ENGN8501: Advanced Topics in Computer Vision

Week 1

Dylan Campbell

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Australian National University

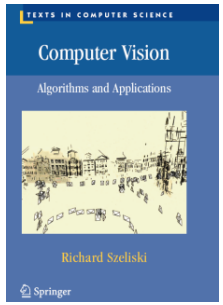
Semester 2, 2020

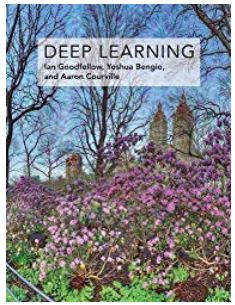
Course Logistics

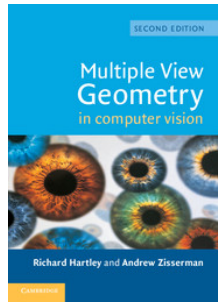
- **Course Staff:**
  Dylan (convener) Sameera Ramasinghe (tutor)

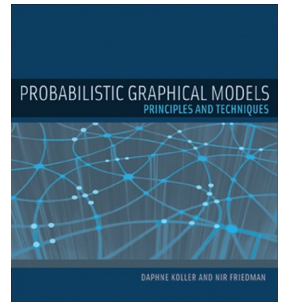
- **Guest Lectures:** Stephen Gould, Yizhak Ben Shabat and Fatemeh Saleh
- **Lectures:** 9am-11pm Mondays (via Zoom)
- **Tutorials:** 11am-12pm or 12pm-1pm Thursdays starting Week 2 (via Zoom)
- **Email:** `dylan.campbell@anu.edu.au`
- **Wattle:** announcements, handouts, assignments
- **Prerequisites:**
  - **Computer Vision** (ENGN6528)
  - Undergraduate-level mathematics and programming skills

Course Logistics (2)









Reference textbooks:

- Szeliski, *Computer Vision: Algorithms and Applications*, 2011
  `szeliski.org/Book`
- Goodfellow et al., *Deep Learning*, 2016
  `deeplearningbook.org`
- Hartley & Zisserman, *Multiple View Geometry in Computer Vision*, 2004
- Koller & Friedman, *Probabilistic Graphical Models: Principles and Techniques*, 2009

Other resources:

- Conference proceedings for computer vision and machine learning, including CVPR, ICCV, ECCV, NeurIPS, ICLR
- online computer vision and deep learning courses

Course Logistics (3)

- **Assessment:**
  - Literature reading groups (50%)
    - reports (2 at 15% each, due end of Weeks 6 and 11)
    - presentation (10%)
    - participation (10%)
    - write up using LaTeX and submit as a PDF through Wattle
  - Group research/design project (50%):
    - proposal (5%, due end of Week 4)
    - report (25%, due end of Week 12)
    - seminar presentation (20%, during Week 12)
    - write up using LaTeX and submit as a PDF through Wattle

Course Logistics (4)

- **Group work and plagiarism:**
  - the research project is a group assignment: everyone is expected to make a significant contribution; if this is not the case, please email the course convenor
  - we will be using Turnitin for the submission of written work
  - we reserve the right to ask you to orally explain your work (see ANU policy on plagiarism `https://www.anu.edu.au/students/academic-skills/academic-integrity`)
- **Late policy:**
  - Where an assignment is submitted after the due date, students are penalised by 5% of the possible marks available for the assessment task per working day or part thereof (see `policies.anu.edu.au/ppl/document/ANUP_004604`)

Course Logistics (5)

- **Grievance resolution:**
  - You can contact the course staff in the first instance
  - Alternatively, contact the Dean of Students for advice
  - If unresolved, you can lodge a formal complaint: `http://www.anu.edu.au/students/contacts/student-complaint-resolution`

- **Warning:** This is an advanced course. You are expected to know your own abilities (and whether or not you have the right background for the course). You are expected to work diligently throughout the semester. We will endeavour to answer questions in lectures, tutorials and online forums, but research can be open-ended and ambiguous. This is part of the challenge, and intended to get you questioning and thinking like a researcher at the cutting-edge of computer vision and machine learning.

Course Overview

- **Review current research topics** in computer vision
- **Develop your research skills** as a precursor to further study or work in computer vision, machine learning or AI
  - Critically reading research papers
  - Finding good research problems
  - Designing effective and novel solutions
  - Implementing using modern techniques

Learning Outcomes

Upon successfully completing the course, you will have the knowledge and skills to:

- describe and analyse the **main research challenges** in the field of computer vision;
- **summarise research literature** and state-of-the-art techniques for solving the challenging research problems in those areas;
- **model and formulate problems**, **propose effective solutions** to the problem and **implement algorithms** using suitable programming languages;
- **design network structure and loss functions** in cases where problems need to be solved using deep learning techniques;
- **analyse the results** and effectively **evaluate the results** on benchmark datasets.

Weekly Study Plan: Overview

Wk	Starting	Lecture	Tutorial	Project
1	27 Jul	3D Visual Perception 1	✗	Form groups (3)
2	3 Aug	3D Visual Perception 2	✓	Finalise groups
3	10 Aug	3D Visual Perception 3	✓	Work on proposal
4	17 Aug	3D Visual Perception 4	✓	Submit proposal
5	24 Aug	Graphical Models 1	✓	Work on project
6	31 Aug	Graphical Models 2	✓	Work on project
	7 Sep	Teaching break	✗	
	14 Sep	Teaching break	✗	
7	21 Sep	Graphical Models 3	✓	Work on project
8	28 Sep	Graphical Models 4	✓	Work on project
9	5 Oct	Human Motion Analysis 1[1]	✓	Work on project
10	12 Oct	Human Motion Analysis 2	✓	Work on project
11	19 Oct	Human Motion Analysis 3	✓	Work on project
12	26 Oct	Seminar presentations	✓	Submit report

[1] Held during tutorial slots due to public holiday on Monday

Weekly Study Plan: Topic A

Wk	Starting	Lecture	By
Topic: 3D Visual Perception			
1	27 Jul	Introduction; overview of depth perception; review of visual geometry	Dylan
2	3 Aug	Single and two-view geometry (single view depth, optical flow, camera pose estimation, shape estimation)	Dylan
3	10 Aug	Interpreting point clouds (representations, classification, segmentation, surface normals)	Itzik
4	17 Aug	Structure-from-motion and SLAM	Dylan

Weekly Study Plan: Topic B

Wk	Starting	Lecture	By
Topic: Graphical Models			
5	24 Aug	Review of probability theory and graph theory; directed graphical models (Bayesian networks)	Steve
6	31 Aug	Sampling and inference (variable elimination, message passing, belief propagation); parameter learning	Steve
	7 Sep	Teaching break	
	14 Sep	Teaching break	
7	21 Sep	Undirected graphical models (Markov random fields); inference in undirected models	Steve
8	28 Sep	Regular potentials and graph cuts, move-making; applications (parts models, segmentation)	Steve

Weekly Study Plan: Topic C

Wk	Starting	Lecture	By
Topic: Human Motion Analysis			
9	5 Oct	Human pose estimation (2D and 3D)[2]	Dylan
10	12 Oct	Human detection and tracking	Fatemeh
11	19 Oct	Human motion prediction	Fatemeh
12	26 Oct	Seminar presentations	Dylan

[2] Held during tutorial slots due to public holiday on Monday

Literature Reading Groups (1)

Objective

To develop independent research skills in critically reading and reviewing academic publications

You will be expected to read two papers each week, participate in discussion, ask questions (some prepared before class), and write critical reviews of a selection of the papers.

Literature Reading Groups (2)

- **Readings:** 2 papers per week; must be read before the tutorial; available on Wattle at least a week in advance
- **Format:** 10–15 minute overview/summary of the paper, presented by the scheduled student, followed by 15 minutes of discussion; and repeat for the next paper
- **Presentation schedule:** a randomised schedule of presenters will be uploaded to Wattle in Week 1

Literature Reading Groups (2)

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- **Format:** 10–15 minute overview/summary of the paper, presented by the scheduled student, followed by 15 minutes of discussion; and repeat for the next paper
- **Presentation schedule:** a randomised schedule of presenters will be uploaded to Wattle in Week 1
- **Participation:** you are encouraged to ask questions during and after the presentation; if you don't understand something, someone else is likely to be able to clarify the matter
- **Zoom Name:** make sure your name is set to your full name and student ID; click on Participants $\rightarrow$ More (next to your name) $\rightarrow$ Rename
- **Tutorial group selection:** sign up on Wattle (under "Week 1" $\rightarrow$ "Tutorial Group Selection") by the **end of Week 1**

Group Research Project (1)

Objective

To develop research skills in finding good problems, designing effective and novel solutions, implementing them using modern techniques, and communicating the research

You will be proposing your own computer vision research project, which must contain some level of technical novelty and be sufficiently complex for a 7–8 week group project.

Group Research Project (2)

- **Group size:** 4
- **Self-selection:** sign up on Wattle (under "Research Project" $\rightarrow$ "Research Project Groups") by the **end of Week 2**
- **Relative contribution:** everyone is expected to make a significant contribution to the group project

Break

Breakout Rooms – 8 minutes

Describe your ENGN6528 Computer Vision research project
[3 sentences or fewer]

CECS Course Representatives

Why become a course representative?

- **Develop skills sought by employers**, including interpersonal, dispute resolution, leadership and communication skills.
- **Become empowered**. Play an active role in determining the direction of your education.
- **Become more aware of issues influencing your University** and current issues in higher education.
- **Ensure students have a voice** to their course convener, lecturer, tutors, and college.

CECS Course Representatives

Roles and responsibilities:

- Act as the official liaison between your peers and convener.
- Be creative, available and proactive in gathering feedback from your classmates.
- Attend regular meetings, and provide reports on course feedback to your course convener and the Associate Director (Education).
- Close the feedback loop by reporting back to the class the outcomes of your meetings.

More information about roles and responsibilities can contact
ANUSA CECS representative Sophie Burgess via sa.cecs@anu.edu.au, or
ANUSA President, Lachy Day via sa.president@anu.edu.au

CECS Course Representatives

Want to be a course representative? Nominate today!

Please nominate yourself on **CECS S2 2020 Course Rep EOI** **by 3rd August 2020** to nominate yourself as a course representative. You are free to nominate yourself either you are on campus or off-shore.

You will be contacted by CECS Student Services by 7th August with the outcome of your self-nomination.

All the course representative meetings will be held in zoom in S2 2020. There are three meetings this semester. The meeting details will be updated to all the course representatives shortly.

Introduction to 3D Vision

Vision: an extraordinary sense

David Marr

"to know what is where, by looking"

Why vision?

Credit: Pixar

Why vision?

Our senses:

- hearing
- smell
- taste
- sight (70%)

Why vision?

Our senses:

- hearing
- smell
- taste
- sight (70%)
- touch
- balance

Why vision?

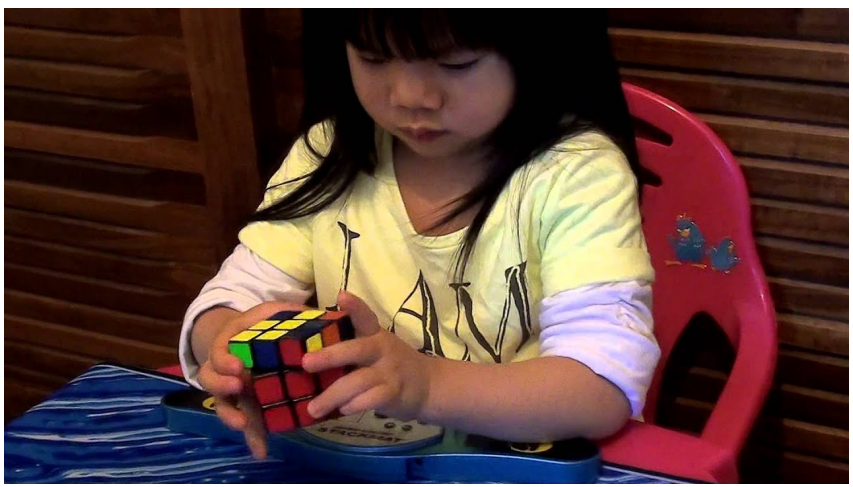
Our senses:

- hearing
- smell
- taste
- sight (70%)
- touch
- balance

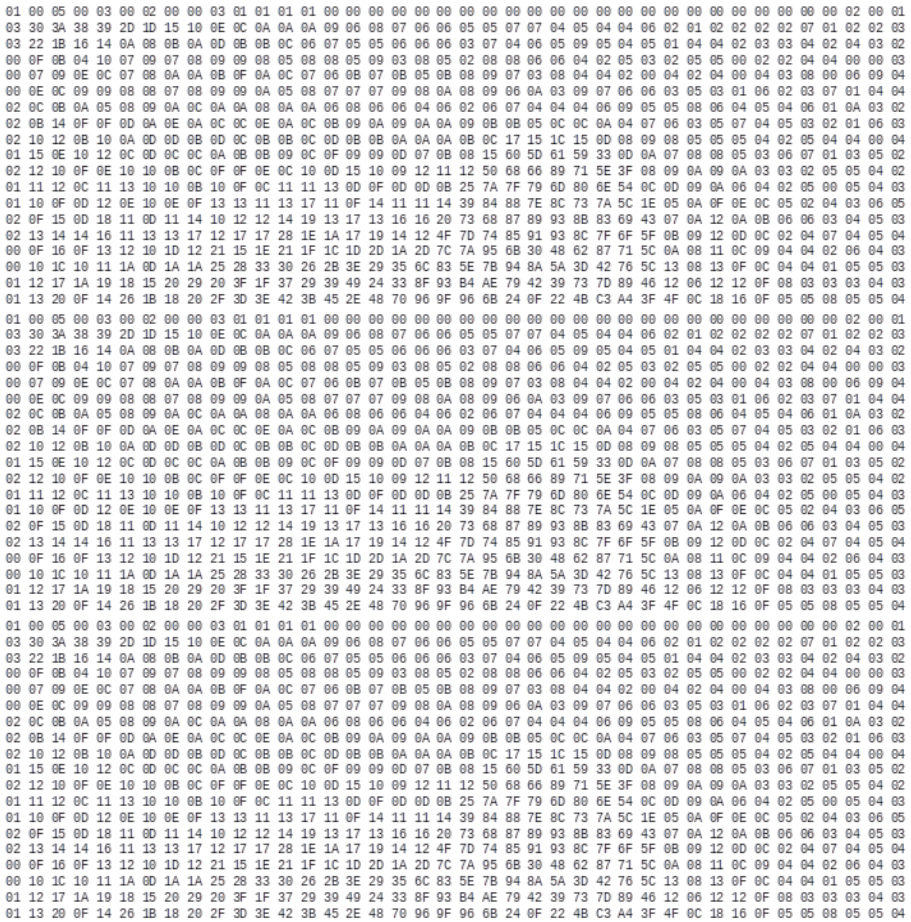
- echo location
- electric field
- magnetism

Why vision?

- Information dense
- Inexpensive (camera)
- Passive



But what does a computer see?



Output:

- A harbour. . .
- . . . with dozens of boats;
- . . . the water is calm and glassy;
- . . . there are vertical masts;
- . . . with mountains in background;
- . . . and a blue sky with a touch of cloud

But what does a computer see?

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- A harbour...
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- ...the water is calm and glassy;
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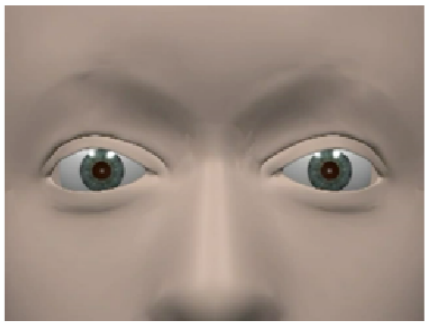
3D vision: eight human tricks

binocular stereo

accomodation



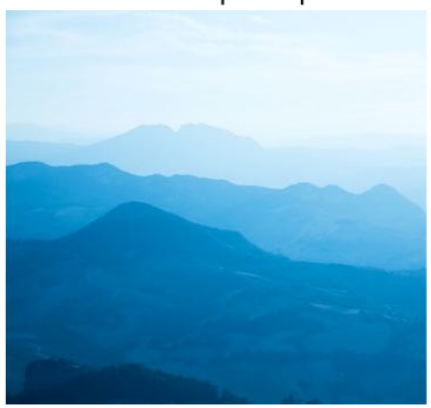
vergence

motion perspective

occlusion

apparent height

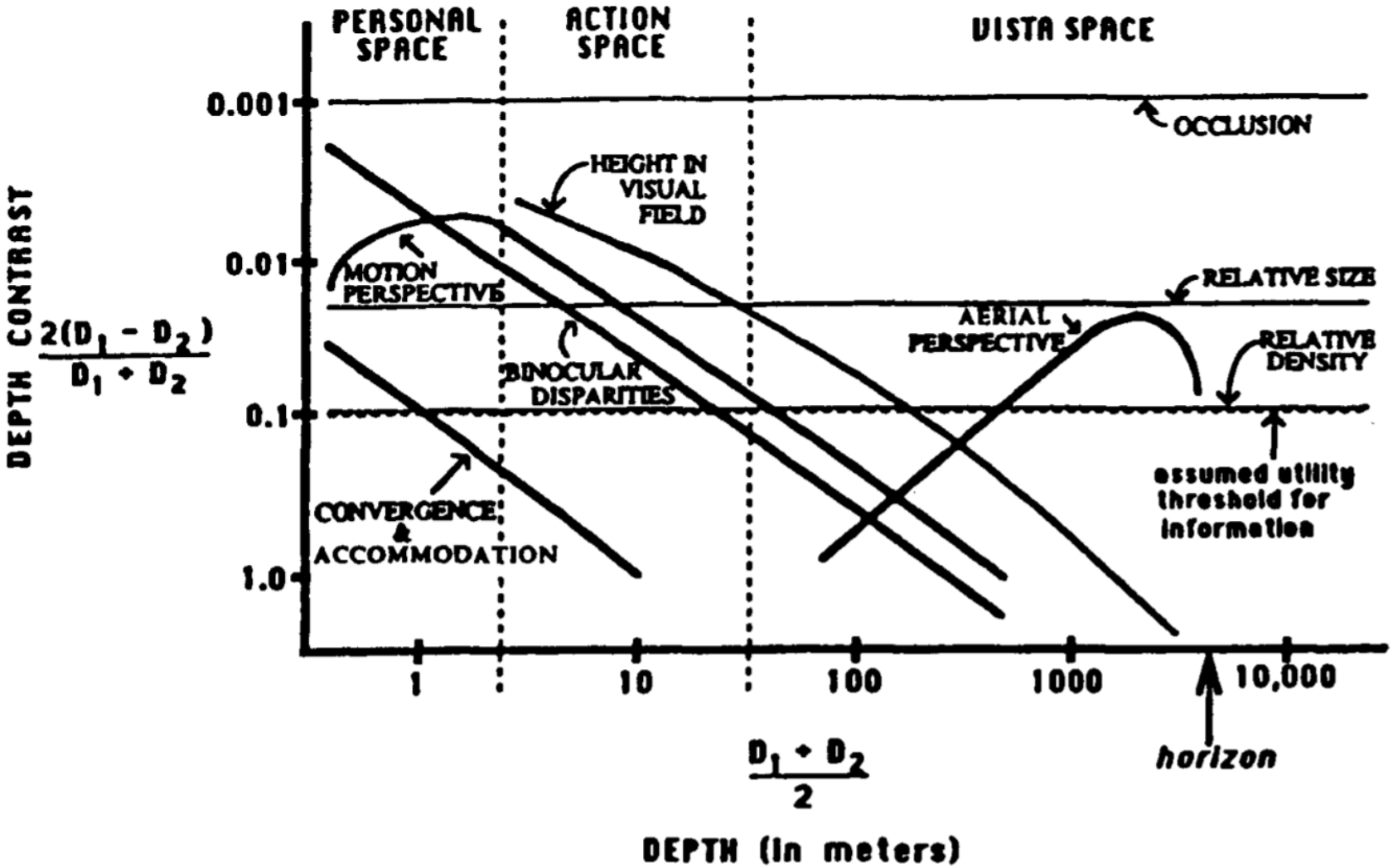
texture density



aerial perspective

Credit: Peter Corke

3D vision: eight human tricks



Credit: J. Cutting, "How the eye measures reality and virtual reality", 1997

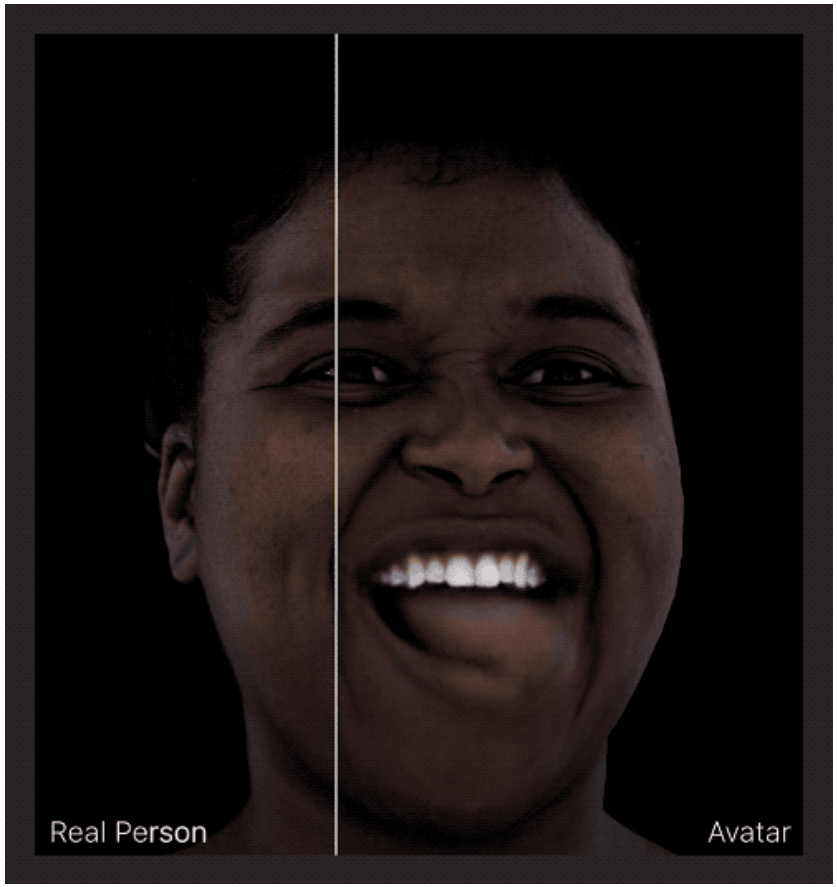
Building Rome in a day

Credit: S. Agarwal et al., "Building Rome in a day", 2009

Telepresence

Credit: Microsoft HoloLens

Telepresence



Credit: Facebook

How to Read a Research Paper

How to Read a Research Paper (1)

Objective

To understand the scientific contributions of the paper

Challenges: It can be difficult to work out how to start reading academic papers. They are often dense, poorly-written, contain many references to previous work, poorly-explained acronyms, terms, and concepts, and unfamiliar mathematics.

How to Read a Research Paper (2)

Approach:

- Read the title and abstract: this will summarise the paper and make its case
- Look at the pictures: they typically illustrate the problem, the solution (often with a flowchart), and the results

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- Read the method: skip any proofs, just try to understand the general approach at first
- Read the results: how well does the method work; can you tell from what the authors have presented?
- Read the rest: related work, discussion and conclusion

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- Read the rest: related work, discussion and conclusion
- Read critically: be suspicious; what have the authors not considered; what are their assumptions; is there a simpler approach?
- Make notes: scribble in the margins, underline, draw pictures

How to Read a Research Paper (3)

At the end, you should be answer the following questions:

1. What is the problem?
2. What is the proposed solution?
3. What are the contributions?
4. Is the approach technically correct?
5. What are the assumptions and limitations?
6. How well does the method perform?
7. Is it a good paper? Does it lead anywhere?

Resources:

- S. Keshav, "How to Read a Paper"
- M. Mitzenmacher, "How to Read a Research Paper"

LaTeX Tutorial

LaTeX Tutorial

- What is LaTeX? A typesetting system where you write your document in a mark-up language which gets compiled into a PDF file (unlike WYSIWYG programs like Microsoft Word)
- Why LaTeX? A powerful tool for typesetting academic papers, with particular advantages in writing mathematics, managing citations, and creating vector graphics for diagrams and plots
- Templates: See Wattle for templates for the different assessment items
- Tutorial: Using Overleaf, an in-browser editor