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MANIPULATOR MOVEMENT SPEED DOWN USING FOR OBJECT WEIGHT ESTIMATION

Tibor Vince

Technical University in Kosice, Faculty of Electrical Engineering and Informatics
Dept. of Theoretical Electrical Engineering and Electrical Measurement
Park Komenskoho 3, 04200 Kosice, Slovakia
e-mail: tibor.vince@tuke.sk

Abstarct: *Teach-Robot is simple 5 axles manipulator built on servo motors used for education purposes. Servo motors based on DC motor slow down due to the increased load. It is possible to estimate object weight by measuring time interval required to reach specific positions. The article presents the possibility of estimating weight of the object using effect of manipulator speed slowdown under load increasing.*

Keywords: *Teach-Robot, weight estimation, time tracking*

1. INTRODUCTION

In field of automation or measuring systems there are sometimes situations, where necessary parameters can be obtained only by indirect way. Also when simple machine is used without special sensors, side design properties can be used to observe much more parameters than it seems at first sight.

The Teach-Robot is not equipped with a sensor that would allow direct weight measurement of the object which the robot is manipulating. It is simple manipulator, which gives information about static position and change the position according to command received from manual controller or from PC. This article shows the way, how to estimate weight of the object and classify it in to five levels of weights.

2. TEACH-ROBOT

The Teach-Robot is a robot model for educational purposes. The construction is derived from an industrial robot and is equipped with 5 axles. Therefore the Teach-Robot is a realistic open scale model for educational purposes and can be used to explain the world of robotics through motion studies. The robot can be used in combination with the educational software appliances for used computer technique and as an example for the use of so called fieldbus-technology.

Robot specifications: number of axles: 5, number of drives: 6 (nr. 1 is gripper), type of drives: dc servo motors, vertical reach max.: 500mm, horizontal reach max.: 450mm, rotation max.: 270°, resolution ± 2mm load capacity max. 0,2kg, weight 2,5 kg, DC voltage 15V, Current max. 0,3A/motor.

Each motor runs under control of an independent microcontroller. The communication between Teach-Box and Teach-Robot is done by TRBus. This “mini-computer” drives the Teach-Robot and handles the communication between the PC and the Teach-Robot. It allows to move the robot to any point of its working area and to store such moving to a chip card. The Teach-Box has a twofold purpose. It allows that the user to use the Teach-Robot manually with only the box. It is also the interface between the microcontroller, which looks after control and the robot. The interface has a chip card reader. The data transport between the interface and the robot takes place by the Teach-Robot bus system.

3. WEIGHT LOAD ESTIMATION

Teach-Robot is a simple handler that does not have load, torque, acceleration or other similar sensors. User can obtain static position and status flags only. It does not provide any direct information from which to determine the weight of the object. The aim of this article is to show the possibility of object weight estimation using indirect indicators. Weight estimation is based on principle that loaded servo motor is slower than unloaded [1]. The description of the robot in the previous chapter among other things specifies that the maximum load is 0.2 kg. The goal of the weight estimation is to classify objects into five level of weight: 0g, 50g, 100g, 150g and 200g.

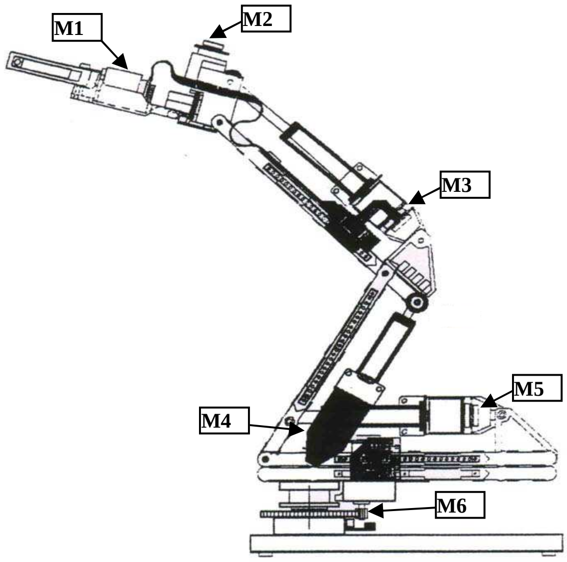

Figure. 1 Teach-Robot's servo motors

In order to reach that the motor movement time would reflect the object weight as much as possible, motor movement must cause vertical movement of the object. In case of Teach-Robot, two motors cause vertical movement – motor M3 and motor M4, according to Figure 1

Comparing the movement time difference of motor M3 and M4 with no load and under the 100g load is shown in Table 1. All times are given as the average time in ten-fold measurements.

motor	**No load [ms]**	**Movement down [ms]**	**Movement up [ms]**
M 3	1466	1593	1650
M 4	1500	1830	1950

Table. 1 Teach-Robot's servo motors

According to the Table 1 data, movement time of motor M4 is much more affected by object weight than movement time of motor M3. Therefore, motor M4 is used for weight estimation..

4. MOVING TIME OBSERVATION

The Teach-Robot itself or controlling element (Teach-Box) is not equipped with a sensor that would allow direct measurement of the movement speed or time duration. Therefore, the time tracking should be done using some of the side properties of the robot.

Communication Unit (Teach-Box) is constructed so that at idle sends special data - to confirm the connection. On request it sends information about the position and status flags of motors. Communication unit receives requests for information on the state of the robot or the requirements to change the position of the robot. In case that a request is to change the position one of the motors, Communication Unit stops the communication with the computer. It will communicate again after reaching the specified position or after time-out. As the communication unit is silent during the moving process, time tracking of the time of this silence gives possibility to determine moving duration of the robot.

Object weight is estimate using time duration, when Teach-Robot reaches upper position (Figure 2) from lower position (Figure 3) and back.

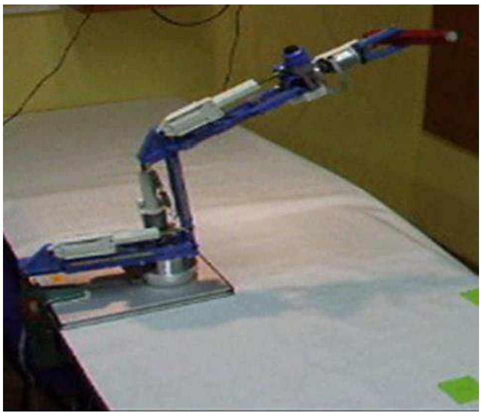

Figure. 2 Teach-Robot's upper position

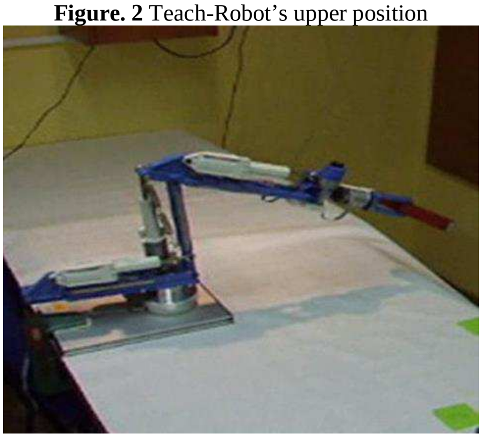

Figure. 3 *Teach-Robot's lower position*

5. MEASUREMENTS

For all load levels: 0g, 50g, 100g, 150g and 200g was carried out a series of 50 measurements of time tracking by reaching the upper and the lower position of the robot. Movement is measured in the upwards and downwards Figure 6 to Figure 10 shows the measured frequency intervals of the robot at different object weight. Time Intervals are the size of 20ms.

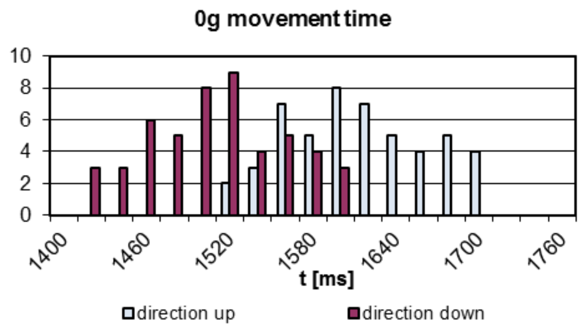

Figure. 3 Movement time by 0g load

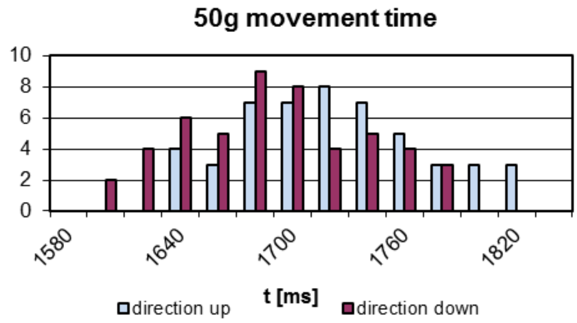

Figure. 4 Movement time by 50g load

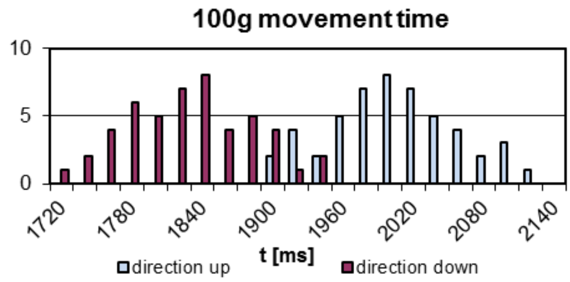

Figure. 5 Movement time by 100g load

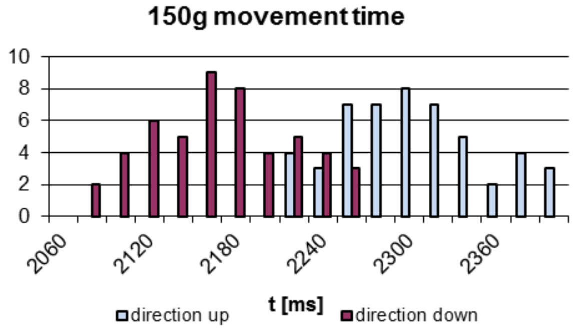

Figure. 6 Movement time by 150g load

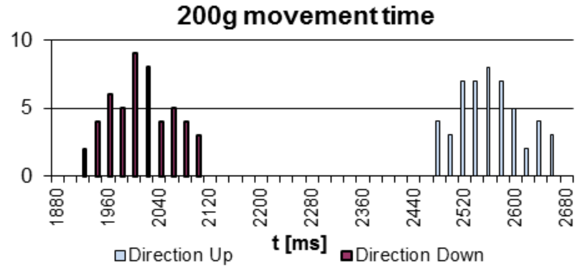

Figure. 7 Movement time by 200g load

From the average time of movements according to the specific object it is possible to create a graph of the average time related to the weight of the object, as shown in Figure 8.

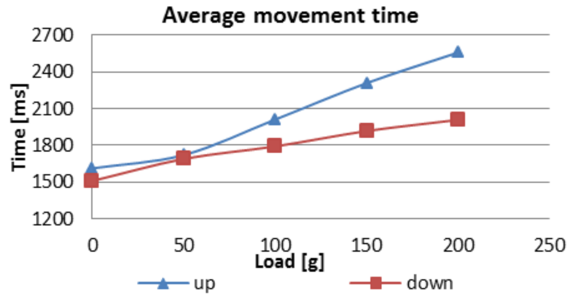

Figure. 8 Average time move according the load weight

The measured data shows that with increased object weight the upwards movement time duration increased as well as downwards move. The difference between those times is increased as well. The problem is that by increasing the mass of the object, the scatter of the measured values is increased too. Interval values measured in one object weight even overlap with the interval of measured values of another object weight. Therefore, to increase the success rate of determining the object's weight level more multiple measurements should be done.

13. CONCLUSION

Teach-Robot is simple 5 axles manipulator used for education purposes. Movement is made by DC servo motors. Using communication unit Teach-Box it is possible to set motors position, get motor position and few simple command like RESET, HOME position, STOP and similar. It does not give any information about torque, speed, real-time position during the move.
Using property of DC servo motors to slow down due to the increased load, it is possible to estimate the object weight by tracking movement time. Classification of object weight to five different levels was achieved by such time observation. Classification success was achieved up to 95%, when 3 measurements were proceeding and average time was take in consideration. Higher success rate can be reached for instance by larger number of measurements. On the software side could be higher success rate achieved by using elements of artificial intelligence, especially Artificial Neural Network or Fuzzy Logic. On hardware site could be accuracy increased by implementation of new sensor giving information about motor speed, torque or weight of the object directly.

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