CSIE 2020 Fall: Introduction to Image Processing, Computer Vision and Deep Learning
(影像處理、電腦視覺及深度學習概論)

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Website: http://robotics.csie.ncku.edu.tw/course.html **Prerequisites:** C, C++ or Python

Class Time/Location: 09:10 ~ 12:00 Friday / room A1302/ for undergraduate and master students

Syllabus: (W: Week - Ch: Bradski's OpenCV book chapter)

	01-01	Introduction to **industry 4.0** and **biomedical research** - Intelligent robotics and automation: Sensors, machine vision, deep learning, big data and IoT (Internet of Things).
Image Processing	01-06	Image processing 1 - **Convolution**: High-Pass (edge) and low-pass (smooth) filters, morphology operation, and CCLabeling (connected-component labeling).
	02-06	Image processing 1 - **Convolution**: High-Pass (edge) and low-pass (smooth) filters, morphology operation, and CCLabeling (connected-component labeling).
	03-05	Image processing 2 - **Image transforms**: Hough transformation, geometric trans., FT (Fourier transform), II (integral image) and histogram equalization.
	04-05	Image processing 2 - **Image transforms:** Hough transformation, geometric trans., FT (Fourier transform), II (integral image) and histogram equalization.
Assignment 1.	05-07	Image proc. 3 – **(Texture) Histograms and matching:** Stochastic and probability.
	06-08	Image Processing 4 – **(Shape) Contours:** Data structure - **Linked list.**
Computer Vision	07-11	Sensor - **Camera models and calibration**: Optimization process and **AR** (Augmented reality).
	08-12	Sensor - Projection and **3D vision**: Geometric transformations between 2D and 3D; and 1) **Stereo**, 2) ToF (Time-Of-Flight, Kinect 2, SoftKinetic), and 3) Structured light (Kinect 1, DLP projector).
	09–	**Buffer**
Assignment 2.	10-09	Image parts and segmentation: **Background subtraction/modeling** - Real-time motion detection using **GMM**.
	11-10	Tracking and motion: **Optical flow** (feature tracking), mean-shift, **Camshift** tracking, and condensation algorithm (particle filter).
Machine Learning	12-13	Introduction to Machine Learning: 1) SIFT (and brief HOG): Feature extraction, 2) AdaBoost: Face detection, 3) PCA, LDA: Linear classification for face recognition, 4) SVM: Non-linear classification
Deep Learning	13-	Deep Learning: From Computer Vision and BPNN (back propagation neural networks) to deep learning.
	14-	Deep learning: Network Design, and Training and Test Processes of Deep Learning
Assignment 3.	15-	Deep learning: Network Design, and Training and Test Processes of Deep Learning
	16-	Deep learning: Network Optimization Factors of Deep Learning
	17-	Deep learning: Network Optimization Factors of Deep Learning
	18-	**Final Project (Group Project)– Deep Learning**

Grading: Assignment x 3: 25% x 3 = 75%, Group Project x 1: 25% x 1 = 25%.

Textbooks/Reference Books:

1. Textbook1: Class lecture notes.
2. Textbook2: Learning OpenCV, Computer Vision with the OpenCV Library by Gary Bradski and Adrian Kaebler, O'Reilly, 2008.

3. Ref1. OpenCV (V.2.4.7 or above) documents including 1) tutorials, 2) reference manual, and 3) user guide.
4. Ref2. Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods, 3rd, Pearson, 2007.
5. Ref3. Computer Vision: Algorithms and Applications by Richard Szeliski, Springer, 2010.
6. Ref4. Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.

課程概述：

這門課上半學期授課將以老師的講義配合 OpenCV 教科書所提供較實用的程式功能論述為主，下半學期將以老師深度學習講義為主來授課。

課程內容將以常會用到的影像處理、電腦視覺及人工智慧-深度學習的理論基礎及技術為主，並學習及實作 OpenCV 的功能與實務應用。為了讓學生了解深度學習的原理是如何結合人工神經網路及電腦視覺發展而來的相互關係，課程中會傳授影像處理中最重要的 convolution 的基本原理與實際應用，並會讓學生了解如何用神經網路來實現並強化 convolution 的功能以完善 Convolutional Neural Networks (CNN) 的架構 (topology)。講解的方法將融入老師 20 幾年的產學合作經驗（臉部偵測、辨識及表情分析、雲端智慧型監控服務、自動光學檢測、智慧製造、智慧型機器手臂控制、自走車）及近年來在臨床醫學影像與精準運動分析經驗來舉實際的範例解釋基礎原理，透過這些理論來解決實際的問題；技術內容包括影像處理、電腦視覺 （即時偵測、追蹤及辨識模組的設計、3D 立體視覺、增擬實境）及深度學習等等。

本課程期待培養學生於影像處理、電腦視覺及深度學習領域技術設計及整合實作的能力，透過務實的作業實例來培育學生具備研發思考、程式設計及解決現存問題的能力，藉由分組計劃的實作來培養學生具備發現問題、解決問題及團隊分工合作的能力與精神，並可把所學的理論基礎應用到工業界、臨床醫學影像處理及精準運動的實務面。

Course Abstract:

This class will focus on the teacher's lecture notes and the more practical functional arguments (function calls) provided by the OpenCV textbook for the first half of the semester about OpenCV. The teacher's lecture notes will be used for the second half of the semester about deep learning.

The content of the course will focus on the theoretical basis and practical techniques of image processing, computer vision and artificial intelligence – deep learning. OpenCV functions and practical applications will also be learnt. In order to let students understand how the principles of depth learning combine artificial neural networks (ANNs) and the interrelationships of computer vision, the most important principles and practical applications of image processing – convolution will be taught. Therefore, students will be able to understand how to implement and enhance the functionality of the convolution in order to perfect the architecture of Convolutional Neural Networks (CNN). In addition, the lectures will incorporate teacher's more than 20 years of experience in industrial cooperation (face detection, recognition and expression analysis, intelligent video surveillance as a service, automated optical inspection (AOI), intelligent manufacturing, visual-guided robot arm control, and automatic guided vehicle (AGV)) and recent practical examples of clinical imaging and AI Sports to explain the

fundamentals and solve practical problems through these theories, including image processing, computer vision (real-time detection, tracking and recognition, 3D stereo or visualization, augmented reality (AR)) and deep learning.

This course looks forward to developing students' ability to design and integrate practical skills in image processing, computer vision and depth learning, and to develop students' R&D thinking, programming design, and practical consideration through practical practice in order to have the ability to solve existing problems. Through the practical work of group project, students' ability and spirit of discovering problems, solving problems and team work-sharing can be nurtured. They can also apply the theoretical foundation to industry, clinical imaging and precision sports analytics.

教學目標:

培養學生具備以下的基本知識及實作能力：

1）具備基本的影像處理、電腦視覺及深度學習理論基礎；

2）融匯貫通深度學習的原理是如何結合人工智慧、電腦視覺及影像處理- convolution 發展而來的；

3）具備以電腦視覺及深度學習的技術來解決即時偵測、追蹤、辨識及增擬實境在生活上、工業界（臉部偵測、辨識及表情分析、雲端智慧型監控服務、自動光學檢測、智慧製造、智慧型機器手臂控制、自走車）及近年來在臨床醫學影像與精準運動分析的實際問題。

4）學習 OpenCV 的功能原理及實務應用。