Industrial AI-Driven Inspection Module & Robotic Integration

A Hands-On Industrial Program by ThinkingCode Education and Unique World Robotics In Association With Vector NDT

PROGRAM OVERVIEW

Bridging Robotics and AI for Real Industrial Systems

Modern industrial systems increasingly combine robotic manipulation with AI-based visual inspection. However, learning both simultaneously can be overwhelming for early-career engineers.

This program is deliberately structured to build strong foundations first. You'll master real hardware and ROS 2 fundamentals before diving into AI-driven inspection. This approach preserves industry realism—no shortcuts, no black-box learning.

The result? Engineers who understand systems end-to-end, capable of reasoning about both physical manipulation and intelligent decision-making in production environments.

Key Principles

- Real hardware from day one
- Physical intuition before AI
- Industry-standard tools and workflows
- End-to-end system thinking

Program Structure at a Glance

01

Phase 1: Robotics Foundation

Weeks 1–6: Master real hardware manipulation using ROS 2 and MoveIt 2 with the Dobot Magician robot

02

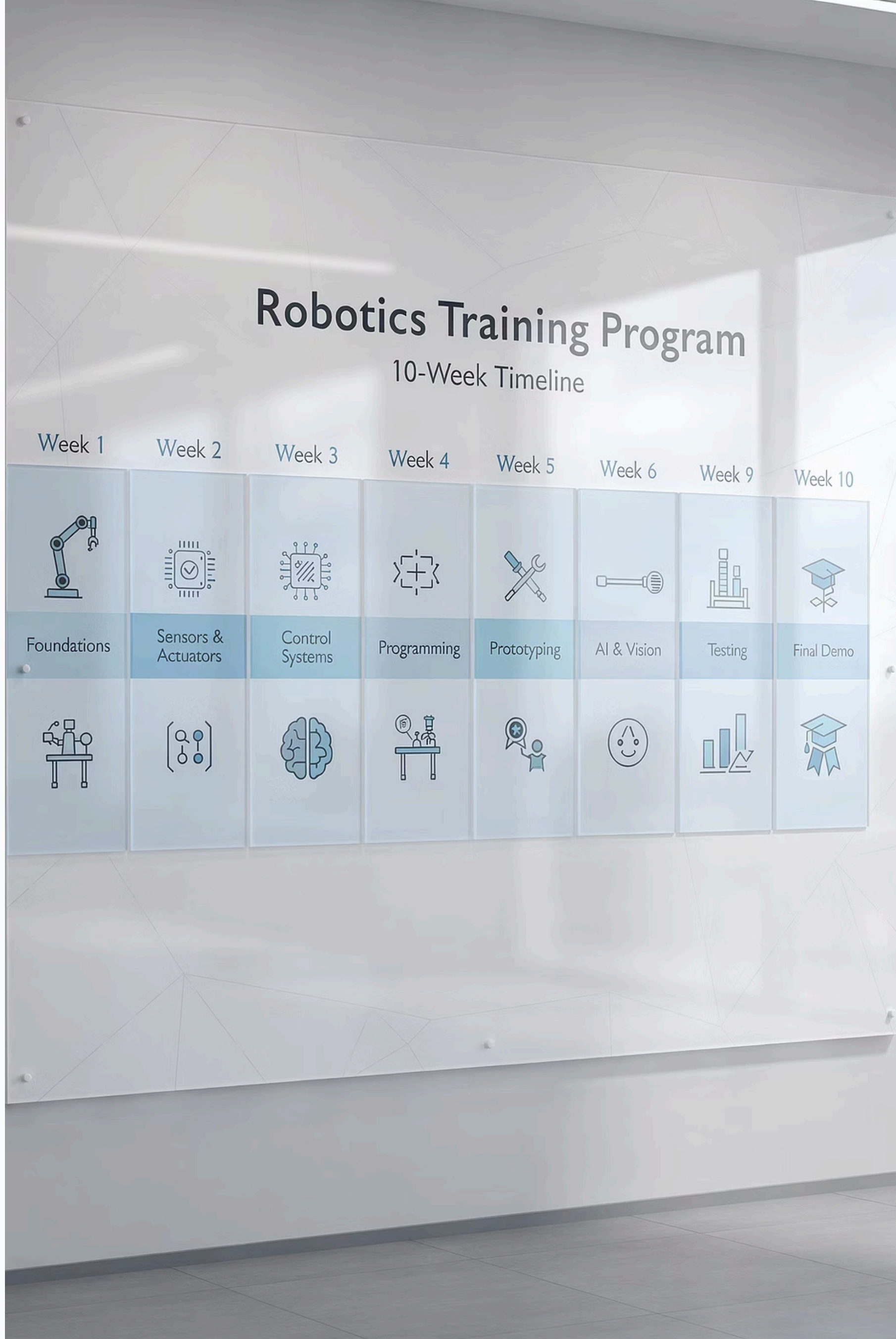
Phase 2: MPI-AI Specialization

Weeks 7–10: Apply AI-driven visual inspection to real-world Magnetic Particle Inspection scenarios

03

Capstone Integration

Final project combining robotic manipulation with intelligent inspection systems



Phase 1

Robotics Foundation

Weeks 1–6 | Real Hardware, ROS 2 & MoveIt 2

This phase focuses entirely on robotics manipulation, ensuring students are comfortable with real robots before any AI is introduced. You'll work hands-on with the Dobot Magician, learning industry-standard tools and building the spatial reasoning essential for complex automation tasks.

WEEK 1

Dobot Magician & ROS 2 Setup

Goal

Get students running the real robot safely and understand the difference between simulated and physical systems.

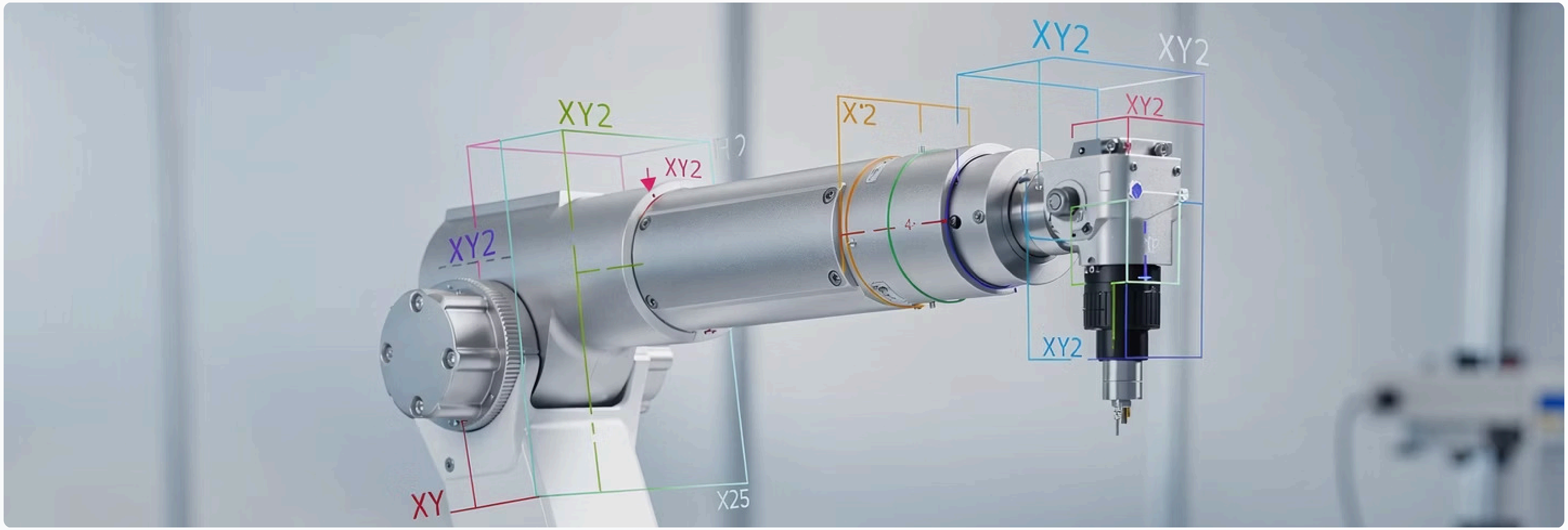
Topics Covered

- Dobot Magician hardware overview
- Degrees of Freedom (DOF), workspace, and physical limitations
- Safety procedures and emergency stop protocols
- ROS 2 manipulation pipeline overview

Hands-On Lab

1. Install ROS 2 environment
2. Install Dobot Magician ROS 2 package
3. Establish USB/network connection to robot
4. Execute Dobot bringup sequence
5. Visualize joint states in real-time

Outcome: Robot connected and responding with clear understanding of real vs simulated systems



WEEK 2

Robot Model, Frames & Tool Center Point

Understanding Coordinate Systems

Learn how ROS 2 represents the robot's position and orientation in 3D space. You'll explore coordinate frames, base frames, and tool frames—the mathematical foundation of all robot motion.

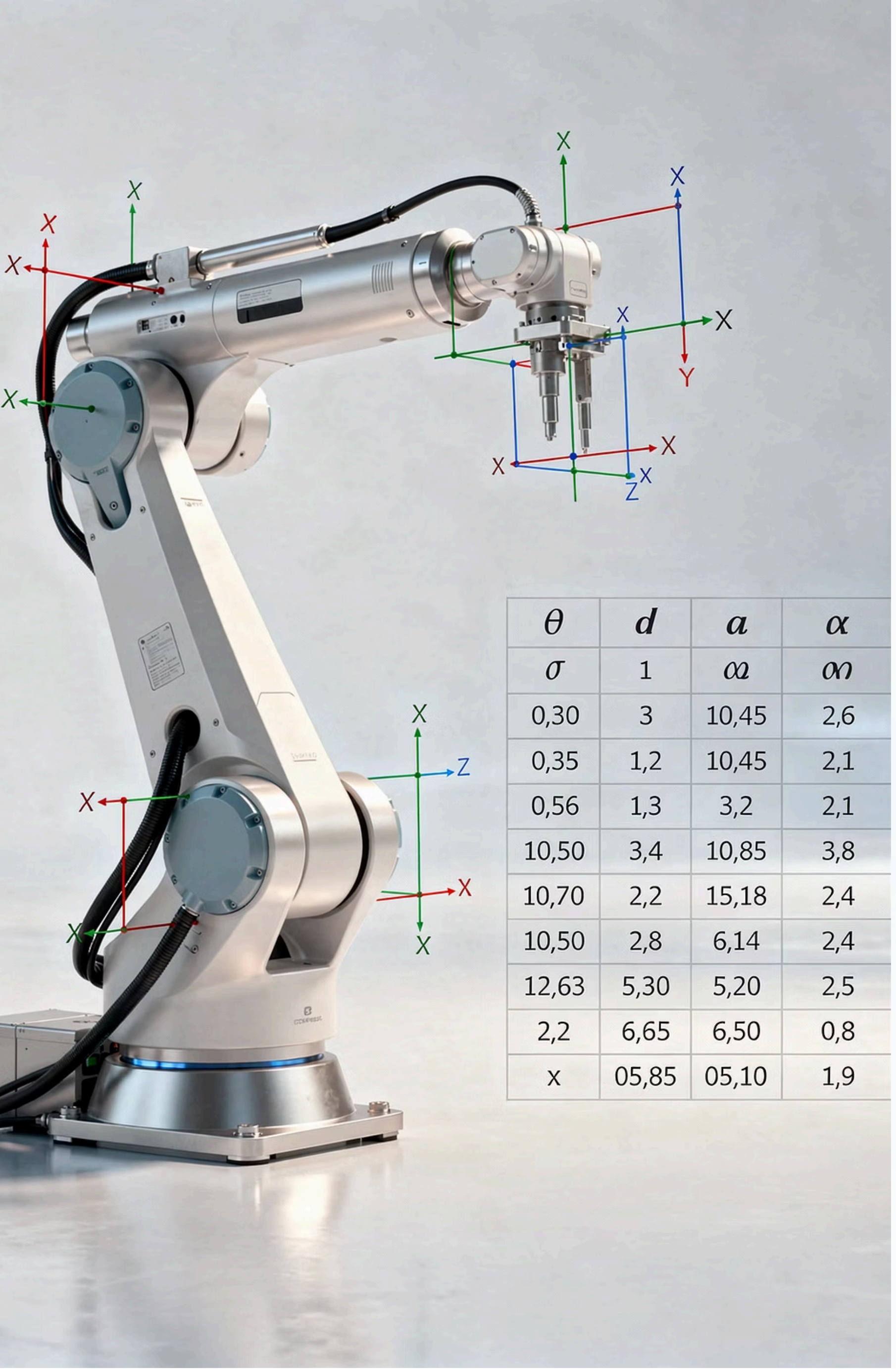
The Critical TCP

The Tool Center Point (TCP) defines where your robot thinks its tool tip is located. Getting this right is essential for accurate manipulation and inspection tasks.

Hands-On Validation

You'll inspect the Dobot URDF model, visualize the TF tree in RViz2, modify TCP settings for different end effectors, and validate everything using point-to-point motion on real hardware.

Outcome: Correct TCP definition and clear understanding of frame transformations that match physical reality.



WEEK 3

Kinematics: Forward Kinematics, DH Parameters & Validation

Goal

Link mathematical models to real robot motion, ensuring your calculations match physical behavior.

Core Concepts

- Kinematic chain of the Dobot Magician
- Denavit–Hartenberg (DH) parameters
- Forward kinematics computation
- Joint-space vs Cartesian-space motion

Lab Activities

You'll create a complete DH parameter table for the Dobot, compute forward kinematics analytically, and then compare your results with both RViz visualization and the actual robot pose. This physical validation builds confidence in your kinematic models.

Key Takeaway: Your FK calculations will match real hardware positioning

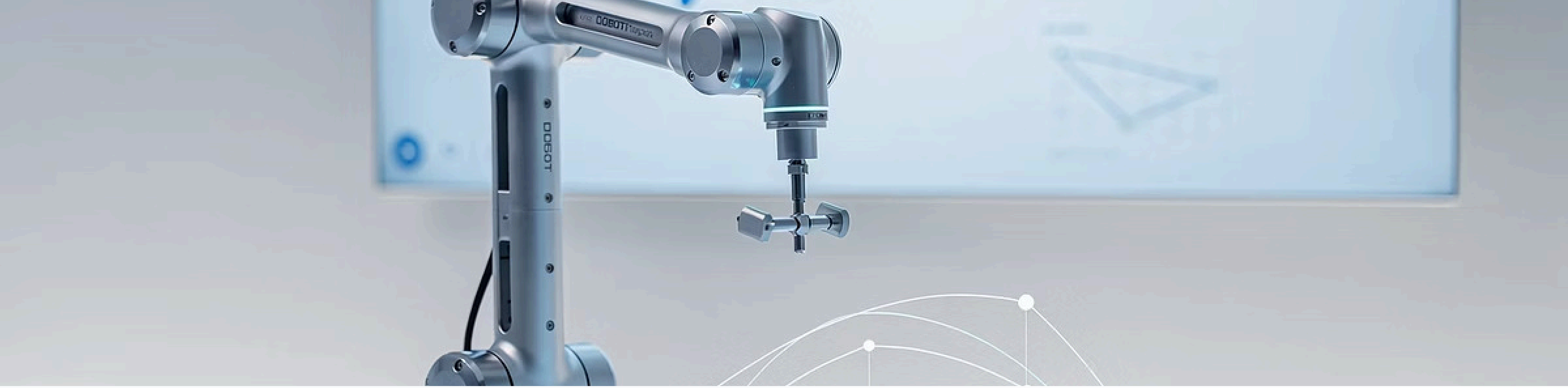
WEEK 4

Inverse Kinematics & ROS 2 Control

1	2	3
The IK Challenge Move the robot by specifying where you want it to go, not by guessing joint angles. Learn about multiple solutions and singularities.	**ROS 2 Control** Master the ROS 2 control framework and joint trajectory controllers for smooth, predictable motion.	**Real Execution** Write ROS 2 nodes that send Cartesian goals and observe how the robot handles challenging configurations.

In the lab, you'll use inverse kinematics through MoveIt 2, write custom ROS 2 nodes sending Cartesian goals, execute smooth trajectories, and observe singularity behavior firsthand. This week bridges theory and practice.

Outcome: Reliable pose-based robot control with understanding of IK limitations on real hardware.



WEEK 5

MoveIt 2 with Dobot Magician

Goal: Build an Industry-Grade Manipulation Pipeline

MoveIt 2 is the industry standard for robot motion planning. This week, you'll master its architecture, including the planning scene, collision objects, and controller switching between simulation and real hardware.

- ### Setup & Configuration
  Run MoveIt 2 with real Dobot hardware using the Setup Assistant for proper configuration
- ### Collision-Aware Planning
  Plan safe trajectories that avoid obstacles in the workspace environment
- ### Real Hardware Execution
  Execute planned motions on the physical robot and debug planning failures systematically

Outcome: Safe, collision-aware motion planning using tools that professional robotics engineers rely on daily.

WEEK 6

Grasping & Object Manipulation

The Physics of Grasping

Reliable manipulation requires understanding gripper mechanics, grasp stability, friction, and contact physics. You'll learn why some grasps succeed while others fail.

Lab: Pick-and-Place Mastery

1. Control Dobot gripper opening and closing
2. Implement complete pick-and-place task
3. Use collision-aware grasp planning in MoveIt
4. Attach and detach objects in planning scene

Outcome: Reliable pick-and-place operations with deep understanding of grasp physics.

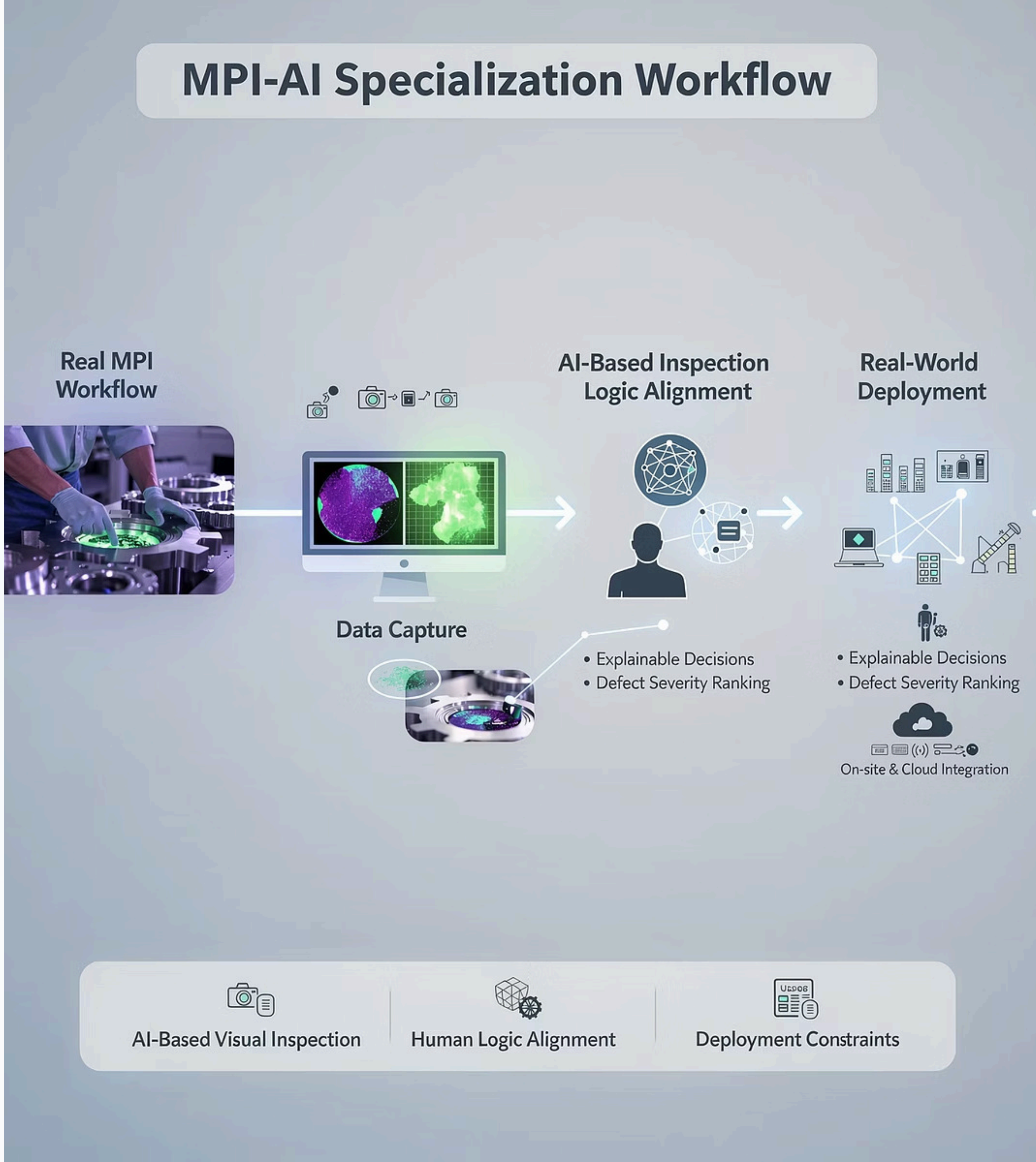
> **Conceptual Bridge:** *At this point, students are introduced to using the robot not just for picking objects, but for precise inspection and scanning tasks—setting the stage for AI-driven vision.*

Phase 2

MPI-AI Specialization

Weeks 7–10 | AI for Real Inspection Systems

This phase focuses on AI-based visual inspection, grounded in real Magnetic Particle Inspection (MPI) workflows under UV fluorescence. You'll learn how AI models must align with human inspection logic and real-world deployment constraints.



WEEK 7

MPI Fundamentals for ML Engineers

MPI Physics

Understand how magnetic particles accumulate at surface-breaking defects and why this matters for AI model design

UV Fluorescence

Learn how fluorescent particles glow under UV light and the unique imaging challenges this creates

Inspector Judgment

Distinguish between relevant indications (actual defects) and non-relevant indications (false positives)

This week emphasizes why machine learning must align with human inspection logic. You'll perform visual analysis of real MPI images and complete a manual annotation walkthrough.

Outcome: Complete MPI image audit report demonstrating understanding of inspection criteria.

WEEK 8

MPI Image Characteristics & Preprocessing

Color Space Analysis

UV fluorescence creates unique imaging characteristics. You'll explore RGB vs HSV vs LAB color spaces and learn why standard preprocessing often fails on MPI images.

Domain-Informed Preprocessing

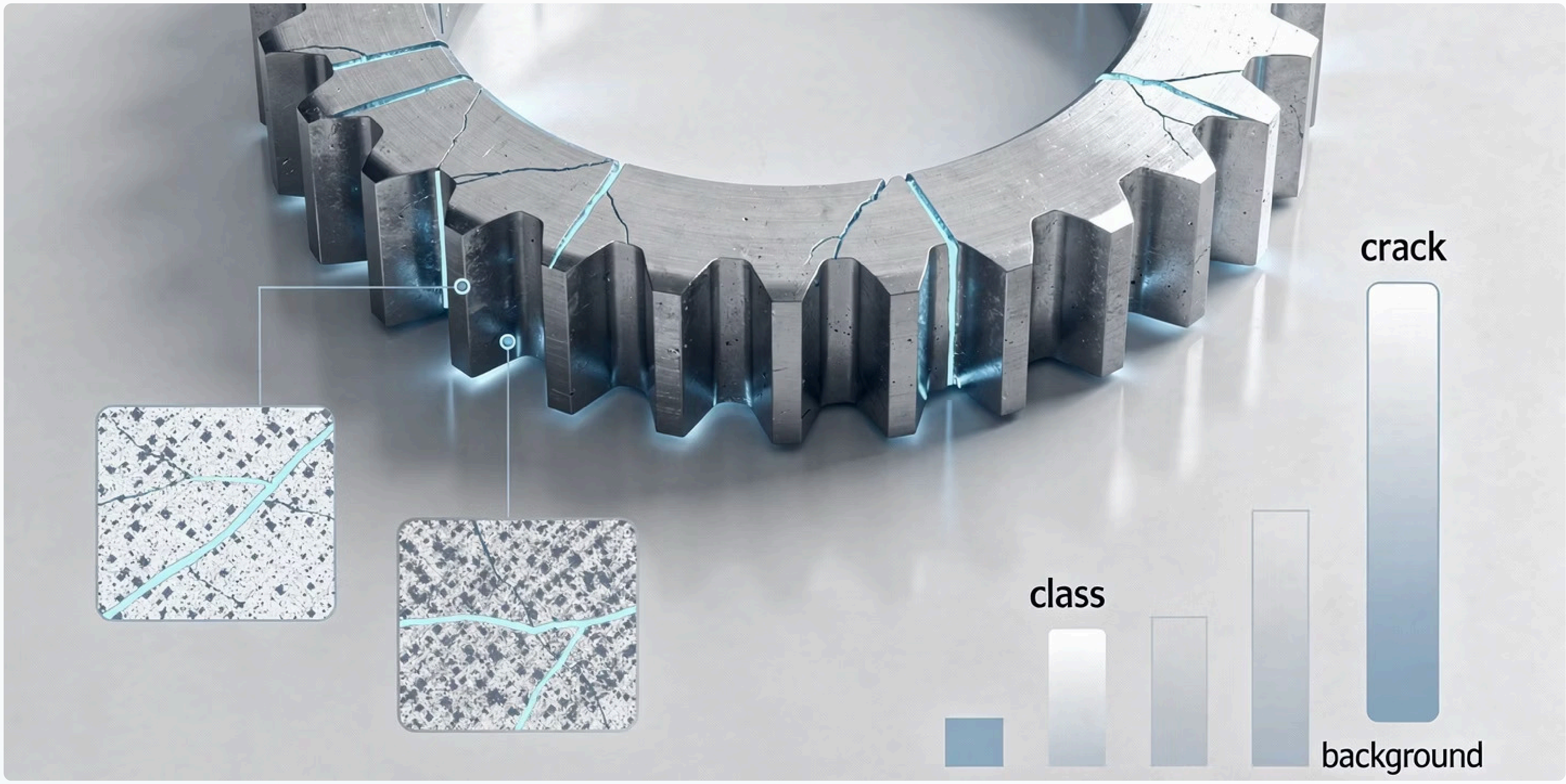
Rather than blindly applying ML techniques, you'll develop preprocessing pipelines informed by the physics of UV illumination and fluorescent particle behavior.

Lab Experiments

- Apply CLAHE (Contrast Limited Adaptive Histogram Equalization)
- Implement background subtraction techniques
- Conduct channel ablation experiments
- Analyze UV illumination artifacts

Deliverable: MPI-specific preprocessing pipeline optimized for crack detection

WEEK 9



Segmentation Fundamentals Applied to MPI

Semantic Segmentation Basics

Learn pixel-level classification for identifying thin crack structures in inspection images

Patch-Based Training

Discover why small defects need focused training approaches rather than full-image methods

1

2

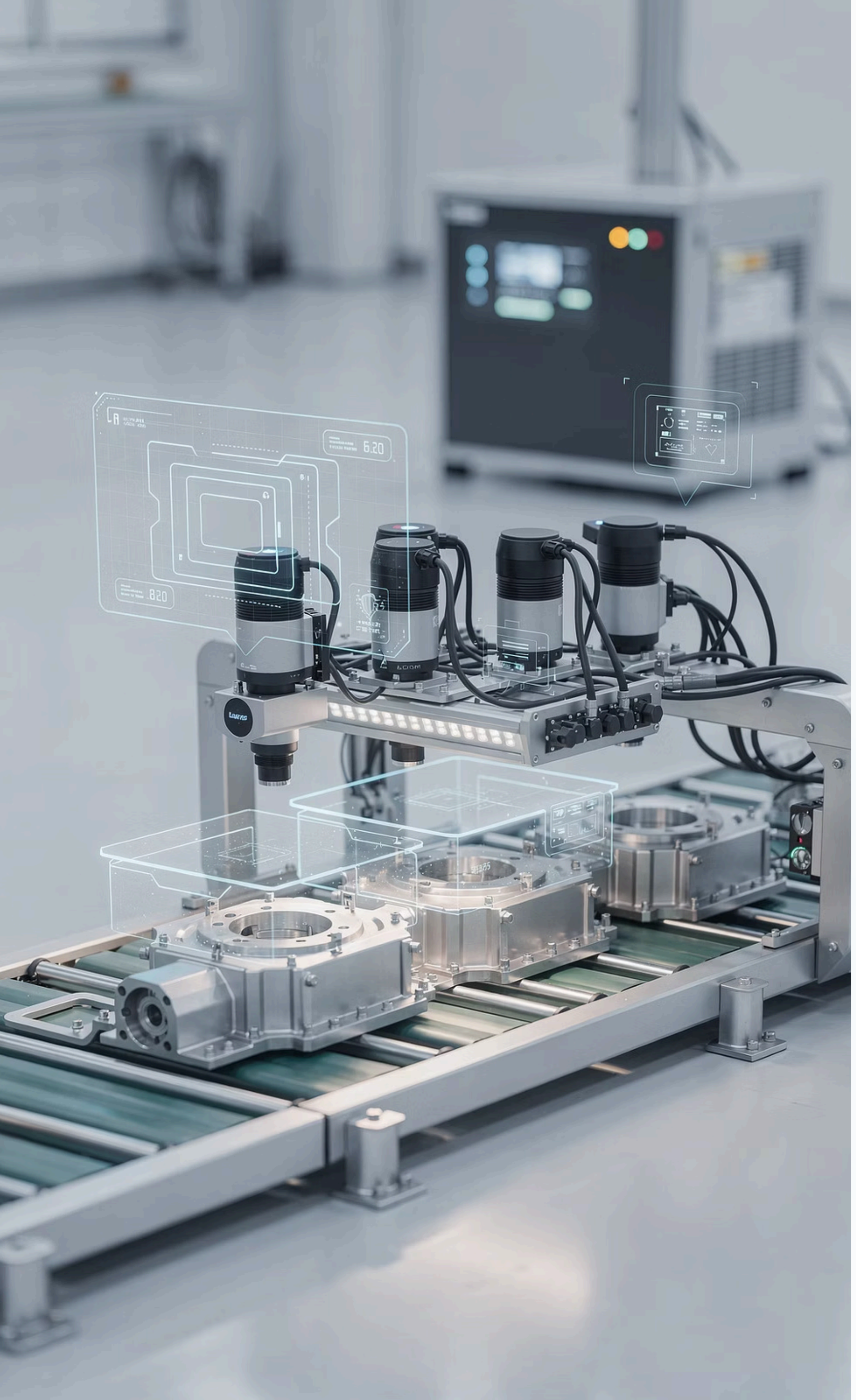
3

Class Imbalance Challenge

Understand why defects (minority class) require specialized loss functions and training strategies

In the lab, you'll train a U-Net baseline model on a real MPI dataset, learning to handle the unique challenges of detecting thin, linear crack patterns against noisy backgrounds.

Outcome: *Working baseline segmentation model that detects MPI indications with measurable accuracy.*



WEEK 10

Attention, Evaluation & Deployment

Advanced Architectures

Explore attention mechanisms and transformer-based segmentation (SegFormer) for shape-aware detection of linear cracks vs blob-like noise

Real-World Metrics

Learn inspection-aligned evaluation metrics that matter to quality engineers, not just ML accuracy scores

Deployment Reality

Balance accuracy vs latency trade-offs and understand model drift in production environments

Capstone Project: Build an end-to-end MPI crack detection demonstration that combines robotic positioning with AI-driven inspection.

Capstone: What You'll Be Able to Do

Control Real Robotic Systems

Confidently operate and program industrial robots using ROS 2 and MoveIt 2, understanding both the mathematics and physical constraints of manipulation

Design Inspection-Aligned AI

Build machine learning models that respect inspection logic, quality standards, and real-world deployment requirements

Reason About Deployment

Evaluate trade-offs between accuracy, speed, and reliability while understanding model drift and failure modes in production

Think Like Industrial Engineers

Approach problems with system-level thinking, considering safety, repeatability, and integration with existing workflows

Who Should Enroll

Final-Year Engineering Students

Ready to bridge academic learning with industry-ready skills in robotics and AI

Robotics & AI Enthusiasts

Seeking hands-on experience with real hardware and production-grade tools

Future Industrial Engineers

Interested in careers spanning Industrial AI, Robotics, and Inspection Systems

This program is ideal for technically minded individuals who want to work with real systems, not just theoretical concepts. You should be comfortable with programming and eager to learn both hardware and software aspects of modern automation.

What Makes This Program Different

Real Robots, Not Simulations

Work with actual hardware from day one. Feel the weight of real constraints, observe physical limitations, and build intuition that simulation alone cannot provide.

Foundations First, AI Second

AI is introduced only after physical intuition is formed. This deliberate sequencing prevents overwhelming students and ensures deep understanding.

Industry-Aligned Use Cases

Learn through real inspection scenarios that matter to quality engineers. Your projects will reflect actual industrial challenges, not academic toy problems.

Engineering Judgment Matters

Focus on deployment reality, reliability, and risk assessment. Learn to think critically about when and how to apply AI in production environments.

Program Snapshot: By The Numbers

10

Weeks

Intensive hands-on training from robotics fundamentals through AI deployment

2

Phases

Robotics foundation followed by AI specialization for structured learning

100%

Real Hardware

Every lab uses actual robots and inspection systems, not simulation

1

Capstone

Integrated project combining robotic manipulation with intelligent inspection

Ready to Build Industry-Ready Skills?

This program transforms enthusiastic learners into confident industrial engineers who understand systems from the ground up.

You'll gain hands-on experience with real robots, master industry-standard tools like ROS 2 and MoveIt 2, and learn to design AI systems that work reliably in production environments.

No shortcuts. No black-box learning. Just solid engineering fundamentals combined with cutting-edge AI techniques—exactly what modern industry needs.

> *"The result is a program that produces engineers who understand systems end-to-end, not just isolated technologies."*

Program Partners

ThinkingCode Education

Unique World Robotics

Vector NDT

Join a program designed by industry professionals for the next generation of robotics and AI engineers.

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