POLITECNICO DI TORINO

Dipartimento di Automatica e Informatica

PhD in Computer and Control Engineering

XXXI cycle

Supervisor

Prof. Vito Cerone

Data-Driven Control System Design with Application to Automotive Problems

PhD Candidate: Mohammad Abuabiah

1. Introduction

Significant research efforts have been devoted in recent years to the problem of designing a control system, under the assumption that a mathematical model for the plant is not available. In particular, several interesting results have been obtained through the **direct data-driven controller** (DDDC) design approach, that is the direct design of the controller from a set of input-output experimental data characterizing the plant behavior. The control specifications are usually given in this context in terms of a desired closed-loop reference model; then, the controller parameters are computed by formulating the problem in terms of model matching design, as shown in Fig. 1.

2. Research goal

The aim of this PhD research activity is to investigate novel approaches to effectively solve the DDDC design problem by properly exploiting recent results obtained in the framework of set-membership identification. Suitable convex relaxation techniques have been exploited to efficiently solve the optimization problems arising from the set-membership formulation of the DDDC problem.

3. A non-iterative approach to direct data-driven control design

1) **From model matching error to output signal matching error:** block diagrams equivalence.

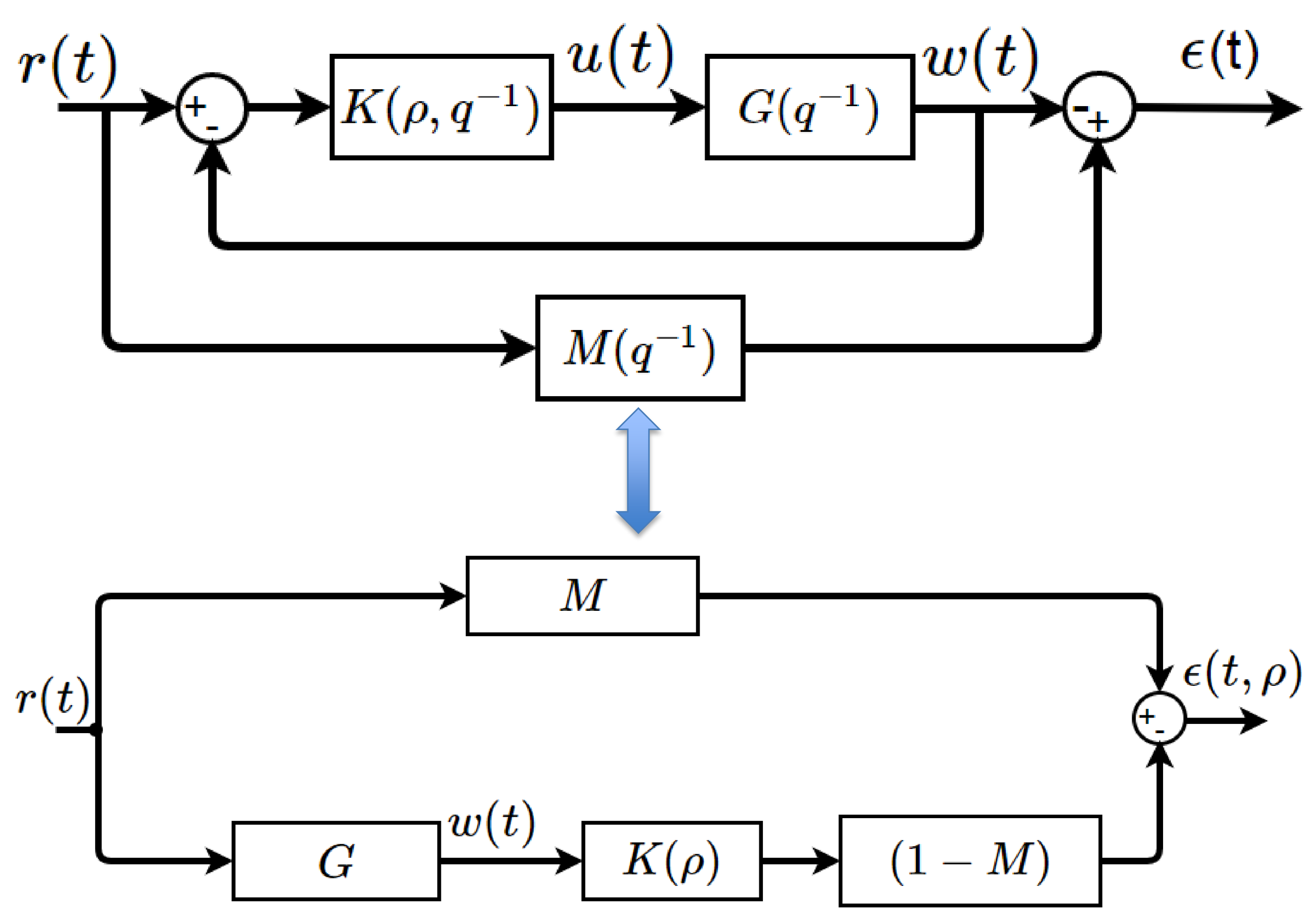

Fig. 1 General Scheme of DDDC design approach

2) **From model matching error to output signal matching error:** mathematical equivalence.

a) $E(\rho,q^{-1}) = M(q^{-1}) - \frac{K(\rho)G(q^{-1})}{1+K(\rho,q^{-1})G(q^{-1})} = 0$

b) $\epsilon(\rho,q^{-1}) = M(q^{-1})r(t) - \frac{K(\rho,q^{-1})G(q^{-1})}{1+K(\rho,q^{-1})G(q^{-1})}r(t) = 0$

c) $M(q^{-1})(1 - M(q^{-1}))^{-1}r(t) = K(\rho,q^{-1})w(t),\ \forall r(t)$

3) **Two original set-membership based design approaches:**

- **Fixed structure controllers**: direct design by means of set-membership errors-in-variables identification via convex relaxation ([1],[2]).
- **Nonparametric controllers**: simultaneous direct design and controller structure selection via kernel-based set-membership identification ([3]).

4. Dual-dry clutch transmission system

The obtained design algorithms has been applied to the problem of controlling the slipping speed of a dual clutch transmission system (project in collaboration with Fiat Chrysler Automobiles (FCA) and Centro Ricerche Fiat (CRF)) [4].

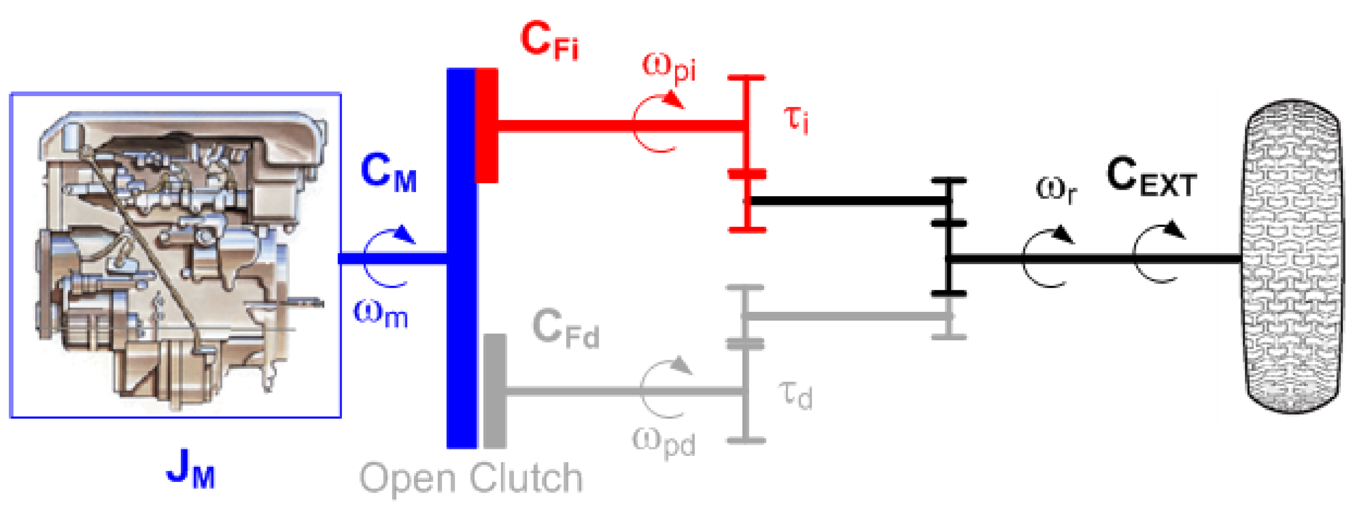

Fig. 2 Dual-Clutch Transmission System

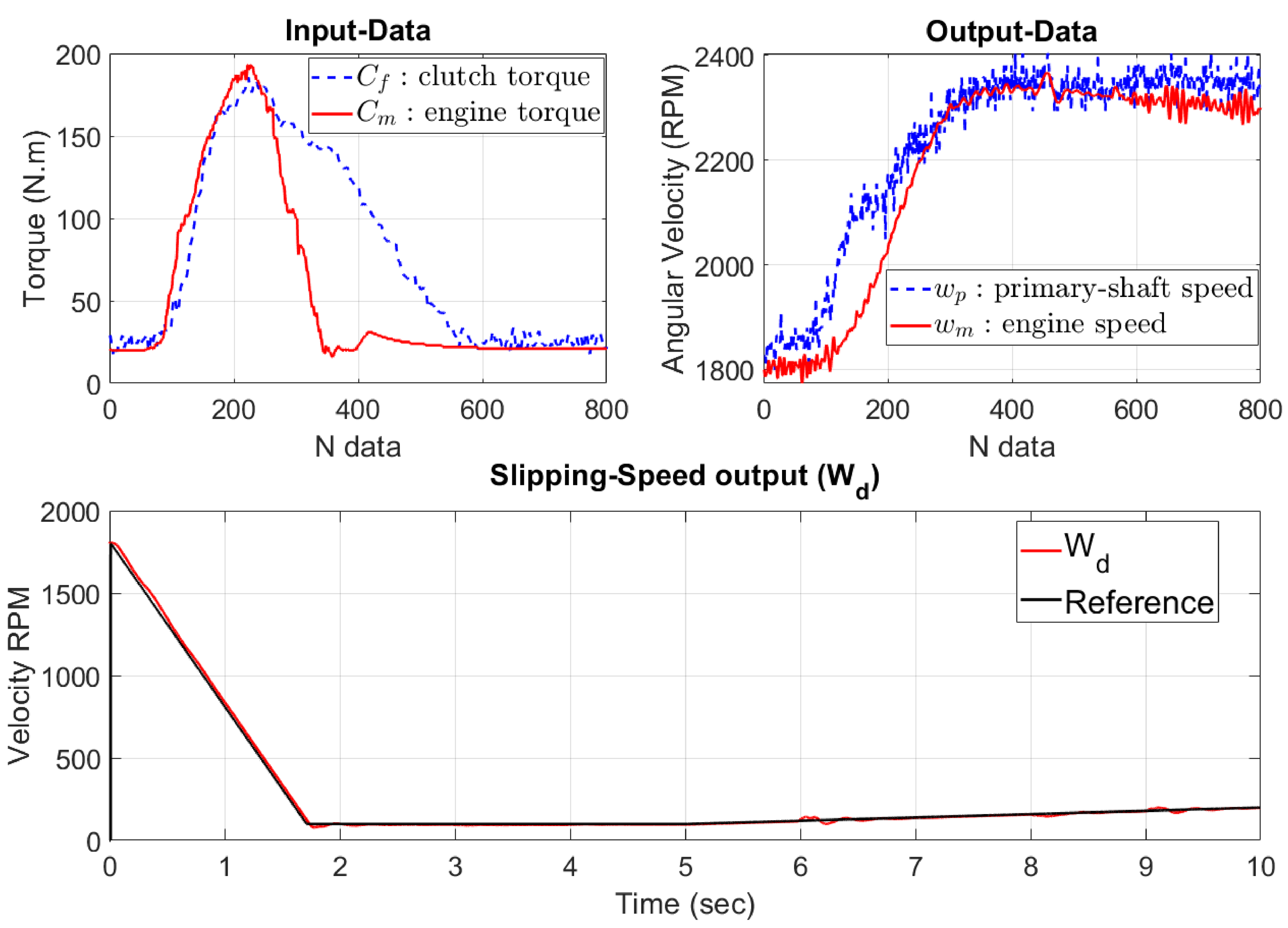

Fig. 3 Main Results

5. References

1. V. Cerone, D. Regruto, **M. Abuabaiah**, "Direct data-driven control design through set-membership errors-in-variables identification techniques", IEEE American Control Conference (ACC), May-2017 (pp. 388-393).
2. V. Cerone, D. Regruto, **M. Abuabiah**, "A set-membership approach to Direct Data-Driven Control design for non-minimum phase plants", proc. of 56th IEEE Conference on Decision and Control (CDC). December-2017 (pp. 1284-1290).
3. V. Cerone, D. Regruto, **M. Abuabiah**, E. Fadda, "A kernel-based nonparametric approach to direct data-driven control of LTI systems", proc. of 18th IFAC Conference on Symposium on System Identification (SYSID). July-2018 (pp. 1026-1031).
4. V. Cerone, D. Regruto, and **M. Abuabiah**, "Set-membership identification of a dry-clutch transmission model", proc. of IEEE Conference on Control Technology and Applications (CCTA). August-2017 (pp. 1159-1164).