

AIRC 101 / FOUNDATIONS

Understand the ideas. Question the evidence.

10 classes / 2 hours per class

AIRC 101 connects the ideas behind language models to the research that moves them forward. Students develop mathematical intuition, examine influential papers, and use research tools to investigate questions and evaluate evidence. Along the way, they learn how a study is designed, written, reviewed, and shared. Students learn to understand a method, question a result, and find the resources to pursue their next idea, with a clearer sense of the research directions they want to explore.

WHAT YOU WILL DEVELOP

- 01 Connect vector operations, loss functions, neural networks, and gradient descent to how language models learn.
- 02 Understand sparse representations, tokenization, embeddings, cosine similarity, and language modeling objectives.
- 03 Find and assess research papers by examining their questions, methods, evidence, and limitations.
- 04 Design meaningful comparisons and use technical tools to investigate a research hypothesis.
- 05 Communicate an idea through a research proposal, clear figures, and an effective presentation.

WHAT YOU WILL TAKE AWAY

Experience reading and evaluating research, developing a proposal, and presenting evidence, with a clearer direction for further study.

WHERE IT CAN LEAD

[ISEF-affiliated science fairs](#) / [S.-T. Yau Science Award](#) / [Journal of Emerging Investigators](#)

AIRC 101 / CURRICULUM

Understand. Investigate.

01 Find your place in the research landscape

Explore how research moves between laboratories, publications, and practical applications. Understand the roles of conferences, journals, and professional organizations, then follow the process through which a paper is reviewed, accepted, and shared with its community.

02 Build the intuition behind language models

Treat language as a machine learning problem. Connect word representations and vector spaces to NLP, then explore recurrent networks (RNNs) and LSTMs to understand the approaches that preceded the transformer.

03 Understand attention and the transformer

Read the central ideas of Attention Is All You Need and connect attention to the transformer architecture. Explore how these mechanisms changed language modeling, building an understanding of the foundations behind today's generative AI systems.

04 Read with a researcher's questions

Use challenges in reasoning models to practice finding and reading research efficiently. Identify a paper's central claim, examine the evidence, and consider its limitations, learning to distinguish an interesting result from an opportunity for further investigation.

05 Design comparisons that mean something

Turn an observation into a research idea and an experimental plan. Explore inference, ANOVA, contrasts, and uncertainty visualization, applying these tools to meaningful model comparisons and considering their role in human evaluations and foundation-model studies.

HOW WE LEARN

Lectures, guided mini-projects, and interactive activities connect mathematical intuition with research practice. AIRC 101 and 201 can be taken independently, according to readiness and interests.

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Make the case for an idea.

06 Use tools to investigate an idea

Construct experiments with selected AI frameworks, including LangChain and Giskard. Connect implementation and evaluation choices to a research hypothesis, using practical tools to investigate whether the evidence supports an idea.

07 Make the argument clear

Develop a research proposal and learn how a paper supports its argument. Use resources such as Overleaf and Matplotlib to organize academic writing and create figures that help a reader understand the evidence.

08 Present the question, method, and evidence

Practice introducing a research project to an audience: why the question matters, what the approach contributes, and how it was investigated. Develop a presentation that helps listeners follow the reasoning and understand the significance of the work.

09 Connect the research process

Revisit the development of a modern language model and connect the decisions across its research pipeline. Reflect on how the course's mathematical, technical, and communication skills fit together, and identify the aspects of research that interest you.

10 Choose what to explore next

Survey current research directions and consider the questions opening within them. Use the course's approach to reading, experimentation, and evaluation to identify a direction for further learning and the resources that can help you begin.

BEFORE THE FIRST CLASS

Bring a Mac or Windows computer. Install VS Code and Python, and create a GitHub account. Tools are introduced in the context of classroom research activities.