CompositesAI™

An AI-Powered Expert System for Composites

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OVERVIEW **CompositesAI consolidates and delivers expert knowledge through LLMs fine-tuned for composites. It delivers answers with authority of world-leading experts and precision of advanced simulation codes.**

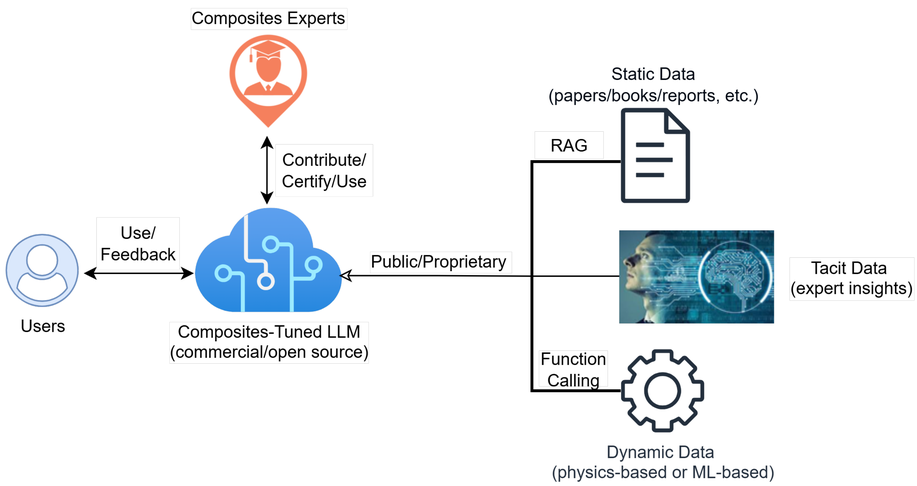
Challenges

➢ Access to data and resources

- ❑ Static data: technical papers, books, reports, database, etc.; siloed and disparate sources
- ❑ Dynamic data: physics-based models, machine learning models; disconnected and not available for entire supply chain
- ❑ Expensive computing hardware and software
- ❑ Some in public domain (commercial or free) and some proprietary

➢ Access to talent

- ❑ Most composites engineers lack formal training in the field. Composites-related typically courses taught at graduate level
- ❑ PhDs needed for executing sophisticated composites software for reliable simulation
- ❑ PhDs trained in narrow subdomains, multiple PhDs needed for the entire production workflow, not affordable for lower tiers of the supply chain (SMEs)



Solutions by CompositesAI

➢ Large language model (LLM)

- ❑ Leverages general knowledge, intelligence, and natural language processing capabilities of LLM
- ❑ Is designed to be LLM-agnostic, ensuring seamless integration with emerging and advanced models
- ❑ Delivers highly technical knowledge through intuitive, natural language chat prompts

➢ Retrieval-augmented generation (RAG)

- ❑ Consolidates multimodal, publicly available static data using a federated vector database
- ❑ Optimizes RAG by applying best practices in data storage, chunking, retrieval, and ranking
- ❑ Intelligentizes proprietary corporate knowledge within a private and secure environment

➢ Function calling

- ❑ Integrates simulation software through APIs
- ❑ Enables automatic execution of simulation codes and linking them into seamless workflows
- ❑ Democratizes simulation by chats, eliminating complexity of preparing inputs and interpreting outputs
- ❑ Performs parametric studies and optimization automatically, requiring simple prompts without extra coding

➢ Human-in-the-loop reinforcement learning

- ❑ User provides questions and feedbacks
- ❑ Admin reviews user feedbacks and assign experts to reviews
- ❑ Expert reviews feedbacks and generates new knowledge as structured questions-pairs
- ❑ CompositesAI updates with the new knowledge

➢ Versatile front end

- ❑ Signup/Login using email, Google, Microsoft, or LinkedIn
- ❑ Ask questions using text or voice in your own language
- ❑ User can provide detailed responses including numerical score, reason, and text comments
- ❑ Different users can access to different customized models

➢ Ecosystem for community development

- ❑ Powerful workspace allows expert to create their own AI assistants (private, or shared with others)
- ❑ Model-agnostic design allows experts to experiment with different models
- ❑ A marketplace for all the agents developed by experts.
- ❑ User-friendly interface for experts to submit knowledge & tools

PURDUE UNIVERSITY

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Composites Manufacturing & Simulation Center™

A Typical Use CASE (Simulation using Prompts)

An engineer needs to determine the relative difference between the longitudinal and transverse shear moduli of UDFRC but lacks the expertise to operate FEA-based multiscale software such as SwiftComp. CompositesAI bridges this gap by allowing engineers to obtain accurate results without needing to learn or run complex simulation codes. By understanding the engineer's intent, CompositesAI identifies the appropriate computational tool, gathers the necessary inputs through natural, intuitive prompts, and delivers results efficiently and precisely.

for a unidirectional fiber reinforced composites, I would like to know G13 and G23, do you have a tool to help me compute it?

CompositesAI

Yes, I have a specialized tool that can compute the shear moduli G_{13} and G_{23} (as well as other engineering constants) for unidirectional fiber-reinforced composites. This tool requires the following inputs:

Fiber and matrix elastic properties (E, ν or full set if anisotropic)
Fiber volume fraction
Packing arrangement (e.g., hexagonal, square)

If you provide:
Fiber modulus (E_f) and Poisson's ratio (ν_f)
Matrix modulus (E_m) and Poisson's ratio (ν_m)
Fiber volume fraction (V_f)
Packing type (default is hexagonal if not specified)

I can obtain G_{13} and G_{23} for your system. Please supply the above inputs or confirm if you want to use prior examples.

isotropic fiber with E=300 GPa, nu=0.3; isotropic matrix with E=20 GPa, nu =0.4, hexagonal, Vf=68%

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View Result from **homogenize_elastic_constants**

For a unidirectional fiber-reinforced composite with isotropic fibers ($E_f = 300\,\text{GPa},\ \nu_f = 0.3$), isotropic matrix ($E_m = 20\,\text{GPa},\ \nu_m = 0.4$), hexagonal packing, and a fiber volume fraction of 68%, the calculated shear moduli are:

$G_{13} = 28.86$ GPa
$G_{23} = 31.58$ GPa

These values are computed using physics-based homogenization methods appropriate for your specified microstructure and constituent properties.

Your numbers are a bit high. Try Ef = 231 GPa, Poisson's ratio of the fiber is 0.35. Em = 4 GPa, Poisson's ratio of matrix is 0.3.

CompositesAI

View Result from **homogenize_elastic_constants**

For a unidirectional fiber-reinforced composite with the following properties:

Isotropic fiber: $E_f = 231\,\text{GPa}, \nu_f = 0.35$
Isotropic matrix: $E_m = 4\,\text{GPa}, \nu_m = 0.3$
Hexagonal packing, fiber volume fraction $V_f = 68\%$

The computed shear moduli are:

$G_{13} = 7.50\,\text{GPa}$
$G_{23} = 7.21\,\text{GPa}$

These values reflect a physically realistic shear response for your specified composite system.

Powering the Global Composites Community

cdmHUB Community

- **Vision:** to be the premier resource for composites design and manufacturing
- **Mission:** to convene and serve the global composites community by creation, education, evaluation, and sharing of resources for composites design and manufacturing
- **Features:** AI-human Interactive Platform
  - Powered by Discourse, a modern forum software leverage strengths of technical forum and social media
  - Message and chat with CompositesAI, individuals, or groups
  - Directly connects with CompositesAI so it can engage deep technical discussions with others

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