Course Syllabus:
CIVE 497 – CIVE 700

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CIVE 497 – CIVE 700: Smart Structure Technology

UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING

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Course Description

This course offers an introduction to the emerging **smart structure technologies** in civil engineering. Smart structures integrate sensing, actuation, data processing and analysis, and control capabilities so that a structure can sense and respond to its changing external conditions in a rapid and automated manner. Among several topics in smart structure, this course focuses on **structural assessment** using optical sensor data by implementing state-of-art image processing and computer vision techniques. As a special topic, basic concepts in machine learning, neural networks, convolutional neural networks (deep learning) are covered and relevant applications in civil engineering are introduced. An application-based learning approach is emphasized and tasks are designed in such a way that students implement smart structure technology to address contemporary problems in civil engineering. In addition, one of the deliverable for this course will be a research project, in which student will have an opportunity to design a technique with a potential application to smart structures. This course is specially designed to suit the interest of **graduate students** and **senior undergraduate students** who may pursue graduate studies.

Course Objectives

By the end of this course, students should be able to

- Describe smart structure technology and its application in civil engineering
- Explain the **working principle** of an accelerometer and digital camera, and their data acquisition process
- Interpret the concept of image processing techniques through signal processing theory
- Develop programs (MATLAB or Python) to process and analyze 2D and 3D optical data for structural assessment
- Demonstrate how to implement machine learning algorithms in solving real-world problems
- Employ deep convolutional neural network for image classification
- **Devise innovative smart structure technology for civil engineering applications and research**

Prerequisite

This course requires basic knowledge in linear algebra, probability, and signal processing and skills at a sufficient level of a non-trivial computer programming (with **MATLAB** or **Python**). Students also need to know how to use **Markdown**.

- Github
- Matlab and Python
- Matlab live editor
- Power points
- Markdown editor

Class Tips

- Complete tutorials !!
- All computation will be made through the course website. (You will no see any update on LEARN and get an email from them.)
- Bring your laptop into the class and run tutorials.
- Ask as many questions as you can through the course website
- Must submit the task assignments (there is no default score). The instructor and CA will help you finish the assignments.
- Get your project idea from course and the instructor's prior research

- https://help.github.com/articles/be-social/
- https://stackoverflow.com/questions/9843609/view-markdown-files-offline

Course Outline

Class	Topics	Slides	Tutorial	Tasks
Class 01	Introduction I			
Class 02	Introduction II			
Class 03	Data Acquisition			Complete all tutorials
Class 04	Signal Processing I			
Class 05	Signal Processing II			**Task1:** Signal processing & Modal analysis
Class 06	Modal Analysis			
Class 07	Digital Image			**Task2:** Camera sensor
Class 08	Projective Geometry I		link	
Class 09	Projective Geometry II		link	**Task3:** Homography
Class 10	Linear Filtering			
Class 11	Edge Detection			**Task4:** 2D crack detection
Class 12	Corner Detection			
Class 13	Feature (SIFT)			
Class 14	RANSAC		link	**Task5:** Image stitching
Class 15	Camera Model			
Class 16	Multiview Geometry			
Class 17	Structure-from-motion (SfM)			**Task6:** 3D measurement using SfM
Class 18	Introduction of 3D Sensors			
Class 19	Iterative Closest Point Algorithm			**Task7:** Image registration in 3D
Class 20	Machine Learning I			
Class 21	Machine Learning II			
Class 22	Neural Network			**Task8:** 2D crack detection using CNN
Class 23	Convolutional Neural Network			
Class 24	Presentation			

Signal Processing

Image Processing

3D Data Processing

Machine Learning

Project

Students are encouraged to **bring their own problems** related to their thesis, research projects or potential research in civil engineering that they plan to pursue near future. This course gives special attention to exploring theory and potential techniques in the field of smart structure to address real problems that students are exposed to or involved in. Thus, students need to devise feasible project topics that are achievable within your current or future graduate study.

Tell us what you want to get from this course?

Grading

The final grade will be based on the total marks earned during the semester. Each task will be graded on the basis of 100 points and will contribute the final grade with different weights. The evaluation guideline for the project can be seen **here**. Note that undergraduate and graduate students are marked using different evaluation metrics.

Undergraduate student: Task (80%) and Project (20%)

Graduate student: Task (70%) and Project (30%)

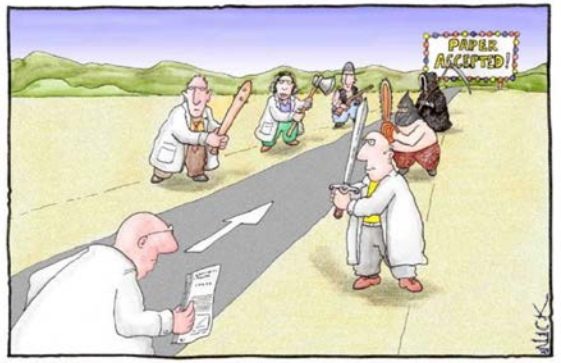
The Most Cited Papers in Computer Vision

COMPUTER VISION, PUBLICATION

The most cited papers in Computer Vision

In Computer Vision, Paper Talk on February 10, 2012 at 11:10 pm

by gooly (Li Yang Ku)



Although it's not always the case that a paper cited more contributes more to the field, a highly cited paper usually indicates that something interesting have been discovered. The following are the papers to my knowledge being cited the most in Computer Vision. (updated on 11/24/2013) If you want your "friend's" paper listed here, just comment below.

Cited by 21528 + 6830 (Object recognition from local scale-invariant features)

Distinctive image features from scale-invariant keypoints

DG Lowe – International journal of computer vision, 2004

Cited by 22181

A threshold selection method from gray-level histograms

N Otsu – Automatica, 1975

Cited by 17671

A theory for multiresolution signal decomposition: The wavelet representation

SG Mallat – Pattern Analysis and Machine Intelligence, IEEE ..., 1989

Cited by 17611

A computational approach to edge detection

J Canny – Pattern Analysis and Machine Intelligence, IEEE ..., 1986

The most cited papers in computer vision and deep learning

In Computer Vision, deep learning, Paper Talk on June 19, 2016 at 1:18 pm

by Li Yang Ku (Gooly)

In 2012 I started a list on the most cited papers in the field of computer vision. I try to keep the list focus on researches that relate to understanding this visual world and avoid image processing, survey, and pure statistic works. However, the computer vision world have changed a lot since 2012 when deep learning techniques started a trend in the field and outperformed traditional approaches on many computer vision benchmarks. No matter if this trend on deep learning lasts long or not I think these techniques deserve their own list.

As I mentioned in the previous post, it's not always the case that a paper cited more contributes more to the field. However, a highly cited paper usually indicates that something interesting have been discovered. The following are the papers to my knowledge being cited the most in Computer Vision and Deep Learning (note that it is "and" not "or"). If you want a certain paper listed here, just comment below.

Cited by 5518

Imagenet classification with deep convolutional neural networks

A Krizhevsky, I Sutskever, GE Hinton, 2012

- https://computervisionblog.wordpress.com/2016/06/19/the-most-cited-papers-in-computer-vision-and-deep-learning/
- https://computervisionblog.wordpress.com/2012/02/10/the-most-cited-papers-in-computer-vision/

Remark

It is not that I’m so smart.

It is just that I stay with problems longer.

- Albert Einstein

https://www.youtube.com/watch?v=G2PJdmG2ICA