Core AI

A concise foundation of Artificial Intelligence

Abdulla Ali Alshamsi
ORCID:0009-0006-4905-5469

December 16, 2025

Contents

Chapter 1

Introduction

This small book explains the stages required to become a strong artificial intelligence developer.This book is based on 17 stages, where each stage has its own dedicated book.This book serves as the index and foundation for all other books.

We will rely on the Python programming language together with PyTorch and CUDA, progressing step by step toward the most important methodologies used in building complete artificial intelligence systems. The projects in this book are problem-driven rather than solution-driven, reflecting how real AI systems are developed in practice.

This book will not provide direct solutions. Instead, the reader is expected to search for answers independently and determine an appropriate approach for solving each assignment. Every task is designed to challenge understanding and encourage critical thinking about the problem itself.

The core objective of this book is to present a collection of small, well-defined problems that must be solved by the reader. This learning strategy is known as problem-solving, and it represents the foundation upon which strong and independent AI engineers are built.

Chapter 2

ALL stages

stage	Title
01	Tensor Mathematics Lessons
02	ALA (Applied Linear Algebra in coder)
03	ABM (Autograd and Backprop Mechanics)
04	OC (Optimization in code)
05	LFTL (Loss Functions and Training Loop)
06	SQL Lessons (PostgreSQL)
07	NoSQL Lessons (MongoDB)
08	Object Storage Lessons (MinIO)
09	Vector Database Lessons (Qdrant)
10	Linear Regression
11	Logistic Regression
12	Perceptron
13	MLP (Feed-Forward Network)
14	RNN (Recurrent Neural Network)
15	LSTM (Long Short-Term Memory)
16	Transformer
17	LLM (Large Language Model)

Table 2.1: Core AI - 17 stages

Chapter 3

Tensor Mathematics Lessons

Before entering the world of artificial intelligence programming, the first essential step is understanding tensors. A tensor is a structured way of representing data, conceptually similar to matrices but significantly more general and complex. To truly understand how tensors operate, they must be studied together with the mathematical laws that govern their behavior and interactions.

Entering the field of artificial intelligence programming requires the ability to integrate multiple disciplines that may not initially appear connected. In particular, information technology and applied mathematics must work together, as mathematical reasoning provides the foundation for how AI algorithms are formed and executed.

Applied mathematics represents the first cornerstone for entering the world of artificial intelligence programming. Without this foundation, it becomes difficult to understand how learning models, optimization processes, and intelligent systems function beneath the surface of the code.

Code	Lesson
T00	Foundations of Scalars and Basic Tensor Concepts
T01	Vector Definitions and Operations
T02	Matrix Structures and Transformations
T03	Tensor Expansion Rules and Dimensionality
T04	Advanced Matrix - Tensor Interactions
T05	Differential Tensor Calculus
T06	Optimization Theory Foundations
T07	Statistical Tensor Applications
T08	Neural Transformation Mathematics

Table 3.1: Tensor (T00 - T08)

Chapter 4

ALA (Applied Linear Algebra in Code)

text..

Code	Lesson
ALA00	Tensor Operations in Code
ALA01	Vector Dot and Norm Computation
ALA02	Matrix Multiplication (matmul - mm)
ALA03	Outer vs Inner Product
ALA04	Broadcasting Rules and Mechanics
ALA05	Shape Reasoning and Dimension Flow
ALA06	Basis, span and projection (Applied)

Table 4.1: ALA (ALA00 - ALA06)

Chapter 5

ABM (Autograd and Backprop Mechanics)

text..

Code	Lesson
ABM00	Computational Graph Construction
ABM01	Forward vs Backward Pass
ABM02	Manual Gradient Calculation
ABM03	Chain Rule in Code
ABM04	Autograd Engine in PyTorch
ABM05	Backprop Through Linear Layers
ABM06	Gradient Flow Debugging

Table 5.1: ABM (ABM00 - ABM06)

Chapter 6

OC (Optimization in Code)

text..

Code	Lesson
OC00	Gradient Descent Implementation
OC01	Learning Rate Effects and Tuning
OC02	Momentum Update Rule
OC03	RMSProp Logic and Behavior
OC04	Adam Optimizer Math + Code
OC05	Convergence and Stability
OC06	Weight Initialization Impact

Table 6.1: OC (OC00 - OC06)

Chapter 7

LFTL (Loss Functions and Training Loop)

text..

Code	Lesson
LFTL00	What is Loss and Why
LFTL01	MSE Loss Implementation
LFTL02	Cross-Entropy Logic
LFTL03	Building Training Loop Manually
LFTL04	Batching + Epochs
LFTL05	Evaluation AND Validation Split
LFTL06	Overfitting Prevention Methods

Table 7.1: LFTL (LFTL00 - LFTL06)

Chapter 8

SQL Lessons (PostgreSQL)

text..

Code	Lesson
SQL00	Relational Data Fundamentals
SQL01	Tables, Keys and Schemas
SQL02	Users, Plans and Limits Storage
SQL03	Query Logic and Transactions

Table 8.1: SQL (SQL00 - SQL03)

Chapter 9

NoSQL Lessons (MongoDB)

text..

Code	Lesson
NOSQL00	Document-Based Data Structures
NOSQL01	Chat History and Session Memory
NOSQL02	Dynamic Storage Models
NOSQL03	Scaling with Replica and Sharding

Table 9.1: NoSQL (NOSQL00 - NOQL03)

Chapter 10

Object Storage Lessons (MinIO)

text..

Code	Lesson
OB00	Binary Data and Large File Storage
OB01	Datasets, Weights and Checkpoints
OB02	Buckets and Access Structure
OB03	Distributed Mode and Fault Tolerance

Table 10.1: Object storage (OB00 - OB03)

Chapter 11

Vector Database Lessons (Qdrant)

text..

Code	Lesson
QD00	Embeddings and Semantic Meaning
QD01	Similarity Search Mechanics
QD02	RAG Integration Workflow
QD03	Indexing and Scalable Retrieval

Table 11.1: Vector Databse (QD00 - QD03)

Chapter 12

Linear Regression

text..

Code	Lesson
LR00	Introduction to Linear Regression
LR01	Model Structure and Components
LR02	Data Preparation and Feature Inputs
LR03	Prediction Function Implementation
LR04	Error Measurement and Loss Definition
LR05	Parameter Adjustment and Gradient Concept
LR06	Training Iterations and Convergence
LR07	Model Evaluation and Performance Metrics
LR08	Result Visualization and Interpretation

Table 12.1: Linear Regression (LR00 - LR08)

Chapter 13

Logistic Regression

text..

Code	Lesson
LG00	Introduction to Logistic Regression
LG01	Binary Output and Decision Logic
LG02	Sigmoid Activation Behavior
LG03	Probability Interpretation Framework
LG04	Classification Boundary Definition
LG05	Loss Representation for Classification
LG06	Model Adjustment and Gradient Direction
LG07	Accuracy Validation and Output Analysis
LG08	Multi-Class Extension Concepts

Table 13.1: Logistic Regression (LG00 - LG08)

Chapter 14

Perceptron

text..

Code	Lesson
PC00	Introduction to the Perceptron Concept
PC01	Input Weights and Bias Structure
PC02	Activation Threshold Behavior
PC03	Output Decision Mapping
PC04	Update Rule and Adjustment Cycle
PC05	Separation Limitations and Boundaries
PC06	Training Dynamics and Convergence
PC07	Multi-Input Handling Logic
PC08	Transition Toward Multi-Layer Networks

Table 14.1: Perceptron (PC00 - PC08)

Chapter 15

MLP (Feed-Forward Network)

text..

Code	Lesson
MLP00	Introduction to Multi-Layer Perceptron
MLP01	Layered Structure and Signal Flow
MLP02	Activation Functions Across Layers
MLP03	Forward Signal Computation Steps
MLP04	Layer Interaction and Weight Influence
MLP05	Expanded Feature Representation
MLP06	Network Depth and Complexity Handling
MLP07	Output Mapping and Decision Formation
MLP08	Extended Use Cases and Applications

Table 15.1: MLP (MLP00 - MLP08)

Chapter 16

RNN (Recurrent Neural Network)

text..

Code	Lesson
RNN00	Introduction to Sequential Modeling
RNN01	Recurrent Structure and State Flow
RNN02	Temporal Dependency Formation
RNN03	Step-Based Output Interpretation
RNN04	State Retention and Signal Transition
RNN05	Sequential Input Handling Logic
RNN06	Pattern Extraction Across Time
RNN07	Prediction Over Ordered Data
RNN08	Practical Use Case Scenarios

Table 16.1: RNN (RNN00 - RNN08)

Chapter 17

LSTM (Long Short-Term Memory)

text..

Code	Lesson
LSTM00	Introduction to Long-Term Memory Networks
LSTM01	Cell State Persistence Concept
LSTM02	Information Retention Gate
LSTM03	Information Addition Gate
LSTM04	Output Extraction Gate
LSTM05	Sequence Memory Stability
LSTM06	Long-Range Dependency Handling
LSTM07	Sequential Prediction Mapping
LSTM08	Applied Use Case Scenarios

Table 17.1: LSTM (LSTM00 - LSTM08)

Chapter 18

Transformer

text..

Code	Lesson
TR00	Introduction to Transformer Architecture
TR01	Attention Mechanism Fundamentals
TR02	Positional Encoding Concepts
TR03	Multi-Head Attention Structure
TR04	Feed Forward Block Interaction
TR05	Layer Normalization Flow
TR06	Token Representation and Mapping
TR07	Sequence Processing and Output
TR08	High-Level Transformer Applications

Table 18.1: Transformer (TR00 - TR08)

Chapter 19

LLM (Large Language Model)

text..

Code	Lesson
LLM00	Large Language Model Fundamentals
LLM01	Tokenization and Vocabulary Systems
LLM02	Embedding Representation Scaling
LLM03	Deep Attention Stack Behavior
LLM04	Context Window Handling
LLM05	Inference and Generation Flow
LLM06	Parameter Scaling and Capacity
LLM07	Fine-Tuning and Adaptation
LLM08	RAG and External Knowledge Integration

Table 19.1: LLM (LLM00 - LLM08)

Chapter 20

Conclusion

text..