Strain mapping-based SHM for an UAV through avionics-based classification and FBGs

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Within the context of structural health monitoring (SHM) based on strain mapping, stiffness changes (local or global) are related to damage occurrence. However, stiffness variations can also be caused by a change in the section's inertia induced by changes in operational conditions (e.g. the change of pitch of a wind turbine blade or aircraft wing). In SHM methodologies based on data-driven models, baseline models for pristine condition must be built and then, using pattern recognition techniques, it is possible to infer changes among such baselines and data for unknown structural condition in order to detect damages. In this context, decoupling the effects on stiffness changes produced by the operational conditions from those produced by the damage occurrence is necessary to build more specific models where both effects do not overlap. This paper presents a classification methodology based on avionics variables for a UAV instrumented with several FBGs, accelerometers, gyroscopes, air speed sensor, GPS among other avionics sensors, for which, several flights were performed for a pristine state and for a damaged condition with induced positive artificial damages. The classification methodology allows building n independent baselines for a discrete number of operational conditions. This allows decoupling the effects produced by changes in operational conditions from those caused by damage. By using PCA, n models are built. In a subsequent stage, data for indeterminate conditions are projected into one of the n models according to the similarity between the avionics variables related to the model and those related to data for unknown condition. Finally, the Q index and detection thresholds are calculated and from these, it is possible to infer if the unknown data belongs to a damaged condition or to an undamaged condition. The results obtained showed that the classification technique based on avionics data is robust, accurate and has a low computational cost, allowing discriminating damages in more than 95% of cases.