Kriging interpolation of periodic phenomena hidden in strain signal measured on hydraulic turbine runner at steady-operating conditions

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Abstract: Stress levels play an important role in the fatigue reliability evaluation of hydroelectric turbine runners. However, due to high costs and time required for the instrumentation, the experimental strain measurements on runners are limited. Thus, we cannot completely obtain the dynamic stress applied on runners over all the possible operating conditions, which could lead to an inaccurate evaluation of fatigue damage. Therefore, our research aims to use existing data measured by strain gauge to interpolate the unknown or not measured information about runner stress at all the steady states of hydroelectric turbines. At steady-operating conditions, a strain signal, measured on the runner, can be separated into two principal components: periodic and stochastic. The periodic phenomenon hidden in the signal is linked with synchronous rotation speed of the turbine and is extracted by the synchronous average method as the first order cyclostationary components. This paper presents the first step of our research that extracts and interpolates this periodic part at steady-operating states. A case study is used to compare two different kriging interpolation methods: the Spatial Kriging Method (based on 2D variogram) and the Spatio-Temporal Kriging Method (based on 3D variogram). The initial parameters are obtained from the strain gauges installed on a Francis turbine runner measured over a set of steady operating conditions. The interpolation results are then compared and validated in this paper with the experimental values. Finally, recommendation is proposed to select the most suitable method for further interpolations of other complex components of runners strain signals such as the non-synchronous and stochastic ones.

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