

AI: What's New for Design?

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Panel "Designing with Intelligence: Exploring the Promise and Challenges of AI in Aerospace"

2024 SciTech Forum, 9 January 2024, Orlando FL

Terms

- Historical origin "**intelligence**" in all versions of AI:
  - Initial premise: build artificial mind.
  - "Intelligence" → target functional domain – problems traditionally solved only by humans: e.g., visual recognition, natural languages.
- **Strong AI:**
  - "AI" evokes AGI: the putative ability of software to duplicate/exceed all intellectual abilities of a human, hypothetically requiring sentience and consciousness. Think Mr. Data.
  - Claims of AGI hints appearing…
- **Weak AI:**
  - Attempts to implement a part of mind.
- **Narrow AI:**
  - Not concerned with mind. Focused on a specific task.
  - Siri ∈ {narrow AI}; natural language processing, in a context.
- **Machine Learning:**
  - Often conflated with AI, as in "AI/ML".
  - ML≠ AI; ML ∈ {AI tools}.

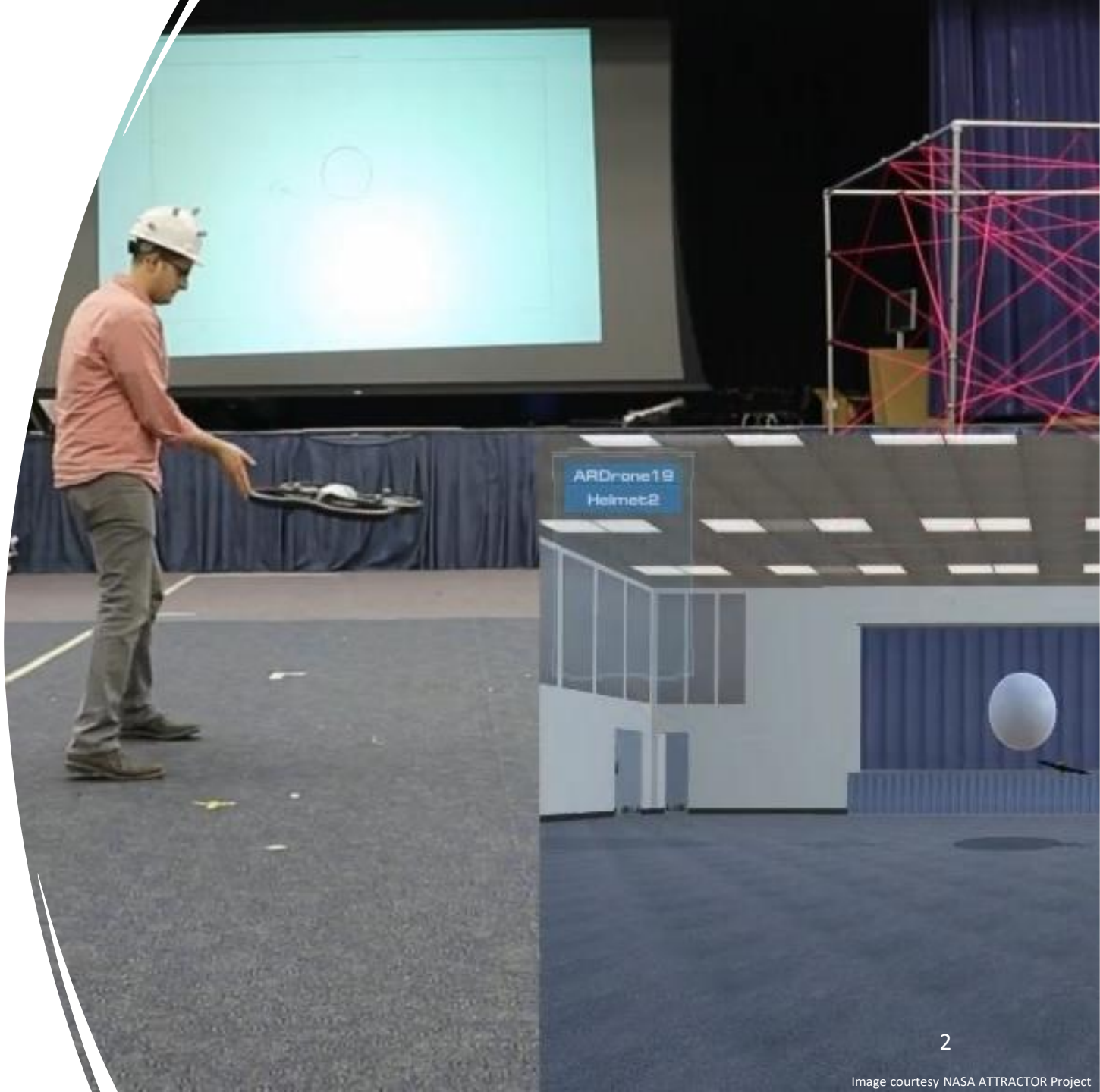
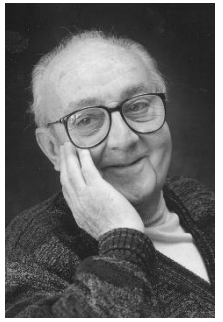


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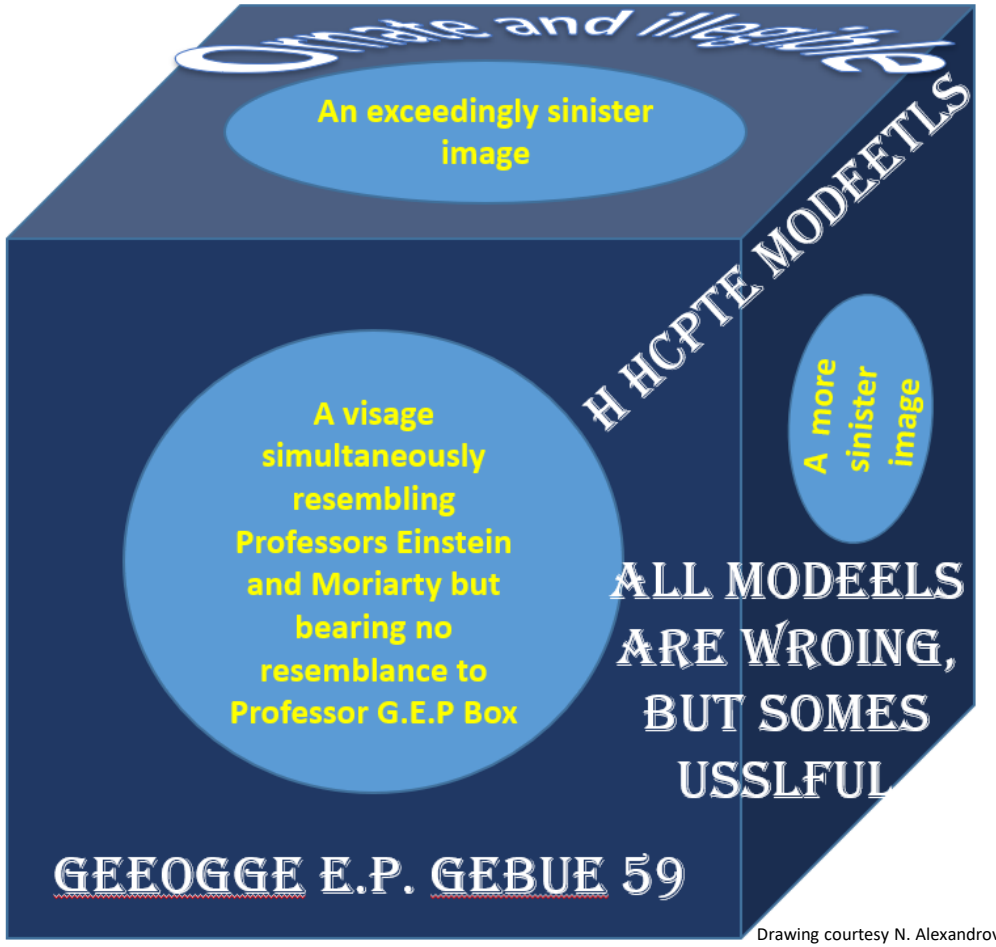
G.E.P. Box, Photo by DavidMCEddy at en.wikipedia, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=14941622



General Facts, "Theorems", Trends

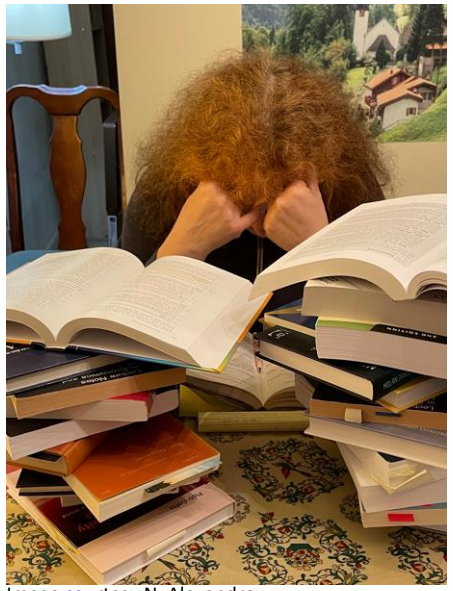
- **All ML algorithms are data-fitting approximators.**
  - Not a new concept.
  - New: computing power and availability of data.
  - But statistical nature is unchanged.
- **Large Language Models (LLM) are not about truth.**
  - LLM are about a statistically most probable next entity.
  - Current putative hints of AGI (e.g., spontaneous creation of internal world models) do not change the statistical nature of the approximator.
- **"Theorem":** Safety-critical systems must not rely on ML for decision-making, for the foreseeable future, given the lack of fundamental safety envelopes.
- **"Theorem":** In human-machine interactions (HMI), under-reliance or over-reliance are well known and almost certain.
  - Current risk: over-reliance; adversely impacts competence and ultimate decision-making ability.
- **Current trend:** focus on explainability
  - IMO, a less productive direction than establishing safety envelopes

Response to my request "generate a photo-realistic image of George E. P. Box with the quote 'All models are wrong, but some are useful' under his image".



Drawing courtesy N. Alexandrov

Narrow AI and ML Use by Functions during Design


Image courtesy N. Alexandrov

Extra! Extra! Read all about it!

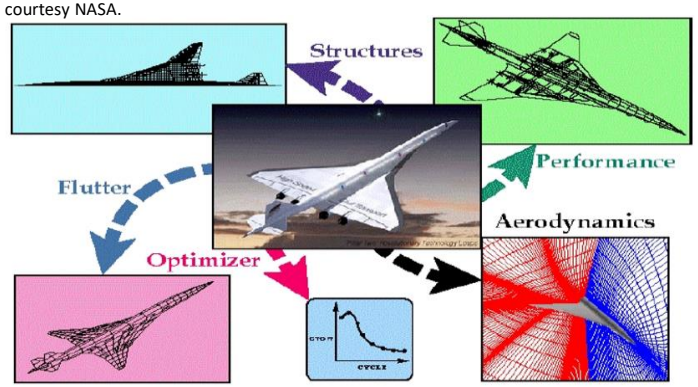
- AlphaTensor finds new tensor decomposition algorithms that improve on record times for matrix multiplication for special cases.
- The nature of the problem is combinatorial search; well suited.
- Qualitatively new algorithms – still an open problem.

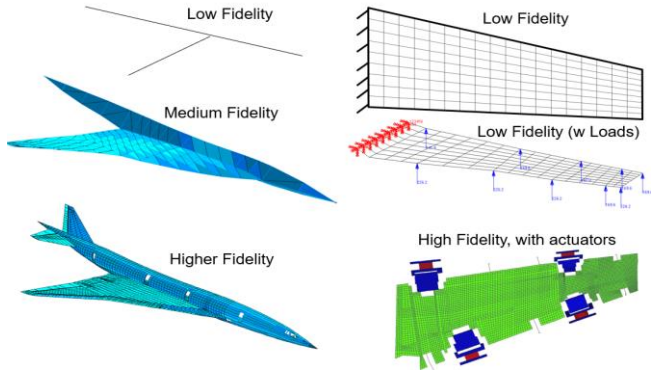

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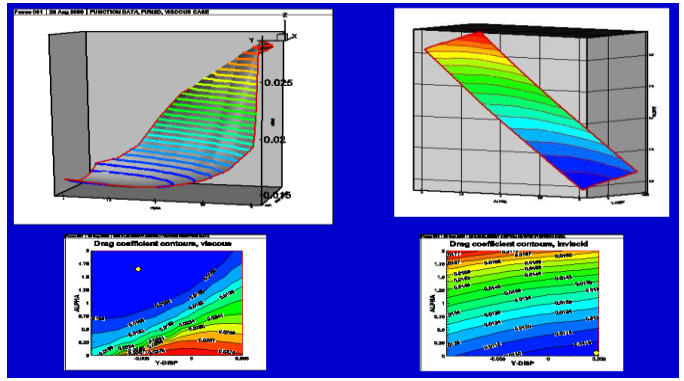
- LLM: Literature Search and SOA Assessment
  - Excellent tool.
  - Well-known: checking required, as usual.
  - Recent NASA crowdsourcing campaign for an "AI Research Assistant"; custom-made functions.
- LLM: Concept/Idea Generation
  - Check for similar ideas. Risk: privacy.
  - New idea requests: nothing new, as expected. Useful for combinatorics. Risk: potential for identical outputs.
  - Useful for a look into other domains.
- ML: Concept/Idea Generation
  - Deep subject matter needed to pose and represent the problem.
- LLM: Requirement Elicitation
  - Useful in real-time tuning, deepening, and coordination of questions for subject matter experts.
  - Useful in real-time generation of back-of-the-envelope images, in support of requirement elicitation. Risk: function may be curtailed.
  - Simultaneous use of multiple AI for various POV.

Narrow AI and ML Use by Functions during Design, cont.

All images courtesy NASA.







Mathematical Λ Computational Problem Formulation

- Future: rapid assembly and analysis of formulation alternatives
- Future: adversarial development of formulations with feedback to requirement elicitation:
  - "Why didn't you include this variable?
  - "Did you think of including that constraint?"
  - "What algorithms are available for this formulation?"
  - "Is the formulation tractable?"
  - "What will sensitivity analysis look like for this formulation?"
  - "What models are available for the functions represented?"
  - …

Computational Analysis

- Physics-based modeling remains.
- ML models of human behavior may be useful.
- ML assists in algorithm discovery, coding, performance improvement, risk/uncertainty assessment, model fidelity selection for the context.

Computational Design

- Add more "M" to MDO (Multidisciplinary Design Optimization), including operations and operators.
- Selection of optimal formulation-analysis-optimization strategies.
- Improved strategies for multiobjective optimization (e.g., via inverse reinforcement learning).
- Develop rigorous MDO for late-stage (detailed) design.

In Conclusion

- Unprecedented complexity of future environments.
- Challenge: knowledge / model representation amenable to analysis and computation.
- Understand and manage ML uncertainties, V&V.
- Understand where AI and ML models are truly beneficial.
- AI: advisor, controller, or autonomous agent?
  - In human-machine systems, both human and AI must be part of design *ab initio*, not just a matter of a nice interface.
  - Who/what makes the ultimate decisions in what context?
  - **H**MI fraught with risks (e.g., reduction in competence, inability to take over when needed).
  - When is complete machine autonomy necessary?
- One take-away suggestion: do not relinquish critical faculties (ever) or yield authority to "AI" unless AI is provably trustworthy in an appropriate context, and the transfer is necessary.



Image courtesy N. Alexandrov



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