NOISE REDUCTION IN CONTROL SIGNALS OF INDUSTRIAL SEWING MACHINES USING ADAPTIVE FILTERING

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Degree of Master of Science

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DECLARATION

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ABSTRACT

Control signals of a typical industrial sewing machine are distorted when they are connected to the controller. Such distortions due to noise appear at the input port of the control signals and they are, in general, non-stationary signals. Furthermore, access to the controller of an industrial sewing machine is restricted. Therefore, such distortions cannot be attenuated using classical adaptive filters such as Wiener filters. In this dissertation, an adaptive algorithm is developed in order to solve this challenging problem. Here, an additive inverse of the distortion is generated and added to the control signals so that the distortion is significantly attenuated. In order to generate the additive inverse of the distortion, the Normalized Leas-Mean Square (NLMS) algorithm is employed as the adaptive algorithm with an external reference signal. In general, the error signal to the filter is the estimation of the signal, However, based on the nature of the adaptive filtering problem, the NLMS algorithm is formulated in a way that, the error signal to the filter is the difference between the noise signal and the estimated noise signal. The experimental results obtained with the control signals of a typical industrial sewing machine confirm that the proposed method effectively attenuates the distortion signal with fast convergence of the NLMS algorithm.

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LIST OF ABBREVIATIONS

AC	Alternating Current
ECG	Electrocardiogram
EMI	Electromagnetic Interference
EMG	Electromyography
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
I-O	Input-Output
LMS	Least Mean Square
NLMS	Normalized Leas-Mean Square
rpm	Revolution Per Minute
VFD	Variable Frequency Drive

LIST OF MATHEMATICAL OPERATOR NOTATIONS AND SYMBOLS

$e[n]$	Discrete-time error input signal
$E\{r\}$	Expected value of scalar r
h	window length of adaptive Wiener filter
N	Length of a signal
p	Adaptive filter order
T	Sampling period
$u[n]$	Discrete-time input signal of the external controller
$\mathbf{v}$	External reference input signal vector
$v(t)$	Continuous-time distortion of the input signal
$v[n]$	Discrete-time distortion of the input signal
$\hat{v}(t)$	Continuous-time estimated distortion of the input signal
$\hat{v}[n]$	Discrete-time estimated distortion of the input signal
$v_1(t)$	Continuous-time external reference input signal of the adaptive filter
$v_1[n]$	Discrete-time external reference input signal of the adaptive filter
$\mathbf{w}$	FIR adaptive filter coefficient vector
$x(t)$	Continuous-time input signal of the sewing machine
$x[n]$	Discrete-time input signal of the sewing machine
$\tilde{x}(t)$	Continuous-time distorted input signal of the sewing machine

$\tilde{x}[n]$	Discrete-time distorted input signal of the sewing machine
$\hat{x}[n]$	Discrete-time estimated input signal of the sewing machine
$\mathbf{x}^T$	Transpose of vector **x**
$z[n]$	Discrete-time input signal of the sewing machine
β	Normalized step size of the NLMS adaptive filter
Δv	Smallest voltage span of the input signal
ϵ	Small positive parameter used in NLMS algorithm
$\nabla\xi[n]$	Gradient of $\xi[n]$ with respect to **w**
$\xi[n]$	Mean square error
μ	step size of the LMS adaptive filter
ρ	Sample correlation coefficient