Degree of Freedom and Rotacam

Project based learning-1 (4th Sem) (MC2270)

Name: Ritvik Mahapatra

Registration Number: 199403001

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Under the guidance of: Dr. **Manish Rawat** (**Assistant Professor),** Department of Mechatronics, SAMM, Faculty of Engineering, Manipal University Jaipur, India.

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Content (index)

Objective (Problem Statement)

In this project-based learning I have decided to make a Motion following / sensitive camera. Which can track the object and follow them continuously. There are several fields of work or various applications where we might require more range of vision and more field of view in our vision for particular process, be it drone camera or production process where a camera can be remotely controlled to view much of the process of production without any need of human assistance or there might be some unreachable places where human presence is impossible or unrequired or may the case be of a CCTV camera which follows the motion in night or just keeps on changing its field of view or it can also be controlled remotely. There are various application where we require to remotely control a device about various DOF, and it should be sensitive to its surrounding or follow a particular object. Thus, with some knowledge of DOF, some sensors, some servos and control of each of element we can make a motion follower camera which can follow an object. We can also implement this as remote camera control or an image recognizer and follower. Thus, this basic implementations can have various applications in real world problems.

This representation (Project) has a main motive to solve security (CCTV) or production process (Object follower) related problems.

Introduction

In today's world, mankind has various needs and requirements. These may range from one to other. But various needs in the domain of manufacturing or production are fulfilled by the implementations of knowledge in physics or mechanics, to a certain extent.

During production process which is automated we may need a certain machine element to move in certain direction or rotate about a particular axis. This is where concept of Degree of Freedom comes.

Manufacturing is just an example, concept of DOF is applicable on most of the machines around us, may it be a fridge's door, a table fan, AC's which have controllable swing area {they may cool the area around by following you through a motion sensor and setting the swing of AC at that angle only} or a CCTV camera which can rotate itself at any angle by following the motion of an object or person.

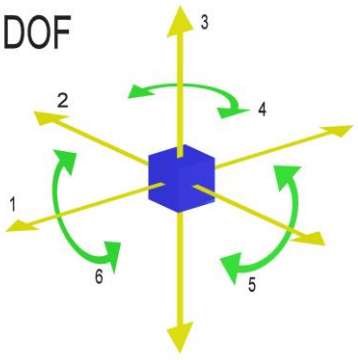
We will here discuss a motion following camera which detects the motion from 4 ultra-sonic sensors and the camera moves in the direction where the distance of the object is minimum from the sensors. Also, the camera input can be used to follow the object in place of ultrasonic sensors.

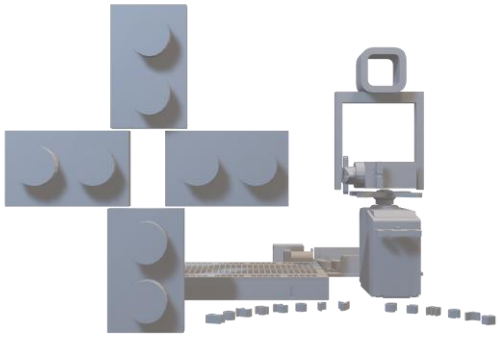
Literature Review (DOF)

In physics, the degrees of freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration or state. It is important in the analysis of systems of bodies in mechanical engineering, structural engineering, aerospace engineering, robotics, and other fields.

The formulae for DOF is given by 6(n-1)-5p1-4p2-3p3-2p4-p5

For our case we have 3 links (n=3) (2 servos and 1 camera link) and p1=2(pair of links whose DOF is 1(reduced by 5) i.e., about x and y axis), therefore our DOF comes out to be 12-2*5=12-10=2





Methodology

Construction and 3-D model

Firstly, there are 4 Ultrasonic Sensors which determines the distance of the object from themselves so that we know in which direction the camera should rotate such that it follows the object (we consider the object to be in the front of our setup).

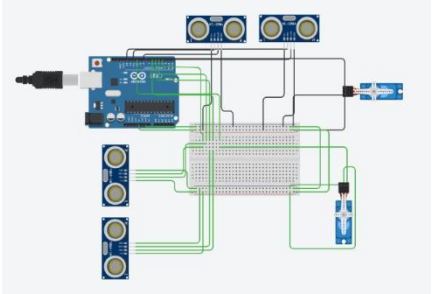
Then we have two servos, one is fixed with ground (giving 360 view about x axis, we will consider for 180 degrees only). The other servo fixed on the rotator of 1st servo, such that their axis is perpendicular to each other (this can rotate about 270 degrees about y axis; however, we will limit it to 180 degree only).

We have connected/fixed the camera with the help of connections as shown in the figure (initially, along the axis of the first servo). The camera faces the front direction. The DOF of the setup is 2 as it rotates about x-axis and y-axis.

Circuit

To implement a 2 DOF motion follower (about x and y-axis about 180 degrees) we have used four ultrasonic sensors (namely top, bottom, right and left) to detect the object and its distance from the sensors, so that the camera can rotate in the direction where the object is detectable or the nearest to the sensor. The Arduino is being used to detect the inputs; it also finds out the distance between the object and the sensor so that the camera can rotate in the direction of the object (that is, in the direction where distance in minimum or where the sensor detects the object). Two of the servos are connected to the Arduino to control the angle of rotation of the camera, respectively.

The ground and the power of all the elements are connected with the Arduino's gnd and 5v terminal, respectively. The servos signals are received from the pin 9 and 10 of the Arduino.



Ultrasonic sensor

The ultrasonic sensors used here have the echo and trigger terminal. The trigger pin is in input pin for the ultrasonic sensor. The trigger takes the input from the Arduino and If it is high the transmitter of the sensor emits the ultrasonic wave, if the object is encountered, then the waves are reflected to the sensor and the receiver part of the sensor detects the reflected U.S. wave. This enables the echo (output pin of the sensor) to go high, which can be used to determine the time after the sensor receives the signal, i.e., the time difference between the trigger pin going high and echo going high (receiving the signal). From the time we can find the distance of the object with the help of some relations.

Code Explanation

- Firstly, we have included the servo library for controlling the angle of rotation and declared to two servo's objects (horizontal and vertical).
- Declaring all the input/output pins and variables. Taking the initial threshold (distance from the sensor as ten inches and initial angle for both the servos as 90 degrees.
- Void setup () – here we setup the servo signal pins.
- Void loop () –
    - setup the trigger input for every sensor and set the trigger as high then low for certain time so that the signals are sent.
    - Then we determine the time after which the output of ultrasonic sensor (echo) goes high for each sensor.
    - Then we find out the distance of the object from each sensor by using relation distance(in) = time difference(mS)/148
    - Then we call the follow function for each of the servo.
- Void follow () (for horizontal servo-right and left ultrasonic sensor):
    - First, we check whether the distances are greater than the threshold (distance or range limit) or not.
    - If any one of the distances is more than the threshold distances, then we compare the distances of both the ultrasonic sensors (right and left).
    - For e.g., if the right sensor's distance is less than the left sensors distance by a minimum difference of 2 inches then the servo should rotate in the right direction, i.e., in the right direction as the object is closer to right sensor.
    - Similarly, if left sensors distance is less the servo rotates in left direction.
    - The minimum and maximum limits are 0 and 180 degrees (no rotations beyond these limits).
- Similar process repeats for the vertical servo: - up and down U.S. sensor.
- These processes under void loop () repeats continuously.

Note: Click on the circuit link in the bibliography or find the .ino file in the upload for the source code

Findings and Discussions

The final outcome of this project is that we can make a camera or any other thing to follow the motion or become motion sensitive. Thus, we can make it to follow any body's motion. We have therefore successfully used the knowledge of DOF, Arduino architecture, Working of Servos and Ultrasonic sensors and some coding to achieve the task of following one's motion.

Future Prospects

This project can have various applications, but here are some future improvements that one can implement:

1) Increase the Degree of freedom for more better reachability and range.
2) Increase the angle of rotation for more freedom and better range.
3) We can control it from an app or wirelessly.
4) We can add different modes like to follow only particular type or material of an object (depending on the wavelength sensed by using IR sensors instead of ultrasonic sensors).
5) We can also make it to follow multiple objects at ones.
6) Instead of using the ultrasonic sensors we can also use a recognition enabled camera and can implement AI or ML for image recognition or we can make it to follow a particular type of object which it can recognize on its own and follow it across various axis or DOF.

Applications of The Motion Follower System

1. Security / CCTV cameras and system.
2. Automation of manufacturing and production processes.
3. Smart lighting system- lights following the person.
4. AC swing control- supplying the cool air where more people are there.
5. Environmental sensing.

Bibliography (in APA)

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Link for Circuit-https://www.tinkercad.com/things/7eray7TTn8B-rotacam-motion-follower-circuit

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