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Engine Knock Margin Estimation Using In-Cylinder Pressure Measurements

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Abstract:

Engine knock is among the most relevant limiting factors in the improvement of the operation of spark-ignited engines. Due to an abnormal combustion inside the cylinder chamber, it can cause performance worsening or even serious mechanical damage. Being the result of complex local chemical phenomena, knock turns out to have a significant random behavior but the increasing availability of new on-board sensors permits a deeper understanding of its mechanism. The aim of this paper is to exploit in-cylinder pressure sensors to derive a knock estimator, based on the logistic regression technique. Thanks to the proposed approach, it is possible to explicitly deal with knock random variability and to define the so-called margin (or distance) from the knocking condition, which has been recently proven to be an effective concept for innovative knock control strategies. In a model-based estimation fashion, two modeling approaches are compared: one relies on well-known physical mechanisms while the second exploits a principal component analysis to extract relevant pressure information, thus reducing the identification effort and improving the estimation performance.

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I. Introduction and Motivation

The combustion process in SI engines is normally triggered by the spark, whose timing is accurately defined in order to achieve the desired engine performance. In particular engine operating conditions, a too early spark timing may cause an abrupt unburned mixture (end-gas) self-ignition, due to the high-temperature and pressure conditions reached inside the cylinder chamber. This event is usually termed knock, recalling the typical metallic sound caused by the shock waves generated by the spontaneous detonation of the air/fuel mixture. Such an event limits the improvement of engine performance, being responsible for some undesirable effects: while it can cause serious cylinder damages, less dramatic consequences are powertrain oscillations, a

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