MAXPID CONTROLLED FUNCTION CHAIN

Field of the device: Robotics, agricultural field.

Device: Maxpid scale model, composed of an axis control of a picking robot.

Topic: Kinematics of solid bodies, modeling of mechanical actions.

Technical problem: Determine and validate the geometrical model of transformation and tuning of movement.

I Presentation of the technical problem

The Pellenc company designs automated robots which allow to:

- automatically sort garbage (Planeco robot);
- pick apples and lemons (Magali/Citrus robot);
- transplant rose trees (Rosal robot).

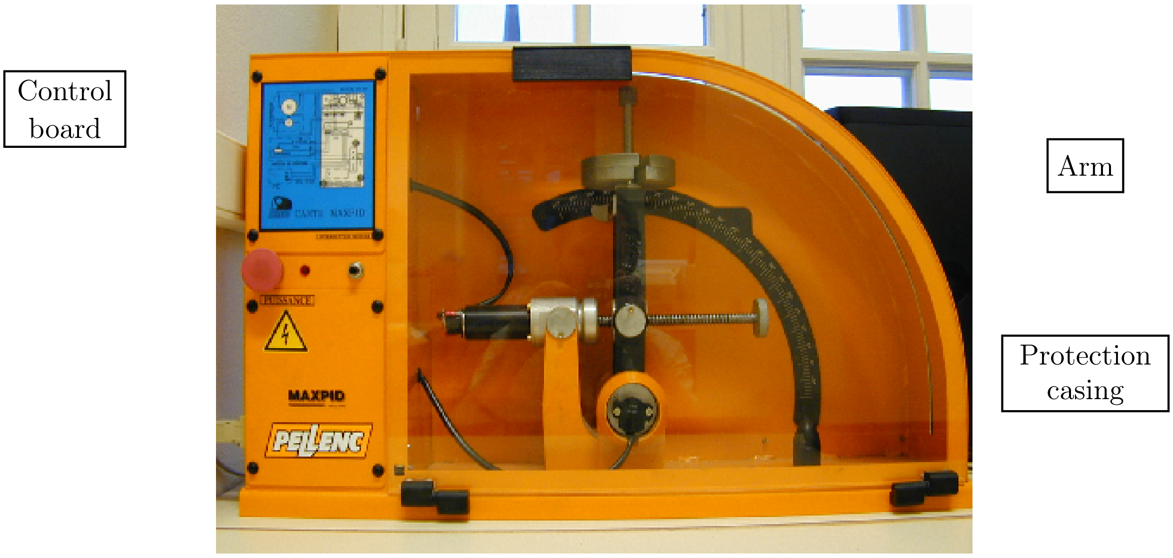
A video named "Pellenc" is available on the desktop and allows to see the operation of the different robots.

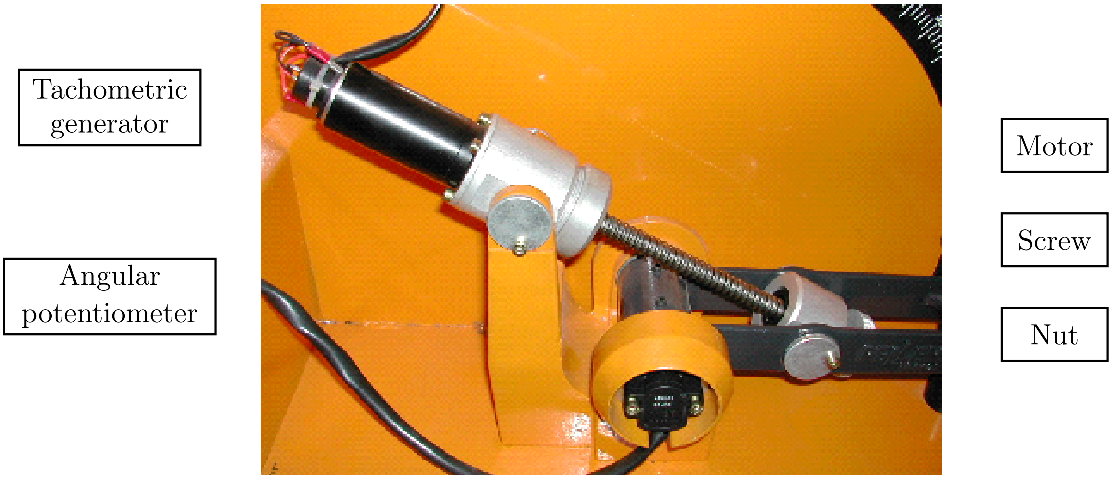
The global architecture of all these robots is the same, and their orientation is performed by means of three function chains which pilot the different axes of rotation of the robot. These three function chains have the same structure. The MAXPID controlled function chain represents one of these function chains.

II Presentation of the device

The arm of the MAXPID controlled function chain is moved by means of a screw-nut system and by a set of mechanical links between the different parts of the mechanism. The screw is driven by a motor. A tachometric generator allows to measure the rotation speed of the screw with respect to the body of the motor, and an angle sensor allows to measure the angle of rotation of the arm with respect to the frame. The motor voltage is controlled by a chopper located inside the digital control board. The control board treats the information provided by the angle sensor, compares the measured angle with the reference angle, and generates the control law for the chopper.

Question 1: *complete the pictures below by using the presentation of the device.*





III Determination of the experimental input/output relation

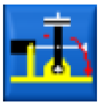
Manipulation:

- Check that the door of the device is closed. Unlock the emergency stop button (pull gently). Power on the device on its left side. Switch on the desktop and select the Maxpid program (click on continue). Click on the "On/Off" switch on the screen. Choose the "Com6" port, then "Établir la connexion" (Connect).

- In the main window, click on the icon 

and then tick the box "Maxpid asservi" (controlled Maxpid). Input 50 for the value of the proportional gain (Gain Proportionnel) and 0 for the integral gain (gain intégral) and derivative gain (gain dérivé). Do not modify any other parameter. Validate.

- Click on "Travailler avec Maxpid" (work with Maxpid) and then on "Schéma Cinématique animé" (animated kinematic diagram). Choose a velocity of 0.1 rad/s (by clicking on PID).

- Click on the button  "Envoyer un mouvement à Maxpid" (send a movement to Maxpid).

- Perform the movement between 0.5° and 90° (position désirée: 90°).

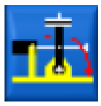
- Save this motion in the file Montee 0.1.mvt (this file format is compatible with an Excel-type software).

Question 2: *open Microsoft Excel. Import the .mvt file. Then plot the input/output relation of the rotation of the arm to the rotation of the motor.*

The Maxpid arm uses a screw/nut system with pitch p.

Manipulation: measure the approximative pitch of the screw thanks to a ruler, and indicate whether the screw has a left-hand or a right-hand thread.

Question 3: *give the relation between the position variation (translation) Δx of the nut and the angular variation (rotation) $\Delta\beta$ of the screw according to the pitch p. Justify the sign of the relation by precising in which direction the nut moves with respect to the screw.*

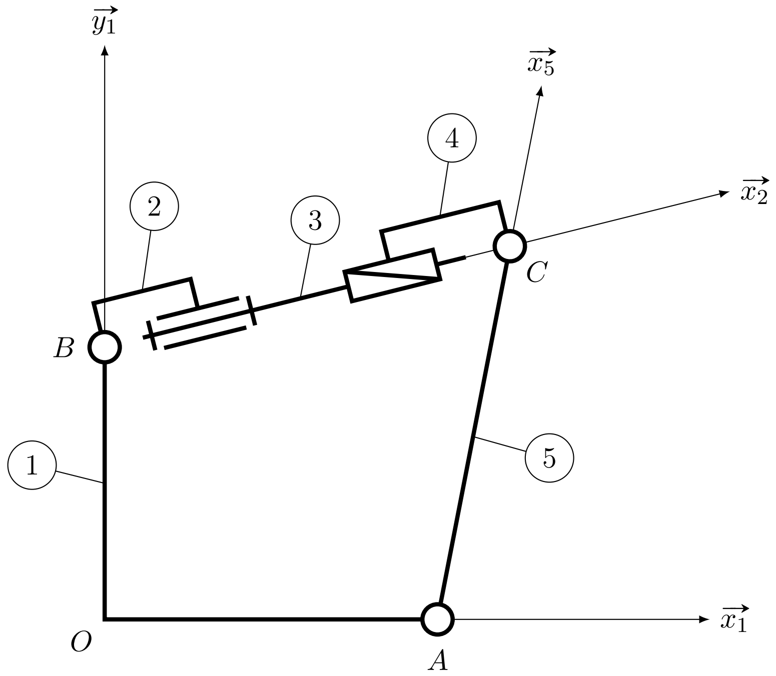
Manipulation: choose a velocity of 0.4 rad/s (by clicking on PID). Click on the button  "Envoyer un mouvement à Maxpid" (send a movement to Maxpid). Note the ininitial values of the position x of the nut and the rotation angle β of the screw (the arm must be in its lowest position), then perform a movement between 0.5° and 90° (position désirée: 90°). Observe the movement. The movement can be saved in the file Montee 0.4.mvt.

Question 4: *check that the measured value of the pitch corresponds to the one from this experiment.*

IV Modeling of the device

The aim of this part is to analyze the device to propose a model with links between parts in order to determine the input/output relation of the device. This latter allows to know the control law to provide to the motor to obtain the expected evolution for the arm. We will then verify that the analytical input/output relation is the same as the experimental one.

To do so, we will work on the real device. We will consider the following equivalence classes: the **body**, **motor support**, **screw**, **nut**, and **arm**. The kinematic diagram is provided below and we note $OA = a$, $OB = b$, $AC = c$, and $BC = x(t)$.



Question 5: *indicate the angular parameters which allow to locate base b_5 with respect to base b_1 ($\theta(t)$), base b_2 with respect to base b_1 ($\alpha(t)$), and base b_5 with respect to base b_2 ($\delta(t)$).*

Manipulation: measure the approximate values of the lengths a, b and c on the scale model.

Question 6: *identify the input and output parameters.*

V Determination of the theoretical input/output relation

In order to determine the input/output relation of the device, we are going to write a "geometrical closure" vector equation for the loop identified on the device.

Question 7: *write a loop closure vector relation. Project this equation in the base b_1 and determine two scalar equations.*

Question 8: *determine the input/output relation between the angle of the motor shaft and the angle of the arm through the geometrical characteristics of the device.*

Question 9: *plot this curve in Maple thanks to the command "plot", and compare it with the experimental curve.*