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NEURAL NETWORK ASSISTED GA OPTIMIZATION OF BONDED COMPOSITE JOINTS

E. G. Arhore[1*], M. Yasaee [2], and I. Dayyani[3]
School of Aerospace, Transport and Manufacturing, Cranfield MK43 0AL, UK
edore.arhore@cranfield.ac.uk

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1 General Introduction

The stride to improve lightweight properties in the aerospace and automotive industries have led to the attraction of replacing bolted joints with adhesively bonded joints [1]. The advantages of using this bonded include improved stress distribution and reduced weight among others [2]. In recent times, it has become increasingly important to study these bonded joints to improve their overall properties.

The strength of these joints is dependent on the geometry of their adherends [3] among others. These multiple dependents have resulted in research focusing on singular sections for analysis and or optimization. Different optimization techniques have been used in carrying out this analysis including topology optimization (TOP) [3], shape optimization [4] and parametric studies method [5] among others.

A study performed by [3] has shown that the strength of the joint is dependent on the geometry of the outer adherend. This includes the adherend thickness [6] and overlap length [5] among others.

The purpose of this study is to perform an evolutionary algorithm optimization process while capturing the different failure mechanisms available in an adhesively bonded joint. Most optimization processes performed to date are focused on the elastic properties of the structure. Although some studies have been performed with the inclusion of plasticity, very few studies have included damage mechanisms. The study would also be performed with the aid of artificial intelligence to minimize computational costs.

2 Methodology

The evolutionary algorithm genetic algorithm (GA) was used to carry out this analysis. A legacy optimization process was performed using the GA in collaboration with finite element analysis (FEM). The flow chart of the legacy optimization process is shown in Fig. 1. For this process, the GA toolkit on MATLAB was used in collaboration with ABAQUS explicit. The objective function was set to maximize the strength of the joint. This was performed by carrying out a FEM analysis on the joints. The design variable defined the geometry of the outer adherend.

The optimal joint design obtained from the legacy optimization methods was classified as the Bayes value or target for NN assisted optimization process. The optimization process was performed again using a modified process as shown in Fig. 2. The modification allowed for the inclusion of artificial intelligence (AI) to speed up with optimization process without negatively affecting the results. For this process, the FEM analysis was only carried out for validation when the AI predicts a high strength value for the joint.

3 Results

3.1 L Joint

Fig. 2 shows the optimal strength value obtained from the legacy optimization (Bayes value) compared with the NN assisted values. The results showed that the NN assisted GA optimization process was able to produce a better optimal joint design after retraining. The legacy optimization process required a total of approximately 77 hours averaged over 12 attempts in terms of computational cost. This value was reduced to an average of 12 hours with the inclusion of AI. This equates to about 85% computational cost reduction showcasing the potential gain while performing complex optimization processes.

3.2 T Joint

The optimization process was also performed on a more complex joint which comprised of 3 intersection composite inner adherends and a metallic outer

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adherend. Fig. 4 shows the results obtained from the legacy optimization process and compares them with the NN assisted values. The results obtained are similar to those described in section 3.1. The AI-assisted process provided approximately an 80% drop in computational cost without negatively affecting the results. However, for this case, the legacy optimization process produced the global optimal strong and thus the AI-assisted process did not produce an improved structure.

3.3 Figures and Tables

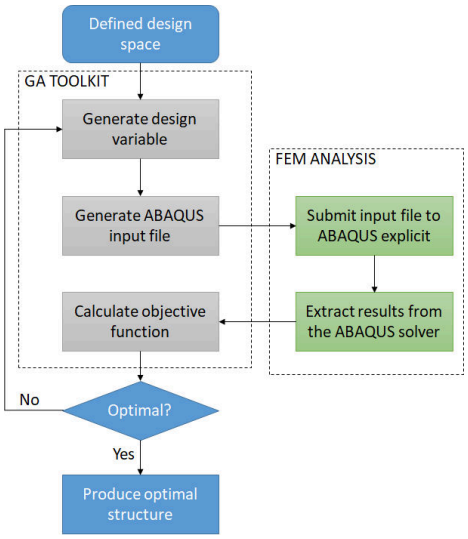


Fig. 1 Legacy optimization flowchart

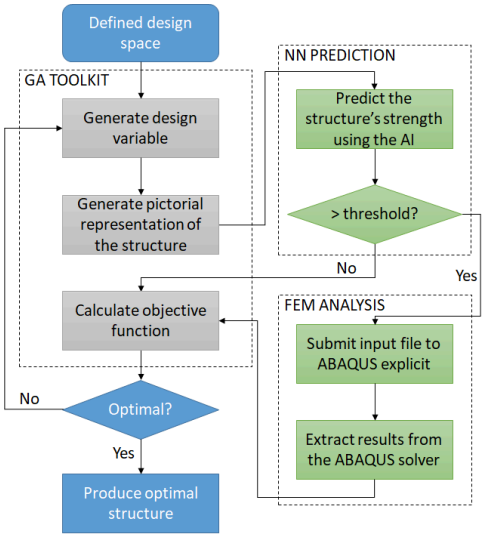


Fig. 2 NN assisted GA optimization

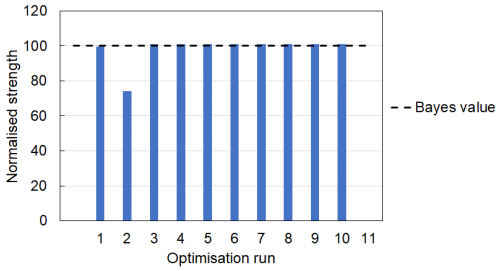


Fig. 3 Optimization results from NN assisted optimization of L joint

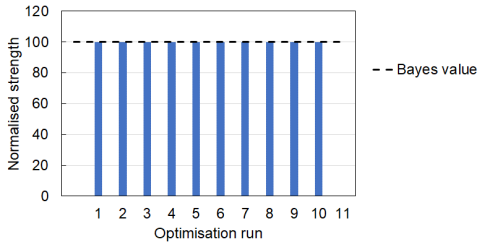


Fig. 4 Optimization results from NN assisted optimization of T joint

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Arhore, Edore G.; Yasaee, Mehdi; Dayyani, Iman

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École Polytechnique Fédérale de Lausanne (EPFL) Infoscience

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