Technical Review - Servo Motor State of the Art

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***Abstract*— This paper covers the current state-of-the-art of servo motor technology, including its various commercial applications, operation of the underlying technology, and basics of implementation.**

I. INTRODUCTION

Servo motors are rotary actuators that allows for precise control of angular position. It is similar to a standard motor, but with a feedback sensor to provide precise rotary control and a focus on position instead of speed. There are a wide variety of applications of servo motors such as robotics, manufacturing, photography, and solar tracking. They can vary greatly in size, strength, price, and more. The current available servo motors will be explored in addition to the applications in which they might be commonly be found. Another important topic included is the mechanics of their operation and basic steps in implementing a servo motor in an application including additional necessary components and how to choose a servo motor.

II. MARKET PRESENCE OF COMMERCIAL APPLICATIONS

Currently on the market are a large number of different servo motors, varied by their size, power consumption, motion profile, and torque. Some of the high end servo motors on the market now are sold by Omron Electronics and feature high speed and precision, low settling time, and network connectivity and can cost upwards of ten thousand dollars each. These motors are most commonly found in industrial applications such as manufacturing where high power and precision are needed. On the lower end, servo motors such as those sold by Adafruit or Seeed Technology can cost as little as five dollars, and are very low power, low torque, and low precision, but are often acceptable for hobbyist applications. For robotics applications, a middle ground is found from HITec or Tower, which sell motors for all applications ranging from the ten to a few hundred dollar price range, offering various torque, speed, size, and weighting combinations. While the method by which a servo motor operates is relatively standard, the strength, size, and price can vary. Servo motors seen today also have additional application specific qualities such as construction and corrosion resistant materials and water and explosion proofing. Food grade servos are available for appropriate applications. The inner portions can vary in gear ratios and in usage of rare earth magnets. Less precise applications can boast high ”torque per dollar” ratios. Small scale applications such as for miniature planes or drones can have use for some micro-servos on the market.

III. HOW A SERVO MOTOR OPERATES

Servo motors are a popular method of motion control. These servos, like standard DC motors, have a power and ground but differ in that they additionally have a control line which allows for more precision control. Many servo motors also do not rotate freely like DC motors but instead have a limited angle of rotation which is controlled by the third control line described before. The control line will specify an angle of rotation to which the motor will move. This results in higher torque, precision, and speed at the expense of range of motion. The control line is PWM controlled, where the duty cycle corresponds to the angle of rotation. The motor will hold this position with up to the maximum torque. Inside the servo is a potentiometer which measures the angle of rotation of the motor. This information is sent to a feedback loop which allows the motor to sustain an exact angle. This setup abstracts away most of the complexity from the user, removing the need for motor controllers, feedback systems, and so on. The motor is usually connect to the outer rotational actuator by a set of gears. Because of the small range of motion, having very high rpm is not necessarily needed. Instead, a high inner gear ratio provides for a higher torque rating at the expense of lower speed. Many servo motors will use rare earth magnets such as iron or neodymium for their rotor because they are stronger than ferrite or ceramic permanent magnets and enable much greater performance in a smaller, lighter motor. Although, these magnets are rather expensive and greatly drive up the price of the motor. Perhaps just beyond state of the art servo motors started to incorperate electromagnetic stators with steel rotors for a similarly powerful motor without the use of rare earth magnets. However, these motors have not yet substantially come to market.

IV. USING A SERVO MOTOR

As stated before, much of the complexity of the servo is abstracted away from the used. The only items that are needed for the servo are a microcontroller to control the angle of the servo and a power source, which can often be the same as the microcontroller. The microcontroller needs to be set up to send the correct signal to the servo to achieve the desired angle of rotation. The information about the correlation between high time and angle can be found on the data sheets. Most standard microcontrollers have the ability to send a PWM signal through one function call, without any additional knowledge. There do exists some servo motor control circuits though, which will handle all control for the user, requiring only an angle to be sent to the controller, which will then send the proper signal to the servo.

When choosing a servo, several design constraints should be considered. Firstly, the necessary torque of the motor should be evaluated. The torque is how much turning force is needed for the motor. This can be calculated for a given application and a servo with at least that much torque can be found. The voltage requirements are also a major consideration. If using an Arduino or similar microcontroller, a low voltage servo could be preferred due to the ability to power both the microcontroller and the servo off the same voltage source. However, higher torque servos may require higher voltages. In low power applications, lighter motors or motors with better efficiency might be chosen.

REFERENCES

[1] M. Budimir, "How to Size and Select Servo Systems in Eight Easy Steps," in motioncontroltips.com, 2012. [Online]. Available: http://www.motioncontroltips.com/8-easy-steps-to-selecting-the-right-servo-systems/. Accessed: Oct. 22, 2016.

[2] S.-M. Yang and K.-W. Lin, "Automatic control loop tuning for permanent-magnet AC servo motor drives," IEEE Transactions on Industrial Electronics, vol. 63, no. 3, pp. 14991506, Mar. 2016.

[3] D. Sawicz, Hobby Servo Fundamentals. [Online]. Available: http://www.princeton.edu/ mae412/TEXT/NTRAK2002/292-302.pdf. Accessed: Oct. 22, 2016.

[4] "Whats the difference between DC, servo & Stepper motors?," in Mod My PI, 2013. [Online]. Available: https://www.modmypi.com/blog/whats-the-difference-between-dc-servo-stepper-motors. Accessed: Oct. 22, 2016.

[5] "MicroAct magnetic Actuator - 0.4g," in microflight.com. [Online]. Available: http://www.microflight.com/Online-Catalog/Actuators-and-Servos/MicroAct-Magnetic-Actuator-0-4g. Accessed: Oct. 24, 2016.

[6] N. Sonoda, Y. Toyozawa, Y. Iwashita, and F. Corporation, Patent US20160033954 - control system of servo motors improving processing precision of plurality of axes. Google Books, 2015. [Online]. Available: https://www.google.com/patents/US20160033954. Accessed: Oct. 23, 2016.

[7] "Servo motor applications - list of common industrial applications for Servos," in Tigertek, 2014. [Online]. Available: http://www.tigertek.com/servo-motor-resources/common-servo-motor-applications.html. Accessed: Oct. 22, 2016.

[8] "Digikey Product Search," in Digikey. [Online]. Available: http://www.digikey.com/product-search/en/motors-solenoids-driver-boards-modules/motors-ac-dc/983125?k=servo+motor. Accessed: Oct. 22, 2016.

[9] Kollmorgen, "Servo motors," Kollmorgen, 2013. [Online]. Available: http://www.kollmorgen.com/en-us/products/motors/servo/servomotors/. Accessed: Oct. 23, 2016.