differentiation noise, the estimated value of $\dot{\alpha}$ is obtained from the Kalman filter with constant gain below

$$
\begin{align*}
\begin{bmatrix} \hat{\dot{\alpha}}_{m-1}(m) \\ \hat{\alpha}_{m-1}(m) \end{bmatrix} &= \begin{bmatrix} 1 & T \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \hat{\dot{\alpha}}(m-1) \\ \hat{\alpha}(m-1) \end{bmatrix} \\
\hat{\alpha}(m) &= \frac{\hat{\alpha}_{m-1}(m) + [TK_{P\alpha} \\ TK_{V\alpha}]}{[\alpha(m) - \hat{\alpha}_{m-1}(m)]} \\
\hat{\dot{\alpha}}(m) &= \frac{\hat{\dot{\alpha}}_{m-1}(m) + [TK_{P\alpha} \\ TK_{V\alpha}]}{[\alpha(m) - \hat{\alpha}_{m-1}(m)]}
\end{align*}
$$

where $\hat{\dot{\alpha}}(m)$ is the estimation of $K\dot{\alpha}$, and $T$ is the servo control period. By here, all the feedback information is obtained.

IV. EXPERIMENTAL RESULTS

The aim of this research is to endow a glass-cutting DD robot developed in our laboratory [2] with the ability of getting coordinates of the points on the drawing contour. A CCD camera is mounted on the end of the forearm. In order to speed up the image processing, a transputer-based parallel controller with four T800 chips is installed, such that acquisition of the working trajectory and the servo tracking by the robot can be carried out simultaneously. An image-grabbing card digitizes the video signals input by the camera and transmits them to the transputer through the links manufactured by the INMOS Company. It has a spatial resolution of 256 pixels × 256 pixels corresponding to a 26.4 mm × 26.4 mm field of view. With the above robotic system, it is commanded to track and then plots a circle with a radius of 198.5 mm on white paper. The dynamic parameters are the same as in [3], and the control parameters are selected to be $K_\alpha = 40.0$, $k_\alpha = 1.0$, $k_{P\alpha} = 0.2$, $k_{V\alpha} = 43.1$. Let the desired tracking speed $u = 150$ mm/s. The error curve for tracking one circle is demonstrated in Fig. 3. The average tracking speed does not change the performance much.

In the curve reproduction, since the discrete data recorded in the tracking procedure are polluted by the noise introduced in the tracking procedure, they cannot be used directly for path planning. Therefore, the discrete data recorded in the tracking procedure are preprocessed by using a Kalman filtering algorithm. Using the data preprocessed in the filtering (including the coordinates, the space velocity, and acceleration of the discrete points), the expected joint position, velocity and acceleration, and the feedforward compensation torque in every servo period can be calculated off-line based on kinematic and dynamic equations. The results of the planning are then fed into the controller to control the robot, so that it can reproduce the tracked curve. The final reproduction accuracy is less than 1 mm.

V. CONCLUSIONS

A visual servoing control scheme for drawing curve tracking has been proposed. The control is decomposed into tangential and normal directions of the curve. The velocity control in the tangential direction ensures smooth tracking, and the position control in the normal direction ensures tracking accuracy. Experiments are carried out on a SCARA-type DD manipulator. Stable tracking with high speed is realized in the case of a small field of view (26.4 mm × 26.4 mm).

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REFERENCES


John Chiasson and Robert T. Novotnak

Abstract—In the paper by Gökdere and Simaan, a comparison is made between a passivity-based controller and an input–output linearization controller. We point out that this comparison is not valid as the same trajectory was not used for both controllers.

Index Terms—Induction motor, input–output control, passivity control.

I. INTRODUCTION

In the above paper, the authors compare the performance of a passivity-based controller for induction motors to a controller based on input–output linearization given in [1]. The above paper repeatedly points out that the passivity-based controller does not estimate the motor flux compared to other controllers, including the input–output controller. It is also implied that the tracking error can be made smaller with the passivity-based controller. Unfortunately, we would like to thank the anonymous reviewers for their helpful comments.
Response to Comments on “A Passivity-Based Method for Induction Motor Control”

Levent U. Gökdere and Marwan A. Simaan

Abstract—Contrary to the claims made in the comments on our paper by Chiasson and Novotnak, there is experimental evidence demonstrating the benefits of the passivity-based controller developed for induction motors. These include closer tracking of the same mechanical trajectory, and less sensitivity to magnetic saturation, when compared with the input–output linearization controller.

Index Terms—Induction motor, input–output linearization method, passivity-based method.

I. INTRODUCTION

In the above comments, it is pointed out that the comparison in our paper2 between the passivity-based controller and the input–output linearization controller [1] for induction motors is not complete, since the passivity-based controller was not tested on the same mechanical trajectory used for the input–output linearization controller. It is also stated that there is no evidence demonstrating the benefits of the passivity-based controller.

First, contrary to what is mentioned in the above comments, we had no intention to present a comparison between the passivity-based and input–output linearization controllers. The main purpose of our paper was to show that the passivity-based controller is capable of providing close tracking of time-varying speed/position and flux trajectories without knowledge of the rotor electrical state variables, hence, overcoming the requirement for a state estimator.

Second, the claims made in the above comments are incorrect. There is indeed experimental evidence demonstrating the benefits of the passivity-based controller for induction motors over the input–output linearization controller.

II. A COMPARISON OF PASSIVITY-BASED AND INPUT–OUTPUT LINEARIZATION CONTROLLERS FOR INDUCTION MOTORS

In [2], the passivity-based controller was tested on the same experimental setup used for the input–output linearization controller [1], [3]. Most of all, for comparison purposes, the same time-varying speed/position and flux trajectories as in [3] were used. In the experiments, speed/position trajectories that require 90% of the maximum positive torque achievable by the motor under the voltage and current limits were considered. The results are summarized as follows.

1) The position tracking error obtained with the input–output linearization controller [3] reached the values as high as 0.14 rad (that is, 64 encoder counts), while the position tracking error obtained with the passivity-based controller [2] remained within 0.037 rad (or 17 encoder counts). In brief, the use of the passivity-based controller results in reduced position errors.

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L. U. Gökdere is with the Department of Electrical and Computer Engineering, University of South Carolina, Columbia, SC 29208 USA (e-mail: gokdere@ece.sc.edu).

M. A. Simaan is with the Department of Electrical Engineering, University of Pittsburgh, Pittsburgh, PA 15261 USA (e-mail: simaan@ee.pitt.edu).

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2 Even so, the division required in [1] could be avoided by simply using a lookup table of 1/\(\pi\), just as one uses sin/cos lookup tables.