Carnegie Mellon University

AI Engineering

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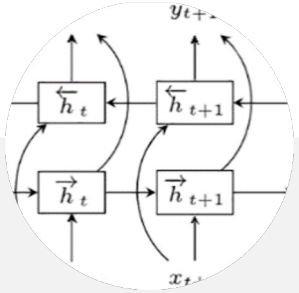
From Sci-Fi to Algorithm to Engineered System

AI in Pop Culture



AI as an Abstract Concept

AI in the Physical World

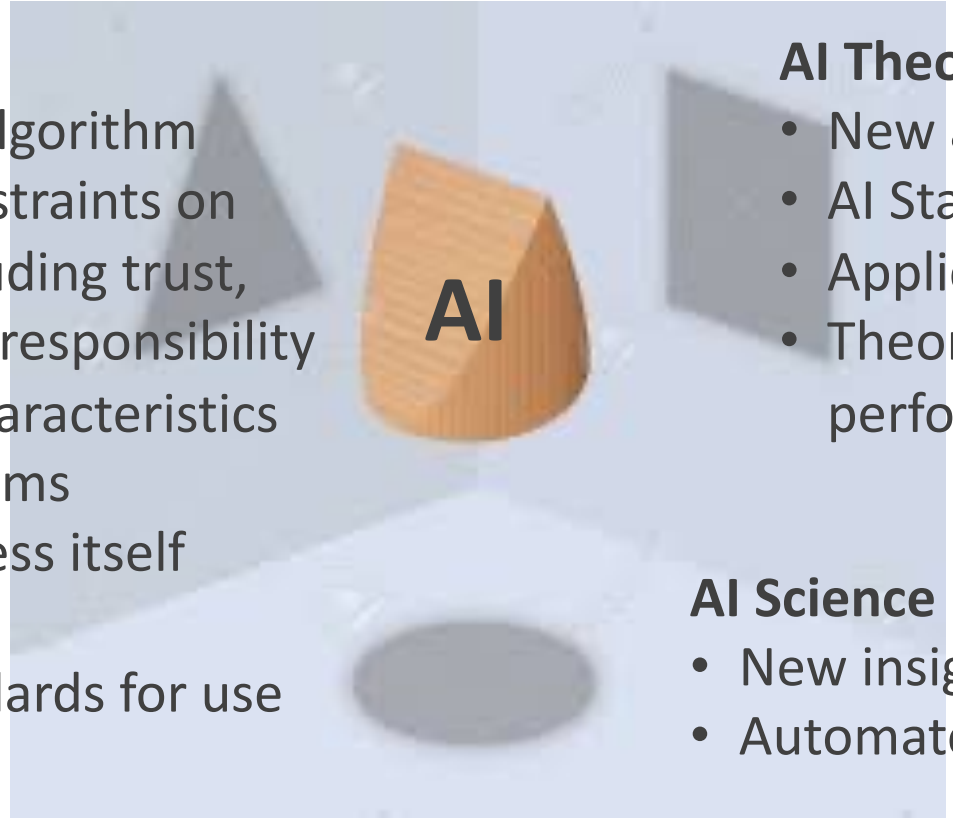
From fantasy to algorithm

From algorithm to engineered system

Artificial Intelligence: Three sides of one “coin”

AI Engineering

- Applications require algorithm performance and constraints on system behavior, including trust, safety, resiliency, and responsibility
- Engineered system characteristics enable better algorithms
- The engineering process itself is transformed
- Development of standards for use of AI



AI Theory

- New algorithms and theory
- AI Stack
- Applications inform theory
- Theoretical bounds and performance

AI Science

- New insights and discoveries
- Automated experiments

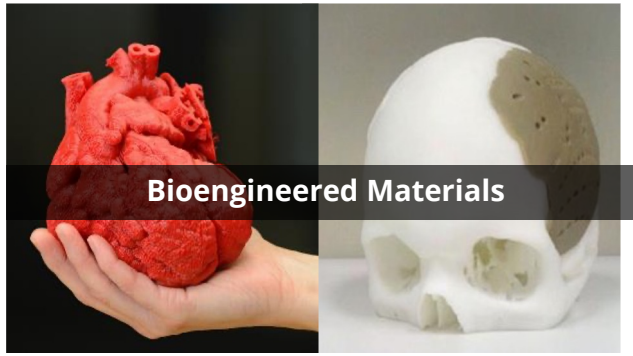
AI Engineering Principles

Realizing the potential of AI depends not just upon new advances in AI algorithms and technology

— *it depends critically on the Engineering of AI into systems*

- AI must be engineered in from the start, not bolted on, for it to be effective
- Domain expertise is key and provides a basis for developing AI algorithms and technology that use system characteristics to work dramatically better
- Solutions must be developed within ethical constraints that ensure system scalability, efficiency, robustness, equity and trustworthiness

AI Engineering will transform all engineering disciplines



AI Engineering

Orchestrate the entire life-cycle of AI-enabled engineered systems,

from design to sustainable deployment and operation,

combining domain knowledge with data-driven insights to improve system function.

AI Engineering Pillars

Engineering of AI mechanisms

Redefining the Engineering Discipline with AI

AI in Engineered Systems

Teaching AI Engineering

Engineering of AI Mechanisms

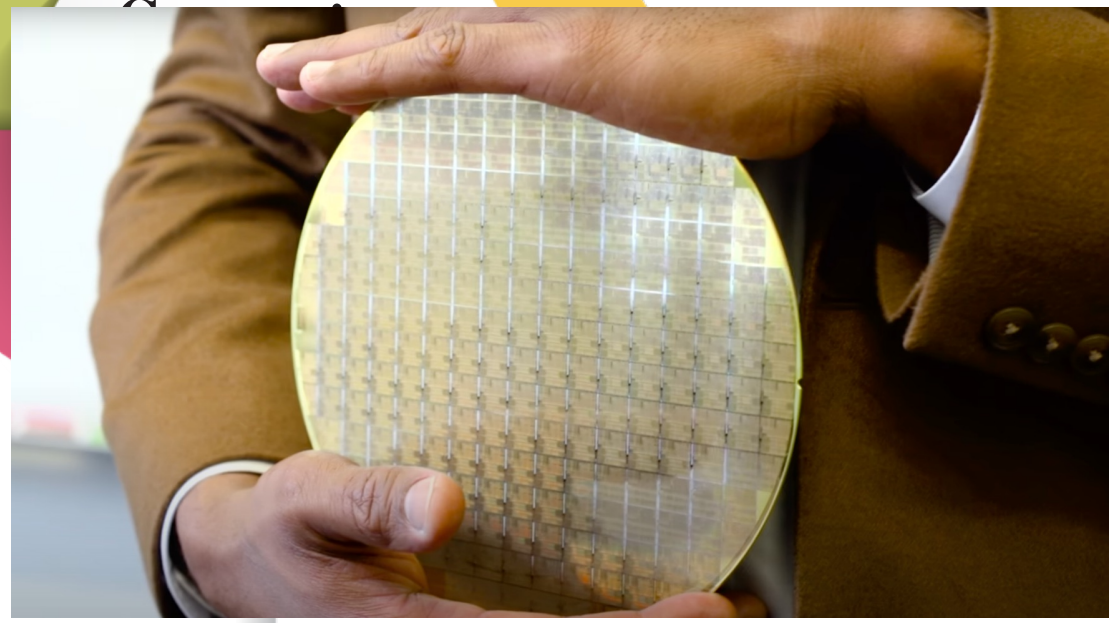
Engineering compute, sensors, architectural constructs, specialized algorithms and software to orchestrate AI into systems

Hardware for AI

- Network computing architecture serving as a bridge between edge devices and the cloud
- IoT applications can be hosted with advanced security, robustness, performance, and privacy guarantees

Security & AI

- Data driven networking and security
- Data transparency in the absence of trust
- Usable Privacy & Security



AI in Engineered Systems

Build AI-orchestrated products and services that are more functional, safe, secure and resilient

20 Million Patients in USA Suffer Limb Paralysis

- To restore motor function after stroke, CMU is leveraging AI/ML to electrically stimulate neural networks in spinal cord
- Data used to learn representation of stimulation parameters conditioned on muscle activity, joint-torque, and movement
- Use the nonlinear, state-dependent neuromuscular system as model constrains to generate stimulation parameters for targeted biomechanics

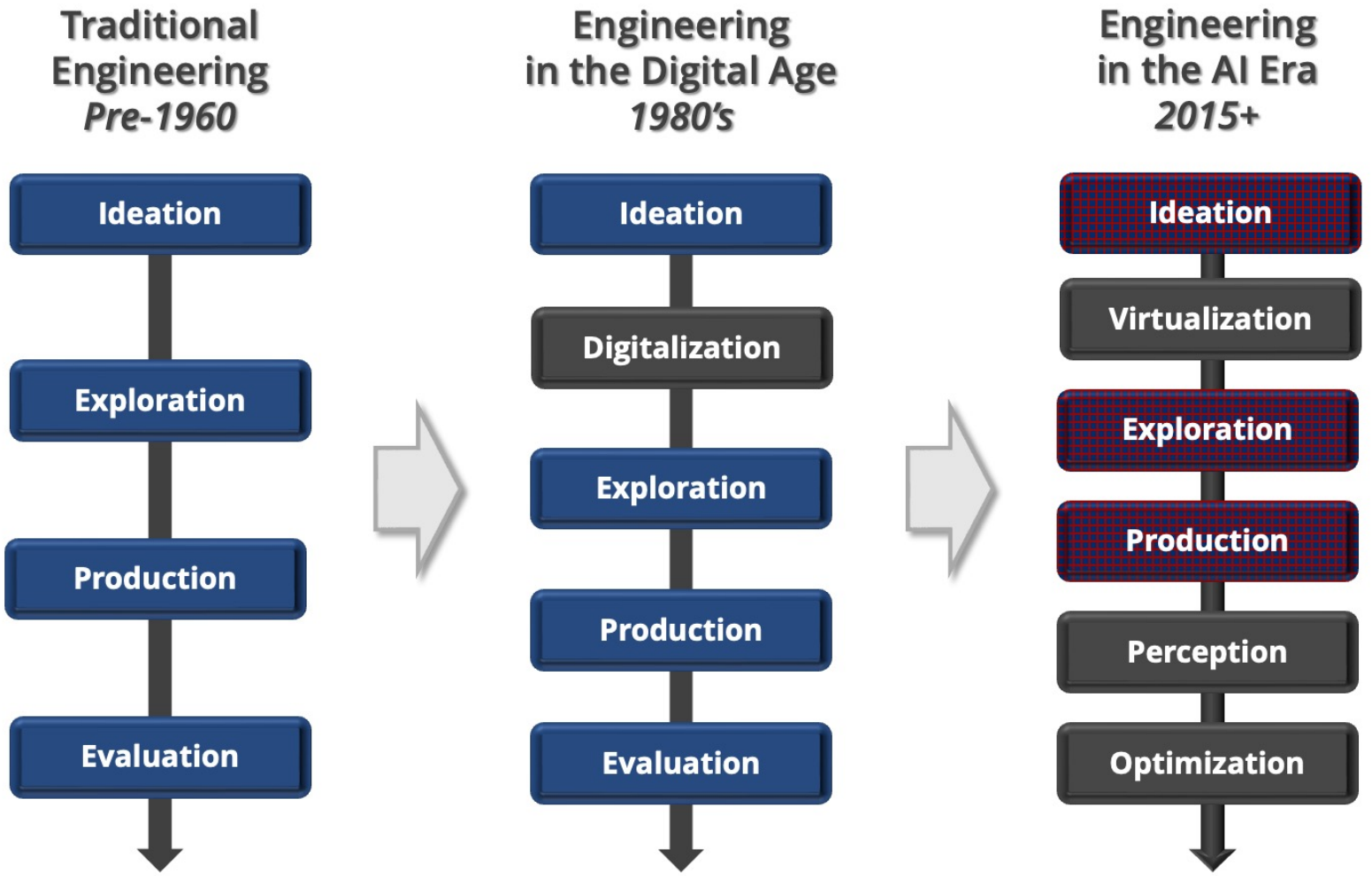
Intervention

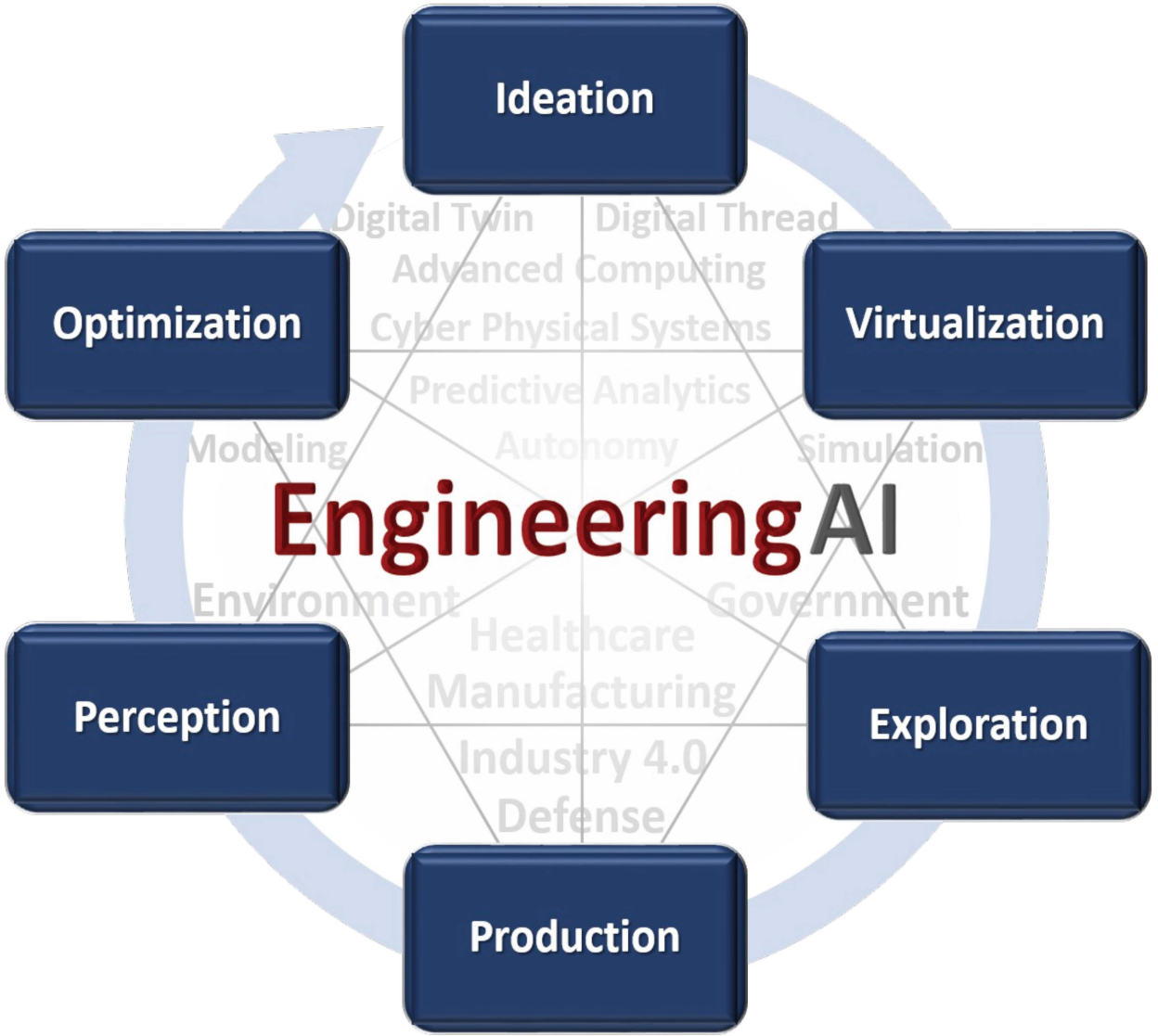
- Wearable sensors detect user's actions
- Stim controller selects task-appropriate patterns for stimulating spinal cord

Professor Doug Weber

Redefining the Engineering Discipline with AI

Much as computer aided design and modeling did in the past, AI is in the process of reshaping the way engineers work and the way they approach problems.

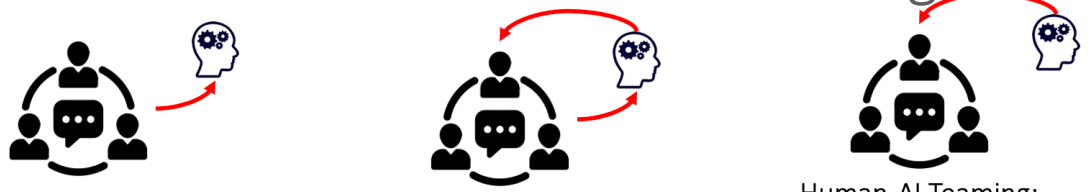



Ideation
Optimization
Virtualization
Perception
Exploration
Production
Digital Twin
Digital Thread
Advanced Computing
Cyber Physical Systems
Predictive Analytics
Modeling
Autonomy
Simulation
EngineeringAI
Environment
Government
Healthcare
Manufacturing
Industry 4.0
Defense

Exploration: AI as a Manager in the Engineering Design Process

- Teams designed drone fleets and package delivery plans
- Agent uses prior data to track team performance
  - How often people talk,
  - what they say to each other,
  - what changes to the design they make
- Agent then decides whether to intervene with nudges to the human team members
- The AI manager performed equally to the human manager

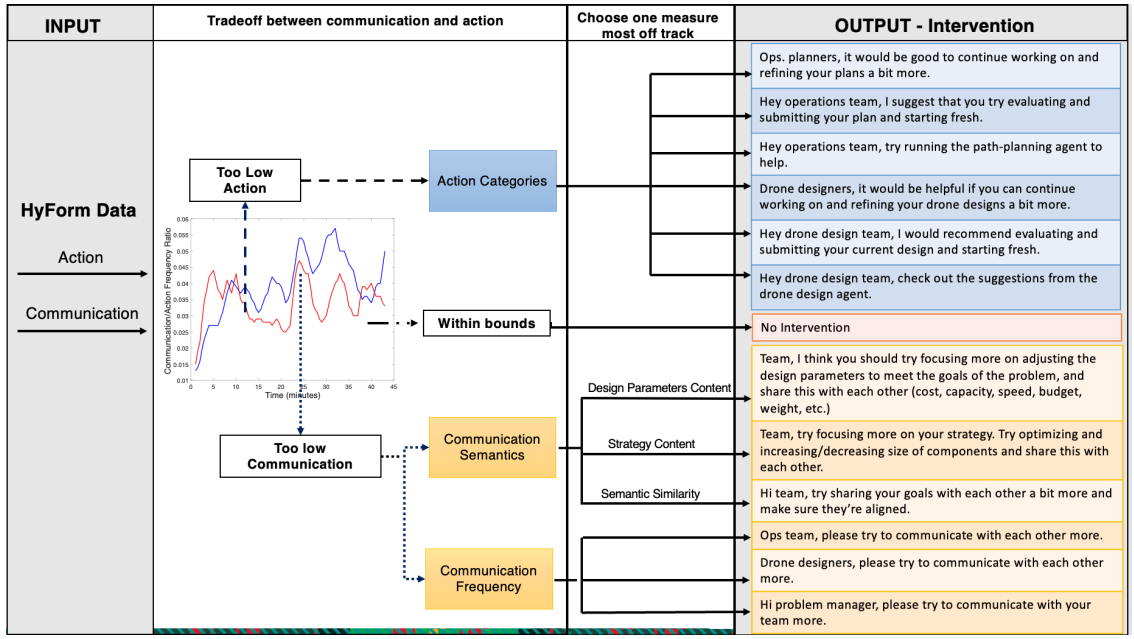
Three modes of human-AI teaming:



Human-AI Teaming: AI as tool

Human-AI Teaming: AI as partner

Human-AI Teaming: AI as manager



Educating AI Engineers

Teach the state-of-the-art knowledge in AI from a unique engineering perspective

AI Engineering MS Degrees

Pittsburgh PA

- Mechanical Engineering
- Electrical and Computer Engineering
- Information Security Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil and Environmental Engineering
- Materials Science and Engineering

Kigali, Rwanda

- Engineering AI

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Introducing a new AI Engineering Curriculum

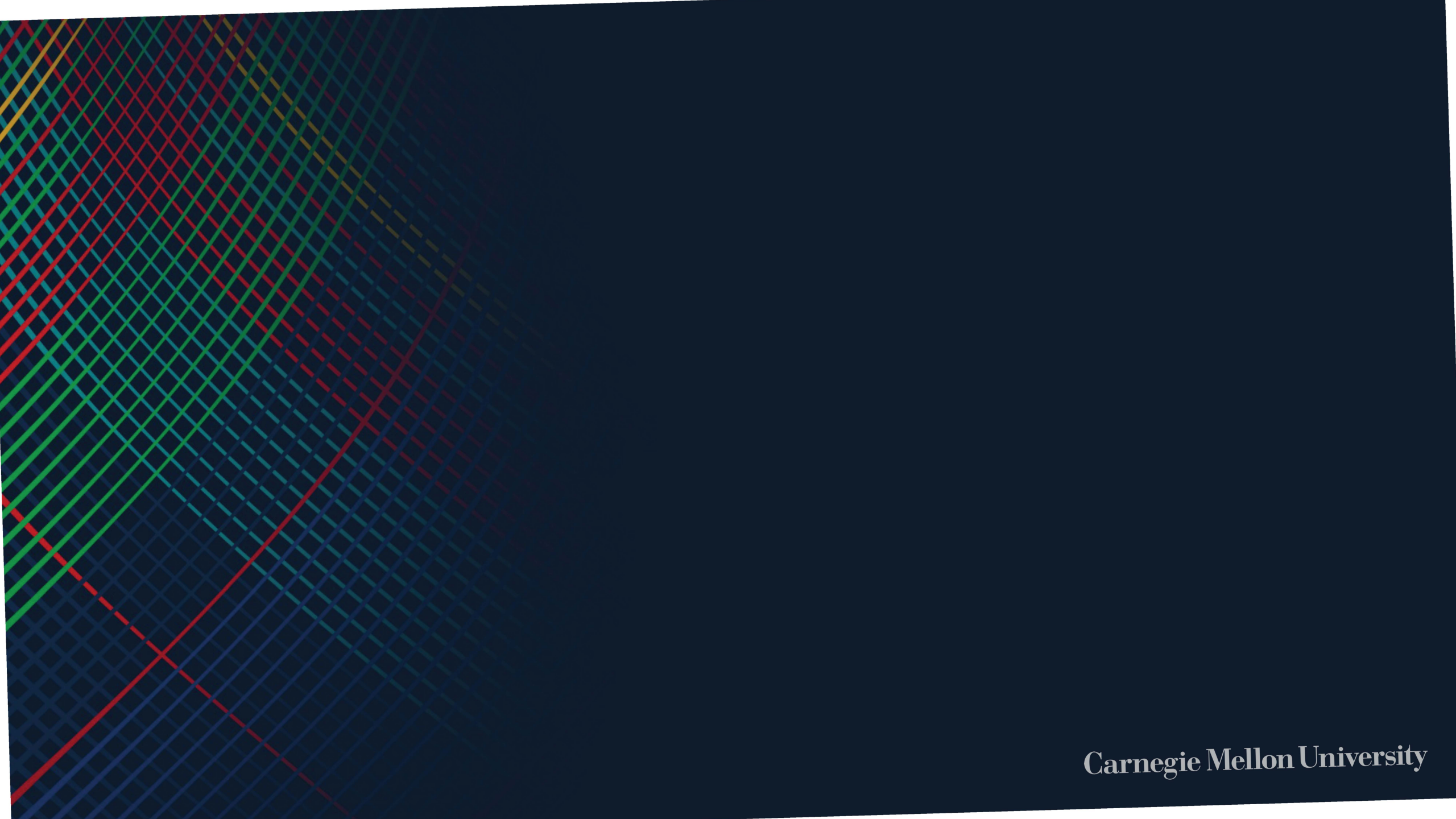
CMU's College of Engineering is the first in the nation to introduce a coordinated set of Master's degrees teaching how to engineer AI into a broad set of systems:

- MS in AI Engineering – Biomedical Engineering
- MS in AI Engineering – Chemical Engineering
- MS in AI Engineering – Civil and Environmental Engineering
- MS in AI Engineering – Electrical and Computer Engineering
- MS in AI Engineering – Information Security Engineering
- MS in AI Engineering – Materials Science and Engineering
- MS in AI Engineering – Mechanical Engineering

Building on an Engineering AI MS degree launched at CMU-Africa in Fall 2021.

AI Engineering

- Engineering of AI Mechanisms
- AI in Engineered Systems
- Redefining the Engineering Discipline with AI
- Teaching AI Engineering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