Course Syllabus: CIVE 497 – CIVE 700

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CIVE 497 – CIVE 700: Smart Structure Technology

UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING

Last updated: 2020-01-06

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**.

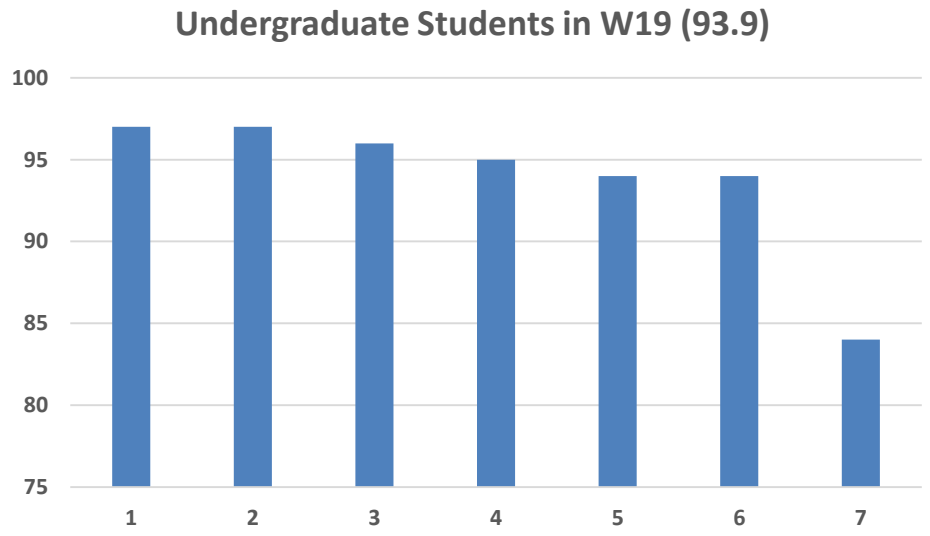
Course Objectives

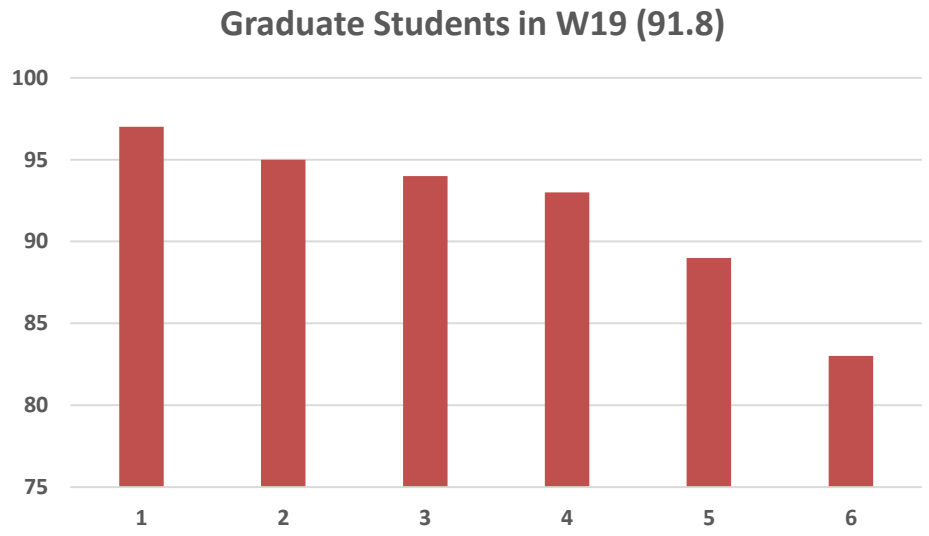
By the end of this course, students should be able to

- 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**

Course in W19

Based on the feedback received from the course in 2019 (six undergraduate and seven graduate students registered the course), you are expected to spend extra 12 hours or more week studying class materials as well as working on task assignments and research project. You will see the course outline and task assignments in W19.





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**.

- Matlab or Python
- Markdown editor
- Github
- Matlab live editor

Course Outline

Class	Topics	Slides	Tutorial	Tasks
Class 01	Introduction			
Class 02	MATLAB Tutorial			
Class 03	Data Acquisition			
Class 04	Signal Processing I			
Class 05	Signal Processing II			
Class 06	Modal Analysis			
Class 07	Digital Image			
Class 08	Projective Geometry			
Class 09	Review			
Class 10	Linear Filtering			
Class 11	Edge Detection			
Class 12	Feature 1			
Class 13	Feature 2			
Class 14	RANSAC			
Class 15	Camera Model			
Class 16	Multiview Geometry			
Class 17	Structure-from-motion (SfM)			
Class 18	Review			
Class 19	Microsoft Azure Tutorial			
Class 20	Machine Learning I			
Class 21	Machine Learning II			
Class 22	Neural Network			
Class 23	Convolutional Neural Network			
Class 24	Presentation			

Introduction

Signal Processing

Image Processing

3D Data Processing

Machine Learning

Tasks

There will be 7-9 tasks and posted on either weekly or biweekly on this course website. The instructor encourage students to work in groups through collaborative learning, but to submit their assignments individually. The task will have programming components or photography components, where students will use their own camera to capture and process their own images and discuss the results. Students are supposed to complete all tasks and turn their works in by the due date. After the due data, there is 25% deduction in the final mark and students must submit their works within a week after the due data. After then, the submission of the works will not be accepted unless accompanied by a valid excuse and some additional points might be deducted depending upon the circumstances.

Tasks in W19

Hanging a nice picture

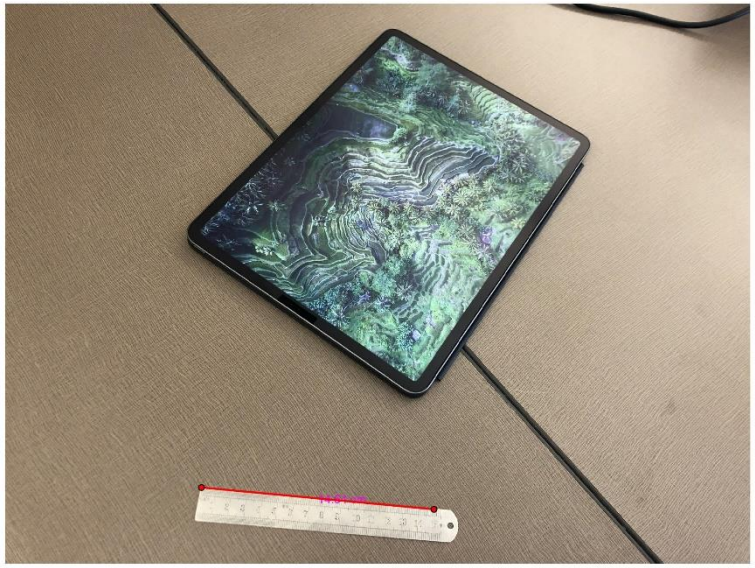
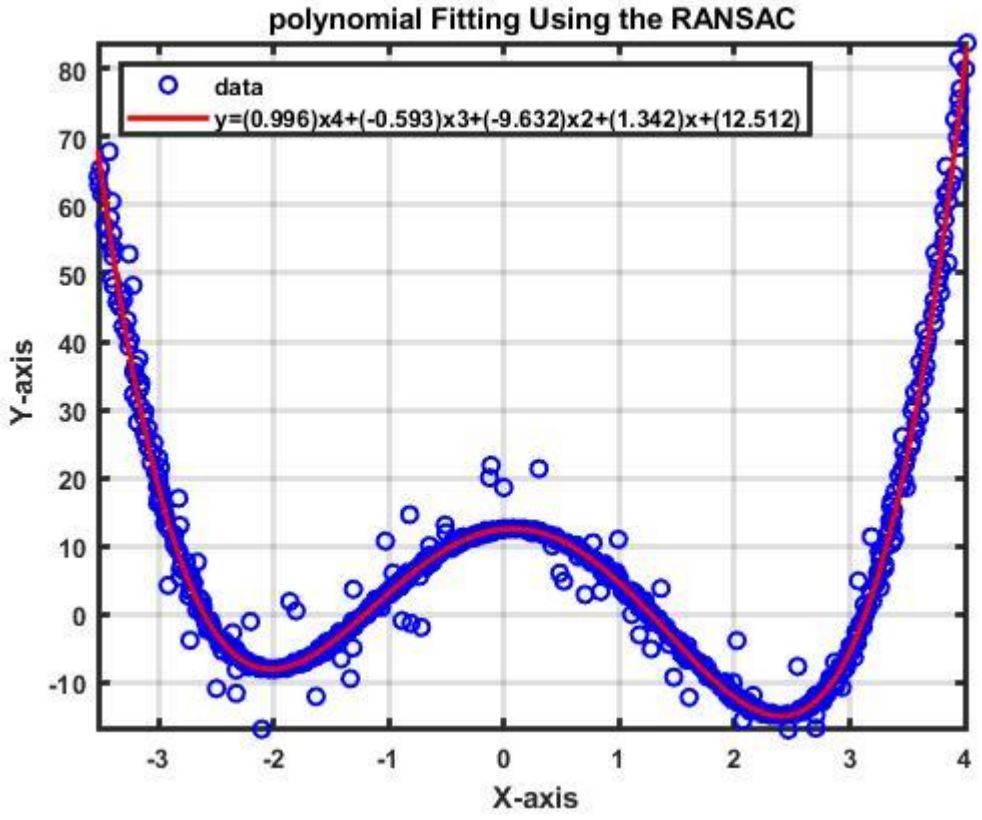


Image-based measurement

Tasks in W19 (Continue)



Polynomial fitting

Book detection

Class Tips

- You can allow to bring your laptop into the class but should not do homework during class!
- Ask as many questions as you can through the course website.
- Must submit the task assignments (there is no default score).
- Ask for help from the instructor and CA
- Think about how to apply knowledge from the course to your research or job
- Make friends who become your long-term research partners.

Project (for Graduate Students)

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 in the course website. Note that undergraduate and graduate students are marked using different evaluation metrics.

Undergraduate student: Task (100%)

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

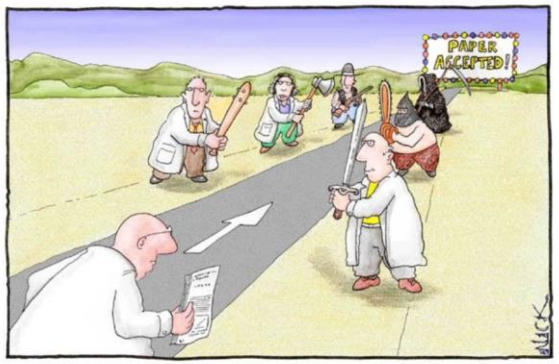
The Most Cited Papers in Computer Vision

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

imagenet classification with deep convolutional neural networks

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Scholarly articles for **imagenet classification with deep convolutional neural networks**

Imagenet classification with **deep convolutional neural** ... - Krizhevsky - Cited by 52919

[PDF] ImageNet Classification with Deep Convolutional Neural ...

https://papers.nips.cc › paper › 4824-imagenet-classification-with-deep-co...

by A Krizhevsky - 201 - Cited by 52919 - Related articles

We trained a large, **deep convolutional neural network** to **classify** the 1.2 million high-resolution images in the **ImageNet** LSVRC-2010 contest into the 1000 dif- ferent classes. On the test data, we achieved top-1 and top-5 error rates of 37.5% and 17.0% which is considerably better than the previous state-of-the-art.

Search Results Web results Random sample consensus a paradigm for mod

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Random sample consensus: a **paradigm** for **model fitting** with applications to image analysis and automated cartography

MA Fischler, RC Bolles - Readings in computer vision, 1987 - Elsevier

A new paradigm, Random Sample Consensus (RANSAC), for fitting a model to experimental data is introduced, RANSAC is capable of interpreting/smoothing data containing a significant percentage of gross errors, and is thus ideally suited for applications in …

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Multiple view geometry in computer vision

Articles

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[BOOK] **Multiple view geometry** in **computer vision** [PDF] ucsd.edu

R Hartley, A Zisserman - 2003 - books.google.com

A basic problem in computer vision is to understand the structure of a real world scene given several images of it. Techniques for solving this problem are taken from projective geometry and photogrammetry. Here, the authors cover the geometric principles and their algebraic …

☆ Cited by 26241 Related articles All 29 versions »

Multiple view geometry and the L/sub/spl infin//-norm [PDF] ieee.org

F Kahl - … IEEE International Conference on **Computer Vision** …, 2005 - ieeexplore.ieee.org Get It!@Waterloo

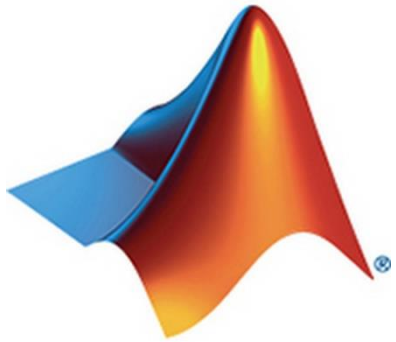
This paper presents a new framework for solving geometric structure and motion problems based on L/sub/spl infin//-norm. Instead of using the common sum-of-squares cost-function, that is, the L/sub/spl infin//-norm, the model-fitting errors are measured using the L/sub/spl …

☆ Cited by 206 Related articles All 14 versions

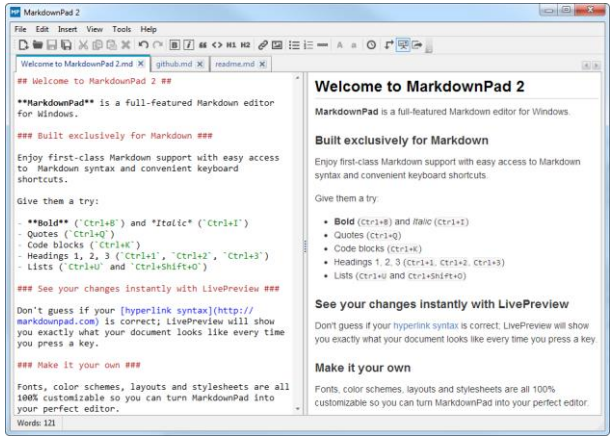
EGT for **multiple view geometry** and visual servoing: robotics **vision** with [PDF] ieee.org

- 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/

How To Use Tools



https://github.com/chulminy/AE121/tree/master/lab/lab01



https://github.com/chulminy/CIVE497-CIVE700/tree/master/tutorial/markdown

How To Use Tools (continue)

https://help.github.com/en/github/receiving-notifications-about-activity-on-github/watching-and-unwatching-releases-for-a-repository

https://www.youtube.com/watch?v=77W2JSL7-r8

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