

Identification of the Dynamic Parameters of NaVARo, a parallel robot with multiple actuation modes

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The identification of the dynamic parameters of a 3-DOF planar parallel manipulator with multiple actuation modes, called NAVARO, is the purpose of this paper. Conversely to classical parallel robots, a transmission system permits to the robot to change the location of its actuated joints and thus changes its kinematic and dynamic performance. For the identification of the dynamic parameters of the NAVARO, the continuous acceleration blends method for trajectories with via points is used. Then, its dynamic parameters are identified for two actuation modes through some simulations and experiments. Finally, the robot dynamic model is improved with the identified parameters and experimental results show the quality of the new model.

Extended abstract

A drawback of serial and parallel mechanisms is the inhomogeneity of the kinetostatic performance within their workspace. For instance, dexterity, accuracy and stiffness are usually bad in the neighbourhood of singularities that can appear in the workspace of such mechanisms [1]. Nevertheless, it is difficult to come up with a large operational workspace free of singularity.. As the singularity loci depend on the actuation scheme, the NaVARo has eight actuation modes thanks to three double-clutch systems located at the first revolute joint of each leg. (Figure 1).



Fig. 1: The NAVARO prototype

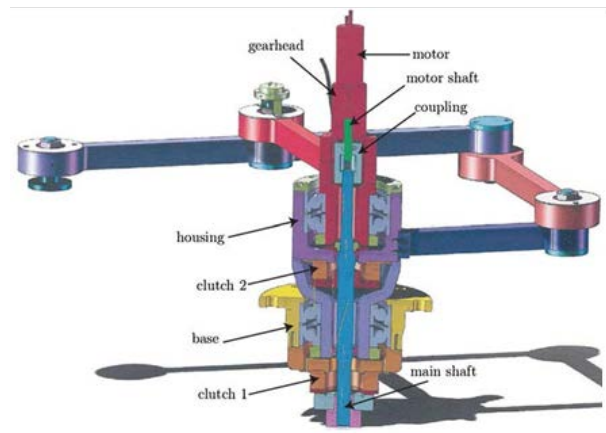


Fig. 2: The NAVARO transmission system

Each transmission system has four actuation schemes, namely, (i) None of the brake is active; (ii) Brake 1 is active; (iii) Brake 2 is active; Both brakes are active. By activating only one brake per leg, the robot admits eight actuation modes (Figure 2) [2].

The dynamic models of the legs are expressed as a function of the generalized coordinates, obtained using the classical method for serial robots, while the dynamic model of the platform is expressed as a function of its Cartesian coordinates, obtained by Newton-Euler approach giving the total wrench exerted on the platform. The leg dynamic model is the same for all the legs because NAVARO has three identical legs. The first step is to open the closed loop chain of the leg, leading to the equivalent tree structure. As shown in Fig. 3, the chosen cut

joint is E_i . In this figure a frame is attached to each joint following the Modified Denavit-Hartenberg convention [3].

The dynamic model of the equivalent tree structure has been obtained with SYMORO+ [4], together with the evaluation of the base inertial parameters, which allow us to reduce the computational cost when using the dynamic model and are the only identifiable parameters. Table 1 shows the base inertial parameters of the equivalent tree structure. Then, the platform dynamic model is computed using the Newton-Euler equations. Finally, both models are computed and can be projected into the active joint space.

j	XX_j	XY_j	XZ_j	YY_j	YZ_j	ZZ_j	MX_j	MY_j	MZ_j	M_j	Ia_j
1	0	0	0	0	0	ZZR_1	0	0	0	0	0
2	0	0	0	0	0	ZZ_2	MX_2	MY_2	0	0	Ia_2
3	0	0	0	0	0	ZZR_3	0	0	0	0	0
4	0	0	0	0	0	ZZ_4	MX_4	MY_4	0	0	Ia_4

Tab. 1: Base inertial parameters of the equivalent tree structure

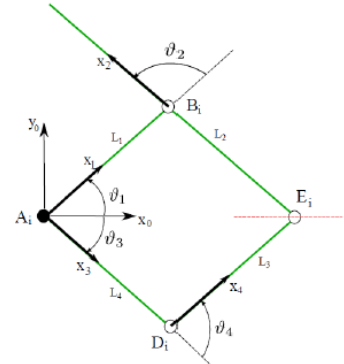


Fig. 3: A leg of the NAVARO prototype

To perform the identification of the parameters, we are using continuous acceleration blends as it provides better robot performance. The robot does not have to stop in via points and the trapezoidal velocity model used to connect the via points is smoothed by the continuous acceleration blends. For the dynamic parameter identification, an off-line procedure is used based on the method introduced in [3]. The identification of the dynamic parameters has been performed for two different actuation modes that amount to 3 $-RRR$ and 3 $-RRR$ parallel manipulators. The friction model used is composed of Coulomb and viscous friction together [5].

Conclusions

This paper dealt with the identification of the dynamic parameters of the NAVARO for two actuation modes, showing a good accuracy in both cases not only for the identified trajectory but for general trajectories too. Some simplifications were made to assess that the four joints of each leg have the same properties. Thus, the effect of friction is present mainly in the motorized joints, being negligible in the passive joints. It was also shown that the simplification of the dynamic model does not affect the accuracy of the torque estimation of the robot at hand and can be kept in order to reduce the computational burden.

References

- [1] J. P. Merlet. Parallel Robots, second edition. Springer, INRIA, Sophia-Antipolis, France, 2006.
- [2] N. Rakotomanga, D. Chablat and S. Caro. Kinetostatic Performance of a Planar Parallel Mechanism with Variable Actuation. Advances in Robot Kinematics: Analysis and Design, pages 311-320, 2008.
- [3] W. Khalil and E. Dombre. Modeling, Identification and Control of Robots. Elsevier Butterworth Heinemann, 2004.
- [4] W. Khalil and D. Creusot. SYMORO+: A system for the symbolic modelling of robots. Robotica, 15:153-161, 1997.
- [5] N. Farhat, V. Mata, A. Page, Francisco Valero. Identification of dynamic parameters of a 3-DOF RPS parallel manipulator. Mechanism and Machine Theory 43, 2008.