Training Course on Computer Vision for Autonomous Systems

Professional Development Training Course Outline

Category	Data Science	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

The advent of **autonomous systems**, including **self-driving cars** and advanced **robotics**, is fundamentally transforming industries and daily life. At the core of these revolutionary technologies lies **Computer Vision (CV)**, enabling machines to "see," interpret, and interact with their environments with unprecedented accuracy. This intensive training course delves into the cutting-edge of **perception systems**, equipping participants with the essential **deep learning**, **sensor fusion** , and **real-time processing** skills needed to develop robust and intelligent autonomous solutions.

Training Course on Computer Vision for Autonomous Systems provides a comprehensive understanding of **CV algorithms** and their practical implementation in **autonomous navigation** and **object recognition**. Through hands-on projects, case studies, and practical exercises, participants will master techniques like **semantic segmentation**, **3D vision**, and **predictive analytics**, crucial for building the next generation of **AI-powered autonomous vehicles** and **intelligent robotic systems**. Prepare to contribute to the future of **mobility**, **industrial automation**, and **smart infrastructure** by becoming proficient in this high-demand field.

Programme Curriculum

Training Course on Computer Vision for Autonomous Systems

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Course Objectives

1. Master Deep Learning architectures for image and video analysis in autonomous contexts.
2. Understand and apply Convolutional Neural Networks (CNNs) and Vision Transformers (ViTs) for perception tasks.
3. Develop proficiency in Object Detection and Object Tracking algorithms for dynamic environments.
4. Implement Semantic Segmentation and Instance Segmentation for precise scene understanding.
5. Explore 3D Computer Vision techniques including point cloud processing and LiDAR integration.
6. Understand and apply Sensor Fusion methodologies for combining data from multiple sensors (camera, LiDAR, Radar).
7. Gain expertise in Visual Odometry and Simultaneous Localization and Mapping (SLAM) for robust navigation.
8. Learn Real-time Image and Video Processing techniques for low-latency autonomous operation.
9. Acquire skills in Predictive Analytics and Behavioral Prediction for intelligent decision-making in autonomous systems.
10. Explore Generative AI for synthetic data generation and dataset augmentation in CV.
11. Understand Edge AI deployment strategies for efficient on-device processing in autonomous vehicles.
12. Analyze and mitigate challenges related to Adversarial Attacks and Ethical AI in computer vision for autonomy.
13. Develop a strong foundation in Robotics Perception for manipulation, navigation, and human-robot interaction.

Organizational Benefits

- Equip teams with the specialized skills to design, develop, and deploy cutting-edge autonomous solutions faster.
- Foster an environment of innovation by enabling the creation of advanced computer vision capabilities for next-generation products and services in automotive, logistics, and manufacturing.
- Implement AI-driven perception systems for enhanced automation, predictive maintenance, quality control, and superior safety in industrial and transportation applications.
- Leverage advanced computer vision techniques, including synthetic data generation and efficient model deployment, to optimize development cycles and reduce resource expenditure.
- Attract and retain top engineering talent by offering advanced training in a rapidly evolving and high-demand field, making the organization a leader in autonomous technologies.
- Stay at the forefront of technological advancements by building internal expertise in critical areas like deep learning, sensor fusion, and ethical AI, crucial for the future of intelligent systems.
- Empower engineers to analyze vast amounts of visual data, enabling more informed design choices and performance optimization for autonomous platforms.

Target Audience

1. Robotics Engineers and Autonomous Vehicle Developers.
2. Machine Learning Engineers and Data Scientists
3. Software Engineers
4. Researchers and Academicians.
5. Product Managers and Technical Leaders Graduate Students
6. Hardware Engineers Professionals from Automotive, Logistics, Manufacturing, and Defense industries looking to implement vision-driven automation.

Course Outline

Module 1: Introduction to Computer Vision for Autonomous Systems

- Fundamentals of Computer Vision: Image formation, digital images, color spaces.
- Overview of Autonomous Systems: Self-driving cars, industrial robots, drones.
- Role of Perception in Autonomy: Sensing, understanding, and decision-making.
- Key Challenges in Real-world Autonomous Vision: Variability, lighting, occlusions.
- Historical context and future trends of CV in autonomy.
- *Case Study: Evolution of perception systems in Waymo's self-driving vehicles, highlighting the shift from rule-based to deep learning approaches.*

Module 2: Image Processing Fundamentals

- Image filtering: Convolution, smoothing, edge detection (Sobel, Canny).
- Feature detection and description: Harris corners, SIFT, SURF, ORB.
- Image transformations: Affine, projective, homographies.
- Camera models and calibration: Pinhole model, intrinsic and extrinsic parameters.
- Image stitching and panorama creation.
- *Case Study: Applying image preprocessing techniques for lane detection and road boundary estimation in real-world driving scenarios.*

Module 3: Introduction to Machine Learning for Vision

- Supervised, Unsupervised, and Reinforcement Learning paradigms.
- Classical Machine Learning algorithms: SVMs, K-NN, Decision Trees for image classification.
- Feature engineering vs. end-to-end learning.
- Evaluation metrics for classification and regression.
- Introduction to data augmentation techniques.
- *Case Study: Building a simple traffic sign recognition system using traditional ML classifiers and hand-crafted features.*

Module 4: Deep Learning Foundations for CV

- Neural Networks: Perceptrons, activation functions, backpropagation.
- Convolutional Neural Networks (CNNs): Convolutional layers, pooling layers, fully connected layers.
- Popular CNN architectures: LeNet, AlexNet, VGG, ResNet, Inception.
- Training deep networks: Optimization algorithms (SGD, Adam), regularization.
- Transfer learning and fine-tuning.
- *Case Study: Training a CNN for vehicle classification (car, truck, bus) from scratch using a public dataset.*

Module 5: Object Detection

- Introduction to object detection: Bounding boxes, confidence scores.
- Two-stage detectors: R-CNN, Fast R-CNN, Faster R-CNN.
- One-stage detectors: YOLO (v1-v8), SSD.
- Anchor boxes, Non-Maximum Suppression (NMS).
- Evaluation metrics: IoU, Precision, Recall, mAP.
- *Case Study: Implementing a YOLO-based object detection system for real-time pedestrian and cyclist detection in urban driving environments.*

Module 6: Object Tracking

- Single-object tracking: Kalman Filters, Particle Filters.
- Multi-object tracking (MOT): Deep SORT, tracking-by-detection.
- Data association techniques: Hungarian algorithm, greedy assignment.
- Challenges in tracking: Occlusions, re-identification, dense environments.
- Applications in autonomous driving (vehicle tracking, pedestrian tracking).
- *Case Study: Developing a multi-object tracking system to track multiple vehicles and pedestrians through intersections from dashcam footage.*

Module 7: Semantic and Instance Segmentation

- Understanding semantic vs. instance segmentation.
- Architectures for semantic segmentation: FCN, U-Net, DeepLab.
- Architectures for instance segmentation: Mask R-CNN.
- Loss functions and evaluation metrics for segmentation.
- Applications: Drivable area estimation, road marking detection, object contouring.
- *Case Study: Applying Mask R-CNN for precise segmentation of road lanes, sidewalks, and various road agents to enhance path planning.*

Module 8: 3D Computer Vision and Point Clouds

- Introduction to 3D data: Point clouds, meshes, voxels.
- LiDAR data processing: Filtering, segmentation, clustering.
- PointNet and PointNet++ for point cloud feature learning.
- 3D object detection from point clouds: SECOND, PointPillars, VoteNet.
- Introduction to 3D reconstruction from 2D images (Structure from Motion, MVS).
- *Case Study: Using LiDAR point cloud data for obstacle detection and free space mapping in off-road robotics applications.*

Module 9: Sensor Fusion for Autonomous Systems

- Motivation for sensor fusion: Complementarity, redundancy, robustness.
- Fusion architectures: Early, mid, and late fusion.
- Kalman Filter and Extended Kalman Filter for state estimation.
- Unscented Kalman Filter and Particle Filters for non-linear systems.
- Practical sensor fusion examples (camera-LiDAR, camera-radar fusion).
- *Case Study: Developing a multi-sensor fusion system to combine camera and LiDAR data for enhanced object detection and tracking in adverse weather conditions.*

Module 10: Visual Odometry and SLAM

- Ego-motion estimation: Visual Odometry (VO) principles.
- Feature-based VO vs. Direct VO.
- Introduction to Simultaneous Localization and Mapping (SLAM).
- Graph-based SLAM, visual-inertial odometry (VIO).
- Loop closure detection and global consistency.
- *Case Study: Implementing a visual SLAM system for a robotic vacuum cleaner to autonomously map and navigate an indoor environment.*

Module 11: Planning and Control Integration

- Perception-to-Action pipeline in autonomous systems.
- Introduction to motion planning: Path planning, trajectory generation.
- Behavioral planning: Finite state machines, rule-based systems.
- Control algorithms: PID, Model Predictive Control (MPC).
- Simulation environments (CARLA, Gazebo) for testing perception-planning loops.
- *Case Study: Integrating a trained perception model (object detection, semantic segmentation) with a basic motion planning algorithm to enable obstacle avoidance in a simulated self-driving car.*

Module 12: Real-time Deployment and Edge AI

- Optimizing models for inference: Quantization, pruning, knowledge distillation.
- Hardware accelerators: GPUs, TPUs, FPGAs, ASICs for edge deployment.
- Edge computing architectures for autonomous vehicles.
- Deployment frameworks: TensorRT, OpenVINO, ONNX Runtime.
- Monitoring and maintaining deployed models.
- *Case Study: Deploying a lightweight object detection model onto an NVIDIA Jetson platform for real-time inference on a small-scale autonomous robot.*

Module 13: Adversarial Robustness and Ethical AI

- Understanding adversarial attacks on computer vision models.
- Techniques for adversarial defense.
- Bias in datasets and its impact on autonomous system fairness.
- Interpretability and explainability (XAI) for perception models.
- Ethical considerations in the development and deployment of autonomous systems.
- *Case Study: Analyzing the impact of adversarial examples on a self-driving car's perception system and discussing strategies for improving robustness.*

Module 14: Emerging Trends in Computer Vision for Autonomy

- Generative AI for synthetic data generation (GANs, Diffusion Models).
- Self-supervised learning and unsupervised domain adaptation.
- Multimodal learning: Fusing diverse sensor modalities for richer understanding.
- Vision-language models for human-robot interaction.
- Reinforcement Learning for complex perception tasks.
- *Case Study: Exploring the use of synthetic datasets generated by GANs to augment real-world training data for rare driving scenarios (e.g., specific weather conditions, uncommon obstacles).*

Module 15: Advanced Robotics Perception & Future Outlook

- Perception for robotic manipulation: Grasping, pose estimation.

- Human-robot collaboration and shared perception.
- Perception in unstructured environments (e.g., agriculture, construction).
- Legal and societal implications of widespread autonomous systems.
- Future research directions and career opportunities in autonomous perception.
- *Case Study: Discussing the perception challenges and solutions for autonomous robots performing complex tasks in a manufacturing assembly line, focusing on collaborative robotics.*

Training Methodology

This course adopts a highly interactive and hands-on training methodology, designed to ensure practical skill acquisition and deep conceptual understanding.

- **Lectures & Discussions:** Engaging theoretical sessions covering core concepts, algorithms, and advanced architectures.
- **Live Coding Demonstrations:** Step-by-step implementation of GANs using Python with popular deep learning frameworks (TensorFlow 2.x and Keras, or PyTorch).
- **Hands-on Labs & Exercises:** Practical coding sessions where participants build, train, and experiment with various GAN models on real datasets.
- **Case Study Analysis:** In-depth examination of real-world GAN applications across diverse industries, highlighting success stories and challenges.
- **Project-Based Learning:** A significant portion of the course will be dedicated to a capstone project, allowing participants to apply learned concepts to a practical problem.
- **Interactive Q&A:** Continuous opportunities for questions and discussions to clarify doubts and foster a collaborative learning environment.
- **Peer-to-Peer Learning:** Encouraging participants to share insights and troubleshoot problems together.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call *+254769199797*

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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