The Functional Model of a Robot System Which Presents a Visual Servoing Control

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***Abstract* - This paper presents some studies regarding the functional model of a robot system that has a visual servoing control, and also the simulation results for the system model. The information given by a visual system of the position of a target, materialized by a moving light source is used to realize the robot control.**

1. Introduction

The functional model of a robot system which presents a visual servoing control is presented in this paper. In fact, the robot system control is a position based visual servoing, the system using for control loop two CCD cameras. The robot block scheme is presented in figure 1.

As the block scheme of the robot system has a global regulator, which compares the real position with the prescribed one, in fact it is possible to say that the robot control is a global control. The robot system cinematic scheme for the system realized by authors is presented in figure 2. The robot system contains a Cartesian robot (TTT structures) respectively a visual subsystem materialized through two CCD cameras. The visual subsystem has to follows the robot end-effector (point G in figure 2). The CCD cameras present two DOF (pan and tilt).

The TTT robot joints are actuated by DC actuators, and the visual device are actuated by three step by step actuators (one generates the motion through Ox axes, and the other two generate the motions trough Oy_v and Oy_v' axes).

II. The Aim of the Functional Model

The aim of the modeling and simulation of the robot system is to foresee how the system works before the effective realization of the system.

While the robot system is a complex system, which has to be dynamically controlled, and because its components are heterogeneous, some of them having continuous parameters while others discrete parameters, it was necessary to create the model for each conceived system component.

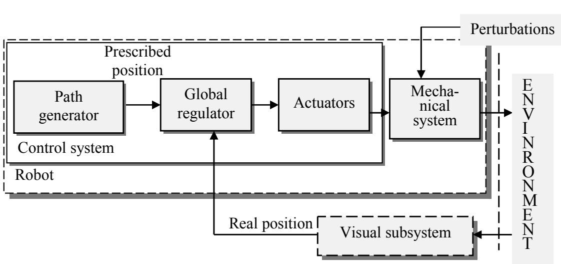

Fig. 1 The block scheme for a robot system which presents a position based visual servoing

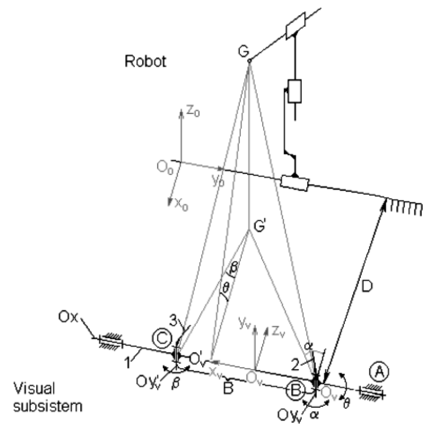

Fig. 2. The robot system kinematics' scheme

The authors generate the model for each component of the robot system to be able to establish:

- the acquisition time of the visual subsystem;
- the command execution time;
- the response time of the computer system,

all of those to establish if the robot system is working or not in real time.

In order to realize the model of the robot system behavior, a program which have the capability of the dynamic behavior redeem of the robot subsystems is needed. MATLAB® SYMULINK® possesses all the attributes necessary to model and simulate systems with time-modifying states.

III. The System Components Functional Model

III.1. The DC motor functional model

The DC motor mathematical model can be found in [1]. The DC motor functional model contains two transfer functions "Electric", respectively "Load", which represents the Laplace transformations of the DC motors differential equations.

The "Load" block output is the motor angular velocity, which after the integration became the angular coordinate of that joint. Supply voltage represents the "Electric" block input.

Frictions during the motor function are modeled using the "Dry and viscous friction" block.

The aim of the block is the study of the dependency of its inputs with speed.

The DC motor model block scheme is presented in figure 3.

T. Sobh (ed.), Innovations and Advanced Techniques in Computer and Information Sciences and Engineering, 19–24.

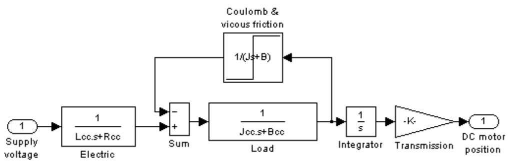

Fig. 3. The DC motor model block scheme

The main components of the DC motor model block scheme are:

- "Electric" represents the transfer function of the DC motor electric. The block input is the supply voltage [V] while the output is the torque [Nm].
- "Load" represents the transfer function of the DC motor mechanical component loaded with a resistant torque. The block input is the torque [Nm], while the output is the angular speed [rad/s].
- "Dry and viscous friction" block deals with viscous friction which depends on speed and dry friction. The input of the block is the angular speed and the output is the friction torque which is to be substituted from the torque.
- "Integration" is the block that realizes the integration of the angular speed necessary to obtain the generalized parameter of the corresponding cinematic couple. [rad].
- "Sum" is the block for two inputs addition.
- "Supply voltage" is the input for the D.C motor [V].
- "Position" represents the angular position of the motor shaft [rad].
- "Real speed" the angular speed of the motor shaft [rad/s].

III.2. The Step Motor Functional Model

Angular displacements of the visual sensor are made using step motors. Mathematic model of the step motor is presented in [3].

The step motors used in experimental device are 4 phase motors. The model for one winding is presented in figure 4.

- The following components were used:
- "In1" – command signal of the winding (step voltage impulses)
- "Winding 1 parameters" – the transfer function of the winding
- "Kmpp" constant of the motor
- "Kgpp" mechanical constant of the transmission
- "Winding 1 position" – function which models the winding position. Its expression is sin(n*u-v) where u is the input, which means the instant position of the rotor and v is the winding position.

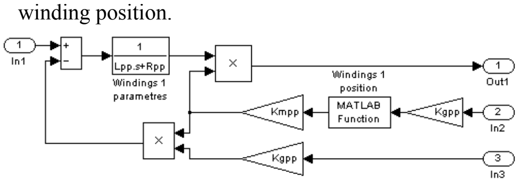

Fig. 4 The simulation model for one step motor winding

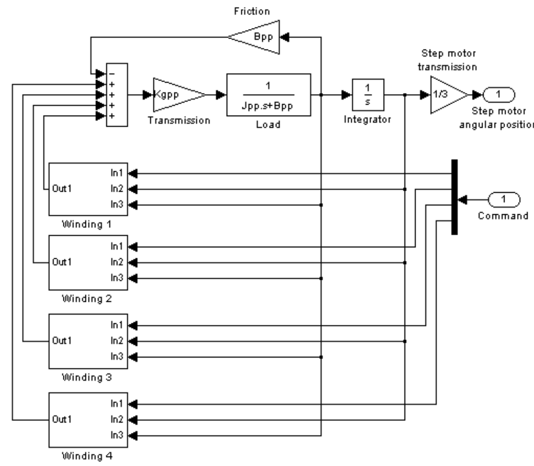

Fig. 5 The complete step motor model

- "±" – summing block
- "x" – multiplying block
- "Out1" – motor torque [daNm]
- "In2" – instant position of the rotor [rad]
- "In3" – instant speed of the rotor [rad/s]

The previously presented model is multiplied by 4 as can be seen in the complete motor model presented in figure 5.

Supplementary, the following blocks were added:

- "Load" – the transfer function which models the motor shaft loading behavior. It contains the inertia moment J, and the dry friction coefficient B. Their calculus is presented in [4].
- "Wear" – the transfer function which models the viscous friction
- "Integrator" – integration block having the same role as the one presented at the d.c. motor model.
- "Angular position MPP" – output of the step motor [rad].
- "Command signal" – port which transmits the command impulse to the windings phase-shifted for each winding.
- "Winding 'n'" – where n represents the winding number is the subsystem obtained from the model presented in fig. 5.
- "Transmission" – represents the mechanical module of the step motor
- "Step motor transmission" – represents a reduction gear with a single pair of tooth gear, having the gear ratio of 1/3.

III.3 Functional model of the visual sensor

Two major aspects were taken into account while realizing the visual sensor model: perspective transformation and discreet character of the image acquisition.

The following characteristic values were defined for the perspective transformation:

- the distance from the sensor lens focus point to the Ox_0y_o plane of the end-effector: "D" (in functional model "dist")
- angle between the instant position of the optical axe of the visual sensor and the perpendicular from the lens focus to the robot axle "α" (in functional model named "alfa");