Foundation Models for Healthcare

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BMDS 271: Foundation Models for Healthcare (CS 277, RAD 271)

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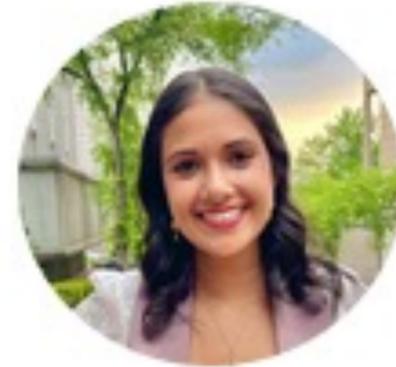
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https://web.stanford.edu/class/cs277/

Foundation Models

Bommasani et al. On the Opportunities and Risks of Foundation Models. arXiv 2021.
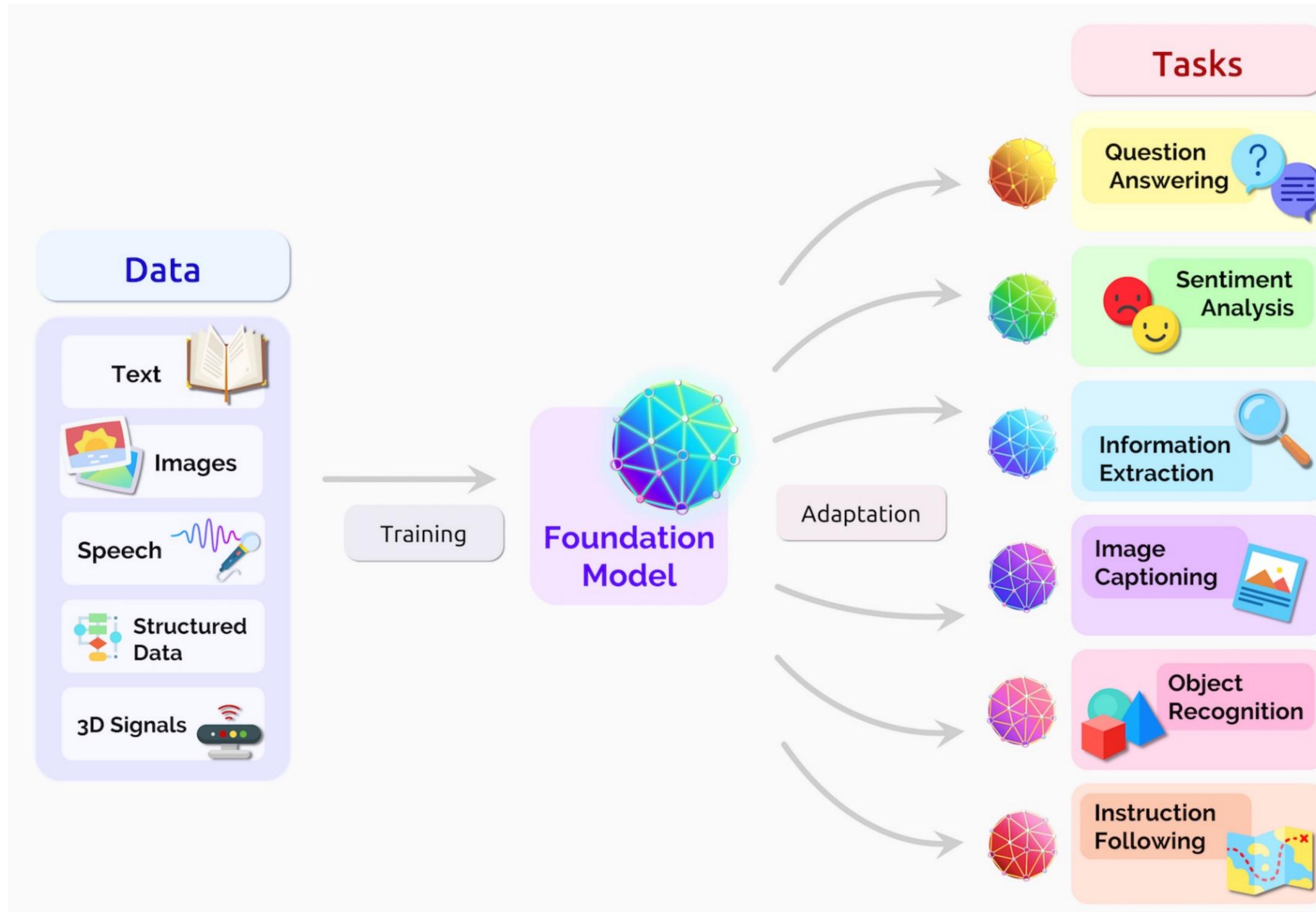
What to Expect from Course

- Provide background and discussion of (some) of the latest large-scale foundation models

- Discuss applications, exciting opportunities, and challenges for adaptation to healthcare

- Educate in this rapidly moving area and help enable high-quality research and applications

What to Expect from Students

- Active participation in course content - discussions, readings, and assignment

- Working towards a high-quality final project

- Flexibility to adapt to a fast-changing field!!

How Do You use FMs?

To What Extent Do You Use FMs?

A. I have used FMs occasionally

B. I use FMs during my day-to-day activities

C. I am a power-user of FMs

What are Your Common FM Uses?

A. Coding

B. General writing

C. Image generation/manipulation

D. Agentic workflows

E. Other

What Settings Do You Use FMs in?

A. Coursework

B. Research Projects

C. Personal

Course Outline: Part 1

Week 1

Jan 05: **BACKGROUND** **Course Introduction & Overview of Foundation Models**

Lecture Material:

- Course Overview

Jan 07: **BACKGROUND** **Introduction to LLMs**

Lecture Material:

- Intro to LLMs

Suggested Reading:

- Monitoring AI-Modified Content at Scale
- Scaling Instruction-Finetuned Language Models
- Training Language Models to Follow Instructions
- Using ChatGPT to Facilitate Truly Informed Medical Consent

Week 2

Jan 12: **BACKGROUND** **Agentic Systems**

Jan 14: **BACKGROUND** **Evaluation of LLMs and Agents, MedArena**

Week 3

Jan 19: **No Class - MLK Day**

Jan 21: **BACKGROUND** **Evaluation of LLMs (Pt. 2)**

Week 4

Jan 26: **BACKGROUND** **Retrieval Augmented Generation, Mixture of Experts**

Jan 28: **BACKGROUND** **Inference Scaling and Reasoning**

Course Outline – Part 2

Week 5

Feb 02:	**BACKGROUND**	**Vision-Language Models**
Feb 04:	**BACKGROUND**	**Mechanistic Interpretability of VLMs**

Week 6

Feb 09:	**BACKGROUND**	**Generative VLMs for Vision**
Feb 11:	**BACKGROUND**	**Generative VLMs for Text**

Week 7

Feb 16:		**No Class - Presidents' Day**
Feb 18:	**BACKGROUND**	**Foundation Models for Segmentation**

Course Outline – Part 3

Week 8

| Feb 23: | APPLICATIONS | SleepFM: Multimodal Foundation Model of Sleep |
| Feb 25: | APPLICATIONS | Regulation and Deployment: EchoNet Case Study |

Week 9

| Mar 02: | BACKGROUND | Advanced Architectures |
| Mar 04: | BACKGROUND | EMR Foundation Models |

Week 10

| Mar 09: | OPPORTUNITIES | Ethics of Foundation Models |
| Mar 11: | PROJECT PRESENTATIONS DUE | Final Presentations |

Course Grading

- 15% Class participation (2 excused in-person absences)

- 40% Homeworks (2 assignments)

- 45% Final Project

Classic ML Models

Input → **ML Model** → Output

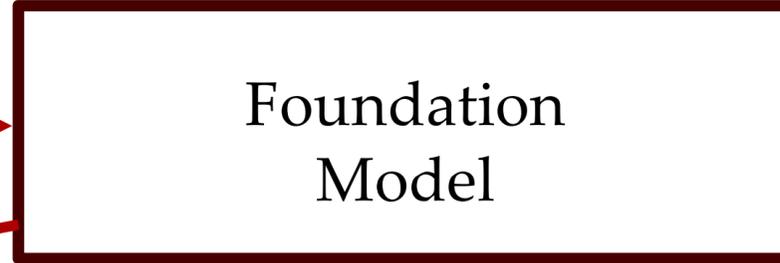| Input	Output	Function	Tasks	Application
• Structured • Time series • Text • Image • Audio • Video • Table • Domain-specific • Multi-D • Multimodal	• Label • Regression • Text • Image • Audio • Video • Table • Domain-specific	• Clustering • Classification • Prediction • Regression • Synthesis	• Recognition • Detection • Segmentation • Captioning • Image/text/synthesis • Audio/Video/. multimodal synthesis • Question answering • Text generation • Autocompletion • Translation • Summarization • Sentiment analysis • Navigation • Search/IR • Recommendation • ….	• Customer service • Social Media • Marketing • Code generation • Automated reporting • Domain-specific

Foundation Models

Input → | Foundation Model | → Output

Input	Output	Function	Tasks	Application

• Trained on a variety of data input	• Different types of output based on downstream use	• Defined based on the scope of ability, range of uses, breadth of tasks or types of output and input
		• Encoder
		• Decoder
		• Encoder-Decoder
			• A single model can accomplish multiple tasks:
			• Sentence completion
			• Sentiment classification
			• Summarization
			• Image Generation
			• ….
			• Works for arbitrary input
			• Can be fine-tuned
				• Same model can serve multiple applications
				  • Customer service
				  • Code generation
				  • Revenue cycle management
				  • …

Benefits of Modern Day FMs

- Can perform generative and discriminative tasks

- Can be conditioned in a variety of ways

- Can be aligned with human preferences

- Can be (easily) adapted

Opportunities in Healthcare

- Vast interconnected set of stakeholders

- Disparate but complementary needs/challenges

Opportunities in Healthcare

Acosta et al. "Multimodal biomedical AI". Nature Medicine 2022.

Opportunities in Healthcare
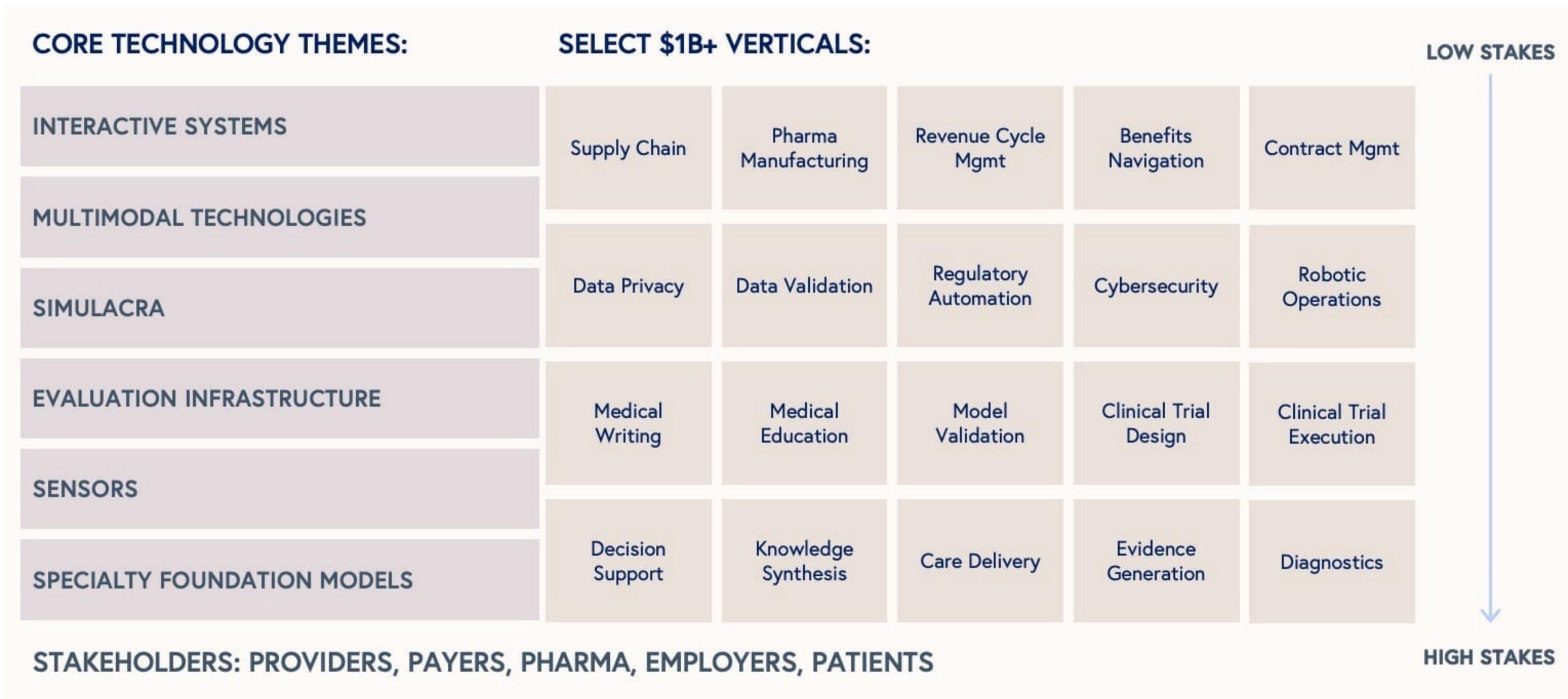

CORE TECHNOLOGY THEMES:

- INTERACTIVE SYSTEMS
- MULTIMODAL TECHNOLOGIES
- SIMULACRA
- EVALUATION INFRASTRUCTURE
- SENSORS
- SPECIALTY FOUNDATION MODELS

SELECT $1B+ VERTICALS:

Supply Chain	Pharma Manufacturing	Revenue Cycle Mgmt	Benefits Navigation	Contract Mgmt
Data Privacy	Data Validation	Regulatory Automation	Cybersecurity	Robotic Operations
Medical Writing	Medical Education	Model Validation	Clinical Trial Design	Clinical Trial Execution
Decision Support	Knowledge Synthesis	Care Delivery	Evidence Generation	Diagnostics

LOW STAKES → HIGH STAKES

STAKEHOLDERS: PROVIDERS, PAYERS, PHARMA, EMPLOYERS, PATIENTS

Cheatham M. "Bessemer Healthcare AI Areas of Focus" from Healthcare AI Thesis Update. 2024.

Challenges of Modern Day FMs

- Data requirements (pre- and post-training)

- Computational demands

- Inference efficiency/costs

- Adequate evaluation