Adaptive predictive vibration control in vehicular rear view mirrors

Antoine Larchez
University of Wollongong

Adaptive Predictive Vibration Control in Vehicular Rear View Mirrors

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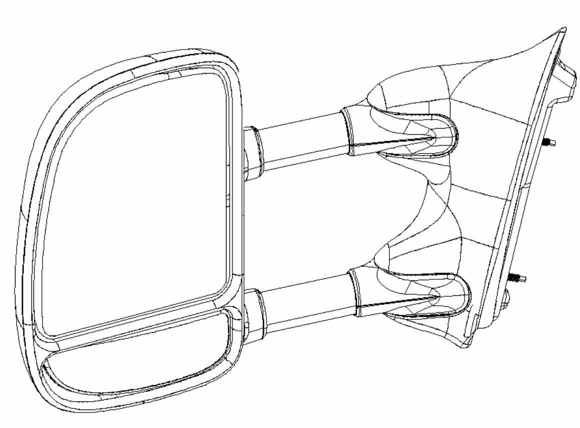

By

Antoine Larchez

Diplôme d'ingénieur (Equ. M.EE), E.S.I.E.E. Paris, France, 2002
DEA, Paris VI University, France, 2002

SCHOOL OF ELECTRICAL, COMPUTER AND
TELECOMMUNICATIONS ENGINEERING

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DECLARATION

This is to certify that the work presented in this thesis was carried out by the author in the School of Electrical, Computer and Telecommunications Engineering at the University of Wollongong, and has not been submitted to any other university or institute.

Antoine Larchez

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ABSTRACT

Reduction in rear view mirror vibration has been identified as a research and development priority by large automotive mirror manufacturers, such as Schefenacker Vision Systems Australia Pty Ltd (SVS), the industrial partner of this project. Mirror vibration, particularly in luxury and heavy vehicles, has proved to be a major source of complaints received from the customers. Such vibration may result in image blurring and the loss of rear vision. This can adversely affect the driver, the control of the car, and the safety of the driver and the passengers. The vehicle mirror vibration is also generally perceived to indicate the poor quality of a vehicle.

Mirror glass vibration is primarily caused by wind as the result of the motion of the vehicle. The structure-borne vibrations also contribute to vibration by affecting the mirror's housing. The vibration intensity will depend on parameters, such as the roughness of the road, the engine speed, and wind intensity. Under some circumstances, the image provided by the mirror is not indicative of the true conditions behind the car, which can lead to incorrect perception and to driver misjudgement, resulting in the increased risk of an accident.

The main focus of this thesis is to investigate the feasibility of developing an intelligent active vibration controller capable of maintaining a sharp reflected image under all driving conditions. An adaptive predictive controller is proposed. As an adaptive method, the proposed system can generate a control signal, according to the driving conditions, to cancel the vibration. The predictive characteristics of the approach can minimise the effect of delay between the measurement of the vibration signal and the generated control signal.

An extensive review of the literature relevant to rear view mirrors, measurement techniques and active control of noise and vibration is carried out. The nature of the mirror vibration based on the road data is obtained empirically and statistically characterised. In order to develop and validate the vibration compensator, a number of experimental rigs are designed and developed.

In a rigorous and systematic approach, a number of active vibration techniques are developed and validated through computer simulation and experimental work. The structure of nearly all of these algorithms is based on internal model control, where the actual disturbance signal is reconstructed analytically. The control structures include at least one variant of the FxLMS adaptive filter in different configurations. The results of modelling and validation are systematically recorded in the thesis.

The results obtained show that the methodologies proposed in this study, outperform the conventional controllers in reducing vibration levels in rear view mirror.

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ABBREVIATIONS

ADC	Analogue-to-Digital Converter
ANVC	Active Noise and Vibration Control
ARMAX	Auto-Regressive Moving Average with eXogenous input
ARX	Auto-Regressive with eXogenous input
AVC	Active Vibration Compensation/Control
AVI	Active Vibration Isolation
BOM	Bill of Materials
CVA	Canonical Variable Algorithm
DAC	Digital-to-Analogue Converter
EMI	Electromagnetic Interferences
ER	Electro-Rheological
FIR	Finite Impulse Response
FxLMS	Filtered-x Least Mean Square
FxRLS	Filtered-x Recursive Least Square
IIR	Infinite Impulse Response
IMU	Inertial Measurement Unit
IV	Instrumental Variable
LIVM	Low Impedance Voltage Mode
LS	Least Square
LVDT	Linear Variable Differential Transformer
MOSFET	Metal-Oxide Semiconductor Field Effect Transistor
MR	Magneto-Rheological
NVH	Noise, Vibration and Harshness
OE	Output-Error
PEM	Prediction Error Method
PWM	Pulse Width Modulation
PZT	Lead Zirconate Titanate
RBS	Random Binary Signal
RGS	Random Gaussian Signal
RMS	Root Mean Square

RPM	Rotation-per-Minute
RTW	Real-Time Workshop
SM	Subspace Method
SS	State-Space
SUV	Sport-Utility Vehicle
UOV	Unexplained Output Variance