

主導課程四：實體人工智慧(Physical AI)

課程基本資料

開設學校：陽明交通大學

開授教師：陳奕廷

班級人數：6500人 (保留300人給開課學校，聯盟校上限100人，若條件式授權盟校自訂)

開課級別：研究所(大學部以上四年級修讀)

授課語言：英文

授權方式：條件式

同步遠距上課時間：星期二13:20~16:20

是否接受非同步授課：是

同步實體期末評量時間：無

遠距上課位置：使用YouTube直播

課程網頁：

建議助教學生比：每10名學生建議提供1名助教

課程概述

Recent years have witnessed remarkable breakthroughs in artificial intelligence—from large language models transforming how humans interact with information to generative models capable of creating increasingly realistic images, videos, and virtual worlds. As AI continues to advance, the next major frontier extends beyond the digital world: Physical AI, where intelligent systems perceive, reason, make decisions, and act in the physical world.

Unlike AI systems operating primarily in digital spaces, Physical AI must confront the complexity and uncertainty of the physical world: incomplete observations, changing environments, embodiment constraints, sensor and actuator failures, interactions with people, and consequences associated with physical actions. This course introduces the foundations and recent advances of Physical AI through the lens of real-world development, evaluation, and deployment. Specifically, as AI moves into the physical

world, we must continuously ask: What challenges emerge when the system leaves the benchmark and enters the real world? How should we evaluate a Physical AI system beyond predefined metrics and state-of-the-art performance? How can evaluation reveal system limitations and, more importantly, guide inference, system improvement, and future development?

Intended Learning Outcomes:

1. Explain the foundations and recent advances of Physical AI.
2. Describe and apply the Sense–Plan–Act paradigm to robotic navigation and manipulation, connecting sensing and perception with planning, decision-making, control, and action.
3. Identify real-world challenges in the development and deployment of Physical AI systems beyond predefined benchmarks, including uncertainty, environmental dynamics, embodiment constraints, distribution shifts, human interaction, safety, and reliability.
4. Recognize the critical role of evaluation beyond predefined metrics and state-of-the-art performance, and analyze system capabilities, limitations, failure modes, robustness, generalization, and safety under realistic conditions.
5. Design evaluation strategies for Physical AI systems that reflect real-world requirements, scenarios, and system behaviors rather than relying solely on aggregate benchmark metrics.
6. Apply evaluation insights to guide inference and system improvement, using observed failures, limitations, and operating conditions to improve Physical AI system design and behavior.

參考書目：

1. Stuart Russell and Peter Norvig (2020). Artificial Intelligence: A Modern Approach, 4th Global ed., Pearson College.
2. Richard Hartley and Andrew Zisserman (2003), Multiple View Geometry in Computer Vision.
3. Timothy D. Barfoot (2024), State Estimation for Robotics, Second Edition, Cambridge University Press.
4. Kevin Lynch and Frank Park (2017), Modern Robotics Mechanics, Planning, and Control, Cambridge University Press.
5. Keet, C. M. (2025). An introduction to ontology engineering (2nd ed.). College Publications.
6. Allemang, D. (2020). Semantic Web for the Working Ontologist : Effective Modeling for Linked Data, RDFS, and OWL / (Third Edition). Association for Computing Machinery. <https://doi.org/10.1145/3382097>

課程內容大綱

週次	日期	課程內容	備註
1	9/8/2026	Introduction	
2	9/15/2026	Recent Advances in Physical AI	
3	9/22/2026	Data Pyramid in Physical AI	
4	9/29/2026	Towards Real-World Deployment of Physical AI	
5	10/6/2026	Simultaneous Localization and Mapping	HW1 Release
6	10/13/2026	Depth Estimation	
7	10/20/2026	Path Planning and Robot Navigation	
8	10/27/2026	Intelligent Driving Systems	HW1 Deadline HW2 Release
9	11/3/2026	Scenario-based Safety Evaluation	Course Project Specification Release
10	11/10/2026	Introduction to Issac Sim	
11	11/17/2026	Robotic Manipulation	HW2 Deadline HW3 Release
12	11/24/2026	Robot Learning for Manipulation	
13	12/1/2026	Introduction ICRA'26 WBCD Challenge	
14	12/8/2026	Policy Evaluation	HW3 Deadline
15	12/15/2026	Human-Centered Physical AI	
16	12/22/2026	Course Project Presentation	Course Project Deadline

成績評量方式

- **Computer Assignment: 50%**

- HW1: 3D Scene Reconstruction and Mapping
- HW2: Robot Navigation
- HW3: Robotics Manipulation

- **Course Project: 50%**

The Course Project is designed to provide students with hands-on experience across the full lifecycle of Physical AI, from real-world data collection, to policy learning in simulation, and ultimately to evaluation. More details will be shared in the kick-off meeting.

課程要求(例如先備知識、軟硬體設備、修課規範, 若無可填無)

本次作業(Computer Assignment)將使用 Habitat 虛擬器。作業內容主要以基本操作為主, 並不涉及高負載的模擬或模型訓練, 因此整體硬體需求不高。

確認電腦是否符合最低需求時, 可以優先檢查以下兩點:

- 電腦是否具備可用的顯示晶片(GPU)
- 記憶體(RAM)是否至少為 8 GB

原則上即可執行本次作業。

詳細硬體需求如下:

GPU

- 最低:支援 OpenGL 3.3 / EGL, 至少 2 GB VRAM
- 建議:4 GB VRAM 以上

CPU

- 最低:x86-64, 4 個實體核心
- 建議:8 核心以上, Boost 時脈 ≥ 3.5 GHz

RAM

- 最低:8 GB
- 建議:16 GB 以上

儲存空間

- 最低:20 GB 可用空間
- 建議:30 GB 以上, 並使用 NVMe / SATA SSD

作業系統

- MacOS
- Linux
- Windows (必須安裝 WSL)

協同老師負責工作(封閉式授權免填)

衛星課程的協同老師，需要獨立完成該盟校所有學生的評分，包含Computer Assignment 的評分、分組簡報評分、期末專題評分等等，各盟校評分獨立作業。

【實體人工智慧】的協同老師，不需要同步跟課，但是需要找尋適合的助教以及協助下列評分，也因此盟校至少要給予一半的授課學分數，若該校學生除了主導課程老師的上課內容外，還需要協同老師另外補充上課，則需給予更高的學分數。總分：協同教師可以決定該課程是要用百分、等第、或通過／非通過的成績。另因 Course Project 將使用 GPU 進行虛擬環境資料收集與模型訓練，課程助教團隊將提供指定 GPU 雲端運算平台之使用點數予各開課學校，相關平台、點數額度及使用方式將另行通知。