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GRADIENT-BASED PIPE ROUTING TOOL FOR AERO-ENGINES

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ABSTRACT

The aerospace industry is constantly striving to make aircrafts lighter, stronger, and more cost effective. The redesign of structural parts is well studied with computational tools such as topology optimization, commercially available to designers which, when given a list of requirements, produce results that improve performance and reduce the design cycle time. Today's aircrafts use complex piping networks to connect various components throughout the engine. Pipe routing is typically a manual and iterative process completed by design engineers without the help of an industry standard tool to automatically generate routes. Given an initial pipe network design, the design process typically goes through several redesign and validation cycles until all requirements are met. Requirements may be performance related, such as structural stiffness and natural frequency, while others may be cost related, such as overall mass and number of elbows used. The goal of this work is to develop a tool capable of producing a single optimal pipe route considering length and structural compliance. This will be the foundation for future pipe routing algorithms which will produce entire pipe networks considering all design requirements stated above. That is, given engine CAD, pipe connection locations, and structural/frequency requirements, the tool will produce the optimal routing design. The proposed tool models a pipe route using the elbow locations as design variables. Keep-away zones are generated from CAD geometry and from this a penalty function is created to ensure routes stay within feasible regions. An initial pipe route is generated using an algorithm which geometrically finds short routes using only the penalty function. Gradient based optimization is then applied to minimize length and over-all compliance, subject to user defined geometric constraints and enforced displacements. The tool, when applied to a simplified engine chassis geometry, showed it can effectively generate routes that avoid obstacle geometry while meeting specified constraints. Future extensions with capabilities such as modal analysis, route branching, and the ability to handle multiple routes at once, will make this tool ideal for the holistic design of complex pipe routing for industry applications.

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