Abstract

In the context of engine vibration monitoring, we address the specific problem of modelling the shaft rotation speed and show first that the rotation period can be modelled as a random process, and then that this model can help improve signal processing algorithms. Indeed in steady-state as well as in nonstationary regime this rotation speed randomly fluctuates around a central trend which can hinder traditional signal processing tools such as the periodogram (cf [2]). To illustrate this, in this article we design a simple engine vibration simulator and test simple angular resampling and evaluate the contribution of fluctuations to the periodogram. A second, more speculative idea, that we start tackilng is to assess the effect of several kinds of damage (gearmesh or bearing damage, foreign object ingestion) on this noise, thanks to ou model.

The data under study are provided by SNECMA and come from the tachometer and the accelerometer of a civil engine. The tachometer is usually used as a keyphasor pulse to interpolate evenly-sampled vibration data and carry-on computer order-tracking. Here it will allow us to find the precise duration of each low-pressure shaft rotation cycle. The vibration data $z(t_k)$ come from an embedded accelerometer and delivers acceleration data sampled at 51,2 kHz.

Firstly, we extract the period length of each low-pressure shaft cycle which we note $p(n)$. Here we notice experimentally that even for nonstationnary data, the sample pdf of the first difference of the cycle length $p(n)$ has a normal law shape. This observation justifies an ARIMA modelling of the time series (see [1, chap.9]): thanks to several classical model selection criteria and to the relevant identification algorithm, we fit such an ARIMA model to $p(n)$.

Then we generate synthetic signals thanks to the parameters we have just estimated. We justify why working on period rather than frequency turns out to be more adapted to the generation of an artificial signal. We compute the periodogram of the obtained signal with different types of cycle fluctuation, and observe the consequences on the periodogramn, which could not be done with real signals. This allows us to select a resampling algorithm as a test case.

Lastly we repeat this process for several damage types, and visualize the obtained parameters in an appropriate space and discuss the existence of consistent clusters.

References

[1] P.J. Brockwell and R. Davis. *Time series: theory and methods. 2nd ed.* Springer, 1991.

[2] K. R. Fyfe and E. D. S. Munck. Analysis of computed order tracking. *Mechanical Systems and Signal Processing*, 11(2):187 – 205, 1997.