# Course Syllabus: Multimodal AI Developer

**Course Title:** Multimodal AI Development: Integrating Vision, Language, and Beyond

**Target Audience:** This course is for experienced AI developers, machine learning engineers, and data scientists with a strong background in either Natural Language Processing (NLP) or Computer Vision. A solid grasp of Python and deep learning frameworks (PyTorch or TensorFlow) is a prerequisite.

**Course Level:** Advanced to Expert.

**Duration:** 10 Weeks

**Course Description:** This curriculum provides a deep, hands-on dive into the world of multimodal AI. You will learn the theoretical foundations and practical applications of models that can process and understand multiple data types, such as text, images, and audio, in a unified way. The course emphasizes the engineering challenges of data fusion, cross-modal reasoning, and building production-ready applications. By the end, you will be able to design, implement, and deploy intelligent systems that can perceive the world with a human-like, multi-sensory understanding.

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## Learning Objectives

Upon successful completion of this course, students will be able to:

- Understand the core architectures and techniques for building multimodal AI models.
- Master data fusion strategies (early, late, and intermediate) to combine different data modalities.
- Design and implement data pipelines to process, align, and prepare multimodal datasets.
- Build applications that perform cross-modal tasks, such as generating text from images or answering questions about video content.
- Utilize advanced multimodal models from major providers (e.g., Google Gemini, GPT-4o) and open-source communities (e.g., LLaVA).
- Apply MLOps principles to deploy and monitor multimodal AI applications in the cloud.
- Recognize and address the unique ethical and security challenges of multimodal AI.

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## Course Structure: A Step-by-Step Learning Path

### Part 1: Foundational Concepts & Architectures (Weeks 1-3)

This section builds a strong theoretical understanding of how multimodal AI works and the frameworks used to build it.

#### Week 1: Introduction to Multimodal AI

- The evolution of AI from unimodal to multimodal.
- The benefits and challenges of integrating multiple data types.
- Key concepts: modalities, data fusion, and cross-modal reasoning.
- Overview of major multimodal models and their capabilities.
- **Hands-on Lab:** Use a pre-trained multimodal model (e.g., Gemini API) to perform a basic text-and-image task.

#### Week 2: Data Fusion & Representation

- **Data Fusion Strategies:** A deep dive into early, late, and intermediate fusion architectures.
- Understanding embedding spaces and how different modalities are represented in a unified space.
- The role of attention mechanisms in aligning information across modalities.
- **Hands-on Lab:** Implement a simple early fusion model to classify data from two different modalities.

#### Week 3: Multimodal Data Engineering

- The unique challenges of data engineering for multimodal AI.
- Building pipelines to collect, clean, and align data from different sources (e.g., synchronizing video and audio).
- Annotation and labeling strategies for multimodal datasets.
- **Hands-on Project:** Create a data pipeline that takes a video and its transcript, and aligns them for a future model.

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### Part 2: Practical Applications & Advanced Techniques (Weeks 4-7)

This section focuses on building real-world applications using different types of multimodal data.

**Week 4: Vision-Language Applications**

- **Image-to-Text:** Building models for image captioning and visual question answering (VQA).
- **Text-to-Image:** An overview of stable diffusion models and their architectures.
- Using frameworks like **Hugging Face's** `transformers` and `diffusers` for these tasks.
- **Hands-on Project:** Build a VQA application that can answer questions about images.

**Week 5: Audio-Language Applications**

- **Speech-to-Text (STT):** An overview of models like **Whisper**.
- **Text-to-Speech (TTS):** Generating natural-sounding audio from text.
- Designing conversational systems that can process and generate both text and speech.
- **Hands-on Lab:** Build a basic audio assistant that transcribes user speech and generates a text-based response.

**Week 6: Video & Temporal Multimodality**

- The challenge of processing video: combining visual frames with audio.
- Video understanding tasks: action recognition, event detection, and video summarization.
- Building applications that can reason about a sequence of events in a video.
- **Hands-on Project:** Build a tool that can generate a text summary of a short video.

**Week 7: Retrieval-Augmented Generation (RAG) for Multimodal AI**

- Extending the RAG paradigm to multiple modalities.
- Using vector databases to store and retrieve multi-modal embeddings (e.g., retrieving an image based on a text query).
- Building a RAG pipeline that can answer questions based on a collection of documents with text and images.
- **Hands-on Project:** Create a "Multimodal Search Engine" that can find relevant images and text snippets based on a user's query.

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**Part 3: Deployment, MLOps, and Professional Practice (Weeks 8-10)**

This final section covers the engineering skills for deploying, monitoring, and maintaining multimodal systems in production.

**Week 8: Multimodal MLOps**

- The unique MLOps challenges of multimodal systems: managing diverse data types, model complexity, and serving large models.
- **Containerization with Docker** for reproducible deployments.
- Monitoring model performance, data drift, and latency for a multi-input system.
- **Hands-on Lab:** Dockerize your Multimodal Search Engine for consistent deployment.

**Week 9: Cloud Deployment & Scaling**

- Deploying a multimodal AI application on a major cloud platform.
- Optimizing inference time and cost for large multimodal models.
- Strategies for scaling your application to handle high traffic.
- **Hands-on Project:** Deploy your containerized application to a cloud service and set up monitoring.

**Week 10: Final Capstone Project & Career Skills**

- **Capstone Project:** Design, build, and deploy a complete, professional-grade multimodal AI application. This project should solve a real-world problem and demonstrate mastery of all the skills learned.
- Building a professional portfolio and resume tailored for Multimodal AI Developer roles.
- Interview preparation and understanding the current industry landscape.



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## Assignments & Grading

- **Weekly Hands-on Labs:** 20%
- **Intermediate Projects (Weeks 4, 7):** 30%
- **Final Capstone Project:** 40%
- **Code Quality & Documentation:** 10%