COURSE SYLLABUS

Instructor:
Prof. Mani Golparvar-Fard (Newmark 3129D)
mgolpar@illinois.edu

Teaching Assistants:
Jacob Lin
Mo Hmaidi
Wil Torres

Lectures: Tue & Thu, 3:30 PM – 5:15 PM
* Please see the Schedule of Sessions for details on location.

Room 2132, Newmark
[Last Update: Jan 18, 2017]
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I. Contact Information

Instructor  Prof. Mani Golparvar-Fard
Department of Civil and Environmental Engineering
Department of Computer Science
University of Illinois at Urbana-Champaign
3129D Newmark Civil Engineering Laboratory
205 N. Mathews Ave., Urbana, IL 61801
Phone: (217) 244-4257 | Fax: 217-265-8039
E-mail: mgolpar@illinois.edu
Office Hours: Tue and Thu 5:00PM-6:00PM.
At all other time only by appointment.

Teaching Assistants  Jacob Lin  jlin67@illinois.edu
Mahmoud (Mo) Hmaidi  hmaidi2@illinois.edu
Wilfredo (Wil) Torres  trrscld2@illinois.edu

Quade Conference Room, Newmark Civil Engineering Lab
205 N. Mathews Ave., Urbana, IL 61801
Office Hours: Mon TBD
Wed TBD

Class Website  http://courses.engr.illinois.edu/cee598vsc/
http://piazza.com/illinois/spring2017/cee598vsc/home

II. Course Description

Course Objective
This course is an introduction to 2D and 3D visual sensing for data acquisition and analysis of buildings and civil infrastructure systems. It is intended mainly for graduate students who want to acquire basic understanding of the theoretical concepts as well as application of computer vision and image processing for sensing buildings, civil infrastructure systems and sustainable construction operations. Some of the topics introduced are:

a) Image-based 3D reconstruction of construction sites and building components
   - Including 2D and 3D computer vision topics in image formation, camera models, geometry of multiple views and shape reconstruction methods

b) Location and action tracking of construction equipment and personnel
   - Low-level image processing methodologies such as edge detection, and feature detection
   - Mid-level vision techniques such as segmentation, clustering, and filtering; and
   - Basic high-level vision techniques in equipment and personnel location tracking and action recognition

c) Semantic analysis and intelligent decision making of sustainable construction operation metrics
   - Transforming visual data into knowledge about performance metrics

By the end of the course, students will have full understanding of the following concepts and will be prepared for further vision-related investigations with engineering and management applications:

1. Basics of image formation and basic processing: digital images and video streams, camera models and camera calibration techniques
2. Fundamental concepts of single-view metrology, multiple view geometry and structure-from-motion and their application for 3D site reconstruction and recognition
3. Basics of image processing, filters, detectors and descriptors
4. Concepts of image and video segmentation/grouping, clustering and filtering
5. Concepts of component, equipment and personnel recognition (feature-based and region-based classifications)
6. Basics of machine learning techniques for interpreting visual features
7. Range, scope and advantages of visual sensing techniques for monitoring construction progress, productivity, safety, quality and carbon footprint of operations in addition to structural health monitoring and stability analysis

**Instructional Approach**

Learning is expected to occur by the following processes:
1) Lectures/discussions in the classroom,
2) Assignments from selected topics covered in the class,
3) Reading assignments and presentations from the textbooks and supplementary materials,
4) Term project.

There will be a number of reading assignments (published journal and conference papers) which will be presented by students. Assignments reinforce all of the material covered, and are required to be submitted by the due date indicated on the Schedule of Sessions.

Self-formed teams of **3 students** will be responsible for executing the final project. Teams **must avoid** splitting the project in pieces whereby each student is responsible for only one aspect of the project and then put together the code and the report for a single submission. When teams operate like this, team members are placed at a serious disadvantage during the presentations.

**III. Course Organization**

The following paragraphs detail the organization of the lectures, readings as well as the evaluation of the students’ work and involvement in the class

**Lectures**

Lectures are scheduled for Tuesdays and Thursdays from 15:30 to 17:15. Lectures will always be in 2312 Newmark Civil Engineering Bldg., unless if we have guest speakers. In those cases, location of the class might be changed. Student will be informed about such changes at least a week ahead of the guest lecture session. Please refer to the Schedule of Sessions (Section X) for more information. Lecture time will be used for teaching course materials and class discussions.

**Readings**

For each lecture there will be a set of readings. All reading materials are listed in section IX of this document. These materials are also posted on the Scholar website. Additional required readings may be assigned during class at least a week prior to the date when the material will be discussed.

**Textbook**

The recommended textbooks are:

  [http://szeliski.org/Book/](http://szeliski.org/Book/)

  [http://www.robots.ox.ac.uk/~vgg/hzbook/](http://www.robots.ox.ac.uk/~vgg/hzbook/)

IV. Course Evaluation

All work will be evaluated and assigned a grade on the “A” to “F” scale.

Grading Policy

The final course grade will be a weighted aggregation based on the following:

- 5% Participation grade for
  - Class participation (Attendance and involvement in class, and interpretations and suggestion to the questions posted on the Piazza)
- 30% Assignment grade; i.e., the grade for written assignments and submitted codes
- 10% Paper presentations: Thoughtful and well-organized presentations
- 55% Final term project
  - Project proposal and progress report: 5%
  - Project report: 30%
  - Project presentation: 10%

Electronic submission of Assignments

You should electronically turn-in assignments when they are due. We will use Illinois compass2g (http://compass2g.illinois.edu/) for electronic submission of assignments. Late assignments will be penalized according to the following system:

- 0-24 hours late – deduct 50%.
- More than 24 hours late – deduct 100%.

Participation Grade

Participation grade will constitute 5% of your grade and your attendance in the class is expected. Involvements in class are highly encouraged and are considered towards the grade for attendance.

V. Honor System

The University of Illinois’ Honor Code will be strictly enforced in this course. All assignments submitted shall be considered graded work, unless otherwise stated. All aspects of one’s coursework are covered by the Honor Code. Any suspected violations of the Honor Code will be reported to the Honor System. Honesty in one’s academic work will develop into professional integrity. The faculty and students of University of Illinois will not tolerate any form of academic dishonesty.

Cooperation and team work is encouraged and, in some cases, required, e.g., on term project. Unless otherwise noted, students should be free to work together as they wish. When this is done, both courtesy and academic honesty dictate that help and source material are properly acknowledged on the assignment cover page. However, under no circumstances is it permissible to simply copy the work of another person or allow another person to copy your work. All assignments are to be the sole work of the individual student.

Assignments

Students currently taking this class can work together to conceptualize general approaches to assignments. However, unless otherwise specified for a particular assignment (e.g., for term projects), the work you submit must be done completely on your own. This includes text, numerical calculations, mathematical derivations, diagrams, graphs, computer programs and output. You are also expected to properly reference the source of any information used in a submission that is not your own. This includes any book, article, web page, MS PowerPoint presentation or personal correspondence from someone else that you used to create your work.

It is also inappropriate to use assignments, problem sets, examinations or projects submitted in other schools as a source, unless otherwise authorized.
If you have any questions about how these policies relate to a specific situation, please speak to the instructor for clarification. Just remember, when you have doubts, ask the instructor for assistance.

VI. Paper Presentation

Paper presentations are seen as educational devices to help students master a specific topic on application of visual sensing for Architecture/Engineering/Construction engineering and management. The instructor will give informal feedback on paper presentations.

Instructions to the Presenter

The assigned papers are a starting point for exploring a particular topic in visual sensing. Your presentation should present the key ideas of the assigned works and explain important technical aspects. If the work is focused on a particular technology, the presenter should also tell how the work fits into the broader civil engineering applications. The presentation should be about 15 minutes long and cover the following:

- Motivation: applications and challenges
- Summary of approach
- Key ideas and results
- Strengths and weaknesses
- Ideas for improvement
- Related work (at least three related papers: key ideas and how they relate)

It is highly encouraged to do a demonstration as part of the presentation. For the demo, you should run the software of the proposed paper (this is easier if you can download it) on many examples and use the results to illustrate the strengths and weaknesses of the method. If possible, compare to another approach or implement your own.

Instructions to Non-Presenters

Read the assigned papers sufficiently well to understand them. On the wiki page, there will be a separate section for each presentation, where students will be able to pose their questions or comments.

VII. Term Project

The term project is a chance to further explore a topic of interest with application to a specific engineering problem. Groups of up to four students are encouraged. The projects consist of the following components:

1. Problem component: Formulate a goal and identify a specific building, civil infrastructure, construction or monitoring problem;
2. Technical component: Devise an approach to address the goal with visual sensing and semantic analysis techniques;
3. Application component: Develop reconstruction, recognition, identification and/or detection models and evaluate them for the specific problem identified using an experimental or a real-world case study.

Term Project Report Format

The following is the guideline for term project report format:

- Term project report should not exceed 10 pages.
- Every project will start with the title of the project and authors.
- Project Abstract: short summary of the project with main results.
- The term project report will include 6 distinct sections:
  1. Introduction: introduce the problem you want to solve, explain the significance of the problem why it is important to solve it; and indicate
the method you used to solve it. It is also highly recommended to add a concept figure showing the overall idea behind the method you are presenting.

2.1. Review of previous works: (i.e. previous methods that have explored a similar problem)

2.2. Key contributions of your work: Why your method is better than previous work. Summarize the key main contributions of your work;

3.1. Technical part: Summary of the technical solution

3.2. Technical part: Details of the technical solution; you may want to decompose this section into several subsections; add figures to help your explanation.

4. Experiments: present here experimental results of the method you have implemented with plots, graphs, images and visualizations.

5. Conclusions: what's the take home message?

6. References

- Term project needs to be submitted in PDF format.

Example of ideal format needs will be posted on the course website.

<table>
<thead>
<tr>
<th>Term Project Evaluation</th>
<th>Term project report will be evaluated based on the quality of the writing, the clarity of your technical explanation and, overall, how well you get your message across.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term Project Source Code</td>
<td>Term project source codes of your working program need to be submitted to the course website. This file is due on the project submission deadline date.</td>
</tr>
<tr>
<td>Term Project Presentation in Class</td>
<td>The presentation must be 20 minutes long; if you have a 3-person team, then each of you will present for 7 minutes. There will be 2-5 minutes for questions after the presentation. If your presentation lasts more than 20 minutes, it will be stopped. So please make sure the presentation does not go over 20 minutes.</td>
</tr>
</tbody>
</table>
| Term Project Presentation Format | The idea is to turn your project report into slides; thus, your presentation will need to include slides covering:  
  - Introduction: introduce the problem you want to solve, explain why it is important to solve it; and indicate the method you used to solve it.  
  - Review of previous work (i.e. previous methods that have explored a similar problem)  
    - Why your method is better than previous work; and/or explain the key main contributions of your work;  
    - Technical part: Summary of the technical solution, followed by the details of the technical solution;  
    - Experiments: present here experimental results of the method you have implemented with plots, graphs, images and visualizations.  
  - Conclusions: what's the take home message? |
| Term Project Presentation Evaluations | Your presentation will be evaluated based on its clarity, quality of the slides, how well you get your message across, and how well you handle the questions at the end. Note that the presentation can still contain ongoing (non-final) results; final results may be included in the final report. |
| Term Project Progress Report Format | The following is the guideline for term project progress report format:  
  - Project progress report should not exceed 4 pages.  
  - Every project will start with the title of the project and authors.  

The project progress report will include five distinct sections:  
1. Introduction: introduce the problem you want to solve, explain the significance of the problem why it is important to solve it; and indicate the
method you used to solve it. It is also highly recommended to add a concept figure showing the overall idea behind the method you are presenting.

2. Technical Part: How do you propose to solve it?
3. Achieved Project Milestones: Milestones achieved so far
4. Remaining Project Milestones: Dates and sub-goals
5. References.
   - Project progress report needs to be submitted in PDF format.

Term Project Proposal Format

The following is the guideline for term project proposal format:

- Project proposal should not exceed 2 pages.
- Every project will start with the title of the project and authors.
- The project progress report will include four distinct sections:
  1. Introduction: introduce the problem you want to solve, explain the significance of the problem why it is important to solve it); and indicate the method you used to solve it. It is also highly recommended to add a concept figure showing the overall idea behind the method you are presenting.
  2. Technical Part: How do you propose to solve it?
  3. Project Milestones: Dates and sub-goals
  4. References.
   - Project progress report needs to be submitted in PDF format.

VIII. Special Needs

If you need adaptations or accommodations because of a disability (e.g. learning, attention deficit disorder, psychological, physical, etc.), if you have emergency medical information to share, or if you need special arrangements in case the building must be evacuated, you must identify this need to me by the end of the first week of classes.

IX. Readers

In the course schedule section, there is a list of the reading materials according to lecture subjects. In this list, the textbooks are abbreviated (See the list of textbooks for abbreviations). The following includes a list of useful tutorials, codes and libraries for MATLAB. It also lists a set of recommended papers for class presentations. Students are welcome to select papers according to their own interests, however they need to consult with the instructor.

Matlab Tutorials, Online Codes and Libraries

An introduction to MATLAB (Hany Farid and Eero Simoncelli):  
http://www.maths.dundee.ac.uk/ftp/na-reports/MatlabNotes.pdf
MATLAB tutorial:  
http://www.cs.dartmouth.edu/~farid/tutorials/matlab.intro.html
The process of starting with very general MATLAB code: http://www.mathworks.com/products/matlab-coder/description2.html
Writing fast MATLAB codes:  
http://www.mathworks.com/matlabcentral/fileexchange/5685
Online Codes and Libraries:  
http://web.eecs.umich.edu/~silvio/teaching/EECS442_2010/lectures/code_and_libraries.pdf
List of Suggest Papers (Incomplete)

- Vision-based techniques for automated productivity analysis

- Vision-based techniques for tracking resources on construction sites

- Interactive and Automated image-based 3D reconstructions
# X. Course Schedule

<table>
<thead>
<tr>
<th>Session</th>
<th>Day</th>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
<th>Project</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thu</td>
<td>17-Jan</td>
<td>Course Introduction &amp; Administration</td>
<td></td>
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<tr>
<td>2</td>
<td>Tue</td>
<td>19-Jan</td>
<td>Visual Data Analytics</td>
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<tr>
<td>3</td>
<td>Thu</td>
<td>24-Jan</td>
<td>Linear Algebra/ Geometric Transformation</td>
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<tr>
<td>4</td>
<td>Tue</td>
<td>26-Jan</td>
<td>Camera Models and Projective Geometry</td>
<td>S30-98, FP1&amp;2, HZ6&amp;8</td>
<td></td>
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<tr>
<td>5</td>
<td>Thu</td>
<td>31-Jan</td>
<td>Invited Lecture #2</td>
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<tr>
<td>6</td>
<td>Tue</td>
<td>2-Feb</td>
<td>Calibration and Single-View Geometry</td>
<td>FP3, HZ2-3,7-8</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Thu</td>
<td>7-Feb</td>
<td>Hands-on with Matlab</td>
<td></td>
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<tr>
<td>8</td>
<td>Tue</td>
<td>9-Feb</td>
<td>Image Filtering</td>
<td>FP7&amp;8</td>
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<tr>
<td>9</td>
<td>Thu</td>
<td>14-Feb</td>
<td>Invited Lecture #3</td>
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<tr>
<td>10</td>
<td>Tue</td>
<td>16-Feb</td>
<td>Invited Lecture #4: ETC Business Plan</td>
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<td>11</td>
<td>Thu</td>
<td>21-Feb</td>
<td>Feature Detection and Description</td>
<td>FP 8&amp;9</td>
<td>P00</td>
<td>A2 A1</td>
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<tr>
<td>12</td>
<td>Tue</td>
<td>23-Feb</td>
<td>Feature Detection and Description II</td>
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<tr>
<td>13</td>
<td>Thu</td>
<td>28-Feb</td>
<td>Segmentation and Clustering</td>
<td>FP14</td>
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<tr>
<td>14</td>
<td>Tue</td>
<td>2-Mar</td>
<td>Hands-on with Matlab</td>
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<tr>
<td>15</td>
<td>Thu</td>
<td>7-Mar</td>
<td>Epipolar Geometry</td>
<td>HZ4,9&amp;11; FP10</td>
<td>P1</td>
<td>A3 A2</td>
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<tr>
<td>16</td>
<td>Tue</td>
<td>9-Mar</td>
<td>Stereo Systems</td>
<td>HZ11, FP11</td>
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<td>17</td>
<td>Thu</td>
<td>14-Mar</td>
<td>Structure from Motion</td>
<td>HZ6,14&amp;18; FP12</td>
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<td>No</td>
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<td>16-Mar</td>
<td>Structure from Motion II</td>
<td>HZ10,18&amp;19; FP13</td>
<td>A4</td>
<td>A3</td>
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<td>19</td>
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<td>21-Mar</td>
<td>No Class - Spring Break</td>
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<td>No Class - Spring Break</td>
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<td>21</td>
<td>Thu</td>
<td>28-Mar</td>
<td>Fitting and Matching</td>
<td>HZ4&amp;11, FP16</td>
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<td>Invited Lecture #5</td>
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<tr>
<td>23</td>
<td>Thu</td>
<td>4-Apr</td>
<td>Image Features and Categorization</td>
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<td>24</td>
<td>Tue</td>
<td>6-Apr</td>
<td>Object Recognition</td>
<td>S696-709</td>
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<tr>
<td>25</td>
<td>Thu</td>
<td>11-Apr</td>
<td>Object Recognition with CNNs</td>
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<tr>
<td>26</td>
<td>Tue</td>
<td>13-Apr</td>
<td>Object Tracking</td>
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<td>27</td>
<td>Thu</td>
<td>18-Apr</td>
<td>Activity Recognition</td>
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<tr>
<td>28</td>
<td>Tue</td>
<td>20-Apr</td>
<td>Monitoring Applications</td>
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<td>Thu</td>
<td>25-Apr</td>
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<td>30</td>
<td>Tue</td>
<td>25-Apr</td>
<td>Final Project Presentation</td>
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<tr>
<td>31</td>
<td>Thu</td>
<td>2-May</td>
<td>Final Project Presentation</td>
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</tbody>
</table>

## Remarks

- **Chapter**: Chapter in text to be studied BEFORE session in preparation for discussion.
- **Supp**: Supplemental reading to be studied BEFORE session in preparation for discussion.
- **Out**: Assignments to be discussed and work to start. All “A” assignments from homeworks.
- **Due**: Assignments due at the start of this session.
- **GL**: Guest Lectures may change depending on the availability of speakers. It is very difficult to arrange them 6months in advance due to the professionals’ busy schedules.
- **P**: P00: Project proposal; P1: Project report; P2: Project midsemester report; P3: Term project report.