Unit Outline 2011
Faculty of Information Sciences and Engineering

Computer Vision and Image Analysis PG
(runs as 6978 ISES 1 PG in WIT 2011)
**This Unit Outline must be read in conjunction with:**

a) *UC Student Guide to Policies*, which sets out University-wide policies and procedures, including information on matters such as plagiarism, grade descriptors, moderation, feedback and deferred exams, and is available at *(scroll to bottom of page)*

b) *UC Guide to Student Services*, and is available at *(scroll to bottom of page)*

c) Any additional information specified in section 6h.

## 1: General Information

<table>
<thead>
<tr>
<th>1a</th>
<th>Unit title</th>
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<tbody>
<tr>
<td></td>
<td>Computer Vision and Image Analysis PG</td>
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<td></td>
<td>(runs as 6978 ISES 1 PG in the Winter Term 2011)</td>
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<thead>
<tr>
<th>1b</th>
<th>Unit number</th>
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<tr>
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<thead>
<tr>
<th>1c</th>
<th>Teaching period and year offered</th>
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<tr>
<td></td>
<td>Winter Term 2011</td>
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<table>
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<th>1d</th>
<th>Credit point value</th>
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<tr>
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<table>
<thead>
<tr>
<th>1f</th>
<th>Name of Unit Convener and contact details (including telephone and email)</th>
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<tbody>
<tr>
<td></td>
<td>Dr. Roland Goecke, 11C10, ph 6201 2114, <a href="mailto:roland.goecke@canberra.edu.au">roland.goecke@canberra.edu.au</a></td>
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<table>
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<tr>
<th>1g</th>
<th>Name of Unit Moderator and contact details (including telephone and email)</th>
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<tr>
<td></td>
<td>Dr. Girija Chetty, 11C48, ph 6201 2512, <a href="mailto:girija.chetty@canberra.edu.au">girija.chetty@canberra.edu.au</a></td>
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<thead>
<tr>
<th>1h</th>
<th>Administrative contact details (including name, location, telephone and email)</th>
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<tbody>
<tr>
<td></td>
<td>The Faculty of ISE Office, 11B14, 6201 2153 or 6201 2417, <a href="mailto:ise@canberra.edu.au">ise@canberra.edu.au</a></td>
</tr>
</tbody>
</table>
2: Academic Content

2a Unit description and learning outcomes

Syllabus

This unit provides an introduction to fundamental and state-of-the-art computer vision and image analysis techniques. Computer vision is a field of computer science that is about developing methods and algorithms for computer systems to see and understand their environment and surrounds from camera images. This is achieved by computer vision algorithms that analyse the images and extract useful information, which is then used to infer information about the scene viewed by the system. The closely related field of image analysis is a necessary pre-requisite for computer vision and will, thus, be part of this unit.

The aim of this unit is to provide students with both an overview of fundamental areas of computer vision and image analysis as well as in-depth knowledge of selected topics, which will be explored both in theory and practice. Through specific, applied examples, students will explore this highly topical field in the context of a widespread use of digital camera and image technology. These include examples from application areas such as digital photography, digital image enhancement, computer graphics, object recognition, object tracking, image segmentation, visual motion estimation, and multi-view camera systems. As computer vision and image analysis are fields that draw from a number of other related fields, such as perceptual psychology, digital signal processing, human-computer interaction, artificial intelligence and pattern recognition, students will be introduced to and will be able to explore relevant theories and algorithms in these areas, including topics such as how are images formed and represented, how does the human visual cortex process visual information, how can images be represented as signals, how can computer systems infer knowledge from an image, and how can recurring patterns automatically be recognised.

The unit has a strong focus on developing both an understanding of the theories and practical hands-on skills relevant to the student.

Learning Outcomes

On successfully completing the unit, students will have a sound understanding of and will have gained hands-on experience in:
1. what computer vision and image analysis entails;
2. how images are formed and represented;
3. understanding the basics of image processing and analysis techniques;
4. understanding the concepts of fundamental theories in computer vision;
5. writing Matlab programs for performing computer vision and image analysis tasks;
6. being able to choose appropriate computer vision and image analysis techniques to solve real-world problems; and
7. understanding the relationships between computer vision and image analysis on the one hand and fields such as perceptual psychology, digital signal processing, artificial intelligence and pattern recognition on the other hand.

2b Generic skills

A full list of the generic skills expected of UC graduates can be found at https://guard.canberra.edu.au/policy/policy.php?pol_id=3030. Those which are relevant to CVIA are:

1. Communication

Graduates are expected to be able to:
- express knowledge, ideas and opinions in their professional field, both orally and in written form, with confidence and clarity;
actively listen and respond to the ideas of other people;

2. Information Literacy and Numeracy
Graduates are expected to be able to locate, identify, collate, analyse, manipulate, evaluate, interpret and present information and numerical data.

3. Information and Communication Technology
Graduates are expected to be able to select and use appropriate information and communication technology to retrieve, manipulate and present information.

4. Problem Solving
Graduates are expected to be able to:
- identify problems and analyse the main features of problems relevant to their professional field;
- apply appropriate problem solving processes, arguments, critical and creative thinking;
- implement and evaluate strategies for the resolution of problems;
- anticipate and define new problems; and
- identify and resolve new problems in new fields.

5. Working With Others
Graduates are expected to be able to:
- respect the rights of others irrespective of their cultural background, race or gender.

6. Professional Ethics
Graduates are expected to:
- act responsibly, ethically and with integrity in the context of their profession and their obligations to society; and
- appreciate the social and cultural context of their profession.

7. Lifelong Learning
Graduates are expected to:
- be independent self-directed learners with the capacity and motivation for lifelong learning;
- be aware of how they best learn;
- possess self-knowledge and the ability to assess their own performance critically and accurately; and
- have an understanding of how to apply their knowledge and abilities to many different contexts and fields.

8. Personal Attributes
Graduates are expected to:
- show commitment to ongoing self-development;
- value and respect differing views;
- be confident in themselves and their own skills and knowledge.

2c Prerequisites and/or co-requisites
None.

While no formal prerequisites are required, it is assumed that students have a working knowledge of discrete mathematics, algebra and numerical analysis.
3: Delivery of Unit and Timetable

3a Delivery mode
Lectures, tutorials and computer labs face-to-face.

3b Timetable of activities, such as lectures/ tutorials/ practicals/ field classes, showing key dates and topics (Information might be provided in the form of a table)
The unit will be delivered face-to-face on campus with two 1.5-hour lectures and one 2-hour tutorial / laboratory per week. The lectures cover different topics. They are not repeat lectures. Tutorials and laboratories are in pairs – a one hour tutorial followed by a one hour laboratory – and start in week 1 of the term. A student who enrols in a tutorial is automatically enrolled in the associated laboratory.


Note:
The following topic overview is subject to change. Any changes will be posted on the subject’s Moodle (LearnOnline) homepage.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Lecture</th>
</tr>
</thead>
</table>
| 1     | Introduction to unit:  
- Admin  
- Academic integrity  
- Academic Skills Program  
- General introduction  
- What is computer vision? What is image analysis?  
- A brief history  
- A recap of underlying mathematical concepts |
| 2     | Image formation and image representation  
- How does the human brain process visual information?  
- How do cameras work?  
- How are images formed? What are colour spaces?  
- How are images represented? |
| 3     | Basics of image processing and analysis  
- Point operators  
- Edge / line detection  
- Linear filtering  
- Non-linear filtering |
| 4     | Basics of image processing and analysis  
- Geometric transformations  
- Fourier transforms  
- Image pyramids and wavelets  
- Optimisations |
| 5     | Feature detection and matching  
- Feature point detectors, local invariant image features  
- Vanishing points  
- Patches  
- Feature tracking |
| 6     | Image matching and registration  
- Template matching  
- Similarity measures |
|  |  
|---|---|
| 7 | Feature-based alignment  
- 2D and 3D feature-based alignment  
- RANSAC  
- Pose estimation  
- Camera calibration  
| 8 | Segmentation and clustering  
- Active contours  
- Split and merge  
- K-means  
- Mixture of Gaussians  
| 9 | Segmentation and clustering (cont.)  
- Mean shift  
- Normalised cuts  
- Graph cuts  
| 10 | Motion estimation and structure from motion  
- Optical flow  
- Structure from motion  
- Bundle adjustment  
| 11 | Object tracking  
- Object detection  
- Kalman filter  
- Particle filter  
- Mean shift tracking  
- Statistical model-based tracking  
| 12 | Object recognition  
- Bayesian analysis  
- Eigen-analysis  
- Instance recognition, category recognition  
- Support vector machines  
| 13 | Multi-view geometry  
- Stereo correspondence, epipolar geometry  
- Shape from shading, texture and focus  
- 3D reconstruction  
- Model-based reconstruction  
| 14 | Review and exam preparation  

### 4: Unit Resources

#### 4a Lists of required texts/readsings

**Required:**  
This book is available for purchase, for example, in the Co-op Bookshop on campus. A limited number of copies of this book is also available from the library.

#### 4b Materials and equipment

**Software:**
The software used in the computer laboratory classes as well as for working on different assessment tasks in this unit will be Matlab under the Windows 7 operating system provided in the computer laboratories of Building 11, Faculty of Information Sciences and Engineering. Files used for demonstrations and examples in the lectures and tutorials will be provided on the unit’s Moodle site.

Note:
Students are permitted to use their own computer equipment, but must ensure that their assignment submissions adhere to the requirements listed above. It is the responsibility of users of the Windows Vista or Windows XP operating systems to ensure that their assignment submissions, and in particular the executable files, run on the Windows 7 operating system and Matlab environment provided at the Faculty of Information Sciences and Engineering.

4c **Unit website**
The unit will be administered through the UC online learning environment Moodle (LearnOnline), which can be accessed at http://learnonline.canberra.edu.au/course/view.php?id=6070.

5: **Assessment**

5a **Assessment overview**
Assessment in this unit is based on the Assessment Policy at UC, which can be found at https://guard.canberra.edu.au/policy/policy.php?pol_id=2900.

In CVIA, students are required to satisfactorily complete two assignments (i.e. minimum 50% combined total marks in the two assignments) and to perform satisfactorily in a final written exam. The first assignment has a weighting of 35%, the second assignment has a weighting of 25%, while the final written exam has a weighting of 40%.

**To be awarded a particular grade in CVIA, students must meet the combined assignment and exam requirements set out in the table below.**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Assignments + Exam</th>
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<tbody>
<tr>
<td>Pass</td>
<td>Minimum 50% of combined weighted score of all assessment items, conditional upon:</td>
</tr>
<tr>
<td></td>
<td>- minimum of 50% on combined weighted score from the assignments, <strong>and</strong></td>
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<tr>
<td></td>
<td>- minimum 50% on exam paper</td>
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<tr>
<td>Credit</td>
<td>Minimum 65% combined weighted score of all assessment item, conditional upon:</td>
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<tr>
<td></td>
<td>- minimum of 60% on combined weighted score from the assignments, <strong>and</strong></td>
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<tr>
<td></td>
<td>- minimum 60% on exam paper</td>
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<tr>
<td>Distinction</td>
<td>Minimum 75% combined weighted score of all assessment item, conditional upon:</td>
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<td></td>
<td>- minimum of 70% on combined weighted score from the assignments, <strong>and</strong></td>
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<tr>
<td></td>
<td>- minimum 70% on exam paper</td>
</tr>
<tr>
<td>High Distinction</td>
<td>Minimum 85% combined weighted score of all assessment item, conditional upon:</td>
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<td></td>
<td>- minimum of 80% on combined weighted score from the assignments, <strong>and</strong></td>
</tr>
<tr>
<td></td>
<td>- minimum 80% on exam paper</td>
</tr>
<tr>
<td>Assessment item (including exams held in the exam period)</td>
<td>Due date of assignments</td>
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<tr>
<td>----------------------------------------------------------</td>
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</tr>
<tr>
<td>Matlab</td>
<td>23:55, Sunday, 31 Jul 2011</td>
</tr>
<tr>
<td>Presentation of a computer vision technique</td>
<td>Week 7 (Presentations to be scheduled in consultation with students)</td>
</tr>
<tr>
<td>Final Exam</td>
<td>1 – 12 Aug 2011</td>
</tr>
</tbody>
</table>

**5b Details of each assessment item**

Detailed specifications for the assignments and requirements for satisfactory completion will be made available on the CVIA unit website on Moodle (LearnOnline).

**Assignments** are meant to be individual work, although talking a problem over with another student or tutor is considered one reasonable way of learning. However, the actual submitted assignment must be the student’s own work. Students are expected to familiarise themselves with the University’s [Student Academic Integrity Policy](https://guard.canberra.edu.au/policy/policy.php?pol_id=3175). Experience has shown that students who do not do their own work are unlikely to pass the exam (and therefore the unit).

**Assignments** will be submitted electronically through the Unit Website interface on Moodle (LearnOnline). For the Matlab assignment, students need to submit the Matlab code and any additional files, such as images etc. to Moodle. For the presentation, students need to submit all documents (presentation files) that form part of their presentation to Moodle.

For both assignments, submissions have to be in zipped format, containing the entire folder/directory of your assignment, with the ZIP file uploaded to the unit’s Moodle (LearnOnline) site. For each assignment, the student has to submit the **signed** CVIA Assignment Cover Sheet as part of the electronic submission on Moodle, completing the self-assessment section. The cover sheet can be downloaded from the unit Moodle site.

Assignments will not be marked until a cover sheet has been submitted. Where a student is unable to submit a scanned copy of a hand-signed cover sheet, a cover sheet with an electronic signature is acceptable and will be deemed to be equivalent to the student signing the cover sheet by hand.

Assignment submissions will be assessed for addressing the specific requirements of each assignment, as stated in the assignment descriptions, as well as for employing good programming principles. Assignment submissions will receive a numerical mark, which together in their entirety with the other assessment item (exam) define a student’s final grade as outlined in section 5a.

**Matlab:**

**Purpose:**

- This assignment introduces the student to developing computer vision and image analysis methods in Matlab. These include techniques from background subtraction, feature detection and object tracking, which will be tested on given video sequences.
• This assignment assesses learning outcomes 2, 3, 4, 5, and 6.

Guidelines:

• Students are to develop Matlab programs that implement a background subtraction algorithm, perform feature detection on the separated foreground object and use feature matching for tracking the foreground object.
• Students are to show their knowledge of analysing images in general and working with morphological image operators in particular to separate foreground objects from the background scene.
• Students are to actively demonstrate their understanding and skills of local image feature point detectors.
• Students are to show their knowledge of object tracking in video sequences by implementing a feature based tracking method in Matlab.
• Students need to submit all their files (Matlab files as well as any other files relevant to the project) as a single ZIP file on Moodle.

Assessment criteria:

• The following criteria will be used in marking this assignment:
  o Correct design and implementation of the various required algorithms in Matlab
  o Demonstration of implemented algorithms working correctly when applied to test video sequences
  o Understanding of good programming principles as demonstrated in your Matlab code layout
  o Demonstration of advanced techniques as appropriate for the task

Presentation:

Purpose:

• This assignment requires each student to choose a paper, from a list of carefully selected suitable computer vision and image analysis research papers available on the unit’s Moodle site, and to familiarise themselves with the topic suitably to give a 20min presentation on the paper and topic, explaining the technique or method described in the paper in detail.
• This assignment assesses learning outcomes 1, 2, 3, 4, and 7.

Guidelines:

• Students will be given a list of research papers on Moodle with carefully selected topics from the fields of computer vision and image analysis.
• Students are to choose one paper, individually work on understanding the algorithms and methods described in it and prepare a 20min oral presentation about these to be held in class in week 7.
• Where necessary, students will need to consult further referenced literature to ensure they fully understand the paper’s topic.
• Students are to demonstrate an understanding of the general topic of covered in the research paper and, in more detail, of the computer vision and image analysis technique(s) covered by the paper.
• Students need to submit all files presentation files to the unit’s Moodle site.

Assessment criteria:

• The following criteria will be used in marking this assignment:
  o Demonstrated understanding of the topic and techniques covered by the research paper
  o Demonstrated ability to explain the technical aspects of the research paper to an audience of peers
Examination:
3 hour written examination. Permitted materials:
- 2 Sides, 1 A4 page of handwritten notes,
- Unannotated non-electronic language dictionary (English/Foreign)

5c Special assessment requirements
To obtain a particular grade in this subject, it is necessary that all minimum requirements, as outlined in Section 5a, have been met.

The lecturer / unit convenor reserves the right to question students orally on any of their submitted work.

5d Supplementary assessment
There will be no supplementary tests or exam.

Students who miss the final exam due to illness may be able to sit for a deferred examination. A doctor's certificate stating why the student was not able to sit for the exam should be given to central Student Administration (Bldg. 1, room 1B150) as soon as possible - generally within 3 days of the examination. See Deferred Examination Policy https://guard.canberra.edu.au/policy/policy.php?pol_id=3176 and Deferred Examination Procedures document https://guard.canberra.edu.au/policy/policy.php?pol_id=3177 for more details.

Students will only be allowed to sit for a deferred examination if there are no outstanding submissions or resubmissions for the assignments required to pass the subject as specified above.

5e Academic Integrity
Students have a responsibility to uphold University standards on ethical scholarship. Good scholarship involves building on the work of others and use of others work must be acknowledged with proper attribution made. Cheating, plagiarism, and falsification of data are dishonest practices which contravene academic values. Students are expected to familiarise themselves with the University’s Student Academic Integrity Policy https://guard.canberra.edu.au/policy/policy.php?pol_id=3175.

5f Text-matching software
Your electronic submissions are retained and may be compared with other students’ if the need arises. The unit convenor reserves the right to use text-matching software to this end.

6: Student Responsibility

6a Workload
The amount of time a student will need to spend on study in this unit will depend on a number of factors including the student’s prior knowledge, learning skill level and learning style. Nevertheless, in planning your time commitments you should note that for a 3cp unit the total notional workload over the semester or term is assumed to be 150 hours. These hours include time spent in classes. The total workload for units of different credit point value should vary proportionally. For example, for a 6cp unit the total notional workload over a semester or term is assumed to be 300 hours.

**Expected Average Student Workload:**  *denotes an assessable item*

   a) Lectures (online): 14 x 1.5h = 21h
b) Tutorials / Computer labs: 7 x 2h = 14h

c) Preparation (lectures, tutorials, computer labs, reading): 7 x 5h = 35h

d) * Assignment 1 - Matlab = 40h

e) * Assignment 2 - Presentation = 20h

f) * Final Exam (incl. preparation) = 20h

Total 150 hours

6b Special needs
Students who need assistance in undertaking the unit because of disability or other circumstances should inform their Unit Convener or UC AccessAbility (formerly the Disabilities Office) as soon as possible so the necessary arrangements can be made.

6c Attendance requirements
Students should attend all lectures, tutorials and computer laboratory classes. Experience has shown that students who do not attend these will have more difficulty in passing the subject than those who attend.

6d Withdrawal
If you are planning to withdraw please discuss with your unit convener and course convener. Please see this link for further information on deadlines.

6e Required IT skills
Basic familiarity with Windows operating systems.

6f Costs
Consumables

6g Work Integrated Learning
The Faculty of ISE is committed to providing an environment that enables work integrated learning. Lecture theatre permitting, the lectures of this unit will be recorded and be made available online. Further information will be made available on the unit’s Moodle site.

6h Additional information
It is important that students refer to Unit Website (through Moodle (LearnOnline) – UC’s online learning environment) on a regular basis for any variations in the schedule and deadlines for the assessment tasks, which will be announced on the Unit Website. It is also the student’s responsibility to ensure that they regularly check their UC email account, as electronic messages (whether via the unit’s Moodle site or directly) will be sent to this account.

The online discussion forum on the unit’s Moodle site is as very useful place for posting questions and students are strongly encouraged to make use of it.

7: Student Feedback

All students enrolled in this unit will have an opportunity to provide anonymous feedback on the unit at the end of the Semester via the Unit Satisfaction Survey (USS), which will be presented to you on MyUC (Login via the University’s homepage at http://www.canberra.edu.au). Your lecturer or tutor may also invite you to provide more detailed feedback on their teaching through an anonymous in-class questionnaire administered through the University’s Teaching and Learning Centre (TLC).
8: Authority of this Unit Outline

Any change to the information contained in Section 2 (Academic content), and Section 5 (Assessment) of this document, will only be made by the Unit Convener if the written agreement of Head of Discipline and a majority of students has been obtained; and if written advice of the change is then provided on the unit site in the learning management system. If this is not possible, written advice of the change must be forwarded to each student enrolled in the unit at their registered term address. Any individual student who believes him/herself to be disadvantaged by a change is encouraged to discuss the matter with the Unit Convener.