Impact Detection and Identification in Sensorized Structures by Neural Network Processing of Dynamic Transient Histories

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ABSTRACT

Structural Health Monitoring (SHM) comprises multiple technologies based on the development of smart materials and the incorporation of sensor networks into modern structural designs [1]. In particular, the detection of impact events has become a major challenge for the engineering community due to the severe damages that external menaces can induce in structures: this is the case of airframe components exposed to impact of birds, runway debris, ice, failed engine fragments or tool drop, this latter being the main cause of Barely Visible Impact Damage (BVID) in composites during the manufacturing and assembly stages. Thus, notable efforts are being devoted to the effective monitoring of dynamic transient responses of impacted structures. Experimental tests with sensorized specimens subjected to ballistic impacts are being carried out and correlated with explicit finite element analysis (FEA), with special emphasis on the damage patterns produced by frangible projectiles in materials specifically suited for aerospace applications [2][3].

This work prospects the use of Artificial Neural Networks (ANN) with supervised learning procedure to identify the severity of an impact event (in terms of projectile velocity and angle of incidence) from the dynamic transient histories gauged at discrete points within the structure. The training set is built with Abaqus / Explicit FE simulations of spherical projectiles shot against metallic plates characterized with Johnson-Cook plasticity and damage models. A Bernstein collocation technique [4] is used for the reduction of the sampled data histories down to a selectable number of coefficients. The investigation focuses on the accuracy of the predictions provided by the ANN-FEA scheme and on the sensitivity and robustness of the algorithm versus unavoidable perturbing noise [5] present in the in-service operative conditions of the predictor system.

REFERENCES

[1] D. Balageas, C.-P. Fritzen and A. Güemes (Eds.), *Structural Health Monitoring* (Vol. 493), ISTE Ltd, London, UK, 2006.

[2] J.D. Seidt, J.M. Pereira, J.T. Hammer, A. Gilat and C.R. Ruggeri, “Dynamic load measurement of ballistic gelatine impact using an instrumented tube”, NASA Report NASA/TM—2012-217661, XII International Congress and Exposition on Experimental and Applied Mechanics, Costa Mesa, California, June 11–14 (2012).

[3] A.S. Yaghoubi and B. Liaw, “Thickness influence on ballistic impact behaviors of GLARE 5 fiber-metal laminated beams: experimental and numerical studies”, *Compos. Struct.*, Vol. **94**(8), pp. 2585–2598 (2012).

[4] D. Garijo, "Free vibration analysis of non-uniform Euler–Bernoulli beams by means of Bernstein pseudospectral collocation", *Eng. Comput.*, Vol. **31**(4), pp. 813–823 (2015).

[5] V. Ramírez, J. Hermida, D. Huertos, B. Sánchez and D. Garijo, "An assessment of the effect of random noise in the frequency measurements of a vibration-based SHM system with Artificial Neural Network damage predictor", 8th European Workshop On Structural Health Monitoring (EWSHM 2016), 5-8 July 2016, Bilbao, Spain.