GENERALISED MODEL-BASED CONTROL OF ROBOT MANIPULATORS

by

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TO

MY PARENTS

CERTIFICATE

I am satisfied that the Ph.D. thesis entitled **"Generalised Model-based Control of Robot Manipulators"** by Mr.S.R.Pandian is worthy of consideration for the award of the Degree of Doctor of Philosophy and is a record of the original bonafide research work carried out by him under my supervision. The results contained in it have not been submitted in part or full to any other University or Institute for the award of any Degree/Diploma.

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ABSTRACT

A well-known approach to the control of interconnected systems is to treat the interactions as disturbances and reject their effects by disturbance rejection methods. In this thesis, this approach is reformulated in a model following framework by treating the isolated subsystem as a model for the interconnected subsystem so that the stabilisation of the latter becomes a problem of model following.

In the context of robot trajectory and position control, the above approach provides a generalised model-based control methodology, by incorporating both manipulator and full-order dynamics in control, whereas a majority of existing algorithms in literature ignore the actuator dynamics completely. Flexibility is built into the control law design: depending on the complexity of the application (ranging from simple, low-speed, low-precision tasks to complex, high-speed, high-precision ones, involving direct or indirect arms), the manipulator dynamics can be treated as a disturbance, or compensated either off-line or on-line. The incorporation of nonlinear, time-variant actuator dynamics is straightforward.

Two non-adaptive control algorithms, viz., high gain and variable structure control, are derived as examples of continuous and discontinuous control methods. The problem of

chattering in variable structure control is minimised by replacing the discontinuous control in the vicinity of the sliding mode with a continuous high gain control.

Two adaptive control algorithms are proposed on the basis of the new approach. In adaptive feedback control, the feedforward compensation is fixed and the error feedback gains are adapted. In adaptive feedforward control, the feedback gains are fixed, and the feedforward compensation is adapted using a linear-in-parameters formulation of the full-order actuator-manipulator dynamics.

It is shown that the manipulator `model-based control´ methodology is a special case of the new approach. The proportional-derivative (PD) independent joint control, feedforward control and computed-torque control are special cases of the proportional-derivative-acceleration (PDA) control methods based on third-order motor and manipulator model. Under the control laws proposed in this thesis, however, a trade-off between smaller derivative and acceleration gains on the one hand and reduced speed of response on the other is feasible. The algorithms offer scope for appro- ximations based on physical considerations and facilitate extension of model-based robot control to a range of other problems such as coordinated-arm control and flexible manipulator control.

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