**A continuum damage model for fatigue and its integration scheme**

Description of Research

In material science, fatigue refers to the gradual weakening of a material caused by repeatedly applied loads, which, if undetected, will eventually lead to catastrophic failure. Experimental effort on recording the fatigue life of one material usually includes hundreds of iterations of trial and error, making it extremely expensive and time-consuming. Therefore, the **goal** of this work is to develop and demonstrate a versatile and efficient numerical fatigue model to alleviate the high cost of fatigue experiments, and to validate its accuracy by reproducing experimental results.

This work originated from two ideas: (1) regard fatigue and static damage (i.e., weakening of a material caused by one continuously increasing load) as one unified failure mechanism to reduce the sole reliance on fatigue experiments; (2) improve traditional fatigue computation methods with a mathematical integration algorithm to achieve balance between accuracy and efficiency. Based on the first idea, **continuum damage mechanics** is modified such that the evolution of damage depends not only on the magnitude, but also on the frequency of the applied load. To accomplish the second idea, the so-called **Bulirsch–Stoer method**, an algorithm originally designed for computing differential equations, is implemented and extended to offer accuracy control during fatigue simulation.

This work is **innovative** because: (1) it is one of the earliest efforts to directly relate static damage behavior with fatigue; (2) it is the first to introduce a rigorous numerical method previously only adopted in mathematics to fatigue prediction.

Involvement and Importance

I will be presenting this work as the first author at the American Society for Composites 33rd Annual Technical Conference. It is the first-year conclusion of a project supported by the U.S. Army Research Laboratory. The project aims at developing a user-friendly fatigue analysis tool for composite materials. The continuation of the current work will place focus on implementing the proposed model into commercial software and documenting fatigue behavior of various composite materials.

I have been **involved thoroughly** in this project over the course of the past year. I derived the present fatigue model based on a static damage model, previously developed by a post-doctoral researcher in my group. After that, I played a leading role in numerically realizing the model, selecting and implementing integration algorithms, and designing validation and demonstration examples. I am also responsible for reporting progress during the project’s monthly meetings.

Presenting and publicizing this work will have a **significant impact** on my PhD study, as it will be an essential and concluding part in my PhD dissertation. Suggestions and critique from both researchers and experts in the industry will help broaden my horizon, provide context for improvements, and ensure this work’s relevance. I look forward to representing Purdue University with this invaluable opportunity.