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FAULT DETECTION OF ACTUATORS AND CHANNEL TRANSMISSION USING VIRTUAL SIMULATION

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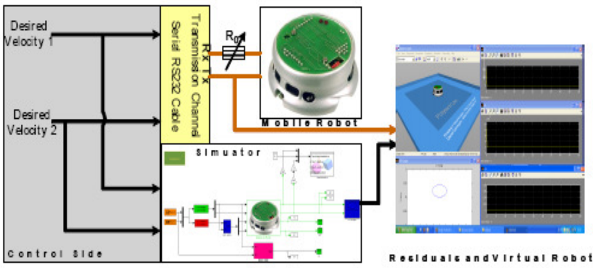
Abstract: This film describes the co-simulation aspect between virtual and real robots, for detection and isolation of actuators and transmission channel faults.

1. INTRODUCTION

In this film, a Co-simulation between a virtual and a real mobile robot is presented. It concerns the on line telediagnosis of transmission channel and actuators faults of a mobile robot. Two innovated points are given through this work: the first concerns the transmission channel which is considered as an uncoupled system, modelled separately from the robot model, and concatenated to this latter for the FDI algorithm synthesis. The second point relates to the development of a virtual simulator which can work in parallel with the real robot. The interest of this simulator is its ability to inform the system supervisor of any transmission and/or actuators faults, without being closer to the real system.



2. MODEL OF GLOBAL SYSTEM

In this section, the modelling of the transmission channel and the miniature mobile robot is presented.

2.1 *Robot Modelling*

The model of the robot is given by:

$$\begin{cases} \begin{pmatrix} \ddot{u} \\ \ddot{\alpha} \\ \ddot{\theta}_1 \\ \ddot{\theta}_2 \end{pmatrix} = \begin{pmatrix} 0 & 0 & \frac{-fm}{m} & 0 \\ 0 & 0 & 0 & \frac{-f_z}{I_z} \\ \frac{-f_1}{J_1} & 0 & 0 & 0 \\ 0 & \frac{-f_2}{J_2} & 0 & 0 \end{pmatrix} \cdot \begin{pmatrix} \dot{u} \\ \dot{\alpha} \\ \dot{\theta}_1 \\ \dot{\theta}_2 \end{pmatrix} \\ \quad + \begin{pmatrix} \frac{1}{m} & \frac{1}{m} & 0 & 0 \\ \frac{d}{2I_z} & \frac{-d}{2I_z} & 0 & 0 \\ \frac{-R}{J_1} & 0 & \frac{1}{J_1} & 0 \\ 0 & \frac{-R}{J_2} & 0 & \frac{1}{J_2} \end{pmatrix} \cdot \begin{pmatrix} F_{x1} \\ F_{x2} \\ U_1 \\ U_1 \end{pmatrix} \\ \begin{pmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \end{pmatrix} = \begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \dot{u} \\ \dot{\alpha} \\ \dot{\theta}_1 \\ \dot{\theta}_2 \end{pmatrix} \end{cases} \quad (2.1)$$

Where: F_{x1} and F_{x2} are respectively the longitudinal efforts, U_1 and U_2 are the control inputs, m is the robot mass, f_1, J_1, f_2, J_2 are respectively the viscous friction parameters and the inertias of the two wheel actuators, f_m, f_z are the viscous friction and the flexion parameters of the robot. $\ddot{u}, \ddot{\alpha}, \ddot{\theta}_1, \ddot{\theta}_2, \dot{u}, \dot{\alpha}, \dot{\theta}_1, \dot{\theta}_2$ are the longitudinal, the yaw and the two rotational accelerations and velocities of the wheels.

2.2 *Transmission Channel Modelling*

The studied serial cable is modelled by a *RLC* cell. Its correspondent elements are identified experimentally

$$\begin{cases} U_0 = U_1 + \frac{R_l}{2}.I_0 + \frac{L_l}{2}.\dot{I}_0 \\ I_0 - I_1 = C_l.\dot{U}_1 \\ U_1 = U_s + \frac{R_l}{2}.I_s + \frac{L_l}{2}.\dot{I}_s \\ U_s = R_f.I_s \end{cases} \quad (2.2)$$

with: l the channel length, R_l, L_l and C_l are respectively the resistance, inductance and the capacity of the cable of length l and they are estimated experimentally according to the cable material' nature. R_f is the internal robot impedance and U_0, U_s are respectively the input and output cable voltages which are experimentally measured.

3. FAULT DETECTION AND ISOLATION ALGORITHM

The FDI proposed approach is based on the calculation of the residuals issued from the Analytical Redundancy Relation (ARR) and it makes the difference between the dynamic system in normal and faulty situations. The expressions of the residuals will not be shown here because of constraints on the number of pages.

4. FILM DESCRIPTION

Three parts are composing this film.

The first part is called 'desired trajectories', where the applied robot velocities are chosen to make a circular trajectory. A model based virtual simulation shows the exact trajectory tracking, while the robot with its link is following the trajectory in parallel.

The second scenario is about including an actuator fault for wheel 1, where an appropriate velocity profile is chosen in order to simulate in reality this studied fault. A Cartesian X-Y robot coordinates shows the virtual robot tracking through this applied fault. This fault will be removed by reconfiguring the input fault velocity requirement as it is shown in the film. The generated residuals indicate the fault detection and isolation. Then, the robot is repeating approximately the same simulator trajectory.

The third scenario concerns the cable fault, by varying the cable transmission resistor (potentiometer), then the robot continue its trajectory according to the old input requirement, because the whole regulators are located inside the robot system.