for M2 and M2.5 are 1.6mm and 2.5mm respectively.

3.8 Advantages of Robotic Arm

The first main advantage the Robotic arm brings to the table is that they can do things that people can do and even things that people are unable to do. The sale and development of these robots will also help increase the economy. Having these robots can make companies more efficient in their work and also spur the economy with their revenue growth. These Robots can soon be in everyday life where they can do the jobs that people generally wouldn't want to do, and do them more efficiently as well.

Another advantage that results from this robot is that they do not make mistakes. They can take care of the elderly and be programmed to insure that they will not be disrespectful, as well

as be around an elderly person full time and be able to care for their needs and safety! These robots not making mistakes and it are also beneficial in the work place. Robots can work in factories and do the same thing over and over again and not do it any differently. Humans on the other hand will get tired after doing the same thing repetitively and could easily make a mistake.

There is another major advantage to Robotic arm and that has to do with children. These Robots have many advantages such as their capability to do many things, the fact that they do not make mistakes and their ability to help children with disabilities. These are already apparent today and these robots are yet to be in society's daily life.

4 CONCLUSION

A 7 DOF autonomous customized ROBOTIC ARM has been developed, which is 16 cm high and weighs 2.2kgs. It can also be programmed using multiple programming languages to do various moves. The features in the robot developed are wireless operation, real time operation using PC and automatic operation.

We can use normal motors to minimize the cost. Due to such motors, high torque cannot be produced to lift heavy objects. Use of normal DC motors can result in complex connections. Therefore, we have used Dynamixel AX-12 actuators. It can work in both the modes i.e. DC continuous mode and fixed rotation mode. These actuators can be connected in series so as to ease the connections. Alternative method could have been taken by changing the sensors used. It can amplify tendency to detect obstacles. Color detection is another approach against edge detection. A camera can be used in place of IR sensors whereas; it will be a costly product.

Robots that can incrementally acquire new knowledge from autonomous interactions with the environment will accomplish tasks by means their designers did not explicitly implement, and will adapt to unanticipated circumstances of unstructured environments. Already, robotic arm can autonomously perform task decomposition necessary to carry out high-level, complex commands given through gesture and speech.

The robotic arm developed is a true open platform robot where users are encouraged to modify both hardware and software. The robot is compatible with various programming languages including C++, Lab VIEW and MATLAB etc. With its modular design, all the hardware can be fabricated by the user with relatively inexpensive tools.

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