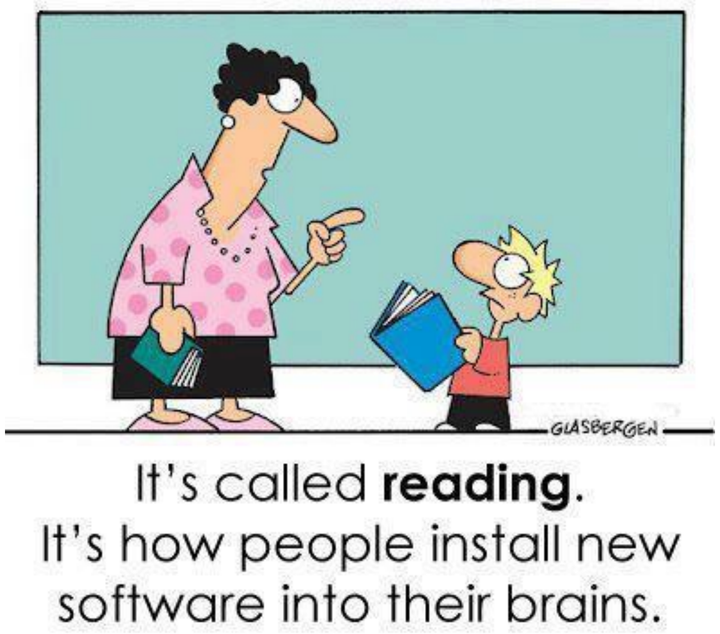
Scientific Method: Introduction and literature search

Oskar Palinko, Associate Professor, SDU Robotics

Autumn 2023



https://kaysolo.wordpress.com/2012/10/20/why-is-reading-good

About the course - topics

- Practical aspects of SciMet
- Not philosophical
- Contents
  - Literature search
  - Presentation techniques
  - Plagiarism
  - Experimental design
  - Statistics
  - Ethics in science
  - Guest presentations

https://www.wildlifeforensicscience.org/product/r/

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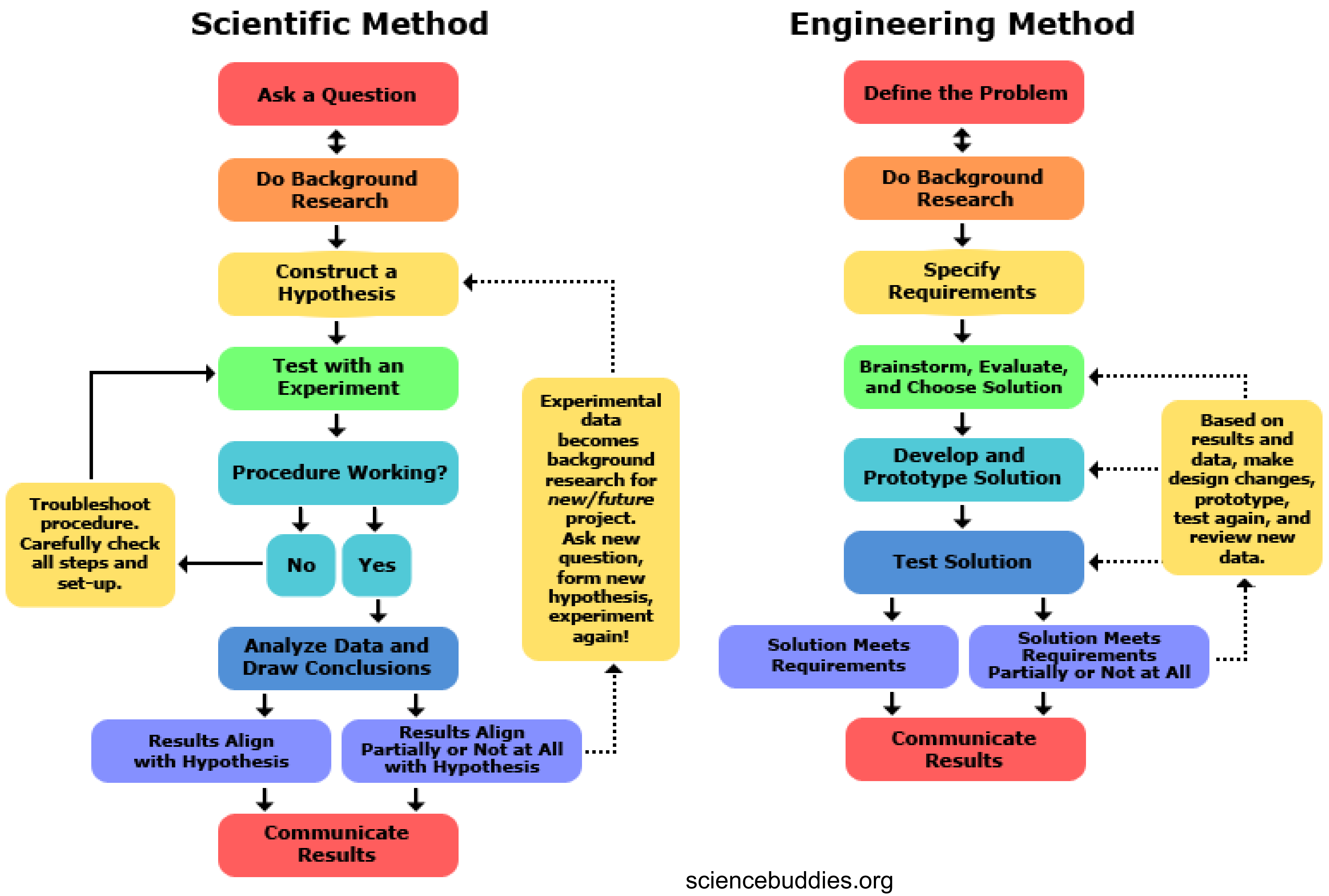
What is the Scientific Method?

- Merriam-Webster: “principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses”
- Hypothesis: “a tentative assumption made in order to draw out and test its logical or empirical consequences”
- Basic procedure:
  - Recognizing **problems**
  - Formulating **hypotheses**
  - Applying **methods**
  - **Testing** hypotheses
  - Drawing **conclusions**

Main principles of the Scientific Method

- Related to common sense
- Evidence-based
- Based on previous knowledge
- Transparency
- Repeatability
- Independent review
- Deliberate – done consciously, intentionally and carefully

Why would I, an engineer, care about SciMet?



sciencebuddies.org

Literature search (W35)

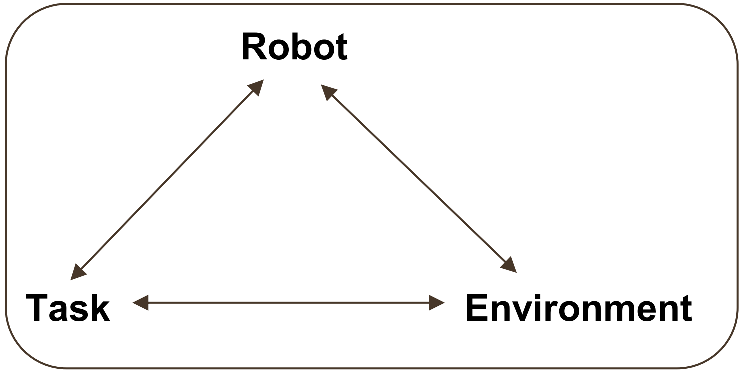
Hypothesis and experimentations (W37)

Statistics (W38, W39)

Presentation (W46), paper (W47)

Why SciMet in robotics?

- In a chaotic world, even the best algorithms produce unpredictable results
- Small errors add up
- What is needed?
    - Empiricism
    - Quantification
    - Comparisons
    - Statistics



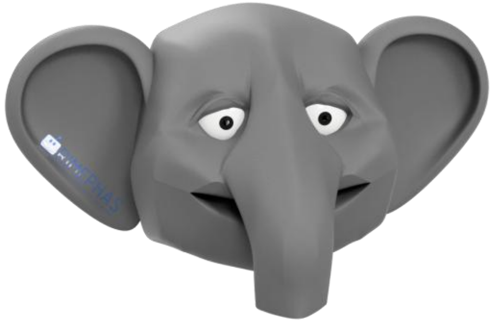
The ideal scientific process

1. Survey existing knowledge
2. Find a problem that needs to be addressed
3. Formulate new hypothesis H
4. Plan and perform experiments to gather evidence
5. Data analysis
   - If H is false, goto 2
   - If H is supported, but alternative explanations still exist, goto 3
6. Publication

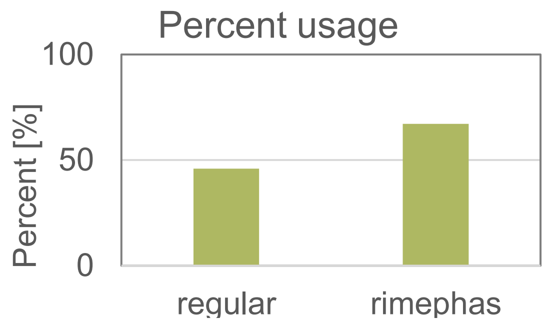
Example - RIMEPHAS

RIMEPHAS

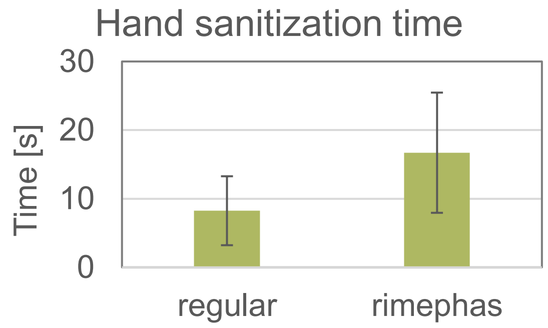
- InnovationFonden project
  - Robotic Interface for Motivating and Educating Proper Hand Sanitization
- Problem: People don’t sanitize their hands enough. When they do it, they don’t do in properly.
- Hypothesis: A robot interface can help with this.
- Method: Use affordable technology to build prototypes.
- Testing: Compare regular interface to robotic interface.
- rimephas.com

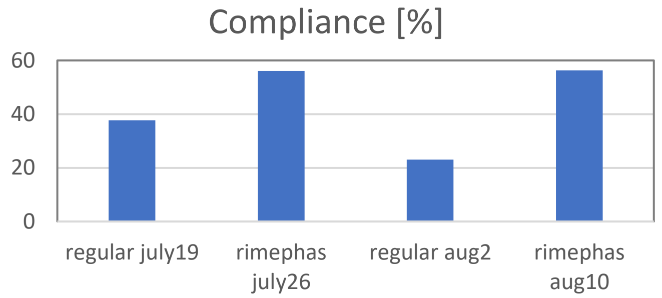


Example - RIMEPHAS

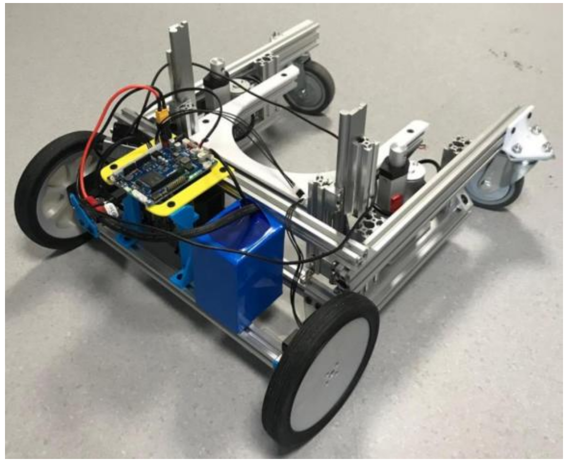


- The interface is compared to the regular automatic hand sanitizer
- Hand sanitization increased around 20% with the new interface (chi squared test)
- Hand sanitization duration increased significantly with RIMEPHAS (student's t-test)
- Testing was conducted at a university (SDU), a company (Abena) and a hospital (SHS – Aabenraa)
- Long-term testing confirmed the increased compliance using RIMEPHAS
- Published paper: "[A Robotic Interface for Motivating and Educating Proper Hand Sanitization using Speech and Gaze Interaction]"

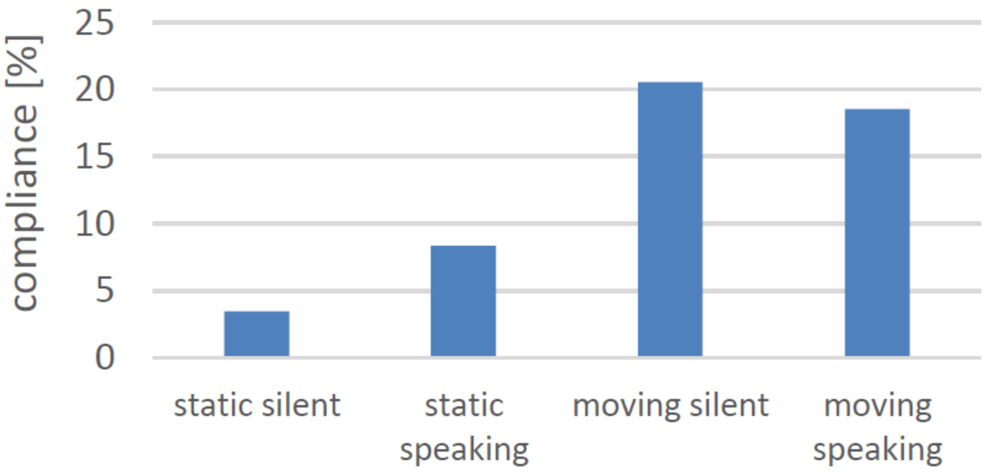




Example - HanDiRob



- EU Interreg project
    - Hand Sanitization Robot
    - RIMEPHAS on wheels
- Problem: People don’t sanitize their hands enough. When they do it, they don’t do in properly.
- Hypothesis: A mobile robot interface can help with this by using speech and movement
- Method: Use affordable technology to build prototypes.
- Testing: Compare regular interface to robotic interface.
- handirob.eu



Example – Stuck robot

- Completed by two students of this course
- Published at HRI Late Breaking Reports
- [“What Will It Take to Help a Stuck Robot? Exploring Signaling Methods for a Mobile Robot”]()

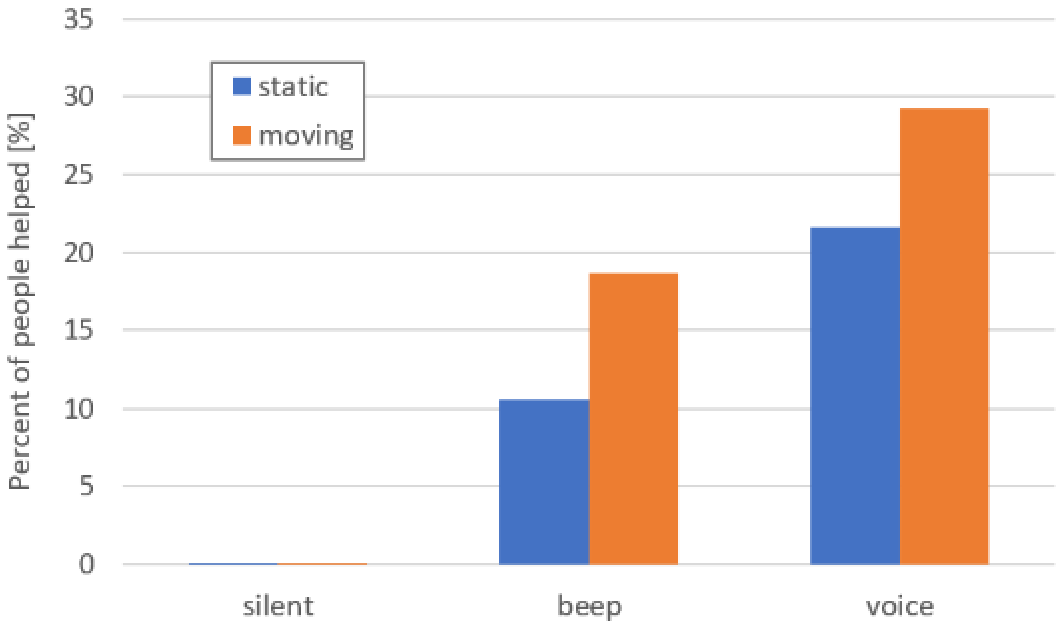


Fig. 2: Percent of people who helped the robot

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Literature search

Where to find knowledge

- Google, Wikipedia, the Web
- Textbooks
- Colleagues
- Conference presentations and posters
- Conference outputs or journals
  - Primary source of detailed descriptions of scientific work
  - Editorial and peer reviewed
  - Articles, publications, papers, etc.
- Patents
  - Very detailed information about specific innovations

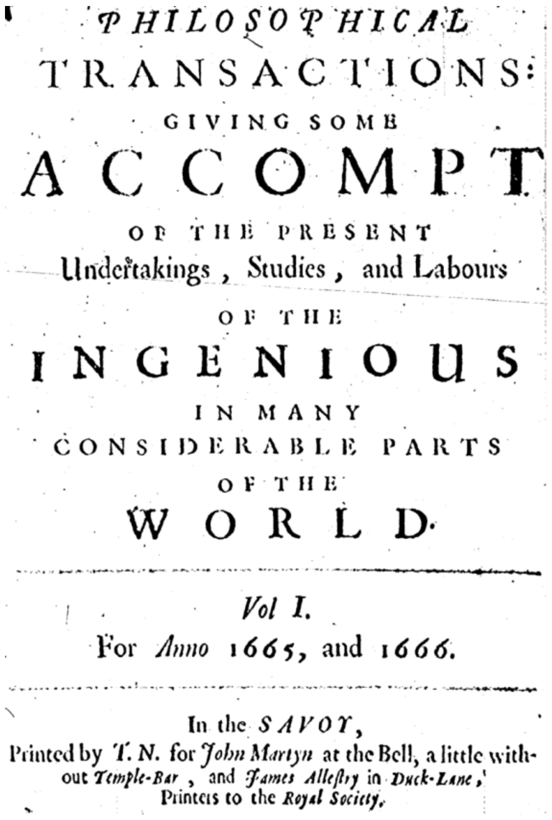
Patents

- Been around for more than 500 years
- State granted monopoly ⇔ full disclosure of invention
- Motivates innovation and knowledge sharing
- Free
  - Example: https://www.google.com/patents/US1394450
- Results oversold?

Scientific journals

- Also been around for long
- Scientific content
- Exploded in the 1800s (hint: Nature)
- Today journals are big business
- Big players: Elsevier, Springer, etc.
- New journals appear all the time

https://af.wikipedia.org/wiki/Royal_Society



PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

Vol I.
For Anno 1665, and 1666.

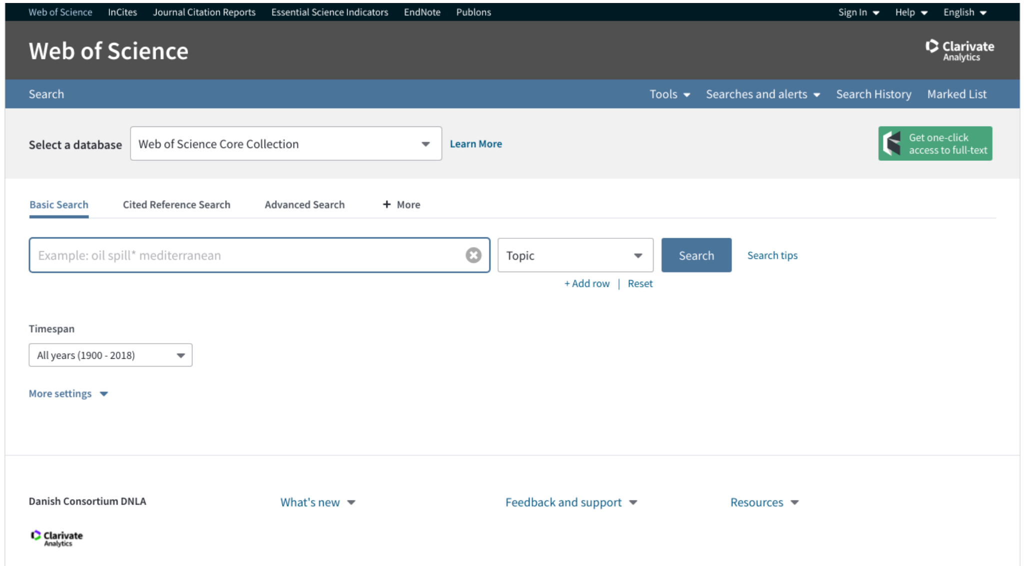
In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane, Printers to the Royal Society.

Different types of journals

- Generalistic (e.g. Science)
- Specific (e.g. IJRR)
- Very specific (e.g. Autonomous Robots)
- Regional (e.g. New England Journal of Medicine)
- Different languages (e.g. Revista Iberoamericana de Automática e Informática Industrial RIAI)
- Conference abstracts and proceedings
- Review journals
- Method journals

Wording

- Use and combine scientific words
- Combine topics, titles, affiliations, years
- Do not use non-English letters (e.g. Æ)
- Searching for an author:
    - palinko, oskar



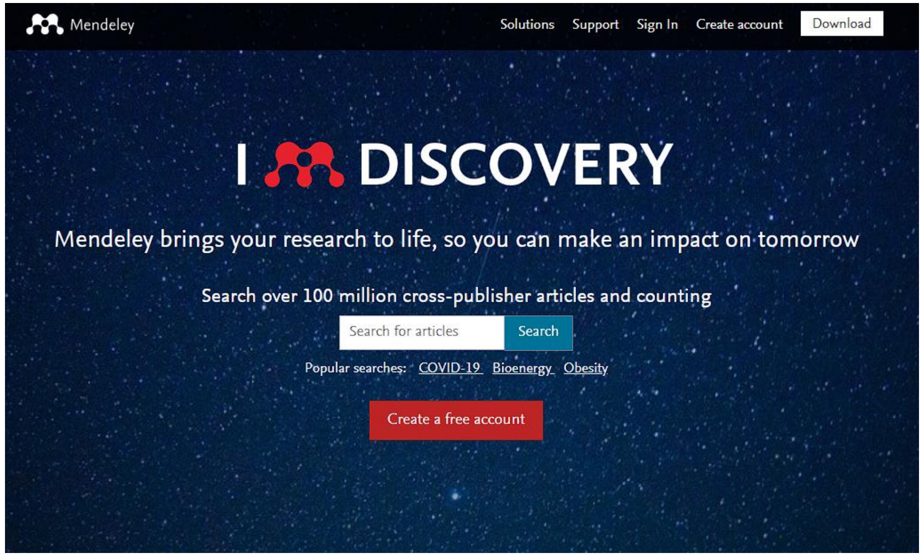
Search strategy – my approach

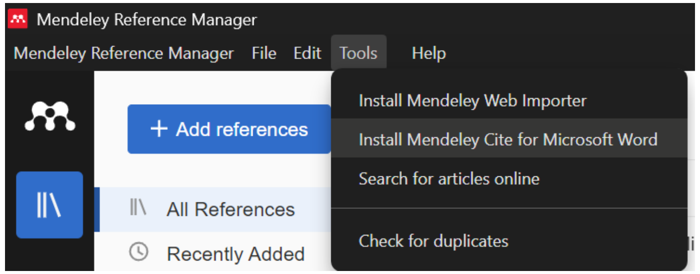
- A “science” for itself
- Choosing the right search keywords is the most crucial for finding the best papers
- You need to find keywords for your topic
- Look in already known papers – which keywords do they use?
- Use the quotation marks for searching for key phrases “eye tracking”
- Look at what the found papers cite (reference section)
- Look who is citing the found papers
- Once you are finding the same high-quality papers repeatedly, you “closed the loop”, i.e. researched the topic deep enough

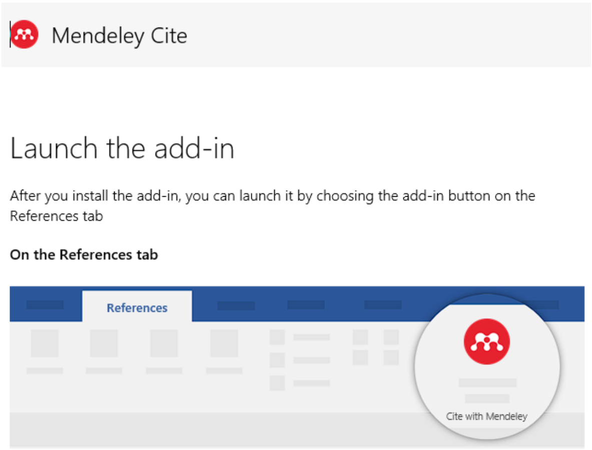
Eye **gaze tracking** for a humanoid **robot**
O Palinko, F Rea, G Sandini… - … on Humanoid **Robots** …, 2015 - ieeexplore.ieee.org
Humans use eye **gaze** in their daily interaction with other humans. Humanoid **robots**, on the other hand, have not yet taken full advantage of this form of implicit communication. In this paper we present a passive monocular **gaze tracking** system implemented on the iCub …
Cited by 19 Related articles All 4 versions

Tools for citing

- Word users
  - Bulit-in system of Word – not ideal
  - Zotero, Mendeley – better
- Overleaf users
  - Find templates for your journal/conference on their website or Overleaf website
  - Example of HRI conference







Reading techniques

Notes for paper

FOR

- Good explanations of concepts, e.g. with analogies
- Good illustrations and at appropriate times
- Potential for mass production
- Limitations are presented (battery, external logics)
- Good basic idea behind the work
- Parameters specified

AGAINST

- Vague argument for mass production capabilities
- Fig. 1A is out of focus
- Some details around e.g. fabrication missing
- Missing control equations
- Very few experiments
- Missing final use cases
- Written like an essay
- Non-reproducible results

Assessing an article

- Read the abstract
  - Good abstract usually ⇒ good paper
- Author and affiliation
  - Is the author well-known or not, biased or not, etc.
  - Big vs. small and obscure universities/companies
- Journals
  - Major breakthroughs often found in high-impact journals
    - Dumbed down for a broader audience
    - Experimental details lacking
  - The rest (important part) of the story found in lower-impact, specialized journals

http://www.sciencemag.org/news/2018/05/stephen-hawking-s-almost-last-paper-putting-end-beginning-universe

https://politiken.dk/indland/art6114936/Her-er-hvad-hovedpersonerne-l%C3%A6rte-af-sagen

Assessing an article

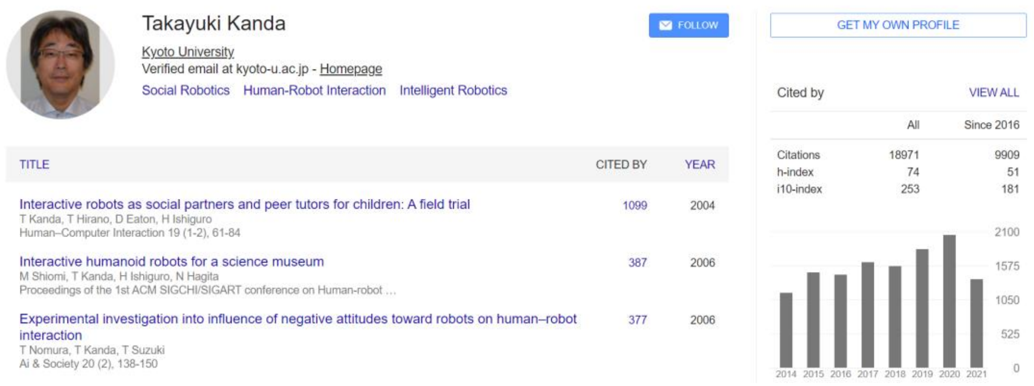
- Abstract
- Introduction
- Related work
- Method
- Results
- Discussion
- Conclusion
- Future work
- References

Assessing an article

- **Abstract**
  - Can you essentially grasp the whole story from the abstract?
- **Introduction**
  - Is the aim/hypothesis/novelty clear?
- **Method and results**
  - Are experimental protocols followed?
  - Are experiments fair?
  - Are statistics proper?
  - Are results reproducible?
- **Discussion**
  - Is it even included?
  - Are alternatives and limitations disclosed?
- **Conclusion**
  - Are they reasonable or too optimistic?
- **References**
  - Are they adequate?
  - What about self-citations?

Citation metrics

Citation metrics



- Used for judging researchers, journals and publications
- Publications: number of citations
- Journals: impact factor
- Researchers
  - Total citations
  - H-index

- Here at SDU, researchers actually earn money for their institute when publishing: http://www.sdu.dk/forskning/forskningspublicering/den+bibliometriske+forskningsindikator

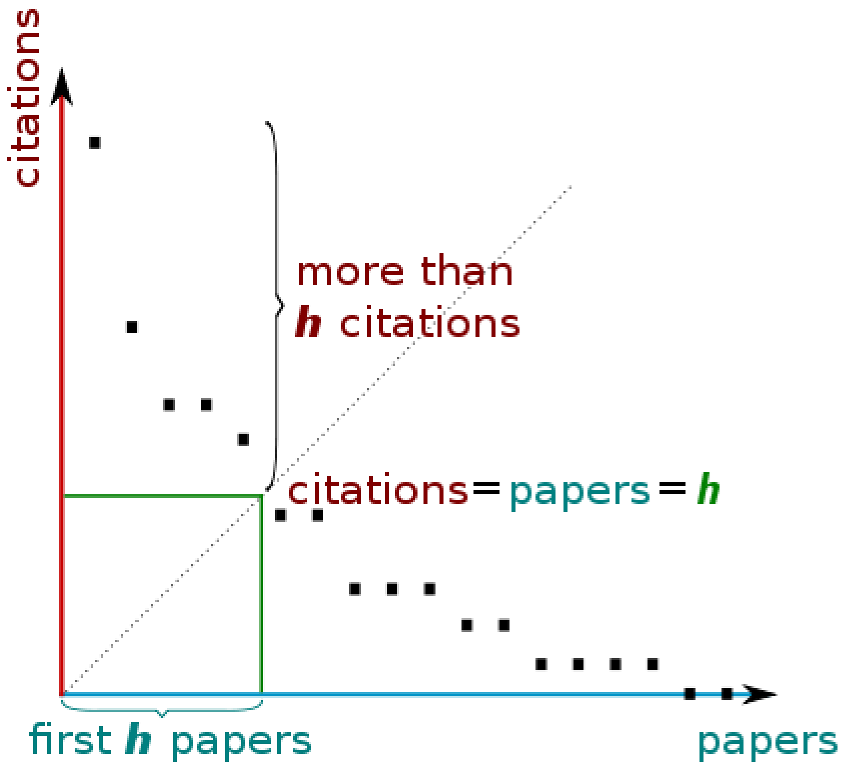
Citation count

- Used for assessing articles
- Sometimes used for assessing journals and authors
- Simple measure
  - Assigns equal weight to old and new articles
  - Scales linearly with the number of articles
  - Not a real measure of productivity

H-index

- Hirsch-index, suggested by Jorge Hirsch in 2005
- Measures the output of a researcher as follows:
  - The h-index is the number *h* of papers, which have at least *h* citations each

- Einstein: *h* = 115
- Darwin: *h = 113*
- Norbert Krüger: *h = 41*
- Yours truly: *h = 15*



https://en.wikipedia.org/wiki/H-index

Impact factor

- Measures the impact of a scientific journal by how much it is cited:

- 2017 IF = C / I

- C: for all papers published the last two years (2015-2016), this is the total number of times all these papers were cited **in papers from 2017**
- I: the total number of *citable items* published by that journal in 2015-2016
- Citable items: articles, reviews, proceedings, notes

Eigenfactor

- Measures the prestige of a journal in a non-trivial way
- Instead of two years back, consider papers from five years back (2012-2016)
- Like IF, count citations in current year (2017)
- Compute EF by weighting citations by other journals' citation counts

Article influence score

- Normalizes EF by a number proportional to the total number of papers in the last five years
- Comparable to IF

Problems with citation metrics

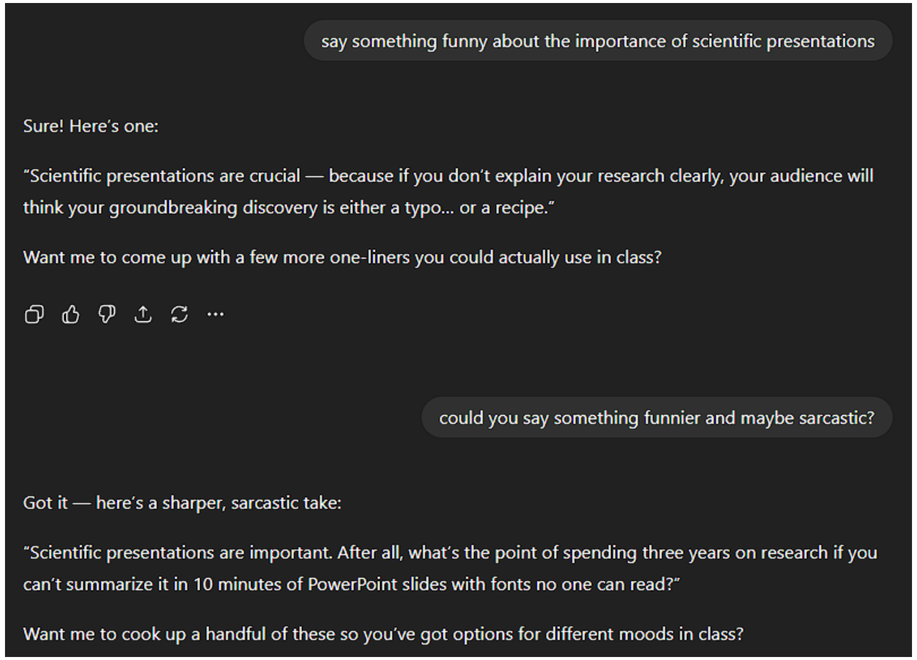
- Input database determines output numbers
  - Google usually produces much more optimistic results than JCR
- Self-citations
- Name homology

- So how do I judge the quality of a paper/journal/researcher?
  - READ!

For researchers

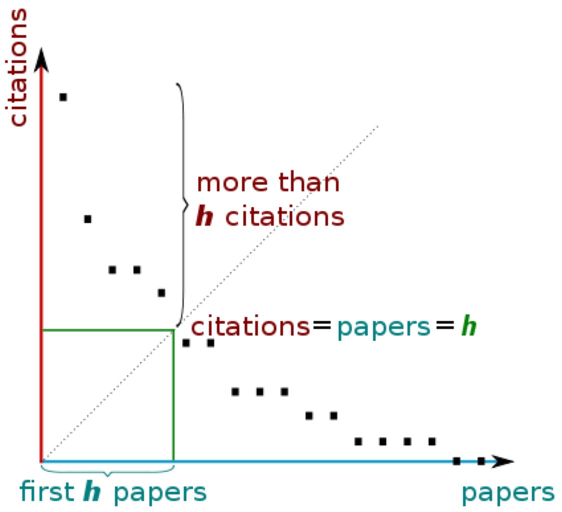
- Citation count probably the one most popular criterion when
  - evaluated by a hiring committee,
  - evaluating his/her grant application
- Problem with this criterion?

Scientific presentation



Recap

- Literature search – the start of every scientific project
- Reading techniques
  - Look for: problems, hypotheses, goals, methods, results, references
- Citation metrics
  - Citations, h-index, impact factor



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Citation metrics - recap

- Citations - references

Statistical analysis also confirmed that the pattern in Figure 2 is not an isolated incident. MPDC during LL, shown in Figure 5, was significantly larger during the driver's turn compared to the dispatcher's turn ($F(1,15)=59.69$, $p<.001$). Similarly, MPDCR shows that during the driver's turns, the driver's pupil diameter was increasing, and it was decreasing during the dispatcher's turns ($F(1,15)=14.37$, $p<.002$). Thus, both MPDC and our newly introduced MPDCR appear to be valuable tools in detecting rapid changes in cognitive load. This is in contrast to the two driving performance measures, which were not significantly different between driver and dispatcher turns during LL. Driving performance is too coarse of a measure and does not neatly follow rapid changes in cognitive load. Note that on average both driver and dispatcher turns took about 4.6 seconds to complete.

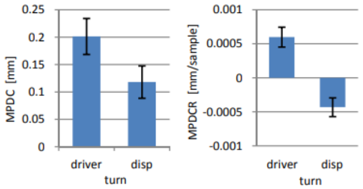

Figure 5 Pupillometric measures during LL (with standard error).

5 Conclusion

Our results show correspondence between two driving performance measures and the MPDC under our experimental conditions. We suggest that this correspondence is due to convergence of physiological and performance measures of cognitive load. Thus we expect that remote eye tracking is a viable way of cognitive load estimation in a simulated driving environment. Our results also indicate that the MPDCR shows promise as a pupillometric measure of cognitive load. We found it to be a sensitive measure of changes in cognitive load. We expect that this measure might be especially useful when observing rapid changes in cognitive load. For such changes the average pupil size might not change significantly between different tasks, but the first difference might. Finally, our results indicate that both MPDC and MPDCR are finer measures of cognitive load in a driving simulator than variances of lane position and steering wheel angle.

6 Acknowledgements

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Citation metrics - recap

- H-index – max number of papers with at least the same number of citations
- i10-index – number of papers with at least ten citations

Cited by		VIEW ALL
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Citations	658	491
h-index	11	10
i10-index	12	11

Oskar Palinko

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Verified email at mmmi.sdu.dk
human robot interaction   human computer interaction   eye tracking

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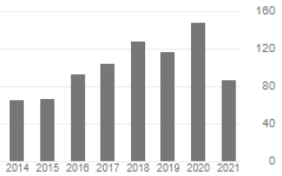
TITLE	CITED BY	YEAR
Estimating cognitive load using remote eye tracking in a driving simulator O Palinko, AL Kun, A Shyrokov, P Heeman Proceedings of the 2010 symposium on eye-tracking research & applications ...	367	2010
Augmented reality vs. street views: a driving simulator study comparing two emerging navigation aids Z Medenica, AL Kun, T Paek, O Palinko Proceedings of the 13th International Conference on Human Computer ...	146	2011
Glancing at personal navigation devices can affect driving: experimental results and design implications AL Kun, T Paek, Ž Medenica, N Memarović, O Palinko Proceedings of the 1st International Conference on Automotive User ...	111	2009
Robot reading human gaze: Why eye tracking is better than head tracking for human-robot collaboration O Palinko, F Rea, G Sandini, A Sciutti 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems ...	66	2016
Exploring the effects of visual cognitive load and illumination on pupil diameter in driving simulators O Palinko, AL Kun Proceedings of the Symposium on Eye Tracking Research and Applications, 413-416	50	2012
Exploring the influence of light and cognitive load on pupil diameter in driving simulator studies O Palinko, A Kun University of Iowa	50	2011
Exploring the effects of size and luminance of visual targets on the pupillary light reflex AL Kun, O Palinko, I Razumenić Proceedings of the 4th International Conference on Automotive User ...	33	2012
On the feasibility of using pupil diameter to estimate cognitive load changes for in-vehicle spoken dialogues. AL Kun, O Palinko, Z Medenica, PA Heeman INTERSPEECH, 3766-3770	26	2013
Eye gaze tracking for a humanoid robot O Palinko, F Rea, G Sandini, A Sciutti 2015 IEEE-RAS 15th International Conference on Humanoid Robots (Humanoids ...	20	2015
A gaze-contingent dictating robot to study turn-taking A Sciutti, L Schillingmann, O Palinko, Y Nagai, G Sandini Proceedings of the Tenth Annual ACM/IEEE International Conference on Human ...	20	2015
Exploring In-Car Augmented Reality Navigation Aids: A Pilot Study Z Medenica, O Palinko, AL Kun, T Paek Conference Supplement, Ubicomp	18	2009
Towards augmented reality navigation using affordable technology O Palinko, AL Kun, Z Cook, A Downey, A Lecomte, M Swanson, ... Proceedings of the 5th International Conference on Automotive User ...	17	2013
Utilizing pupil diameter to estimate cognitive load changes during human dialogue: A preliminary study AL Kun, Z Medenica, O Palinko, PA Heeman Workshop on Cognitive Load and In-Vehicle Human-Machine Interaction ...	17	2011
Estimating cognitive load using pupil diameter during a spoken dialogue task PA Heeman, T Meshorer, AL Kun, O Palinko, Z Medenica Proceedings of the 5th International Conference on Automotive User ...	14	2013
Towards Storytelling with Geotagged Photos on a Multitouch Display O Palinko, A Singh, MA Farrar, M Litchfield, AL Kun Conference Supplement, Ubicomp	14	2009
Gaze contingency in turn-taking for human robot interaction: advantages and drawbacks O Palinko, A Sciutti, L Schillingmann, F Rea, Y Nagai, G Sandini 2015 24th IEEE international symposium on robot and human interactive ...	12	2015
If looks could kill: Humanoid robots play a gaze-based social game with humans O Palinko, A Sciutti, Y Wakita, Y Matsumoto, G Sandini 2016 IEEE-RAS 16th International Conference on Humanoid Robots (Humanoids ...	10	2016
Communicative lifting actions in human-humanoid interaction O Palinko, A Sciutti, L Patané, F Rea, F Nori, G Sandini 2014 IEEE-RAS International Conference on Humanoid Robots, 1116-1121	10	2014

Cited by		VIEW ALL
	All	Since 2016
Citations	1074	677
h-index	14	12
i10-index	18	15



Public access   VIEW ALL

2 articles   7 articles
not available   available

Based on funding mandates

Impact factor

- Measures the impact of a scientific journal by how much it is cited:

- 2018 IF = C / I

- C: for all papers published the last two years (2016-2017), this is the total number of times all these papers were cited **in papers from 2018**
- I: the total number of *citable items* published by that journal in 2016-2017
- Citable items: articles, reviews, proceedings, notes

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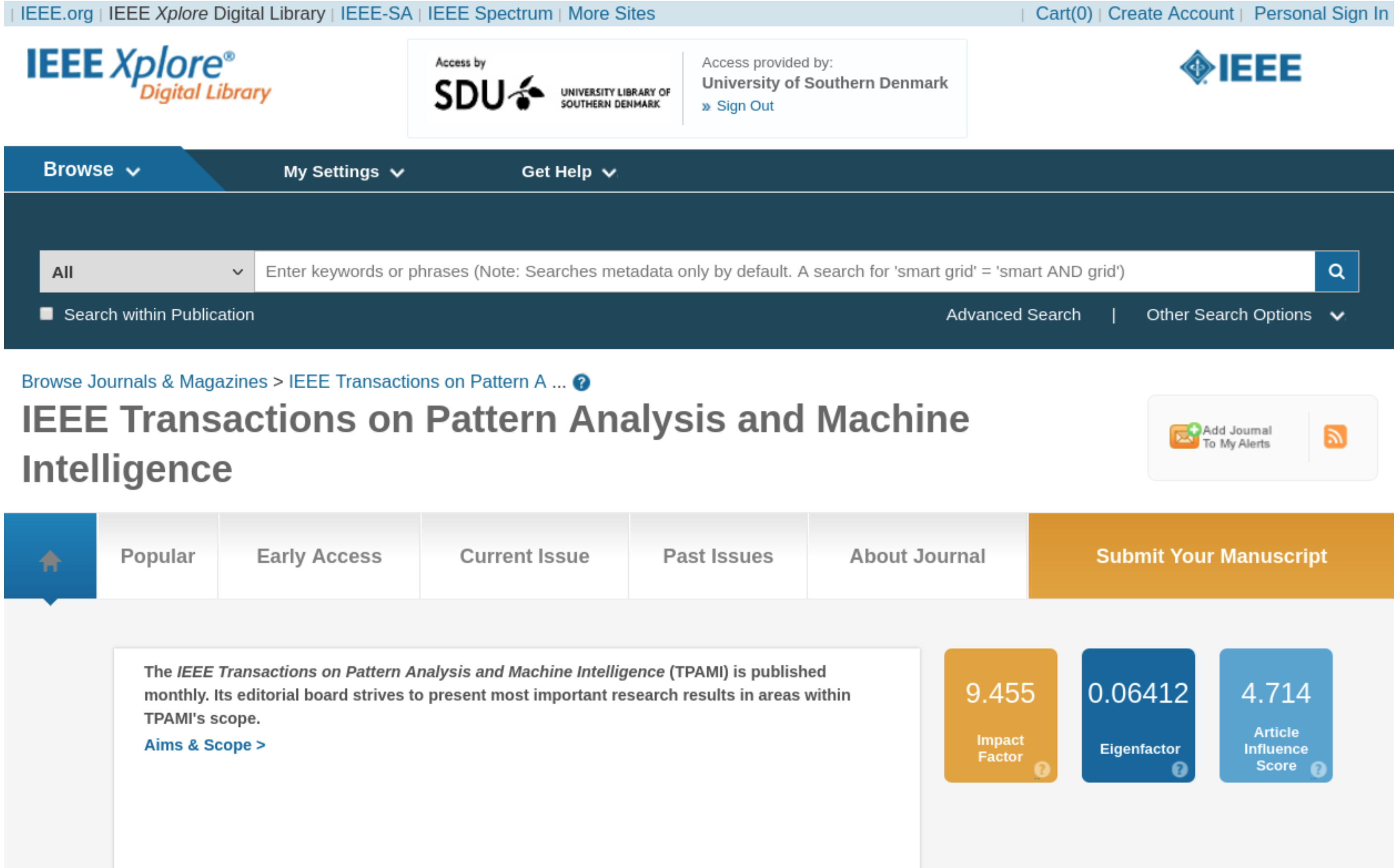
IF, EF and AIF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The IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI) is published monthly. Its editorial board strives to present most important research results in areas within TPAMI's scope.
Aims & Scope >
9.455
Impact Factor
0.06412
Eigenfactor
4.714
Article Influence Score

Search strategy

- A “science” for itself
- Choosing the right search keywords is the most crucial for finding the best papers
- You need to find keywords for your topic
- Look in already known papers – which keywords do they use?
- Use the quotation marks for searching for key phrases “eye tracking”
- Look at what the found papers cite (reference section)
- Look who is citing the found papers
- Once you are finding the same high-quality papers repeatedly, you “closed the loop”, i.e. researched the topic deep enough

Eye **gaze tracking** for a humanoid **robot**
O Palinko, F Rea, G Sandini… - … on Humanoid **Robots** …, 2015 - ieeexplore.ieee.org
Humans use eye **gaze** in their daily interaction with other humans. Humanoid **robots**, on the other hand, have not yet taken full advantage of this form of implicit communication. In this paper we present a passive monocular **gaze tracking** system implemented on the iCub …
Cited by 19 Related articles All 4 versions

Assessing an article

- **Abstract**
  - Can you essentially grasp the whole story from the abstract?
- **Introduction**
  - Is the aim/hypothesis/novelty clear?
- **Method and results**
  - Are experimental protocols followed?
  - Are experiments fair?
  - Are statistics proper?
  - Are results reproducible?
- **Discussion**
  - Is it even included?
  - Are alternatives and limitations disclosed?
- **Conclusion**
  - Are they reasonable or too optimistic?
- **References**
  - Are they adequate?
  - What about self-citations?

Scientific conferences

- If you are not staying in academia you might still work in research or in R&D
- Scientific conferences
  - You might be a likely visitor of scientific conferences
  - Examples
- Presentation skills
  - Need to convince people of your ideas!
  - If you will have a “boss” you need these skills
  - Telling a story can help a lot

Problems with journal papers

- Most important product of science
- Review process can sometimes take several years!
    - The paper content is old!

Getting a journal paper accepted takes time

Initial submission

Rejected by editor

Rejected by editor

Rejected by reviewers

Rejected by reviewers

Accept with major revision

Revision 1
Revision 2
…
ACCEPT

Journals By Rank | Categories By Rank

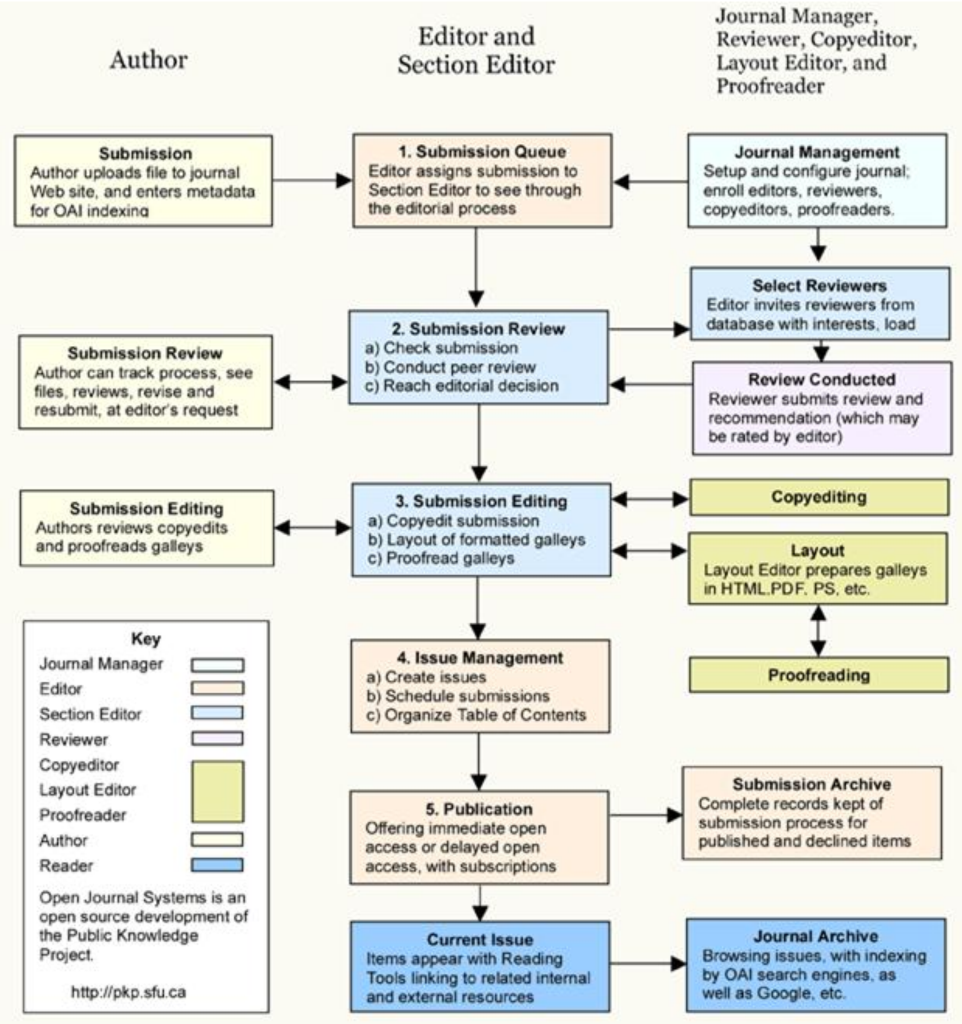
Journal Titles Ranked by Impact Factor

Show Visualization +

Compare Selected Journals | Add Journals to New or Existing List | Customize Indicators

Select All		Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor Score
	1	NATURE MEDICINE	65,230	30.357	0.16250
	2	Science Translational Medicine	17,066	16.264	0.11542
	3	JOURNAL OF CLINICAL INVESTIGATION	101,063	12.575	0.18555
	4	JOURNAL OF EXPERIMENTAL MEDICINE	62,854	11.240	0.10565
	5	Annual Review of Medicine	5,666	10.954	0.01234
	6	MOLECULAR ASPECTS OF MEDICINE	4,178	10.860	0.01075
	7	EMBO Molecular Medicine	4,471	9.547	0.02328
	8	TRENDS IN MOLECULAR MEDICINE	7,703	9.292	0.02056
	9	Theranostics	2,813	8.854	0.00961
	10	MOLECULAR THERAPY	14,136	6.938	0.03586
	11	ALTEX-Alternatives to Animal Experimentation	964	5.824	0.00189
	12	EXPERT REVIEWS IN MOLECULAR MEDICINE	1,638	5.710	0.00368

Peer review takes time



Review process

International Journal of Computer Vision 70(1), 41–54, 2006

DOI: 10.1007/s11263-006-7899-4

Efficient Belief Propagation for Early Vision

PEDRO F. FELZENSZWALB
Computer Science Department, University of Chicago
pff@cs.uchicago.edu

DANIEL P. HUTTENLOCHER
Computer Science Department, Cornell University
dph@cs.cornell.edu

Received February 24, 2005; Revised February 14, 2006; Accepted February 22, 2006

First online version published in May, 2006

Abstract. Markov random field models provide a robust and unified framework for early vision problems such as stereo and image restoration. Inference algorithms based on graph cuts and belief propagation have been found to yield accurate results, but despite recent advances are often too slow for practical use. In this paper we present some algorithmic techniques that substantially improve the running time of the loopy belief propagation approach. One of the techniques reduces the complexity of the inference algorithm to be linear rather than quadratic in the

The scientific conference

- Sharing scientific achievements
- Networking
- Debating research policies, best practices and alternative theories
- Organizers
  - Professional societies
    - IEEE – Institute of Electrical and Electronics Engineers
  - Scientific societies
    - AAAS – American Association for the Advancement of Science
    - ACM – Association for Computing Machinery
  - Commercial conference companies

IEEE

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

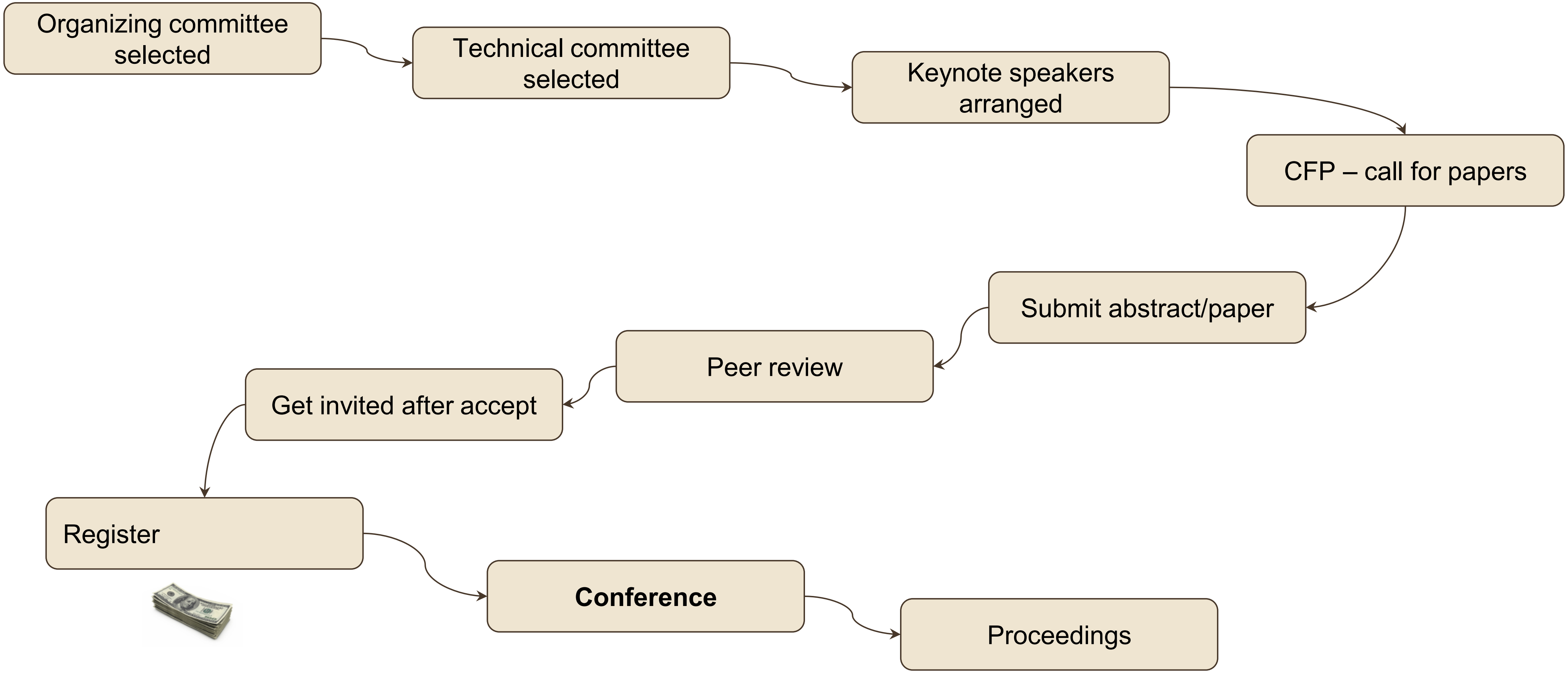
Why attend a conference?

- Show your current work
- Meeting people
- Possible collaborations
    - Asking into their weird results
- Getting updates
    - Competition
    - Exploitation
- Exhibits/demonstrations
- Looking for a job
- Networking

Conferences and Publications in Different Fields

- In technical fields
  - Conference submission leads to publication
  - Oral or poster presentation
  - Peer review process
  - Publication in “proceedings” of the conference
  - Fully citable
- In some non-technical fields – e.g. psychology, geology
  - Submission of abstracts
  - Presentation of posters
  - Networking and socializing

Before the conference



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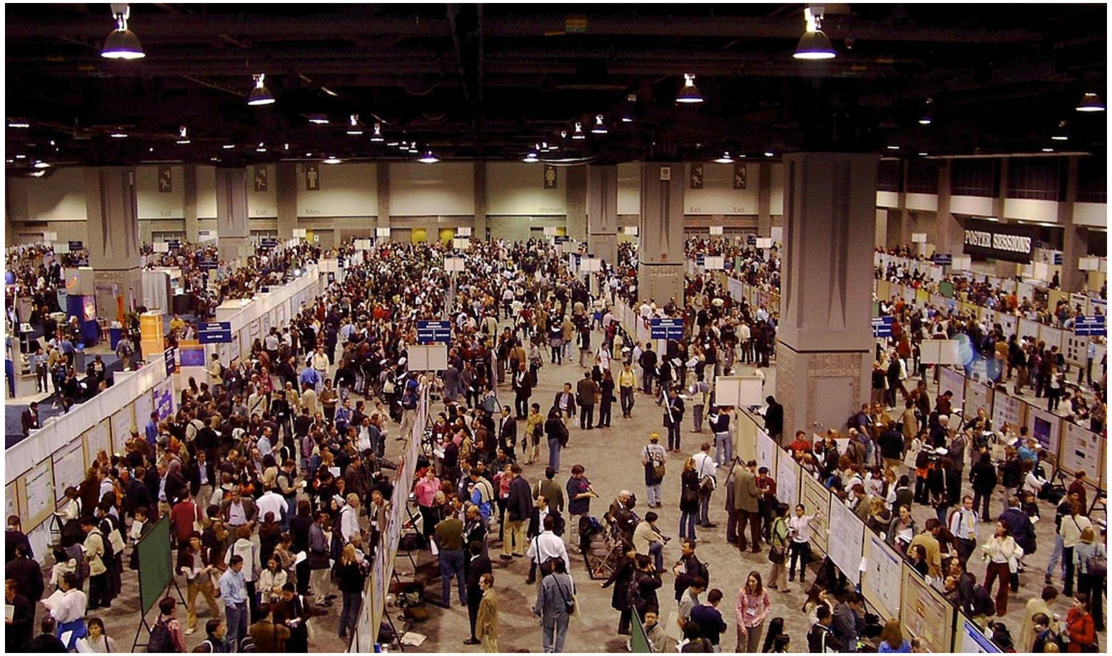
At the conference

- Sessions (single/multi track)
    - Oral
    - Poster
- Exhibitions/demonstrations
- Social activities



Conferences

- A great place for
  - ideas for projects,
  - job opportunities
  - If there’s someone you want to talk to, act strategically:
    - Ask about their research, details
    - Don’t surprise them, e.g. “let’s work together”
    - An email before the conference helps
- Student access usually granted at a much reduced price

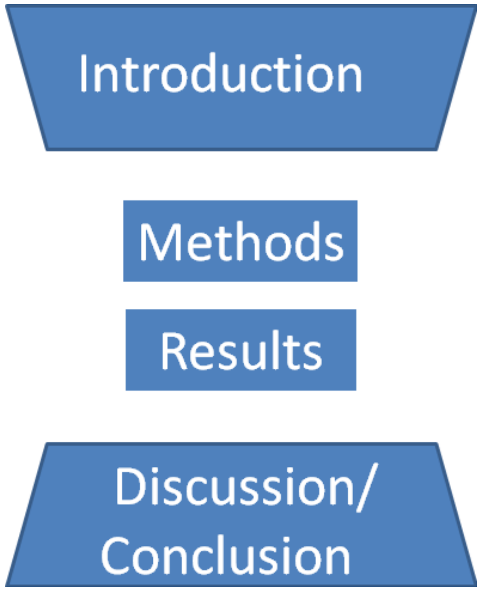
In-house Conference

- Within SciMet course - we need organizing committee
- You will submit your project papers to this conference
- Peer-review from colleagues
- Present your paper

Oral presentations

Structure

- Introduction
- Methods
- Experiments
- Conclusion



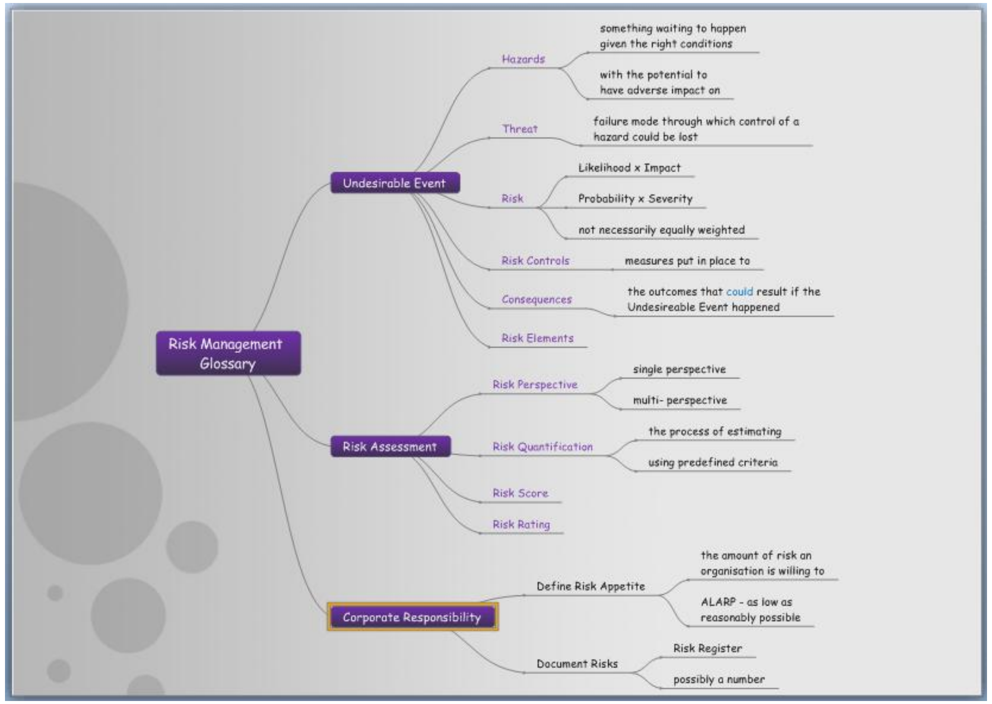
https://en.wikipedia.org/wiki/IMRAD

Introduction

- Introduce yourself
- Motivation: why is your talk important (the hook)
- Introduce key concepts
    - Maybe you provide a high-level overview of your methods

Methods

- Logical order
  - From known stuff → novelties
- Granularity
  - Choose wisely when to go into details
  - Careful with formulas
  - Could some things be explained by intuitive analogies?



Experiments

- Important experiments only
- Logical order - again
  - Not (necessarily) chronological
- One experiment per slide
- Figures
  - Only use the ones that are easy to explain
  - Explain them!

Conclusion

- Main conclusions and innovations
  - Take home message
- Future perspectives
- Acknowledgments
  - Advisors, students, collaborators, institutions, funding bodies, audience

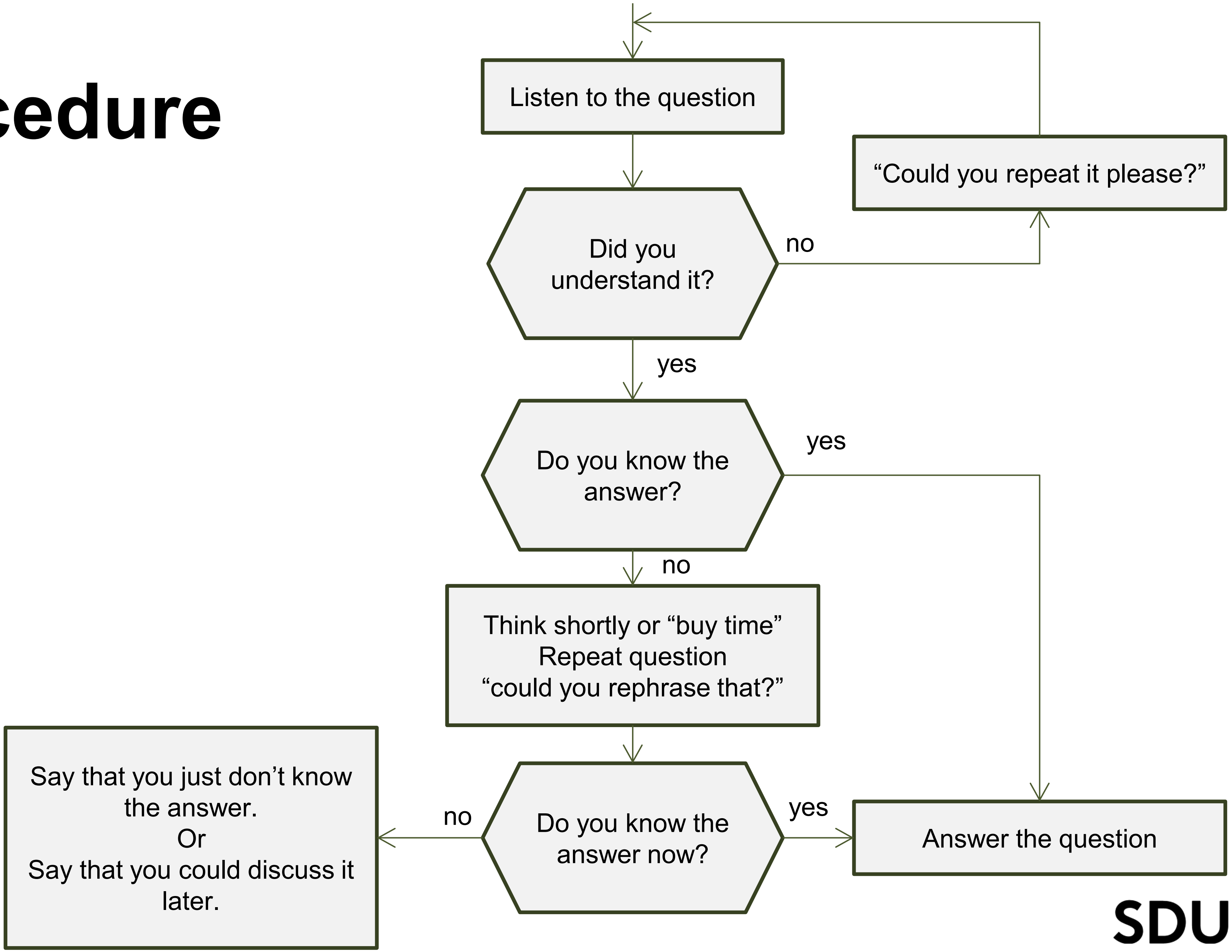
Take questions

- Make sure you understand the question
  - Or else request a rephrase

- Awkward question? Be friendly:
  - “Interesting point. I’ll have to think about it.”
  - “Perhaps we can discuss this after the talk?”

- Silence is your enemy

Q&A Procedure



Q&A ”Buying time”

- Repeat the question (for everyone to hear)
- “That’s a very good question, thank you for asking it”
- “Hmmm” – look to the sky for possible divine intervention
- “Could you rephrase the question?”
- It is ok to say “I don’t know”

For person asking question

- Be polite but ask tough questions if need be

- Start with:
  - “Thank you for your presentation” – if it was bad
  - “That was a great presentations, thanks!” – if you liked it

Q&A Final Thoughts

- Do not stand in silence for more than 5 seconds
- End the question one way or the other
- The questioner might have their own agenda, so be defensive but not too defensive!

Tips when presenting

- Know your audience
  - Adjust the scientific level

- Consider relevancy
  - Make clear to the audience what novelty you are bringing

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Language

- English is the de facto language of science of our age whether we like it or not
- Native English speakers will have an advantage
- Master your English
- For best results: tell a story!

Engage your audience

- Make eye contact
- Ask for their participation
- Do not read your slides (all the time)
- Confidence – fake it till you make it

Timing and Practice

- Do not overstep your time
- Do not make it too short
- Very important presentation
  - practice the night before
  - in front of a mirror
  - 10.000 hours – Malcolm Gladwell – Outliers (book)

Final presentation tips

- Take a course on public speaking
- Confidence (fake it till you make it)
- Articulate what you are saying!
- Watch a video of yourself presenting (learn from Trump)

Public speaking tips

- Counteract nervousness with preparation and practice
- Pay attention to feedback
- Use humor, tell stories if you are able to.
- Use hand gestures and body gestures appropriately
- Don’t read from slides
- Use audiovisual aids wisely

Slides

Possible without slides?

- If you are “brave enough”
- But most often the answer is: it’s much better with slides
- Purpose of slides:
    - Clarify your points
    - Help you remember your points

Clarity

- Clutter
- Information level – too much or not enough
- Animations
  - Attention thieves
  - Limit the use of special effects
  - Help providing a sense of flow

Fonts

- Too large
- *Unreadable*
- Too informal
- Sans serif vs. with serif
- No colors/colors
    - Don't forget what background color you are using
- Comic Sans (please don't!)

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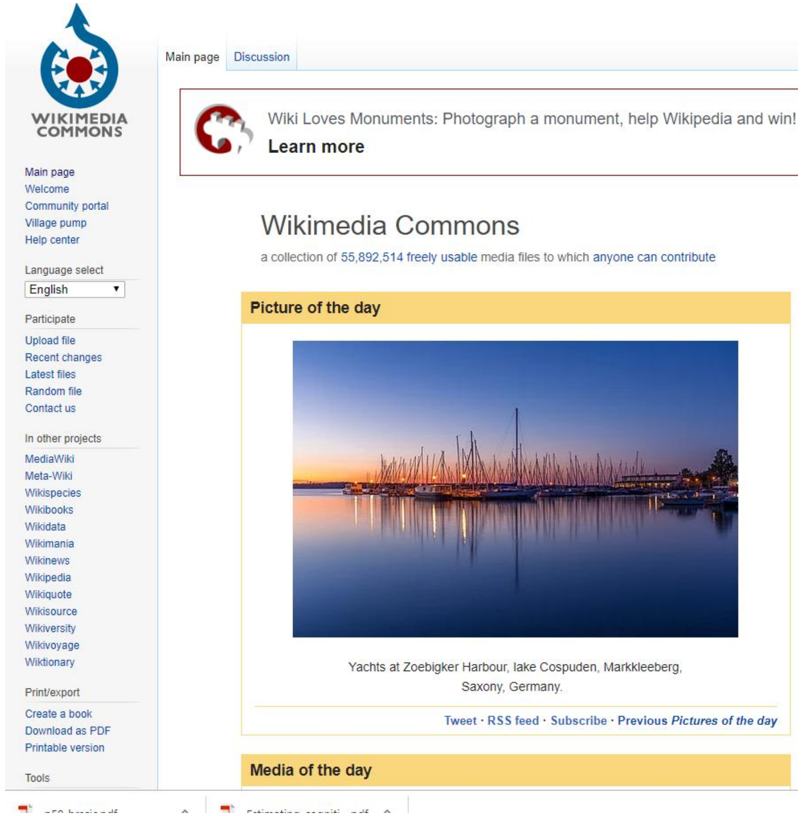
Images

- It’s good to use images to break up monotony
- In papers other people’s images are very rarely used
- In presentations
  - Best to use your own
  - Use others’ images with acknowledgement
  - Fair use
- Wikimedia Commons
  - Pay attention to what the rights to the image are



Text and Bullet Points

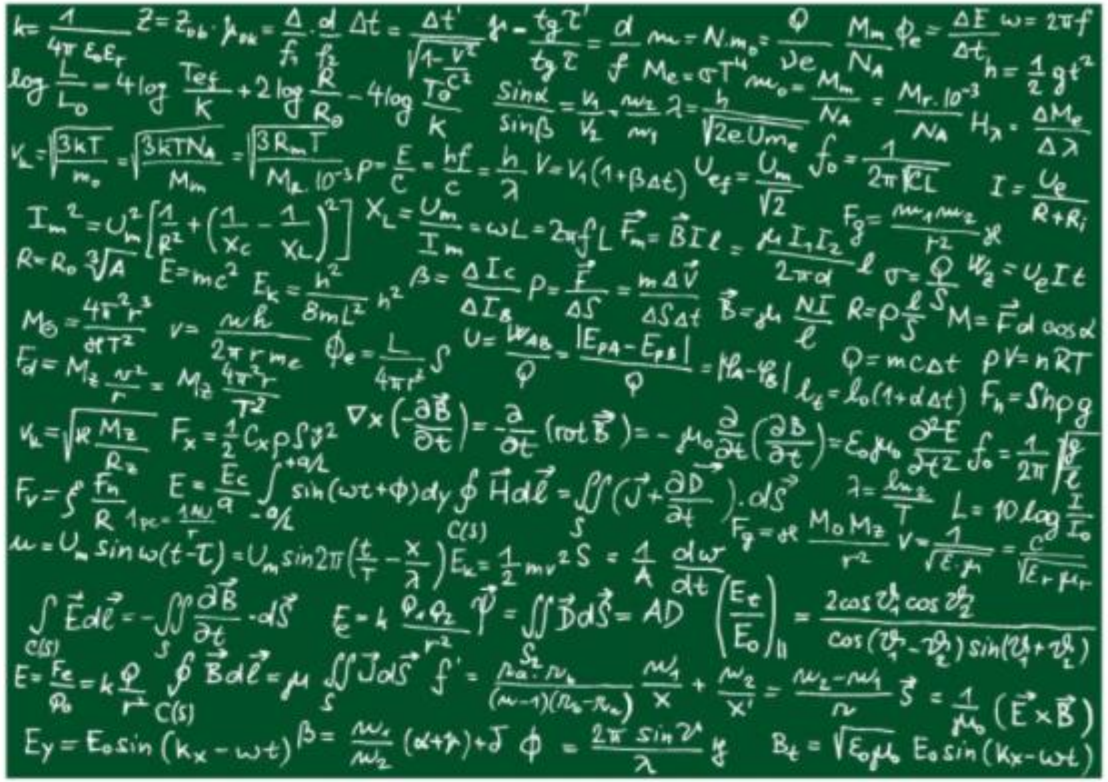
- Do not write a full paragraph of text to make sure that you don't forget to say anything. It is very confusing for the audience if there is too much text because they are either going to miss what you are saying or what is written.
- Ideas, a couple of words
- My approach: use bullet points
- Keep them low in numbers per slide
- Space them out, if possible

Alternative designs

Beware of the increased maintenance

Don’t forget the new colors

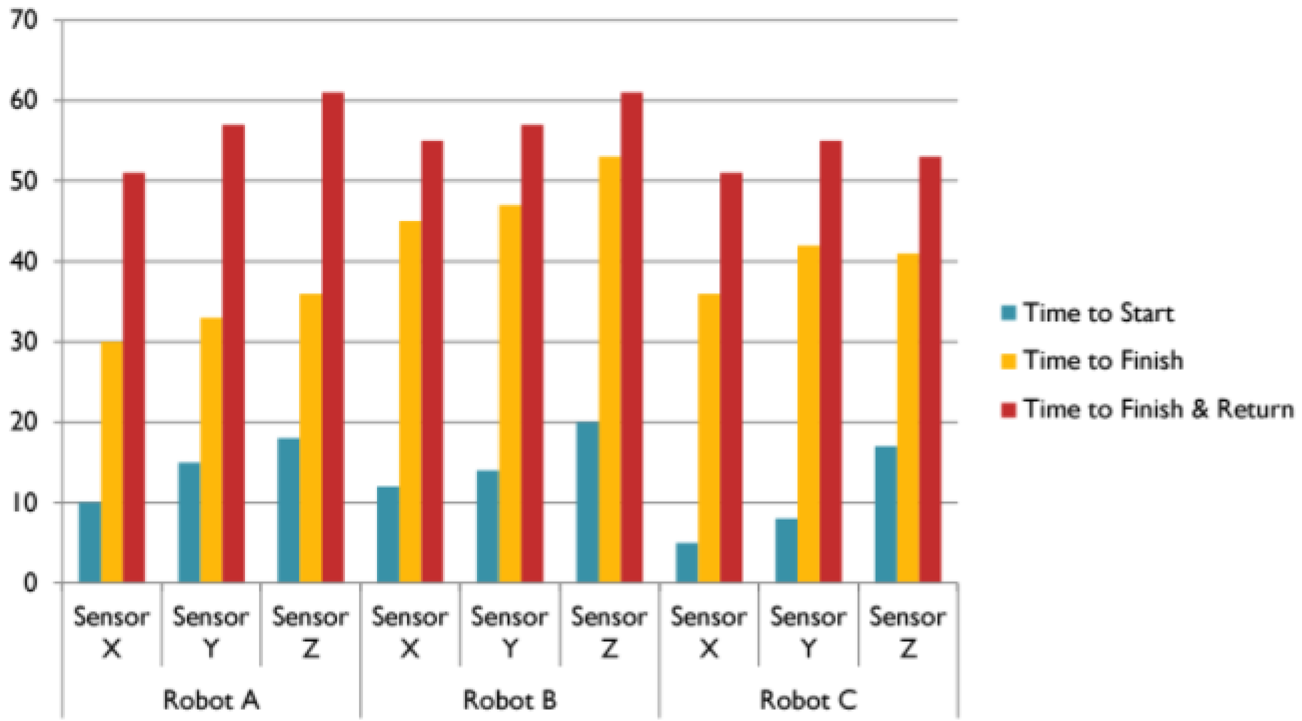
Equations



Tables

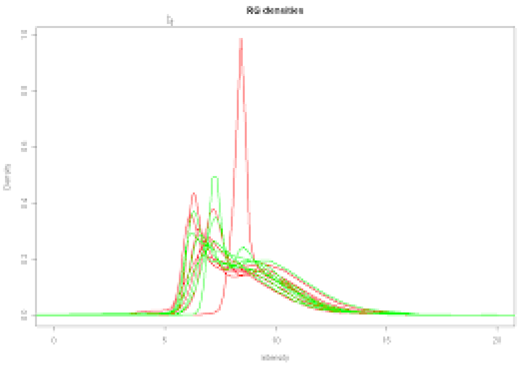
- Require a great deal of explanations
- ⇒ Best to avoid them if you can!

	Robot A			Robot B			Robot C		
	Sensor X	Sensor Y	Sensor Z	Sensor X	Sensor Y	Sensor Z	Sensor X	Sensor Y	Sensor Z
Time to Start	10	15	18	12	14	20	5	8	17
Time to Finish	30	33	36	45	47	53	36	42	41
Time to Finish & Return	51	57	61	55	57	61	51	55	53

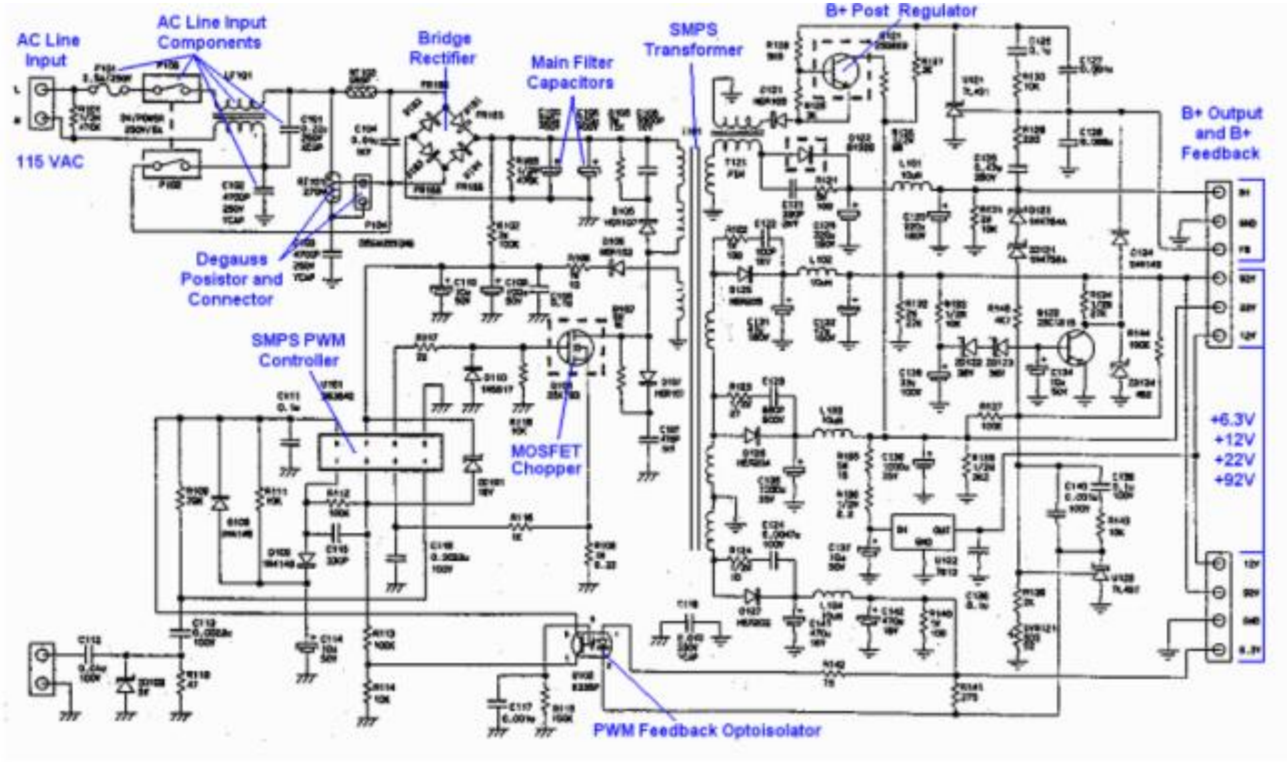


Graphs

- Easy interpretation
- Pitfalls
    - Missing axis labels and/or legend
    - Missing units
    - Too small fonts
    - Too thin lines
    - Too many lines
    - Raster vs. vector graphics

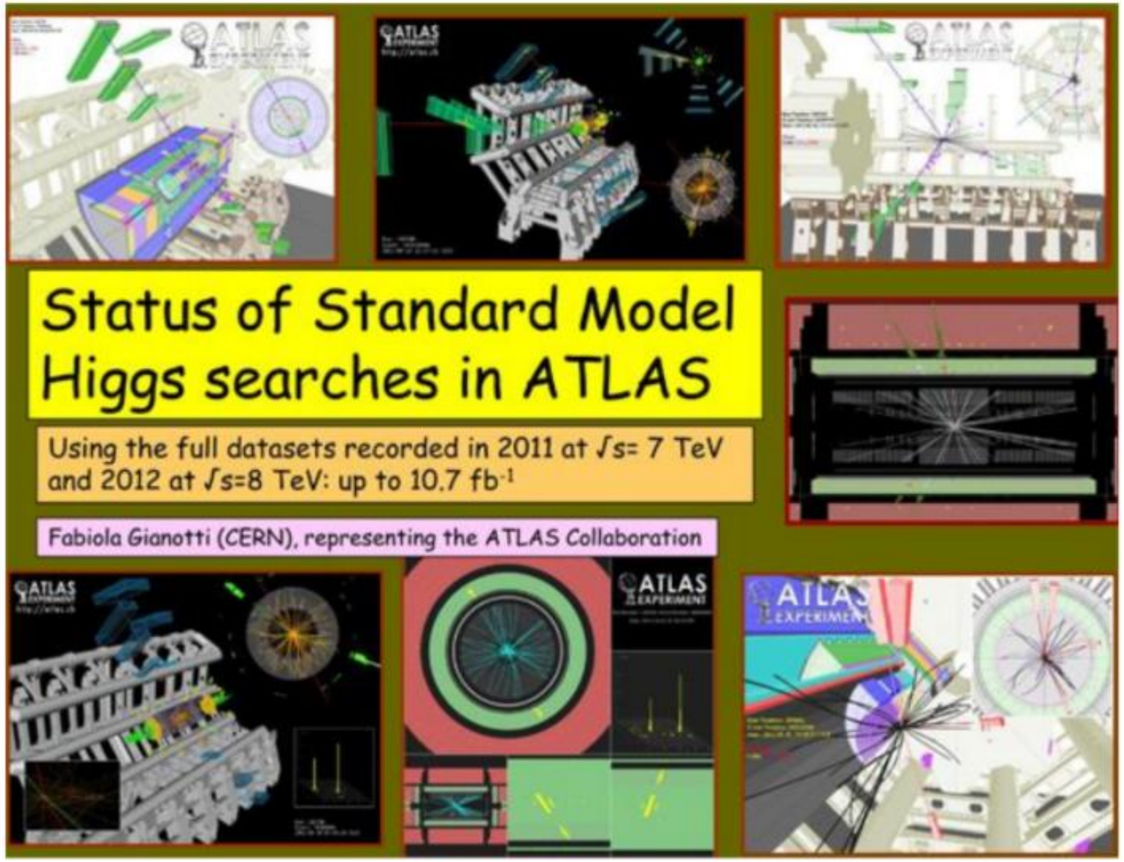


Figures



AC Line Input
AC Line Input Components
Bridge Rectifier
Main Filter Capacitors
SMPS Transformer
B+ Post Regulator
B+ Output and B+ Feedback
115 VAC
Degauss Posistor and Connector
SMPS PWM Controller
MOSFET Chopper
+6.3V
+12V
+22V
+92V
PWM Feedback Optoisolator

Figures - CERN example



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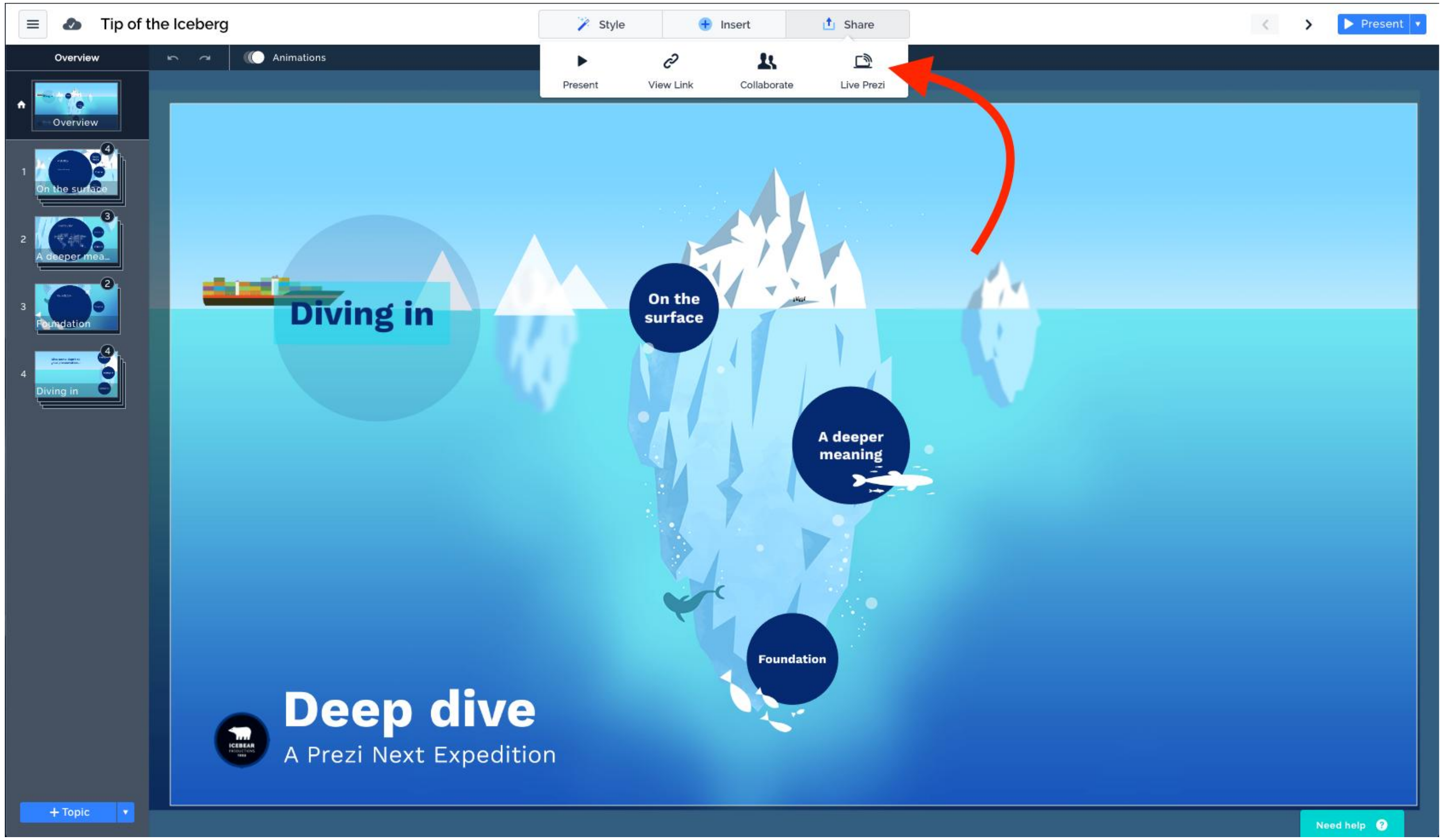
Demo

- Rarely possible
    - But when you can... go for it!
- Adds authenticity
- Make super sure that it works!

Tools

- PowerPoint or similar
- Prezi – [example]



Recap

- Scientific Conferences
  - Quicker way of dissemination compared to journals
  - Getting to know state of the art in a field
  - Networking, job hunting
  - Peer-reviewed in robotics
  - Not only for scientists
    - Demos of latest robots
    - Exhibit own products

Recap

- Oral presentations
  - Usually with slide presentations
  - Be prepared (rehearse)
  - Tell a ”story”
  - Engage your audience
    - Tell a joke (if it makes sense and you are good at telling jokes)
    - Ask them questions
    - Make them participate
    - Look them in the eyes
  - Handle questions with courtesy but expeditiously

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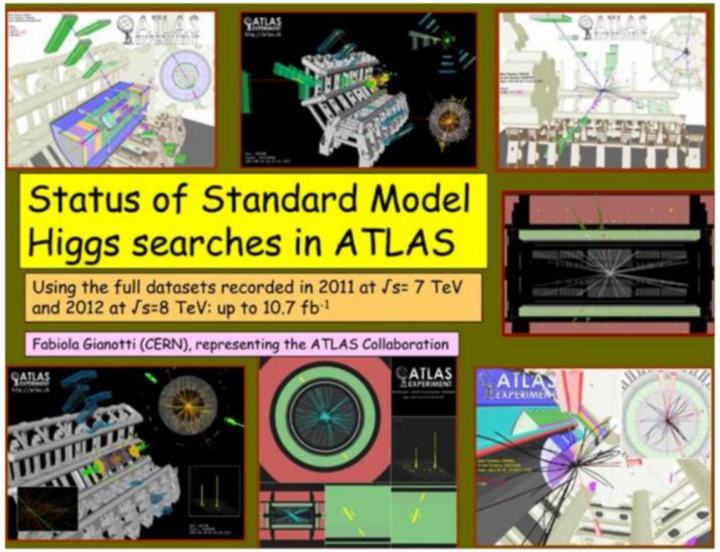
Recap

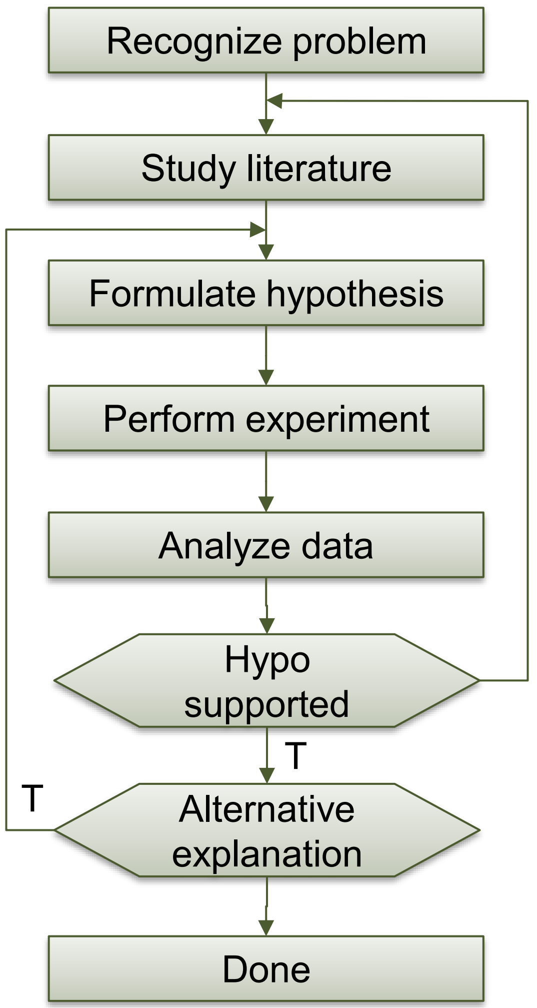
- Slides
    - Information level – Goldielocks
    - Graphs – axes, legend, font size
    - Images
        - Use them to break up text monotony
        - Convey information faster
    - Colors – conservative is better



SDU

Idealized scientific process

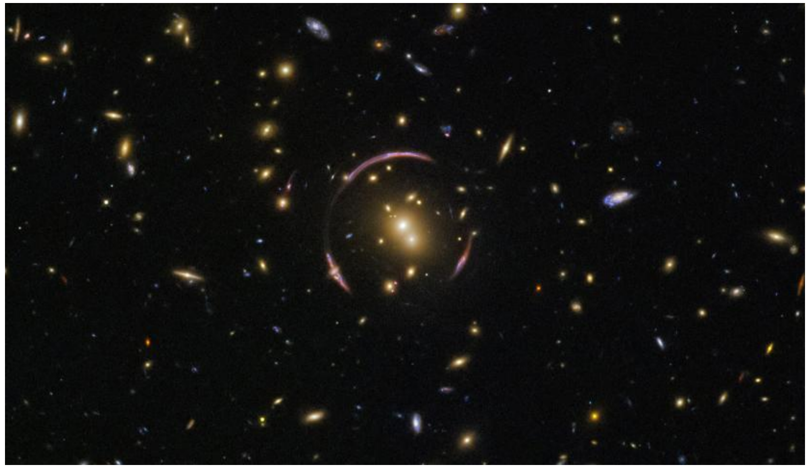
1. Recognize a problem
2. Survey existing knowledge
3. Formulate new hypothesis H
4. Plan and perform experiments to gather evidence
5. Data analysis
   - If H is false, goto 2
   - If H is supported, but alternative explanations still exist, goto 3
6. Publication



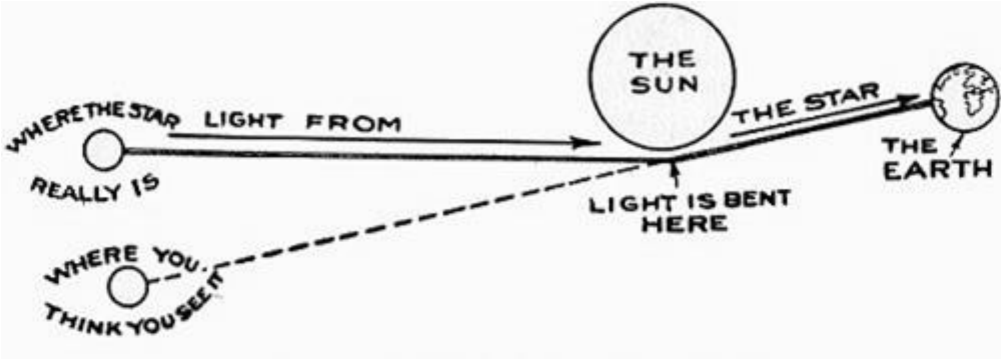
Scientific Problem

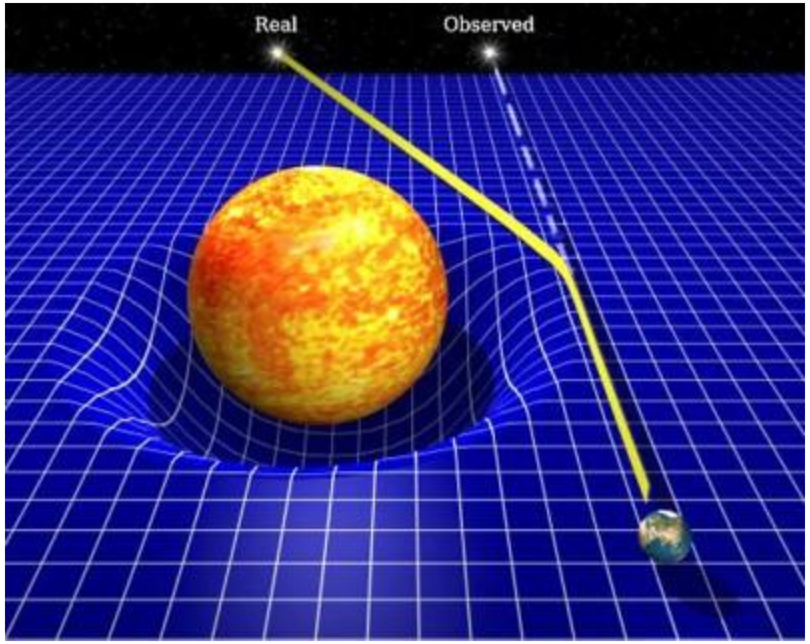
1. A problem in science which has not been sufficiently answered yet
2. Observe world, study literature – come up with problem
3. Based on problem one defines hypotheses

Hypothesis



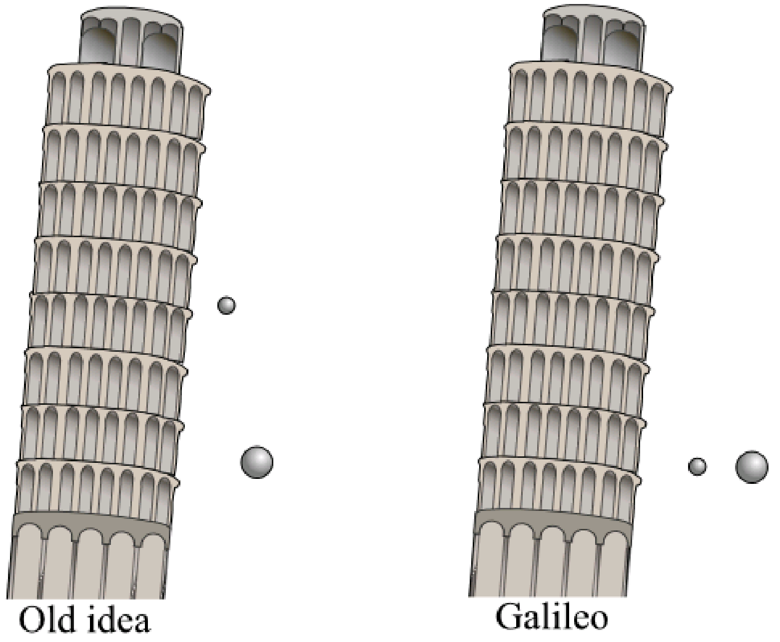
- A statement of predicted outcome, which is not obvious
- A statement, not a question
- A prediction, e.g. based on a theory
- Results may falsify, support, modify or extend a current theory



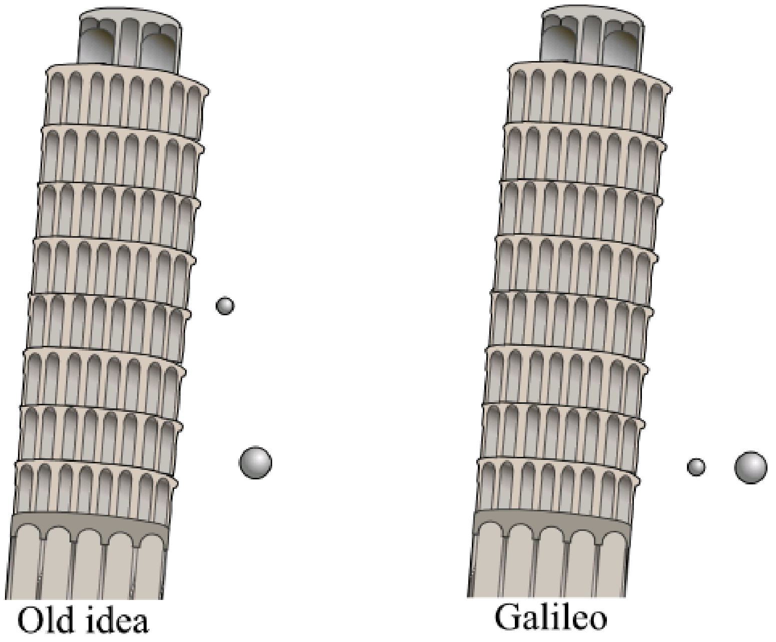


Scientific theory

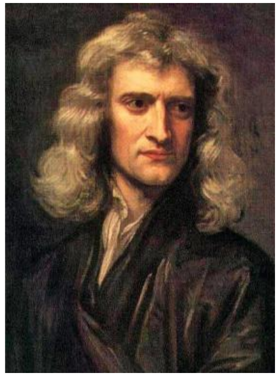
- A framework that explains why things behave as they do
- Theories allow the formulation of predictive hypotheses for testing
- Can be proven wrong?
- Examples
  - Gravity
  - Evolution by Natural Selection
  - Plate tectonics
  - Germ Theory of Diseases
  - Big Bang
  - Giant Impact Theory
  - Atomic Theory
  - Special and general relativity
  - Critical Race Theory
  - Creationism?!

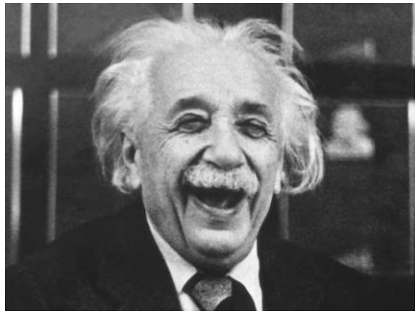


Example: theory of gravity




Free fall


Universal gravitation


“It’s all relative!”

http://www.thestargarden.co.uk/Newtons-theory-of-gravity.html

A good theory

- is based on supporting empirical data,
- can explain all existing data, and
- can make predictive hypotheses

A good hypothesis is

- a statement about an expected outcome
- testable (practically or theoretically),
- objective,
- falsifiable, and
- Original, never proven before!

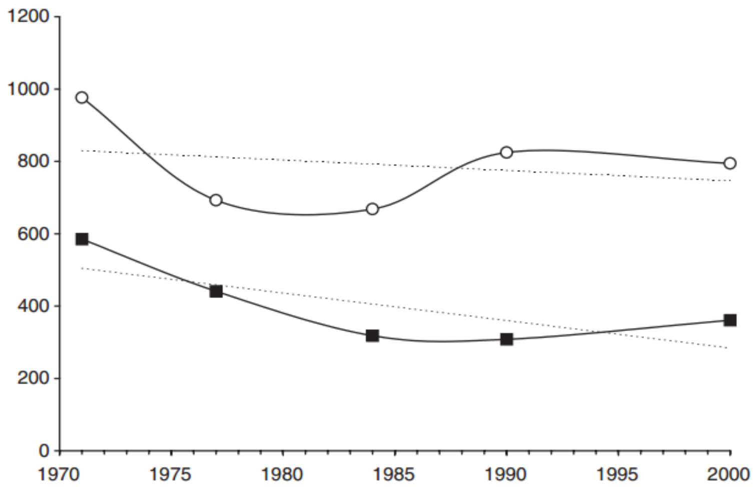
Falsification

- Sometimes complete observation is impossible (observe all swans in the universe)
- Sometimes direct observation is impossible (string theory)
- Let’s flip the picture and *falsify* our hypotheses
- A hypothesis is scientific if it can be tested and proven false

The hypothetico-deductive model

1. **State your hypothesis *H***
2. **Make a prediction *p* based on *H***
3. **Design an experiment to test *p***
    a. If *p* was false, *H* is *falsified*
    b. If *p* was true… then what?

1. **The storks bring the babies**
2. **The more storks I see, the more babies are born**
3. **Count the number of observed storks vs. the birth rate**

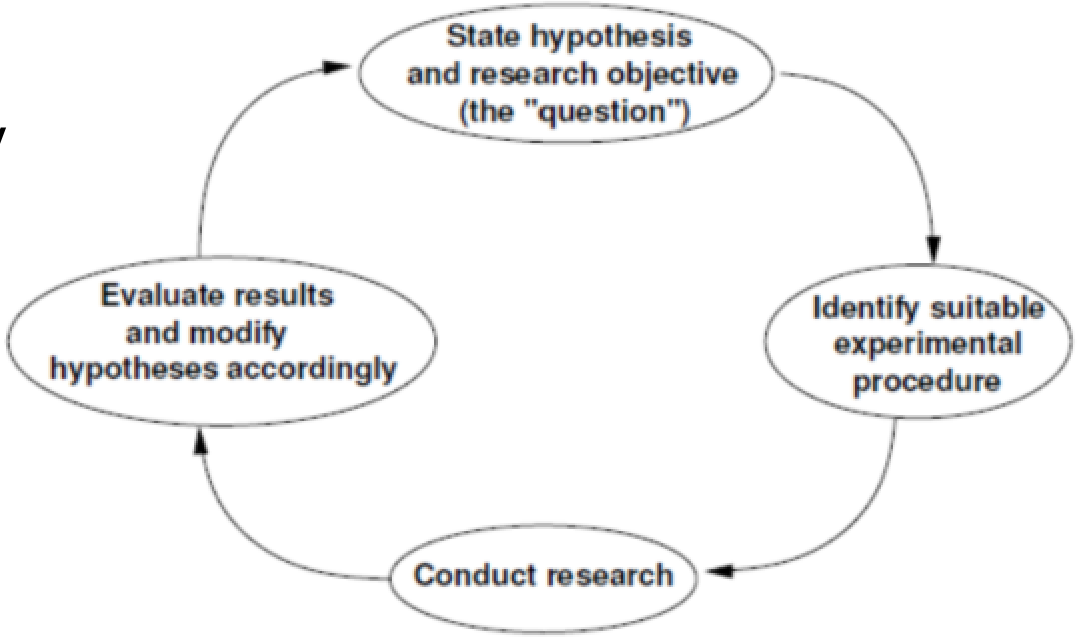


Matthews, Robert. "Storks deliver babies (p= 0.008)." *Teaching Statistics* 22.2 (2000): 36-38.

Höfer, Thomas, and Hildegard Przyrembel. "New evidence for the theory of the stork." *Paediatric and perinatal epidemiology* 18.1 (2004): 88-92.

In practice

- Hypothesis+prediction and confirmatory experiments are the norm
- If experiments fail
  - Review experimental conditions
  - Review the hypothesis
  - Consider revising the underlying theory
- If experiments keep failing
  - Question theory



Tips for hypothesis generation

- State clearly the question(s) you are addressing – scientific problem
- What outcome do you expect? - hypothesis
  - What would be the implications of the different possible outcomes?
- Is your hypothesis testable and falsifiable?
- Experimental considerations
  - How to collect data (and how much)
  - How to evaluate the data

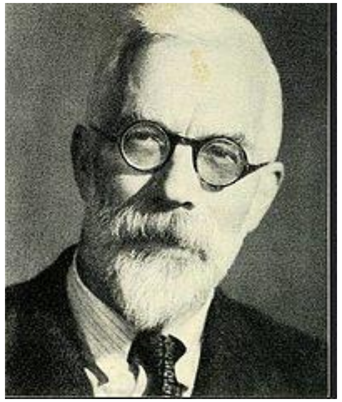
Empirical investigation types

- Observational studies
  - May be carried out without a hypothesis
  - Data collection and statistics important
  - Outcome might not be as strong as for comparative studies
  - Statistics used: regression, correlation, plots, central measures, variability measures
- Manipulation and comparative experiments
  - Clear hypothesis and prediction
  - Compare one condition to the other one (control)
  - Aim to prove/disprove hypothesis
  - Statistics used: chi squared, t-test, ANOVA, Friedmann, etc.

Tips for good experiments

- Based on a good hypothesis
- Measurements
  - Relevancy: measures only the right data
  - Quality: produces high-quality data
  - Sufficiency: produces enough data
- Execution
  - Well-controlled
  - Not biased
  - **Repeatable**

Fisher’s principles



- *Randomization*
  - Reduce the effect of unknown factors
- *Blocking*
  - Avoid “other” sources of variation
  - Example: arrange test subjects into groups of similar age, hair color, etc.
- *Replication*
  - Basically repeating the experiment multiple times
  - Reduce uncertainties
- *Control*
  - What do you compare to?
  - Example: placebo treatment

Variables

- Independent variables (factors)
  - The ones we can change to cause effects
  - E.g. wheel type, number of sensors, robot’s emotions
- Dependent variables
  - The ones that we measure to quantify our output
  - E.g. completion time, distance travelled, subjective opinions

- Need to control independent variables

Other factors

- **Nuisance** factors
  - The annoying ones
  - Have effect on the outcome, but not interesting for experimenter
  - Need to be minimized, explained, accounted for
  - Gender, age, environmental differences, etc.
- **Confounding** factors
  - The scary ones
  - Influences both the independent and the dependent variable
  - Can be a hidden independent variable
  - Example:
    - independent variable: activity level
    - dependent variable: weight gain
    - confounding variable: age

General Terms

- Quantitative data
  - Numerical measurement arising from a natural numerical scale
  - E.g.?
  - Continuous or ordinal values

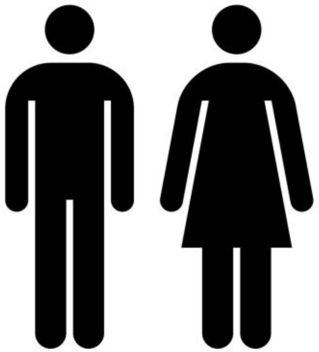
- Qualitative data
  - Measurement without numerical scale
  - E.g?

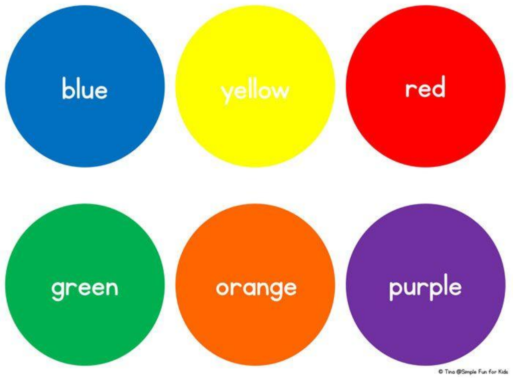
- Danish grading system?
- Likert scale?

Scales of variables

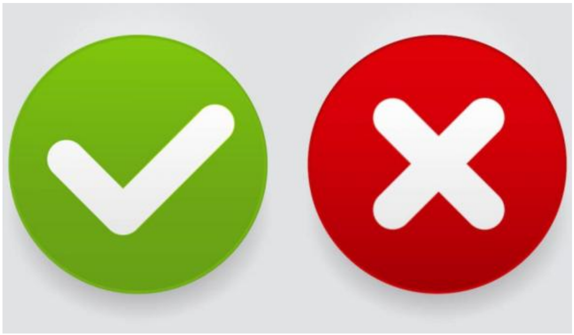
- Nominal
- Ordinal
- Continuous
    - Interval
    - Ratio

Scales of variables

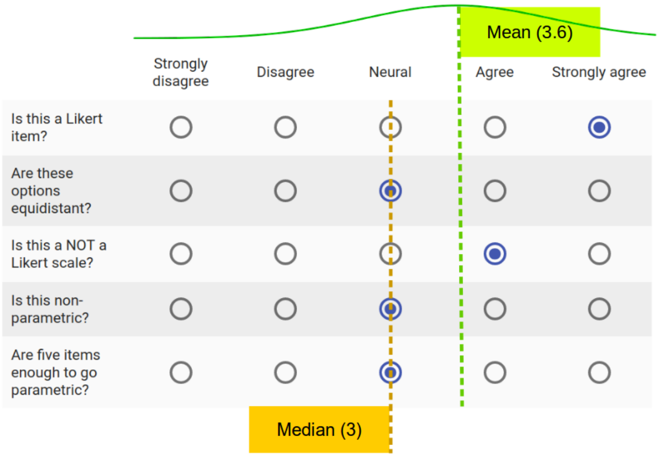




- Nominal scale
  - names categories that values for the variable can fall within
  - no natural order
  - Examples of nominal scales include gender, marital status, college major, and blood type
  - Binary variable – nominal with only two categories, e.g. success/failure, male/female
  - Appropriate measure: mode – which is the most frequent category

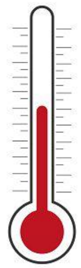


Scales of variables



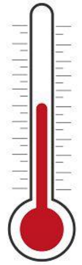
- Ordinal scale
  - name groups in your data, but you can place these groups in a natural order
  - the differences between values might not be consistent
  - Examples of ordinal scales include: education level (primary, secondary, post-secondary), income (low, middle, and high), Likert and other scales of agreement (strongly disagree to strongly agree), rank (such as sporting teams and class standings).
  - Appropriate measure: median, quantiles
  - Inappropriate measurement: mean – because difference between adjacent values might not be consistent

Scales of variables



- Continuous
  - can take on all numeric values, and the scale can be meaningfully separated into smaller increments, including fractional and decimal values.
  - There are an infinite number of values between any two values. And differences between any two values are always meaningful.
  - Examples of continuous data include height, weight, and temperature.
  - Interval or ratio

Scales of variables



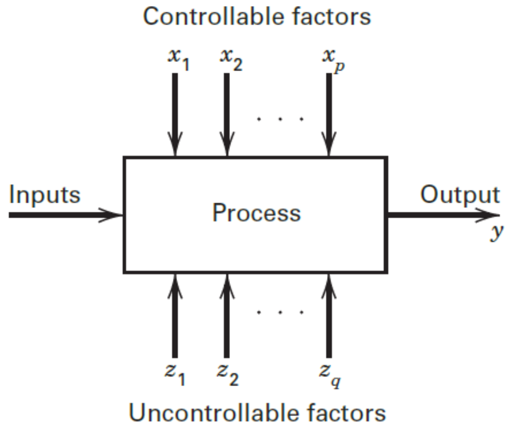
- Continuous – interval
  - the order of values and the interval, or distance, between any two points is meaningful
  - these variables don’t have a zero measurement that indicates the lack of the characteristic
  - measurement ratios are not valid for interval scales
  - can add and subtract values on an interval scale, but you cannot multiply or divide them
  - Exaple: temperature in Celsius, date in the calendar
  - Appropriate measures: mean, standard deviation

Scale of variables

Continuous – ratio

- Like interval measures but here we have a zero value which represents the lack of the measure
- Example: weight, reaction time, speed, temperature in Kelvin
- can add, subtract, multiply and divide values

Experimental Design

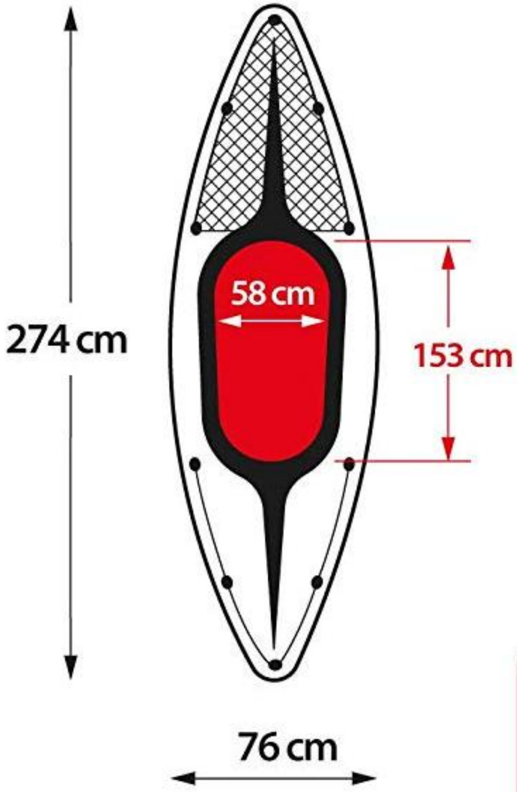


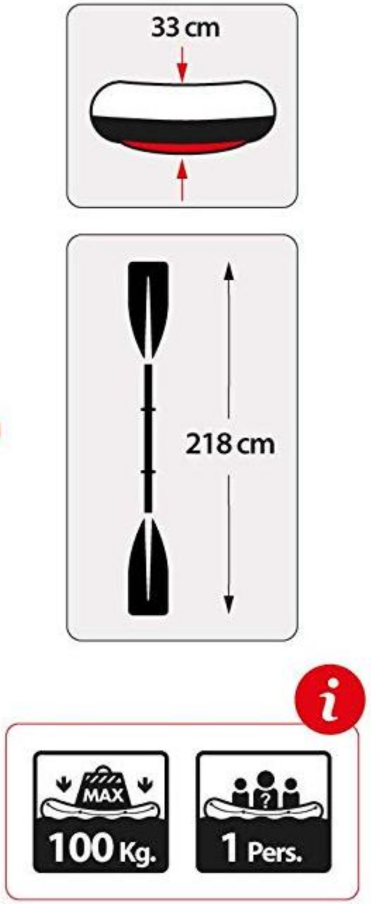
- Definition of the problem that we are addressing
- Recognizing the independent variables (a.k.a. inputs, factors)
- Recognizing the controllable and uncontrollable factors
- Defining the dependent variable (a.k.a. output, response)
- Hypotheses
- Models
- Sample size
- Running the experiment
- Statistical analysis of data
- Draw conclusions

Selection of participants/data

- Representative of the population (students don’t generalize to the whole population)
- About equal number of men and women
- Do not test yourself unless there’s not possible way for you to affect the results
- Don’t test your friends (for a strong paper, relaxed for project)
- Keep people unaware of the purpose of your experiment
- They are trying to help you even if it’s subconscious

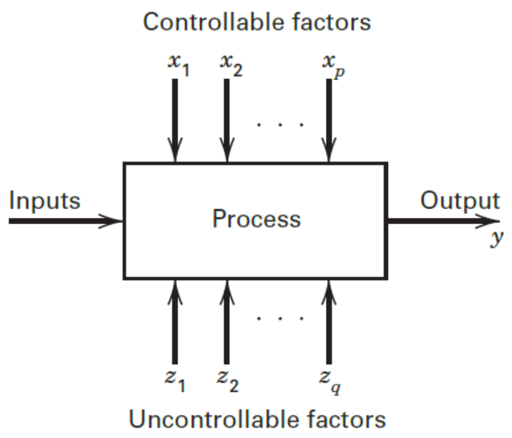
Example experiment





Example experiment

- Problem: I don’t know what influences the speed of my kayak
- Independents: fin_present, inflation, paddle_length
- Levels: (present, absent), (high, low), (short, long)
- Uncontrollable: variable wind speed
- Controllable: water flow – always on lake, not river
- Dependents: kayak_speed, satisfacion
- Hypo: kayak will go faster when more inflated
- Sample size: 10 people
- Alternatively with model: kayak_speed (y) vs inflation (x): y=ax+b



Number of independent variables

- One independent variable – fin

Present	Absent
Subject1 Subject2 …	Subject1 Subject2 ….

- Two variables – fin, inflation

	Present	Absent
high	Subject1 Subject2 …	Subject1 Subject2 ….
low	Subject1 Subject2 …	Subject1 Subject2 …

- Three variables – fin, inflation, paddle_length

short	Present	Absent
high	Subject1 Subject2 …	Subject1 Subject2 ….
low	Subject1 Subject2 …	Subject1 Subject2 …

long	Present	Absent
high	Subject1 Subject2 …	Subject1 Subject2 ….
low	Subject1 Subject2 …	Subject1 Subject2 …

Example experiment - blocking

- Independents: fin_present, inflation, paddle_length
- Levels: (present, absent), (high, low), (short, long)
- Dependent: kayak_speed

Blocking

- Only allowed independent: fin_present, others not changed
- Dependent: kayak_speed

Best guess approach, one factor at a time, factorial

Example experiment - randomization

- Independents: fin_present, inflation, paddle_length
- Levels: (present, absent), (high, low), (short, long)

Randomization, counter-balancing the order

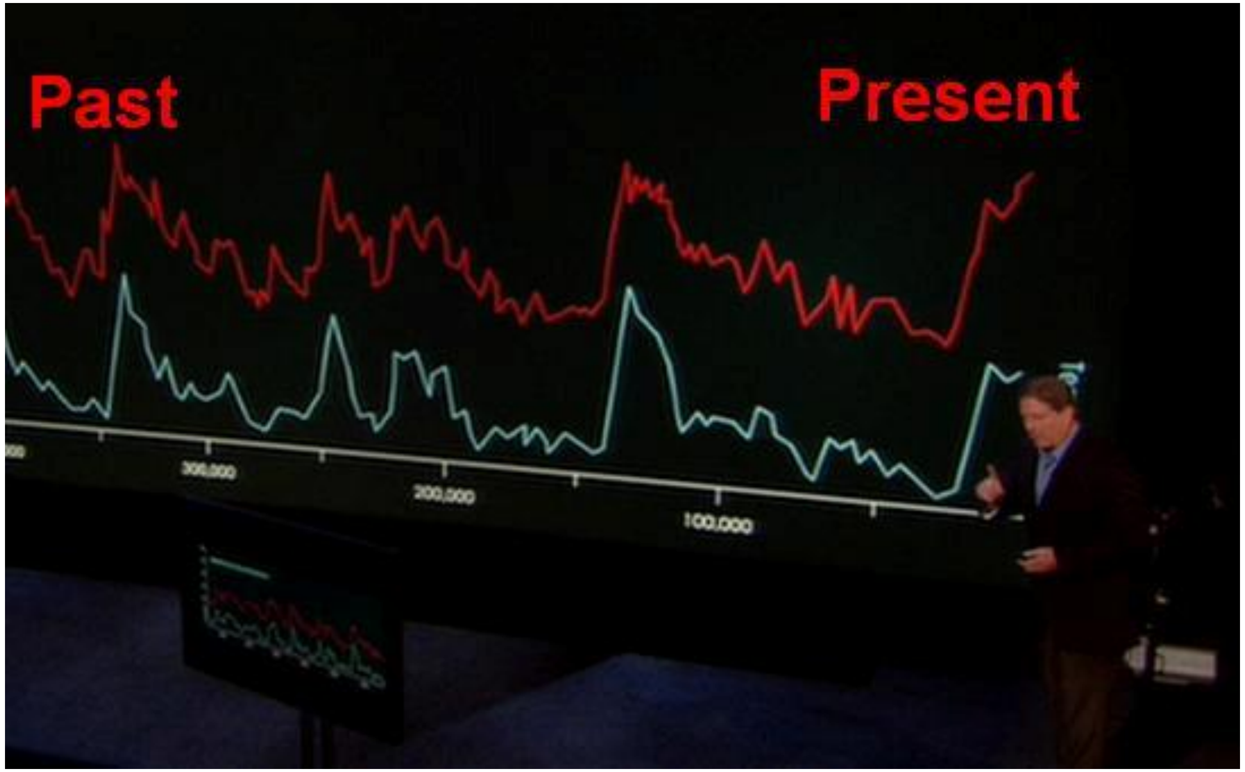
- One independent: fin
  - Subject1: a) present, b) absent
  - Subject2: a) absent, b) present
- Two independents: fin, paddle
  - Subject1: a) present long, b) absent long, c) present short, d) absent short
  - Subject2: a) present long, b) absent long, c) absent short, d) present short
  - Subject3: a) present long, b) present short, c) absent short, d) absent long
  - Subject4: a) present long, b) present short, c) absent long, d) absent short
  - … 4! = 4*3*2*1 = 24

Example experiment - results

- One independent: fin
  - Fin effect: $\frac{8+7+6+9}{4} - \frac{8+5+7+8}{4} = 0.5$
- One independent: inflation
  - Inflation effect: $\frac{10+9+11+12}{4} - \frac{8+6+3+5}{4} = 5$

SDU

Basic and Comparative Statistics



Outline for today

- Paper report
- Project clarification
- Research proposal
- Reading material
- Recap
- Descriptive and Inferential Statistics
- Experimental design (continued from last time)

Tools

- Matlab, SPSS

Recap of last lesson

- Hypothesis
  - Hypothesis vs. theory
  - Good hypothesis: testable, falsifiable, objective, original, not obvious
- Empirical investigation types
  - Comparative vs. observational studies
- Experimental design – comparative example
  - Independent and dependent variables
  - Control of variables
  - Randomization, blocking, replication, control

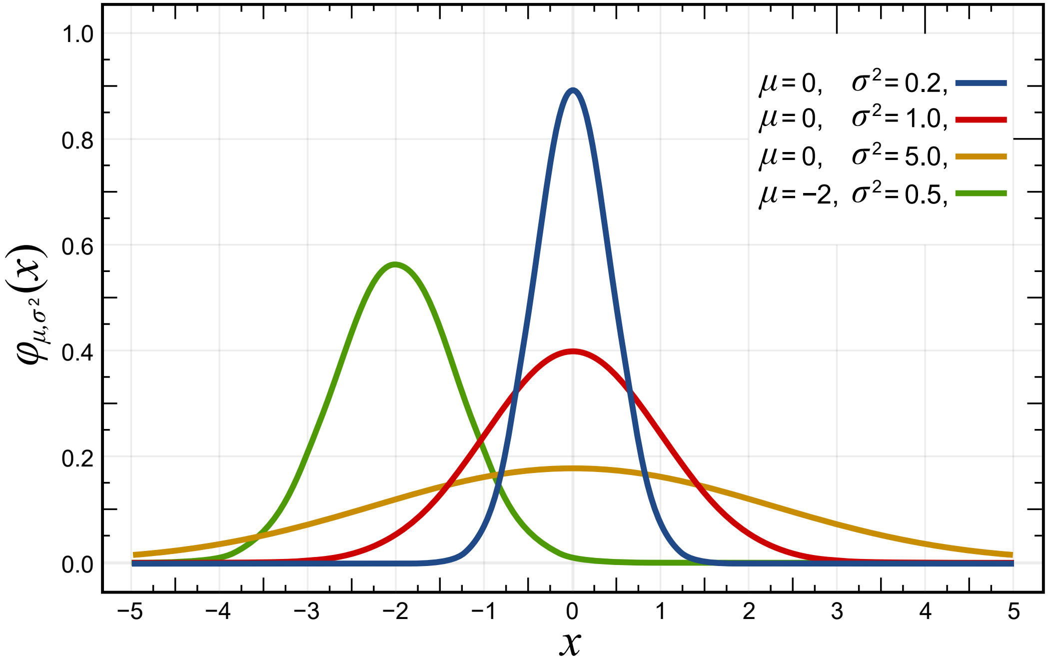
Basic Statistics

Basic Statistics Outline

- General terms
- Tools
- Types of Statistics
    - Descriptive
        - Central measures
        - Dispersion measures
        - Visualization
    - Inferential
        - Confidence intervals
        - Hypothesis testing
        - Regression
        - T-test, ANOVA, etc.

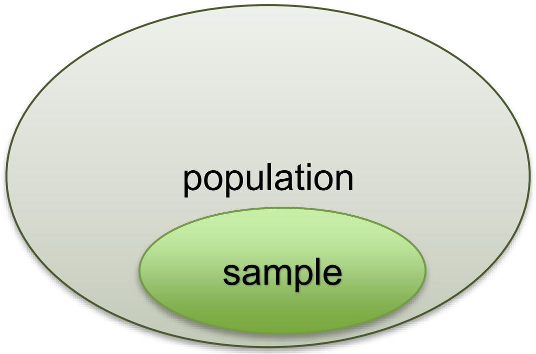
General Terms

- Statistics
  - a discipline dealing with the collection, organization, visualization, analysis and interpretation of data
  - to generate new knowledge based on large amounts of data



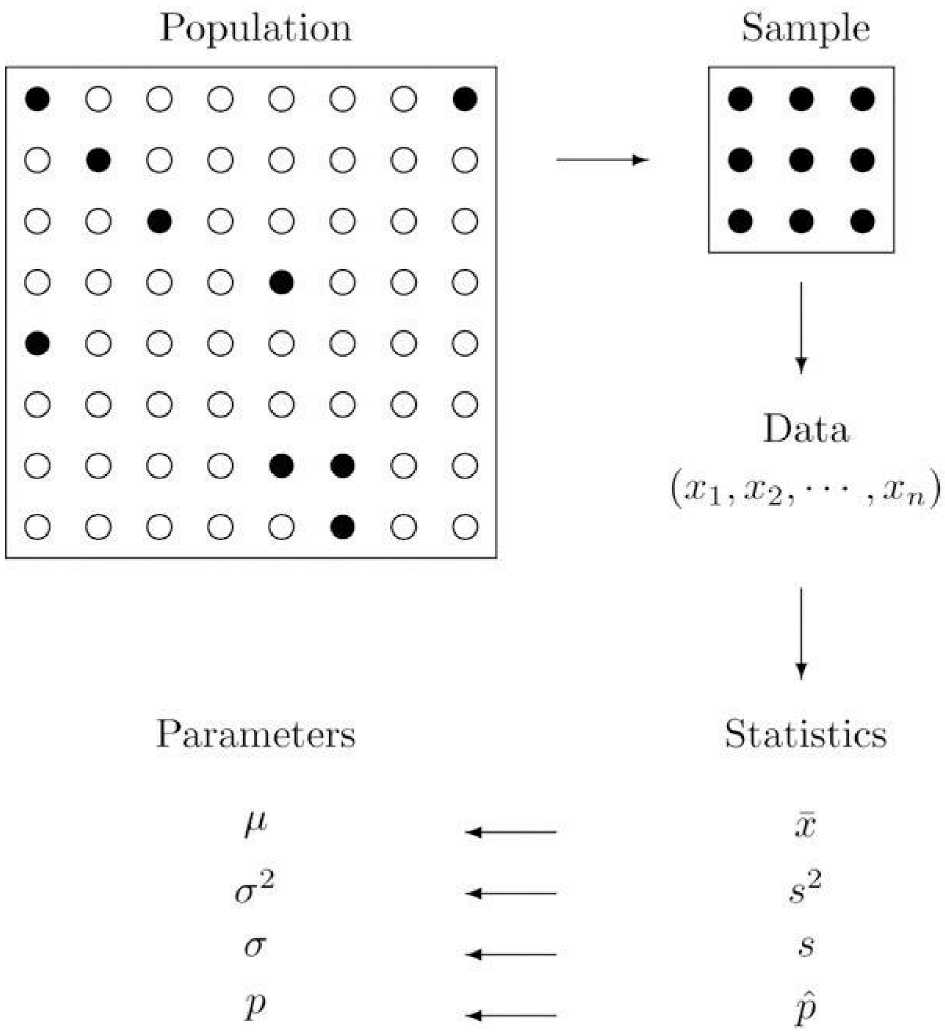
General Terms

- Population – any collection of objects of interest
  - E.g. human population of Earth, lightbulbs produced in a factory, outcomes of dice rolls
- Sample – any subset of the population
  - If it is the whole population, then we call it a census
  - E.g. ten students from this class
- Measurement – a property computed for each member of the population or sample
  - E.g. color of cars on a street, grade for students
  - Measurements of sample elements – sample data
- The sample needs to be representative of the population



General Terms

- Parameter – a number that summarizes some aspect o the population
  - E.g. population mean μ
- Statistic – a number calculated from the data sample
  - E.g. sample mean $\bar{x}$



General Terms

- Quantitative data
  - Numerical measurement arising from a natural numerical scale
  - E.g.?
  - Continuous or ordinal values

- Qualitative data
  - Measurement without numerical scale
  - E.g?

- Danish grading system?
- Likert scale?

Scales of variables

- Nominal
- Ordinal
- Continuous
  - Interval
  - Ratio

Two types of statistics: descriptive vs. inferential

- Descriptive
  - Describe, summarize, visualize a set of observations
  - Works with the sample
  - Does not assume properties of the population
  - Mean, standard deviation, variance, etc.

- Inferential
  - Takes sample data and makes conclusions about the whole population
  - Tools: hypothesis test, confidence intervals, regression analysis
  - ANOVA, T-test, etc.

Remember scientific studies?

- Manipulation and comparative studies
  - Clear hypothesis and prediction
  - Aim to prove/disprove hypothesis

- Observational (exploratory) studies
  - May be carried out without a hypothesis
  - Data collection and statistics important
  - → Maybe formulate new theory

Exploratory studies

- Collect as much data as possible
- Describe the connection between inputs and outputs
- They usually use descriptive statistical tools, but not only those
- Common tools
  - Diagrams, plots, figures
  - Central measures
  - Variability measures
  - Confidence intervals
  - Normality tests
  - Correlation
  - Regression

Comparative studies

- Compare samples from two conditions
- Common statistics
  - T-test
  - ANOVA
  - Friedmann-test

Tools

- SPSS
- JMP
- Excel
- R
- Matlab
- In this class examples are a combination of Matlab and SPSS
    - SPSS and Matlab are available through sw.sdu.dk
    - Matlab Online: https://matlab.mathworks.com

Basic descriptors

Sample size $N = |X|$

Sum $\sum_{i=1}^{N} x_i$

Product $\prod_{i=1}^{N} x_i$

```
length(X)

sum(X)

prod(X)
```

Central measures

Arithmetic mean

$$E[X] = \frac{1}{N} \sum_{i=1}^{N} x_i$$

```
mean(X)
```

Geometric mean

$$\left(\prod_{i=1}^{N} x_i \right)^{\frac{1}{N}}$$

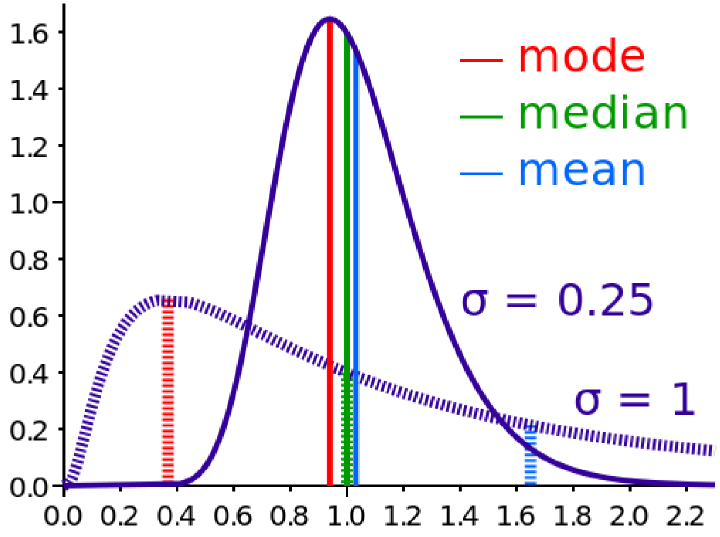
```
geomean(X)
```

Mode

```
mode(X)
```

Median

```
median(X)
```



Central measures

- Mode – the most common value among a group
  - The value that’s most likely to be sampled
  - Not necessarily a single value

- Median - is the value separating the higher half from the lower half of a data sample
  - Doesn’t get skewed by very large or small values as the mean does
  - “typical” value
  - Median household income

Variability/dispersion measures

- Variance – is the expectation of the squared deviation of a random variable from its mean $\mathrm{Var(X)} = E[(X - E[X])^2]$
  - It measures how spread out a random variable is from its mean value

Variability/dispersion measures

Variance $\mathrm{Var}(\mathrm{X}) = E[(X - E[X])^2]$

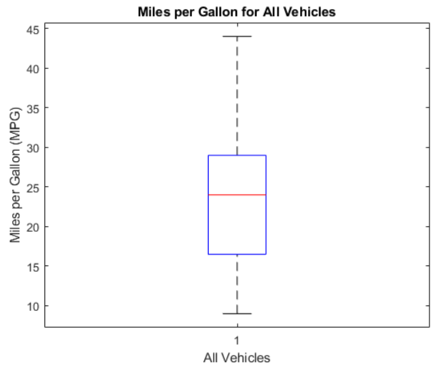
Standard deviation $\sqrt{\mathrm{Var}(\mathrm{X})}$

Quantiles, e.g. 25th, 50th and 75th

IQR – inter-quartile range

```
var(X)

std(X)

Q = quantile(X, [0.25 0.5 0.75])

Q(3)-Q(1) == iqr(X)
```

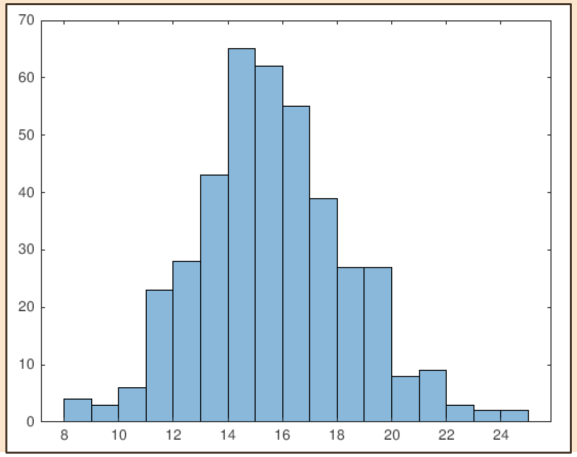
Data displays

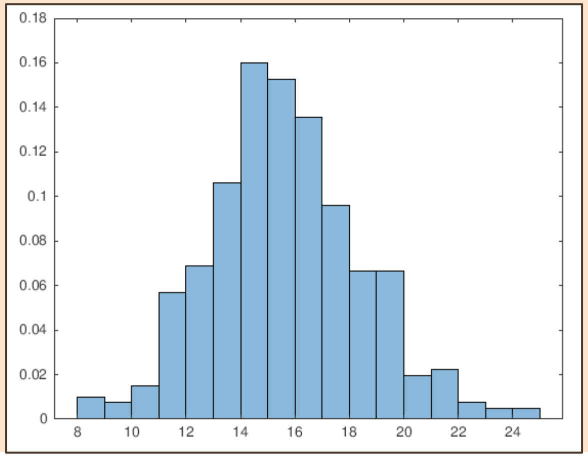


Box plot - depicting groups of numerical data through their quartiles

Histogram – representation of the distribution of data – bars represent frequency of data occurance

```
boxplot(X)

histogram(X) % Since R2014b
histogram(X, 'Normalization', 'probability')
```

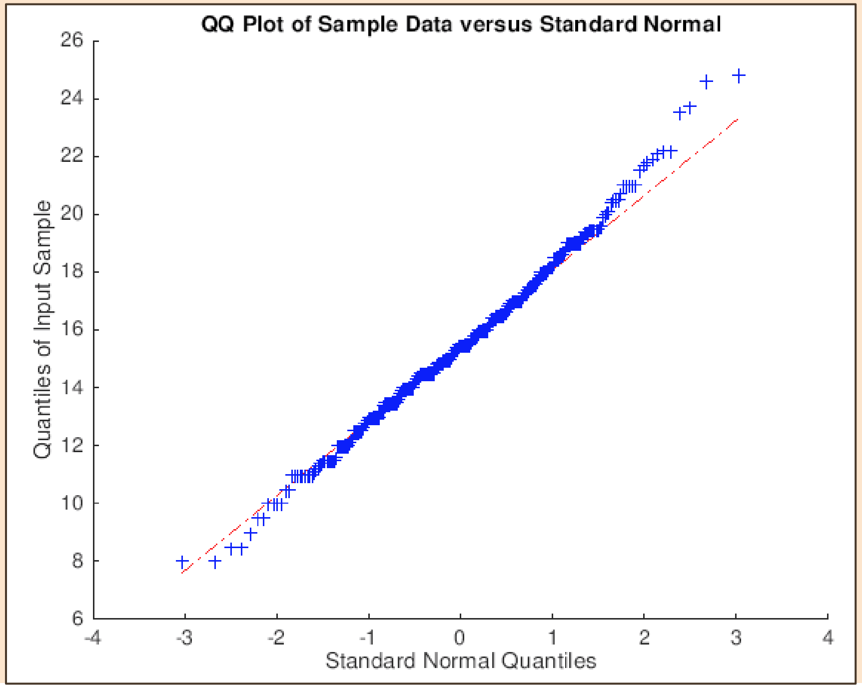




Data displays

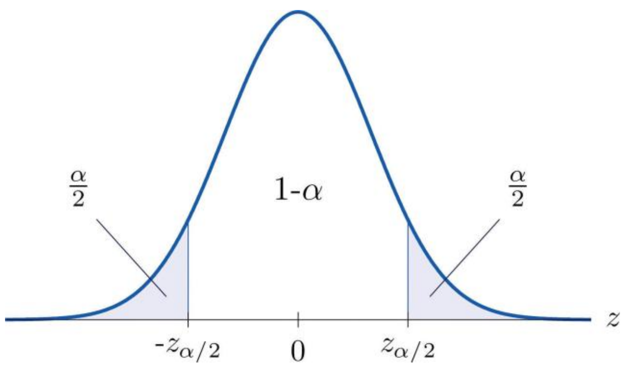
Q-Q plot - a plot of the quantiles of the first data set against the quantiles of the second data set – by default compares to normal distribution

```
qqplot(X)
```



Confidence Intervals

- Estimate population parameter using observed sample statistic
- This parameter is often the population mean μ which is estimated through a sample mean $\bar{x}$
- Confidence interval gives a range that will likely include the unknown population parameter (e.g. μ)
- Confidence level α usually takes the values 0.90, 0.95, 0.99

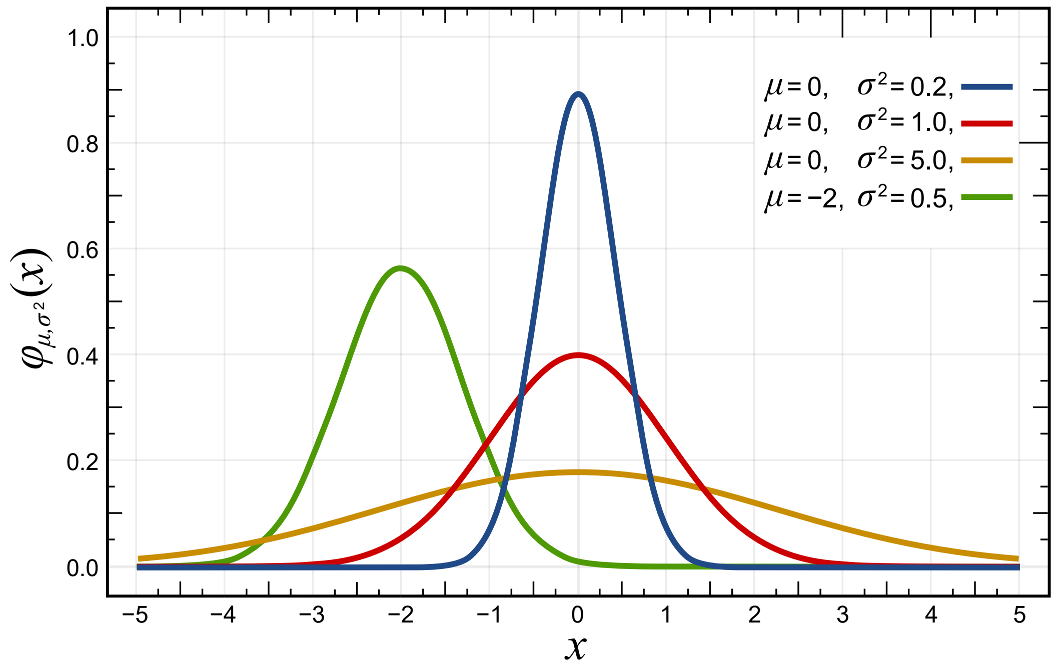


CI – How to report it in papers

- “A formal study has revealed that the average weight of turtles in this population is 300 pounds, 95% CI [292.75, 307.25]”
- It gives information about the population parameter (e.g. mean) and not about the how likely it is that the samples themselves will be in the calculated interval

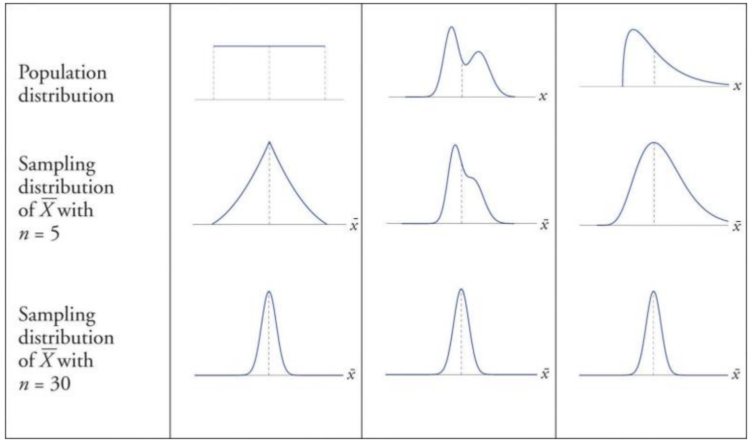
Central Limit Theorem

- when independent random variables are added, their properly normalized sum tends toward a normal distribution even if the original variables themselves are not normally distributed



Central limit theorem

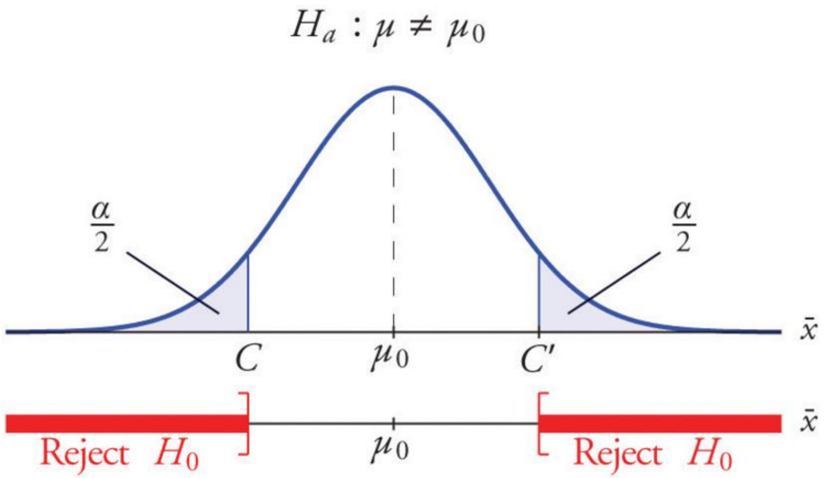
- Look at the sample mean $$\bar{x} = \frac{x_1 + x_2 + \ldots + x_N}{N}$$
- Now treat the individual observations as i.i.d. random variables $$\bar{X} = \frac{X_1 + X_2 + \ldots + X_N}{N}$$
- Resulting variance $$\mathrm{Var}(\bar{X}) = \frac{\mathrm{Var}(X)}{N}$$
- CLT: If $X \sim \mathrm{Dist}(\mu, \sigma^2)$, then $\bar{X} \sim \mathcal{N}(\mu, \sigma^2/N)$ as $N \to \infty$



Hypothesis testing

Hypothesis testing – one-sample t-test

- State a null hypothesis H_0, an alternative hypothesis H_a and an α
  - H_0: $\mu = \mu_0$
  - H_a: $\mu \neq \mu_0$, $\alpha = 0.05$
- *Assuming* H_0, now determine if the observed value falls into the critical region (reject H_0) or not (fail to reject H_0)
  - The observed test statistic under H_0:
  - The *p*-value: $\Pr(T \leq t)$ or $\Pr(T \geq t)$



Example

- State a null hypothesis H_0, an alternative hypothesis H_a and an α
  - H_0: On average, a car has an acceleration of 15 : $\mu = 15$ ($\mu_0 = 15$)
  - H_a: The average car is either faster or slower : $\mu \neq 15$, $\alpha = 0.05$
- Test statistic ($N = 406$, $s = 2.8034$)

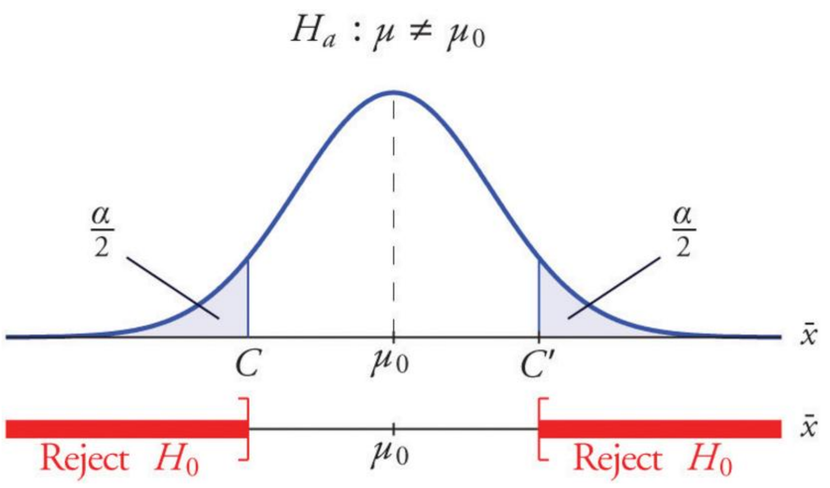
$$T = \frac{\bar{X} - 15}{2.8034/\sqrt{406}}$$

- Observed ($\bar{x} = 15.5197$)

$$t = \frac{\bar{x} - 15}{2.8034/\sqrt{406}} = 3.7354$$

- The p-value

$\Pr(T \geq t) = 1 - \Pr(T < t) = 0.0001 < \alpha/2$



Hypothesis testing – how to report in paper

Coffee drinkers spent more time awake (M = 17.8, SD = 1.4) than the population norm, t(28) = 2.6, p < .05.

df t

Hypothesis testing – one-sample t-test `ttest()`

- Determine if a sample comes from a population with a specific mean
- E.g. does students’ performance at a school significantly differ from a national average
- Assumptions
  - Dependent variable is continuous
  - Data is independent (no relationship between observations)
  - No outliers
  - Approximately normal distribution

- Activity
  - Load examgrades dataset in Matlab
  - Test if the mean of first column is different than 80, using ttest

SDU

Hypothesis testing – one-sample t-test `ttest()`

- H0 is that the exam grades have a mean of 80 points

```
>> load examgrades
>> [h,p]=ttest(grades(:,1),80)
h =
    1
p =
  5.9983e-09
>>
```

- Is H0 supported or rejected?

SDU

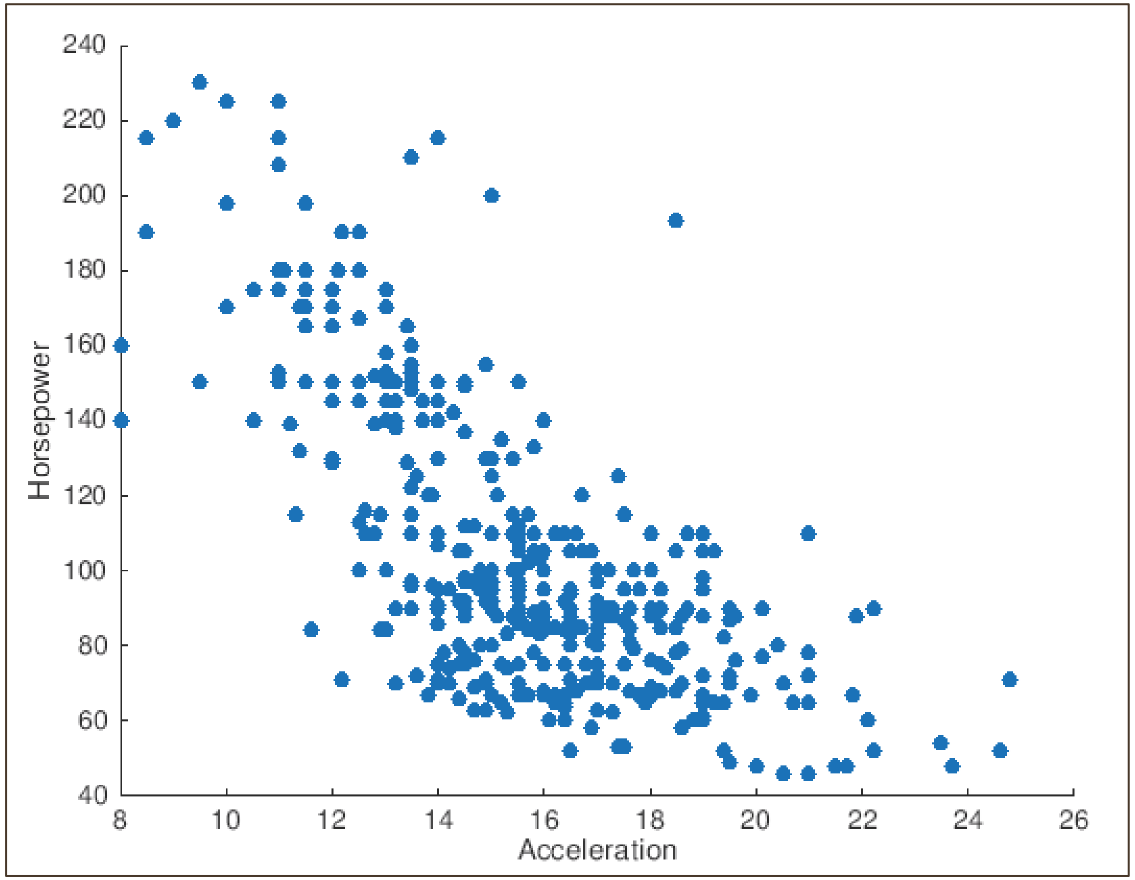
Regression

Regression

- Estimates the relationship between variables
- Helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varied
- Continuous independent and dependent variables

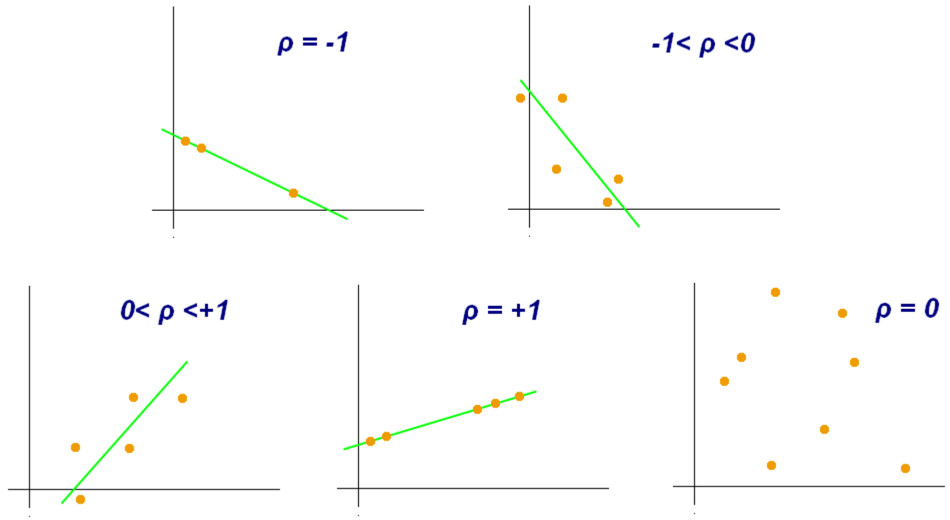
Scatter plot

- Acceleration vs. horsepower



(Co)variance, correlation and regression

- covariance is a measure of the joint variability of two random variables
  - greater values of one variable mainly correspond with the greater values of the other variable, and the same holds for the lesser values, (i.e., the variables tend to show similar behavior), the covariance is positive
- Correlation - degree to which a pair of variables are related
  - they can indicate a predictive relationship that can be exploited in practice
- Pearson correlation coefficient r – is a measure of the linear correlation between two variables X and Y
- Regression – estimation of the relationship between a dependent and an independent variable



(Co)variance, correlation and regression

Covariance

$$\mathrm{Cov}(X,Y) = \sigma_{XY} = \frac{1}{N-1}\sum_{i=1}^{N}(X-\mu_X)(Y-\mu_Y)$$

Correlation (Pearson, linear)

$$r = \frac{\sigma_{XY}}{\sigma_X \sigma_Y}$$

Regression

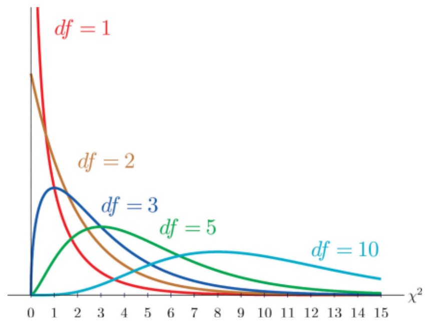
$$\hat{\beta}_1 = s_{xy}/s_x^2$$
$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x}$$

```
cov(X)
cov(X,Y)

corr(X)
corr(X,Y)

[r,b1,b0] = regression(X,Y);
```

Must be rows!

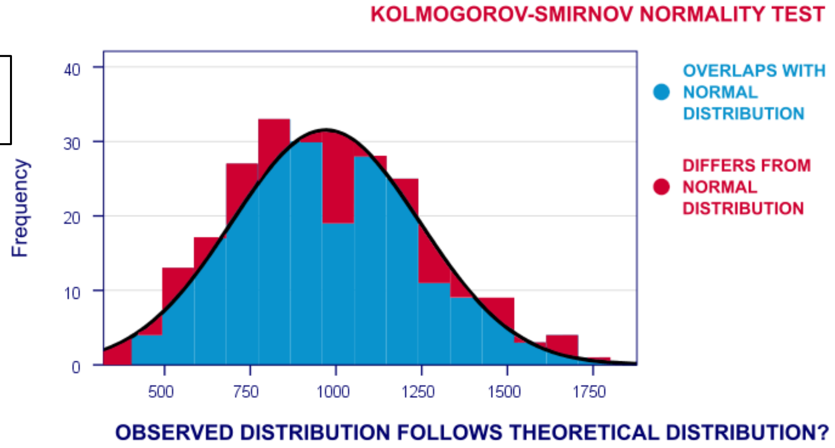
Variance, normality, fit tests

- Important measures for selecting the appropriate test
- Chi squared test of variance `vartest()`
  - H0: $\sigma^2 = \sigma_0^2$
  - Tests if a variance of a population is different than a specific variance value



- Kolmogorov Smirnov test of e.g. normality `kstest()`
  - H0: sample follows normal distribution

- Chi squared goodness of fit `chi2gof()`
  - H0: the sample comes from a normal distribution



Error types

- H_0: Null-hypothesis - A “neutral” statement reflecting current state of affairs
- H_a (sometimes H_1): An indication of the *detection* of an effect, something novel/unexpected/controversial
- **Type I error (FP)**
  - Reject a true H_0
  - We believe in H_a - we got something here!
    - - but in fact, H_0 was valid!
- **Type II error (FN)**
  - Accept a false H_0
  - We found no evidence for “accepting H_a“
    - - but H_a was supported!

		H_0 is in reality	
		Valid/True	Invalid/False
Our decision on H_0	Fail to reject	Correct inference (True Negative)	Type II error (False Negative)
	Reject	Type I error (False Positive)	Correct inference (True Positive)

SDU

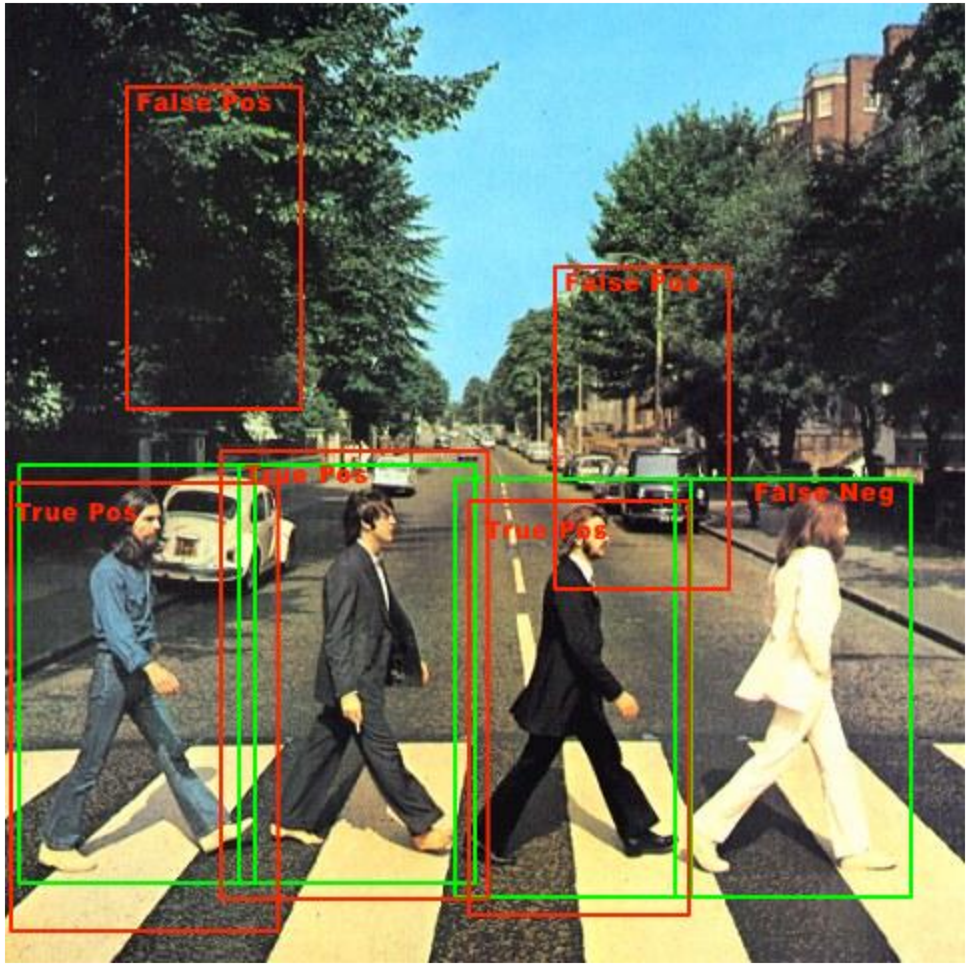
Error types - courtroom trial example

- H_0: The neutral statement – not guilty
- H_a: The controversial claim - guilty

		Reality	
		Innocent	Guilty
Decision	Acquittal	Right decision	Type II error (False Negative)
	Conviction	Type I error (False Positive)	Right decision

Error types - pedestrian detection example

Detector algorithm outputs are in **red**

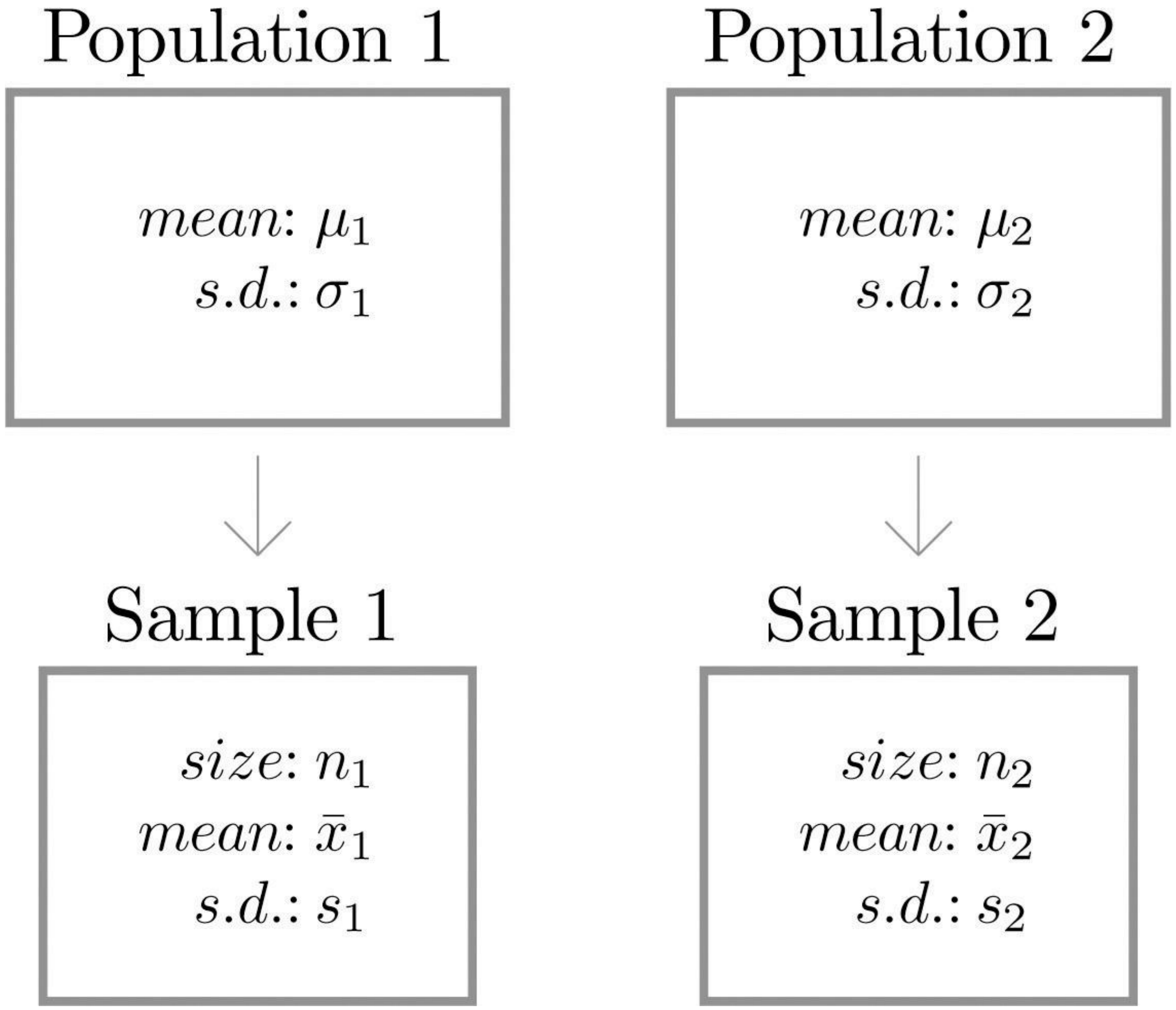


What is H_0 and H_1?

	H_0 is true Background	H_0 is false Pedestrian
Fail to reject **Box contains background**		**Type II Error (FN)**
Reject **Box contains pedestrian**	**Type I Error (FP)**	

Comparative statistics

Comparing population means



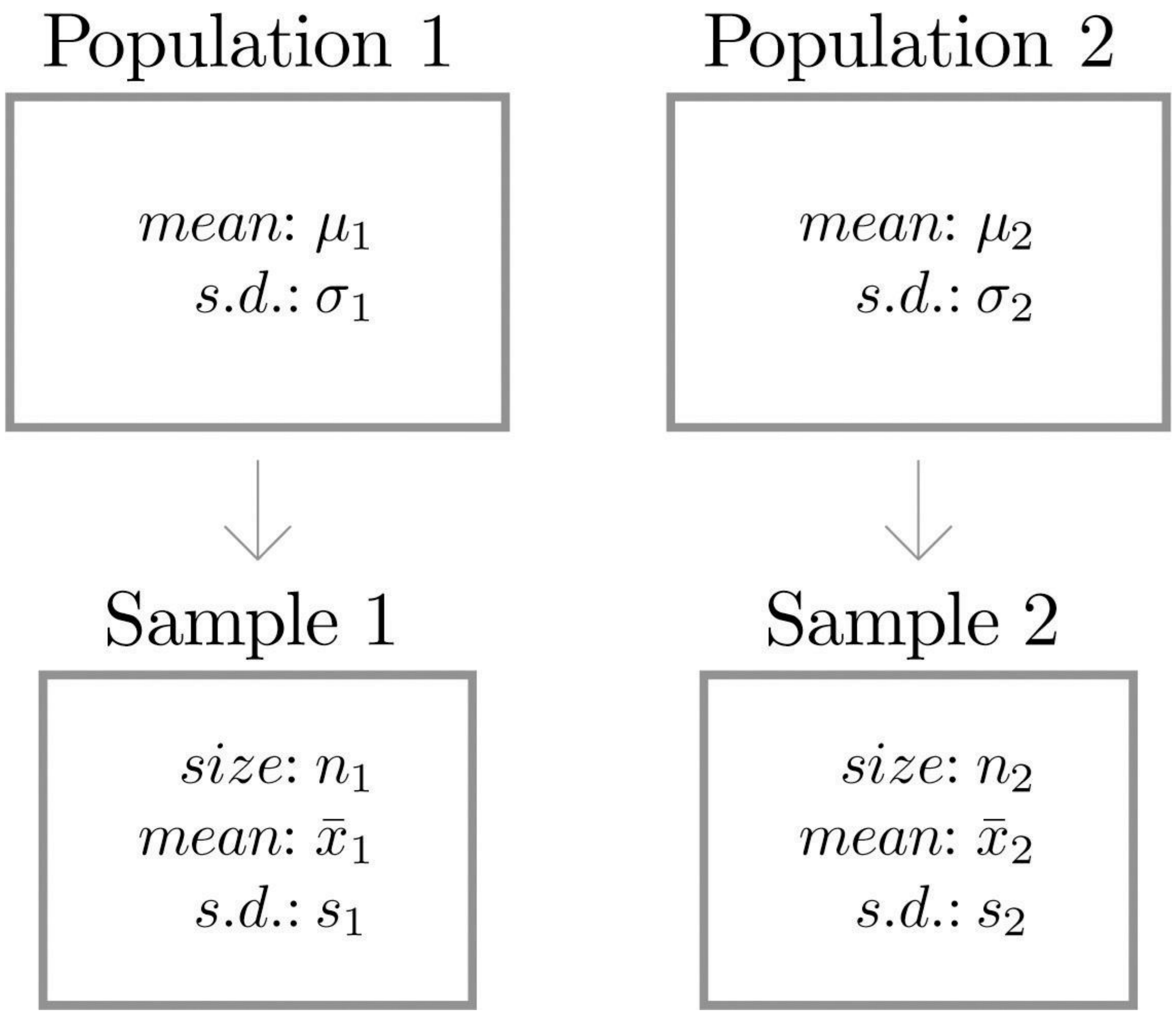
Comparative Statistics and Experimental Design

Outline for today

- Paper report
- Next reading material
- Conference preview
- Quiz
- Comparative Statistics (continuation from last time)
- Experimental design
- Project work

Comparative statistics

Comparing population means



Independent t-test

`ttest2() - Matlab solutions`

- Compares the means between two unrelated groups on the same dependent var.
- Null hypothesis
  H_0: $\mu_1 - \mu_2 = D_0$
- Assumptions:
  - continuous dependent variable
  - Independent variable: two categorical independent groups
  - Independence of observations
  - No significant outliers
  - Approximately normal distribution of the dependent variable
  - Homogenity of variances (can be tested with Levene's test)
- If variances are unequal then use `ttest2()` - with `'Vartype' 'unequal'`

Meaning of p value in comparative stats.

- p – how probable is to obtain these results if the null hypothesis is correct
- Null hypothesis – status quo, assumption of no difference
- Hypothesis – opposite of null hypothesis - presence of difference – “we hypothesize that different kayak inflations will result in different kayak speeds”
- If $p<0.05$ – the samples come from two different populations
- If $p>0.05$ – we cannot say if the samples come from the same population or not

Dependent t-test

`ttest()`

- Also called paired samples t-test, repeated measures, within subject
- Same participants are tested more than once
- Compares the means of two related groups on the same continuous dependent var.
- Assumptions:
  - *Dependent variable is continuous*
  - *Independent variable consists of two categorical related groups (same subject present in both groups)*
  - *No significant outliers*
  - *The distribution of the difference in the dependent variable between the two related groups should be approximately normal*

Independent t-test

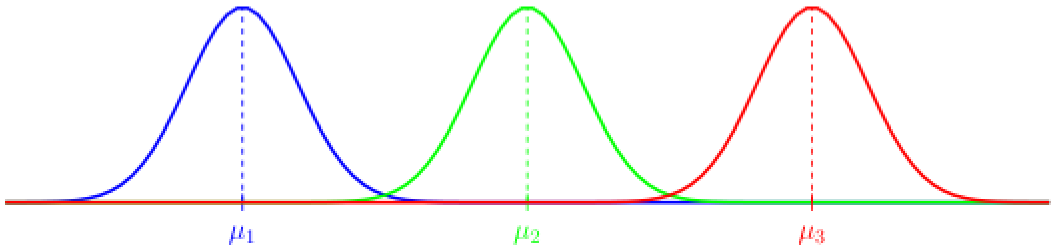
- Also called between subjects
- one participant is performing only one condition
- Compares the means of two non-related groups on the same continuous dependent var.
- Assumptions:
  - *Dependent variable is continuous*
  - *Independent variable consists of two categorical related groups (same subject present in both groups)*
  - *No significant outliers*
  - *The distribution of the difference in the dependent variable between the two related groups should be approximately normal*

Examples of paired samples

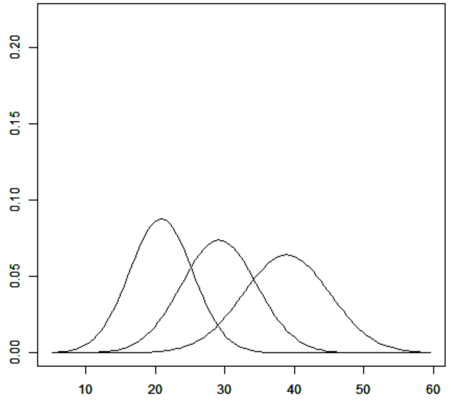
- Asking the same two questions (in random order) to each test subject
- Assessing before and after effect of drugs, diets, etc.
- In general
    - Assigning two treatments to each subject

- E.g. people's opinion on Roomba vs R2D2
    - How fast were they in completing a task

ANOVA in general



- ANalysis Of Variance
- Test statistical difference between the means of three or more groups (levels)
- It returns a significant result if there is difference between any two groups
- Does not tell us which groups have the difference – need for post hoc test
- Why not to a number of t-tests instead?
  - Because they increase the Type I error every time performed
  - ANOVA does not accumulate this error
- Assumptions:
  - Experimental errors in data are normally distributed
  - Equal variances
  - Independence of samples



ANOVA

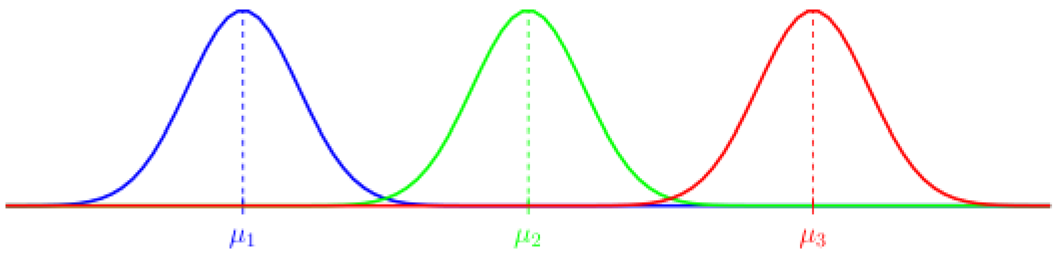
- Common use case
  - Assign different treatments (levels of some factor) to similar groups
- Be aware of one major limitation
  - ANOVA assumes homogeneity of variance
  - Consider a test for this (e.g. Levene’s)
- Alternatives
  - Welch’s F-test (like the *t*-test with unequal variances)
  - Kruskal Wallis – a non-parametric test – no assumptions about normal distribution

- https://statistics.laerd.com/spss-tutorials/one-way-anova-using-spss-statistics.php

Post-hoc test to ANOVA

Usually a T-test

With correction for repeating it (e.g. Bonferroni, Tukey HSD) – alpha (0.05) divided by number of comparisons



Need a two-way ANOVA?

- Have a look at `anova2()`
- Basic test: analyze the influence of two categorical independent variables *X* and *Y* on a dependent continuous variable
  - Row: equal means for the factor in *X* (alias one-way ANOVA for the rows)
  - Col: equal means for the factor in *Y* (alias one-way ANOVA for the columns)
  - Interaction: there is no interaction between X and Y (alias the χ^2 test)

- A good example: https://people.richland.edu/james/lecture/m170/ch13-2wy.html

	Fert I	Fert II	Fert III	Fert IV	Fert V
Seed A-402	106, 110	95, 100	94, 107	103, 104	100, 102
Seed B-894	110, 112	98, 99	100, 101	108, 112	105, 107
Seed C-952	94, 97	86, 87	98, 99	99, 101	94, 98

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Repeated measures ANOVA

`ranova()`

- Groups are not independent – e.g. levels performed by same participants (but counterbalanced for order effects)
- Extension of the dependent (paired) t-test
- Also called within-subjects ANOVA
- Dependent variable must be continuous
- Independent variable either nominal or ordinal
- Normal distributions assumed

If requirements for test are not satisfied

- Then non-parametric tests need to be conducted
- Requirements e.g. - continuous dependent variable, normal distribution, equality of variance

Parametric vs non-parametric

- If normal distribution cannot be asserted, use non-parametric tests

	Parametric	Non-parametric
One independent var., 2 levels Between subjects	Independent t-test	Mann-Whitney
One independent var., 2 levels Within subjects	Dependent (paired) t-test	Wilcoxon
One independent var., 3+ levels Between subjects	One-way ANOVA	Kruskal-Wallis
One independent var., 3+ levels Within subjects	Repeated measures ANOVA	Friedman
Two independent var.	Two-way ANOVA	Two-way Friedman (elusive)

Statistical tools

- SPSS
- JMP
- Matlab
- R
- Excel!
- Even online, search “Wilcoxson singed rank test online”

Methodology check

- Test two behaviors with same people, measure completion time (or opinion Likert)
  - Dependent t-test (or Wilcoxson)
- Test two behaviors with different people, measure completion time (or opinion)
  - Independent t-test (Mann-Whitney)
- Test three behaviors with different people, measure completion time (or opinion)
  - ANOVA (Kruskal-Wallis)
- Test three behaviors with same people, measure completion time (or opinion)
  - Repeated measures ANOVA (Friedman)
- Two independent variables
  - Two-way ANOVA (Two-way Friedman)

Example experiment - RIMEPHAS

- Testing regular vs robotic interface at the entrance of TEK
- Questionnaire filled out later

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RIMEPHAS long-term testing questionnaire August 2021

Age ________ Gender _______ Participant no. ________ Date and time _______________

Experience with robots (circle one): none - some - a lot

Job is technology oriented (engineer, technician, teacher in technical area): yes - no student - staff

Have you noticed the robotic sanitizer at the entrance to TEK in July and August: yes - no

Not at all			From time to time			All the time

I have used the regular hand sanitizer at the TEK entrance during the summer

1	2	3	4	5	6	7

I have used the robotic hand sanitizer at the entrance while it was there during the summer

1	2	3	4	5	6	7

Completely disagree			Neither agree nor disagree			Completely agree

I find the regular hand sanitizer device effective

1	2	3	4	5	6	7

I find the robotic hand sanitizer device effective

1	2	3	4	5	6	7

I find the regular hand sanitizer device useful

1	2	3	4	5	6	7

I find the robotic hand sanitizer device useful

1	2	3	4	5	6	7

Approaching the regular hand sanitizer reminded me to sanitize my hands

1	2	3	4	5	6	7

Approaching the robotic hand sanitizer reminded me to sanitize my hands

1	2	3	4	5	6	7

I think that hand sanitization was important during the pandemic restrictions in Denmark (Sept 10)

1	2	3	4	5	6	7

I think that hand sanitization will stay important after the pandemic restrictions in Denmark (Sept 10)

1	2	3	4	5	6	7

Additional comments

____

____

____

____

____

What were the capabilities of the robot?

____

____

____

____

RIMEPHAS data

Download rimephas_data.xlsx from itslearning
See the results for the questionnaire
How would you analyze the data?
What statistical methods would you use?
What is significant?

How to report on results of a one-way ANOVA with post-hoc test

There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,27) = 4.467$, $p = .021$). A Tukey post hoc test revealed that the time to complete the problem was statistically significantly lower after taking the intermediate (23.6 ± 3.3 min, $p = .046$) and advanced (23.4 ± 3.2 min, $p = .034$) course compared to the beginners course (27.2 ± 3.0 min). There was no statistically significant difference between the intermediate and advanced groups ($p = .989$).

ANOVA

Time

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	91.467	2	45.733	4.467	.021
Within Groups	276.400	27	10.237		
Total	367.867	29			

Multiple Comparisons

Dependent Variable: Time

Tukey HSD

(I) Course	(J) Course	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Beginner	Intermediate	3.60000*	1.43088	.046	.0523	7.1477
	Advanced	3.80000*	1.43088	.034	.2523	7.3477
Intermediate	Beginner	-3.60000*	1.43088	.046	-7.1477	-.0523
	Advanced	.20000	1.43088	.989	-3.3477	3.7477
Advanced	Beginner	-3.80000*	1.43088	.034	-7.3477	-.2523
	Intermediate	-.20000	1.43088	.989	-3.7477	3.3477

*. The mean difference is significant at the 0.05 level.

Chi Square test

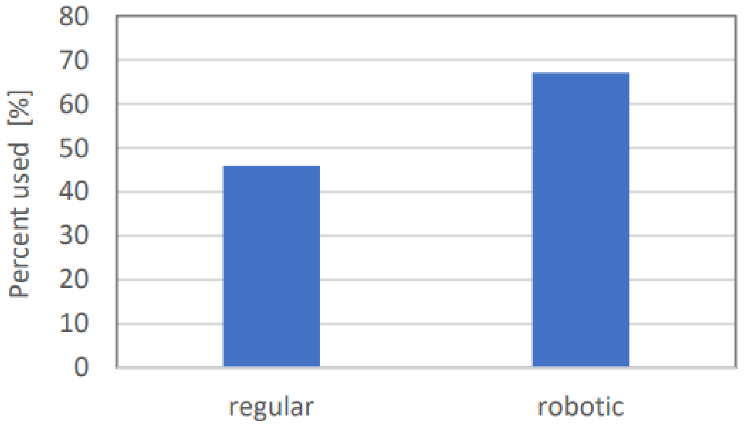

Figure 7. Percentage of use (hand hygiene compliance) of regular and robotic interfaces.

- Comparative test when there is binomial data distribution
  - i.e. when the outcome of the test can take only two categorical values (e.g. pass/fail)
- very useful but not too powerful, needs more samples than t-test
- Typically used when comparing success rates of two conditions

Binomial logistic regression

Deals with binomial data like Chi Square

But can handle more than one independent variable

Read paper: “What Will It Take to Help a Stuck Robot? Exploring Signaling Methods for a Mobile Robot”

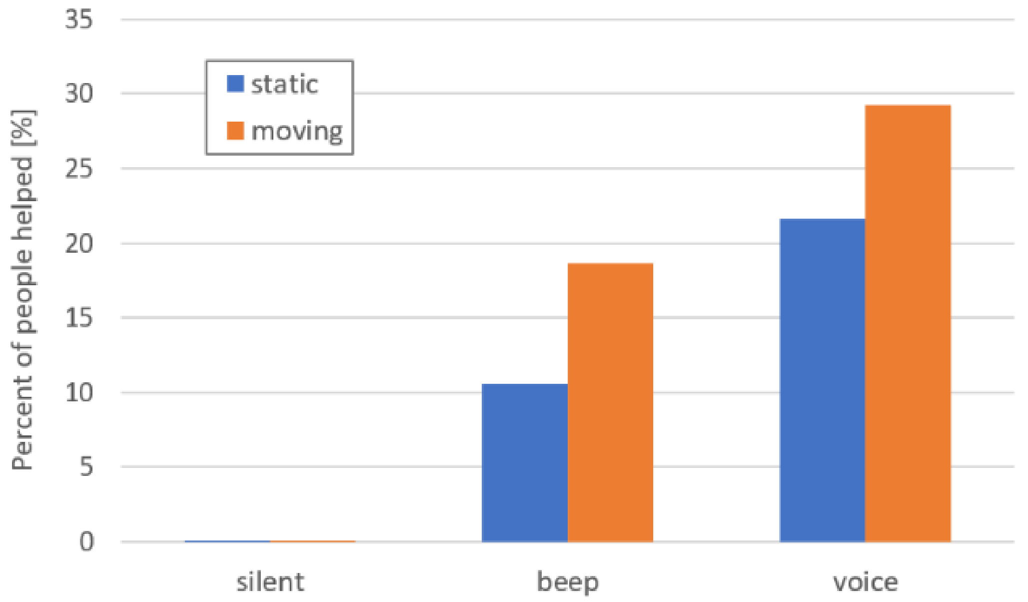

Fig. 2: Percent of people who helped the robot

Binomial logistic regression

Influence of age, gender and weight on presence of heart disease.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	age	.085	.028	9.132	1	.003	1.089	1.030	1.151
	weight	.006	.022	.065	1	.799	1.006	.962	1.051
	gender(1)	1.950	.842	5.356	1	.021	7.026	1.348	36.625
	VO2max	-.099	.048	4.266	1	.039	.906	.824	.995
	Constant	-1.676	3.336	.253	1	.615	.187		

a. Variable(s) entered on step 1: age, weight, gender, VO2max.

How to report on Binomial Logistic Regression

A logistic regression was performed to ascertain the effects of age, weight, gender and VO_2max on the likelihood that participants have heart disease. The logistic regression model was statistically significant, $\chi^2(4) = 27.402$, $p < .0005$. The model explained 33.0% (Nagelkerke R^2) of the variance in heart disease and correctly classified 71.0% of cases. Males were 7.02 times more likely to exhibit heart disease than females. Increasing age was associated with an increased likelihood of exhibiting heart disease, but increasing VO_2max was associated with a reduction in the likelihood of exhibiting heart disease.

How to report on Binomial Logistic Regression

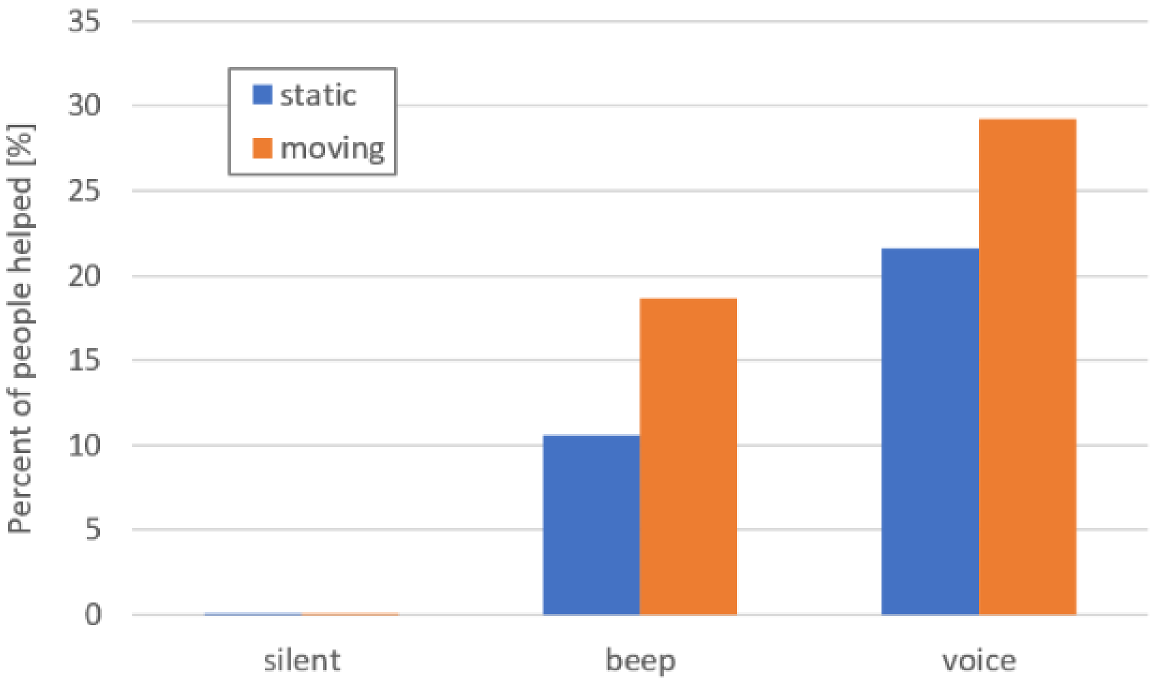

Fig. 2: Percent of people who helped the robot

A. *Interaction frequency*

We observed the number of helping interactions with the robot for each of the 6 experimental conditions and compared it to the number of people who passed by without helping, see Figure 2. It can be noticed that people did not help even once when the robot was silent, in both moving and static conditions. Voice interaction performed better than beeping and the moving robot elicited more help than the static one for both beeping and voice. To test the significance of these differences, we performed a Binomial Logistic Regression of sound and movement on the likelihood of help. This test handles multiple independent variables and binomial data distribution. It proved that the differences between conditions were statistically significant $\chi^2(3) = 16.1, p = 0.001$. The predictive model was able to correctly classify 84.7% of the cases. Further analysis showed that both sound and movement contributed to this significance. Additionally we completed two Chi Squared tests on movement and sound separately. These confirmed the significance of sound but not movement.

Two-way ANOVA

Used to compare means when one has

- two independent variables,
- the dependent variable is continuous,
- Conditions for a parametric test are satisfied

What to look for

- Main effects
- Interaction
- Simple effects

Two-way ANOVA

- In a factorial design, **the main effect** of an independent variable is its overall effect averaged across all other independent variables. There is one main effect for each independent variable.
- There is an **interaction** between two independent variables when the effect of one depends on the level of the other.
- A **simple effects** analysis provides a means for researchers to break down interactions by examining the effect of each independent variable at each level of the other independent variable.

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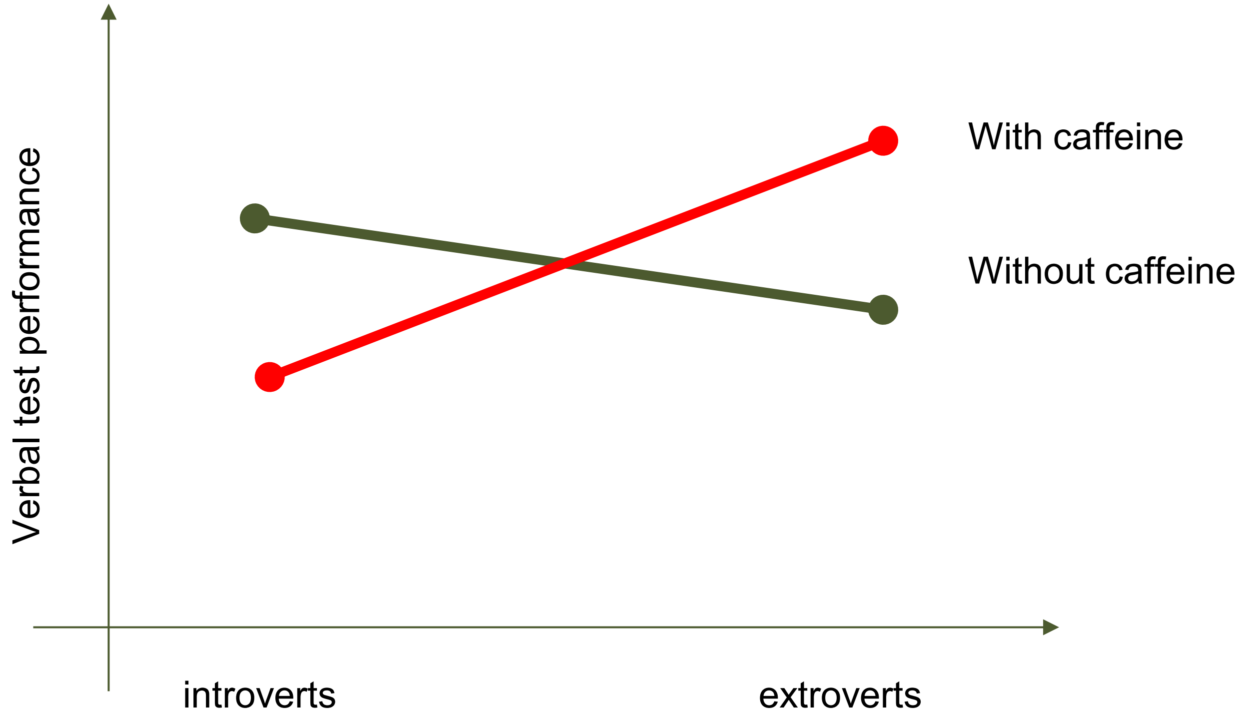
Two-way ANOVA

- No main effects, but there is interaction
- Interaction present when lines not parallel



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How to report results of a Two-Way ANOVA

A two-way ANOVA was conducted that examined the effect of gender and education level on interest in politics. There was a statistically significant interaction between the effects of gender and education level on interest in politics, $F(2, 52) = 7.315$, $p = .002$.

Simple effects analysis showed that males were significantly more interested in politics than females when educated to university level ($p = .002$), but there were no differences between gender when educated to school ($p = .465$) or college level ($p = .793$).

Experimental Design

Remember the H-D model

- Hypothesis
- *Testable* prediction
- Outcomes
  - Hypothesis is supported (sometimes weak)
  - Falsification (often a strong statement)

In practice

- The question of confirmation vs. falsification
- In proof of concept disciplines
  - Confirmation is often adequate
  - E.g. athropology – drawing conclusion from observing tribe behavior

- Falsifiability
  - A hypothesis must be disprovable
  - Non-falsifiable e.g. “God exists.”
  - Falsifiable: “Robots are less dexterous than humans in performing gymnastics”

Example: smoking vs. lung capacity

- As an observational study
  - Find a homogeneous group of subjects
  - Categorize sample into smokers and non-smokers
  - Perform measurements (lung capacity)
  - Draw conclusions (think of H-D)

Order of conducting the experiment with human subjects

- Post advertisements for subjects
- Organize subjects into groups
- Schedule pre-experiment testing of subjects
- Fill out consent forms
- Assign treatment
- Follow up visits
- Post-experiment testing
- Rewards, half at the beginning, half at end?

Consent forms

- Crucial for conducting experiments
- Also called IRB forms: Institutional Review Board
- Requests should be submitted much before start of experiment
- Usually handled at university or institute level
- State all possible threats subject might face
- Legal terms – liability of institution
- Ask if subjects’ data can be used for research
- Usually a separate question: can video be used 1) as part of scientific presentations, 2) freely (youtube)?
- Hard to do tests with naïve subjects

Principles of Experimental Design

- Randomization
- Repetition and replication
- Blocking
    - Last part of today’s talk
- Factorials
    - Self-study, if you are interested

Randomization

- The process of randomly assigning “treatments” to your “subjects”
- Examples
  - Asking individuals to choose their favorite among three colors
  - Removing personal biases in clinical trials with drug/placebo
- Helps avoiding nuisance/confounding factors
  - Unknown and/or uncontrollable factors

Repetition

- Multiple observations of response under the same treatment
- Repeated measures – one subject performing different treatments in succession
- Usually the most time-effective way to test for a factor
- Think of ANOVA:
  - A certain factor (e.g. oven temperature) is tested at different levels
  - At each level, multiple observations are made (e.g. rating of cake quality)

Replication

- Apply the same *full experiment* multiple times
  - In some scientific areas, only when others redo your experiment

Repetition vs replication

- Both are measurements taken at the same combination of factor settings
- Repetitions are taken at the same experimental run or consecutive runs
- Replications are taken at different experimental runs
- Replications may include sources of variability that repetitions don't because:
  - Spread over time (environmental changes)
  - Changing equipment settings

Repetition vs replication example

- Baking cakes
- Independent variables: temperature (150,200,250), humidity (low, high)
- Dependent variables: taste (subjective, Likert), height, volume
- Repetitions
  - Set temperature at 150, humidity at low, make 5 cakes one after another
- Replications
  - 150- low, make one cake; 200-low make one cake… complete all condition combinations
  - Repeat the whole process 5 times

Bias

- Systematic error(s) shift your samples
- Types of biases:
  - Cognitive
    - Anchoring
    - Attribution bias
    - Confirmation bias
    - Halo effect
    - Self-serving bias
    - Status quo bias
  - Statistical
    - Observer-expectancy effect
    - Reporting
    - Social desirability
    - Selection
    - Survivorship
  - Contextual
    - Academic bias
    - Experimenter bias
    - Funding Bias
    - Publication Bias

Anchoring

- Reliance on first piece of information gained while making a decision
- E.g. initial price of the used car
- E.g. sales item at the store

Attribution bias

- Own actions results of external factors; others' actions reflection of internal factors (e.g. personality)
- E.g. I could not paddle the boat because the wind was too strong; he could not paddle the boat because he's weak

Confirmation bias

- Search for, interpret, recall information that confirms one's beliefs, while neglecting information which contradicts it
- Watching news from the (YouTube) channel that agrees with us
- An important bias to be aware of in everyday life!

Halo effect

- Overall impression of a person affects specific perceptions
- Great person – must be honest, smart, etc.

Self-serving bias

- Cognition is affected by the need of a person ho enhance their self-esteem
- E.g. students’ positive feedback on my course is correct, while students who have negative feedback are just jealous (< joke)

Status quo bias

- Current baseline is taken as a reference point
- E.g. old time registration system was better, Blackboard was much better than itslearning

Observer-expectancy effect

- A researcher's expectations causes them to inadvertently influence the results
- E.g. judging a paper from Harvard

Reporting bias

- Selective revealing or suppression of information to one’s own gain
- Cerrypicking of data… very bad
- E.g. guy who didn’t sanitize his hands was too distracted

Social desirability bias

- Survey participants will answer questions in a way that is more socially acceptable
- E.g. Deviant behavior is underreported

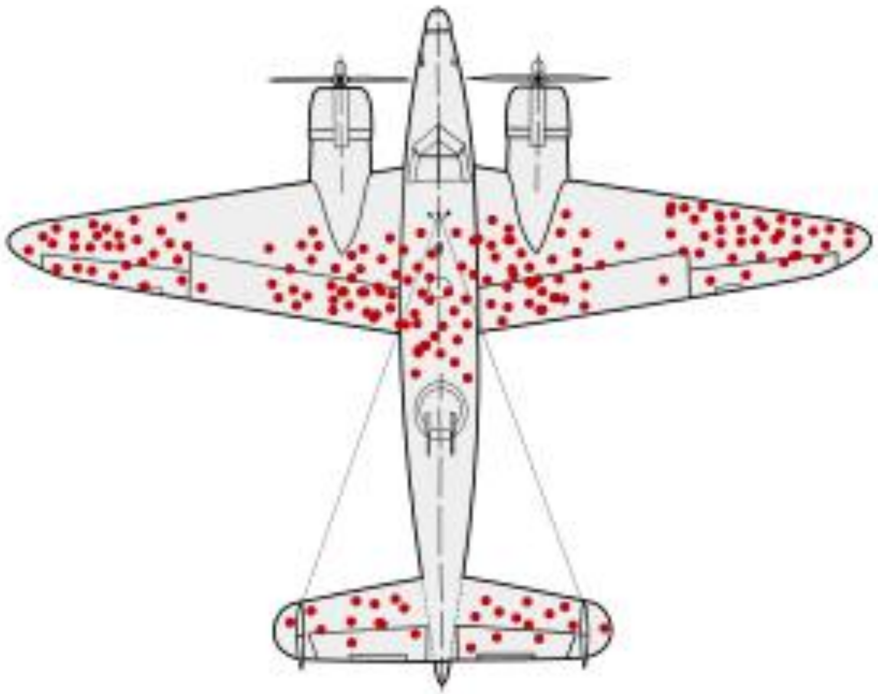
Selection bias

- Conscious or subconscious selection of data which is not representative

- Conduct experiment only with specific gender

Survivorship bias

- Concentrating on outcomes which made past some selection process



Academic bias

- Bias of scholars allowing their beliefs to shape their research

Experimenter bias

- Experimenter’s expectations affect the outcome of the experiment

Funding bias

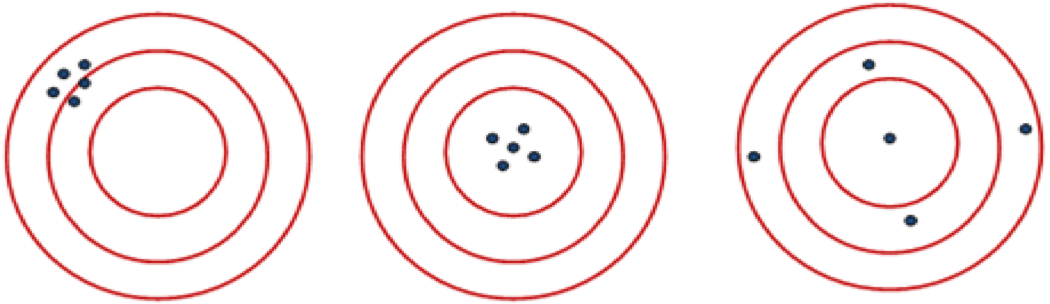
- Outcome of experiment tend to support the funding agency's views – wonder why

Publication bias

- What is publishable shapes research
- E.g. tendency for confirmation of hypotheses

○Accuracy vs. Precision

- accuracy is closeness of the measurements to a specific value, while
-
- precision is the closeness of the measurements to each other



Other factors

- **Nuisance** factors
  - The annoying ones
  - Have effect on the outcome, but not interesting for experimenter
  - Need to be minimized, explained, accounted for
  - Gender, age, environmental differences, etc.
- **Confounding** factors
  - The scary ones
  - Influences both the independent and the dependent variable
  - Can be a hidden independent variable
  - Example:
    - independent variable: activity level
    - dependent variable: weight gain
    - confounding variable: age

To sum up

- A good experiment
  - usually follows the H-D model and has a good hypothesis,
  - has a clear prediction,
  - uses randomization as much as possible,
  - has an adequate number of repetitions/replications,
  - attempts to identify and avoid as many nuisance factors as possible, and
  - **can be replicated**

Controls and blocking

Controlled experiments

- In experimental design, a *control* has a specific meaning
- The classical example
  - The randomized controlled trial
- You, as an experimenter, choose the independent factor
  - Drug (treatment group)
  - Placebo/no drug (control group)

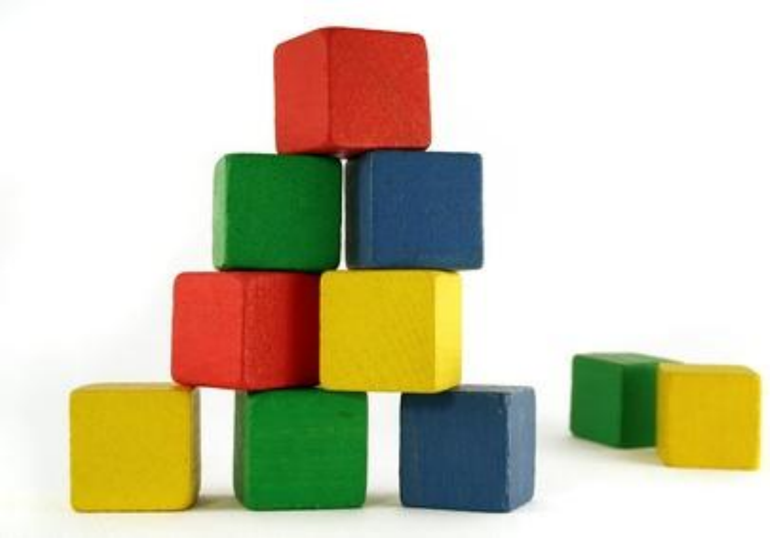
Control

- Example of control (taken from Wikipedia)
  - Test growth of plants
- Two cases
  - With fertilizer (treatment group)
  - Without fertilizer (control group)
- Beware of other factors
  - Method used for spreading
    - By hand
    - Using tractor

Control for a variable

- Setting
  - You suspect that some variable influences your results
- Examples
  - Measuring height differences between women and men
    - Confounders: ethnicity, age, etc.
  - Testing the driving speed of a vehicle indoors vs. outdoors
    - Confounders: temperature, humidity, etc.
- Possible solutions
  - The complete randomized design
  - Keep variables constant and test them one at a time

Blocking



- A principled way to eliminate the influence of factors
- Setting
  - You suspect some spurious, but **controllable** factor influences your result
    - The smoking example: age
    - The plant example: spreading method (hand/tractor)
  - Restrict randomization by blocking factors
    - The smoking example: split subjects into e.g. three groups: young, middle, old
    - The plant example: apply fertilizer as well as normal treatment both by hand and using tractor

SDU

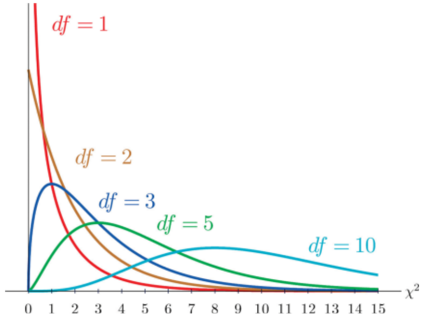
Writing a scientific paper

Today's Agenda

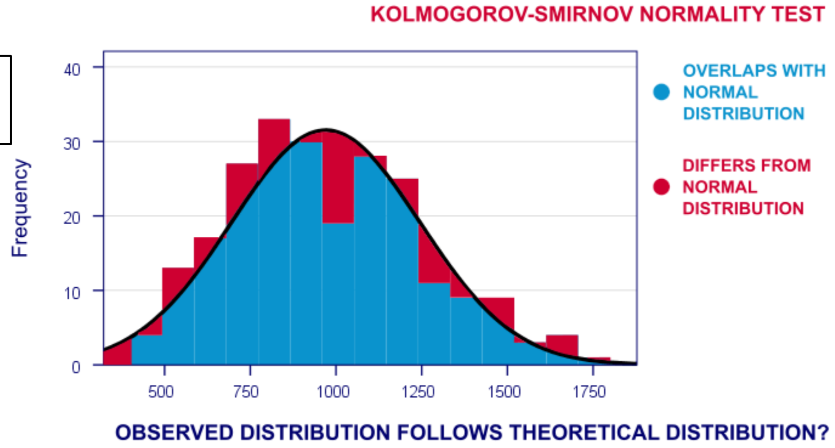
- R install session with Henrik
- Paper report
- New paper assignment
- Midterm feedback
- Project proposal hand-in
- Project hand-in info
- Recap
- Writing a paper
- Plagiarism
- Conference
- Project discussions

Recap of Comparative Statistics

Before comparison - variance, normality, fit tests



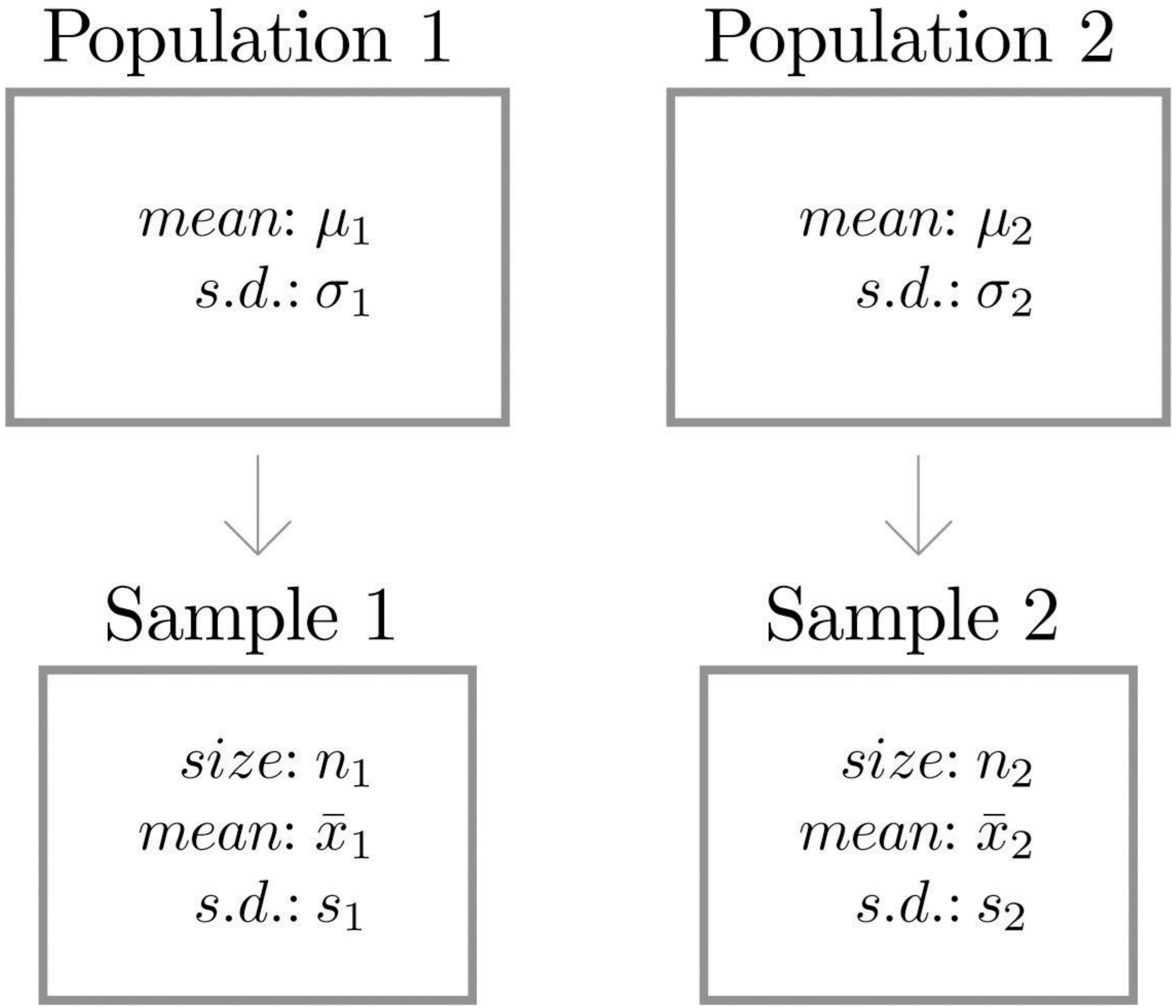
- Important measures for selecting the appropriate test
- Chi squared test of variance `vartest()`
  - H0: $\sigma^2 = \sigma_0^2$
  - Tests if a variance of a population is different than a specific variance value



- Kolmogorov Smirnov test of e.g. normality `kstest()`
  - H0: sample follows normal distribution

- Chi squared goodness of fit `chi2gof()`
  - H0: the sample comes from a normal distribution

Comparing population means



Independent t-test

`ttest2()`

- Compares the means between two unrelated groups on the same dependent var.
- Null hypothesis
  H_0: μ_1 - μ_2 = D_0
- Assumptions:
  - continuous dependent variable
  - Independent variable: two categorical independent groups
  - Independence of observations
  - No significant outliers
  - Approximately normal distribution of the dependent variable
  - Homogenity of variances (can be tested with Levene’s test)
- If variances are unequal then use `ttest2()` - with `‘Vartype’ ‘unequal’`

Dependent t-test

`ttest()`

- Also called paired samples t-test, repeated measures, within subject
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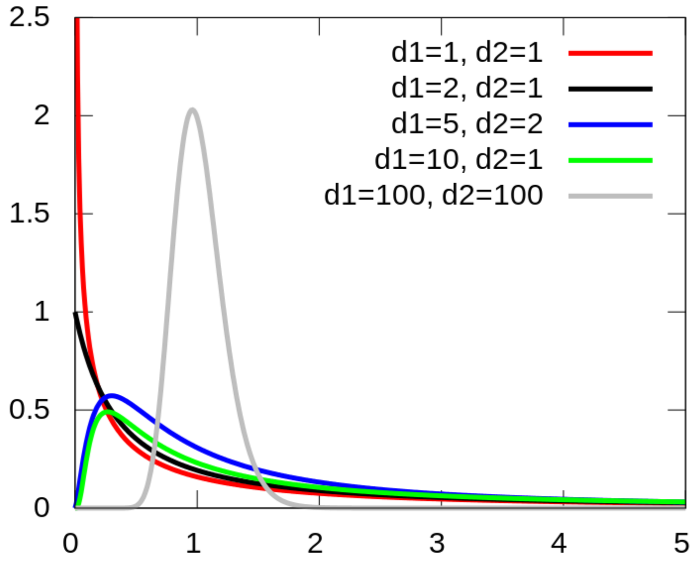
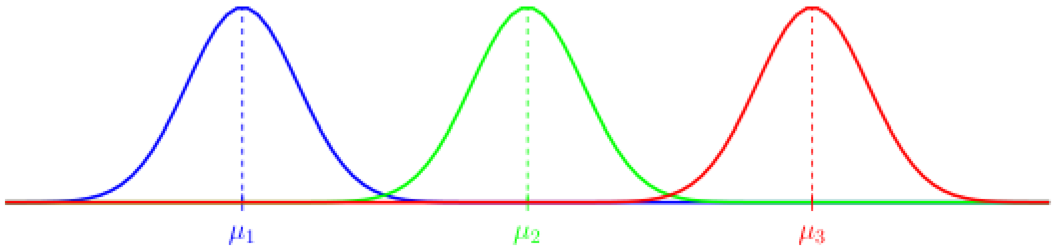
F-test for equality of variance `vartest2()`



- Again we need to assume normality on X_1 and X_2
- Null hypothesis
  H_0: $\sigma_1^2 = \sigma_2^2$
- Test statistic
  $F_0 = s_1^2/s_2^2 \sim F_{N_1-1,N_2-1}$
- Questions it answers
  - Do two samples come from populations with equal variances?
  - Does a new process, treatment or test reduce the variability of the current process?

ANOVA in general



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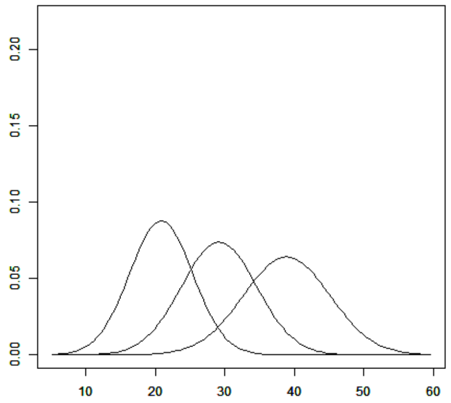
- Does not tell us which groups have the difference – need for post hoc test
- Why not to a number of t-tests instead?
    - Because they increase the Type I error every time performed
    - ANOVA does not accumulate this error
- Assumptions:
    - Experimental errors in data are normally distributed
    - Equal variances
    - Independence of samples



ANOVA

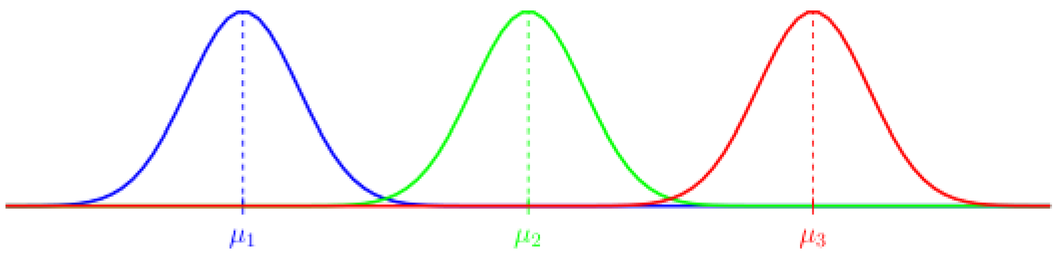
- Common use case
  - Assign different treatments (levels of some factor) to similar groups
- Be aware of one major limitation
  - ANOVA assumes homogeneity of variance
  - Consider a test for this (e.g. Levene’s)
- Alternatives
  - Welch’s F-test (like the *t*-test with unequal variances)
  - Kruskal Wallis – a non-parametric test – no assumptions about normal distribution

- https://statistics.laerd.com/spss-tutorials/one-way-anova-using-spss-statistics.php

SDU

ANOVA

- Tells if there is a difference between at least two levels (if $p<0.05$)
- To figure out between which levels, we need to conduct post-hoc t-tests
- Needs to be done with correction, e.g. Bonferroni correction



ANOVA

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- To figure out between which levels, we need to conduct post-hoc t-tests
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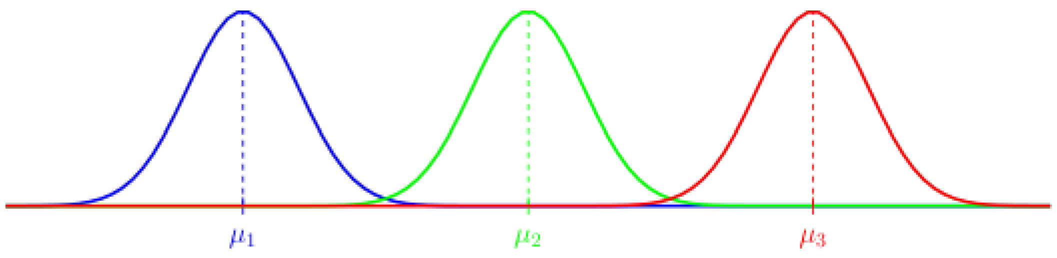


Two-way ANOVA?

- Have a look at `anova2()`
- Basic test: analyze the influence of two categorical variables *X* and *Y* on a dependent continuous variable
  - Row: equal means for the factor in *X* (alias one-way ANOVA for the rows)
  - Col: equal means for the factor in *Y* (alias one-way ANOVA for the columns)
  - Interaction: there is no interaction between X and Y (alias the χ^2 test)

- A good example: https://people.richland.edu/james/lecture/m170/ch13-2wy.html

	Fert I	Fert II	Fert III	Fert IV	Fert V
Seed A-402	106, 110	95, 100	94, 107	103, 104	100, 102
Seed B-894	110, 112	98, 99	100, 101	108, 112	105, 107
Seed C-952	94, 97	86, 87	98, 99	99, 101	94, 98

Repeated measures ANOVA

`ranova()`

- Groups are not independent – levels performed by same participants (but counter balanced for order effects)
- Extension of the dependent (paired) t-test
- Also called within-subjects ANOVA
- Dependent variable must be continuous
- Independent variable either nominal or ordinal
- Normal distributions assumed

Parametric vs non-parametric

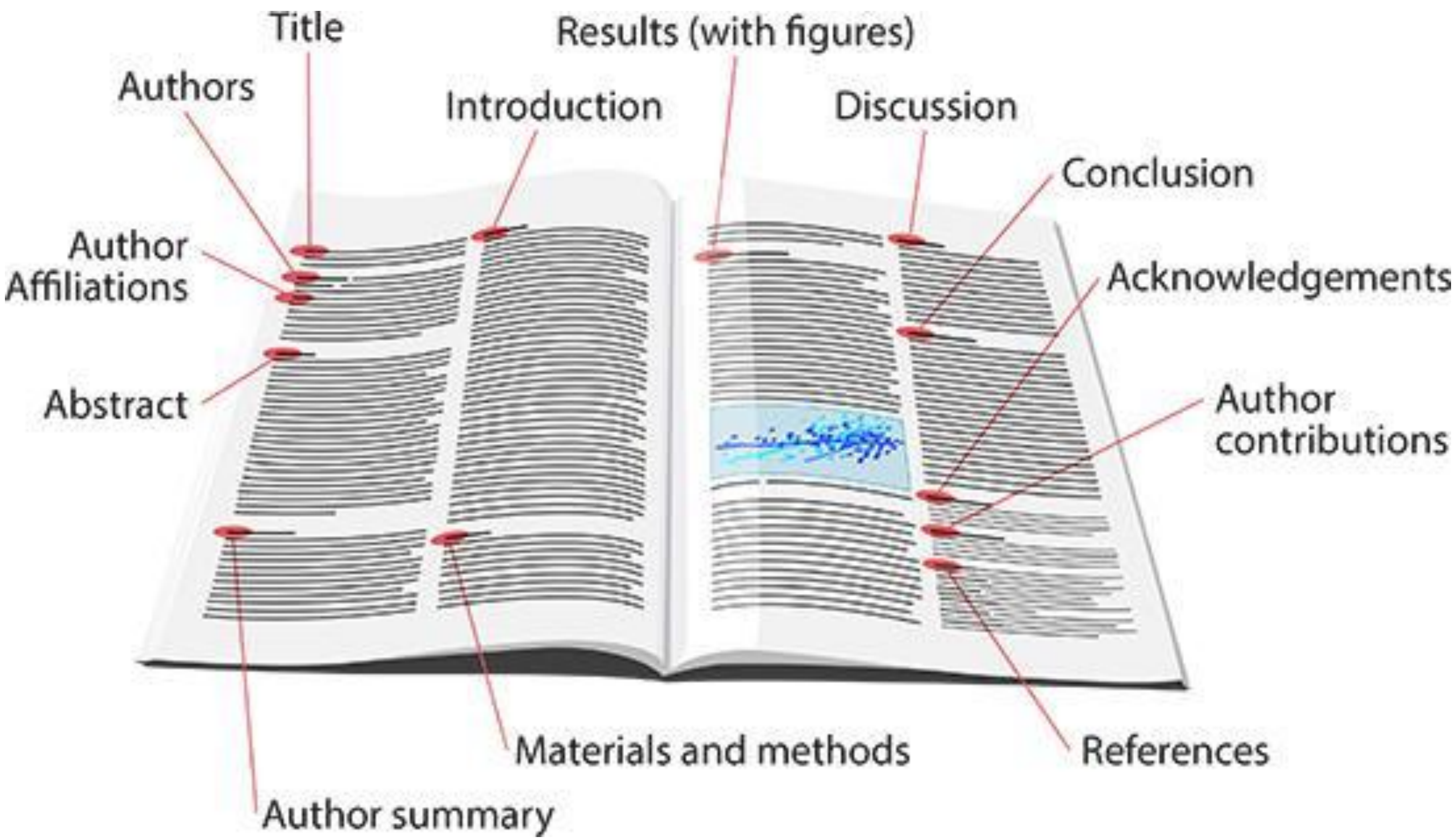
- If normal distribution cannot be asserted, use non-parametric tests

	Parametric	Non-parametric
One independent var., 2 levels Between subjects	Independent t-test	Mann-Whitney
One independent var., 2 levels Within subjects	Dependent (paired) t-test	Wilcoxon
One independent var., 3+ levels Between subjects	One-way ANOVA	Kruskal-Wallis
One independent var., 3+ levels Within subjects	Repeated measures ANOVA	Friedman
Two independent var.	Two-way ANOVA	Two-way Friedman
More independent var.	Factorial ANOVA	Factorial Friedman

What software to use?

- First check: online tools (search for “online anova test”)
- Simple problems: Excel
- Moderate problems: Matlab
- Complex problems: SPSS or similar statistical software

Writing a paper



Why publish?

- How to write a great research paper
- Simon Peyton Jones
- https://www.youtube.com/watch?v=1AYxMbYZQ1Y
- Let’s watch the first 7 minutes

Why to publish?

- Publish or perish
- Your results are only worth something when shared
- Paper drafts can easily be turned into a patent
- A paper is good PR for your method
- Race to publish
- The main metric used when evaluating scientists is the citations

When to publish?

- At least one novel hypothesis or method
- At least a limited, initial number of experimental results

- Premature submission
  - Harsher reviews
  - Higher risk of rejections/revisions
  - More (but less important) papers

- Late submission
  - Fewer, but higher-quality papers
  - Higher risk of getting scooped

The peer-review process

- Not ideal, but the best we have
- The author’s peers (colleagues) review the paper
- Judge the quality of the submission (originality, relevance, contribution, etc.)
- Make decision about acceptance or rejection
- Reviewers either sign up or are invited by editors, chairs
- Conflict of interest needs to be avoided

Blind and double blind peer-review

- Blind
  - The authors don’t know who the reviewers are.
  - The reviewers know who the authors are.

- Double blind
  - Neither the authors nor the reviewers know each other’s identity
  - References to own group should be removed too

- Well educated reviewers can usually guess the authors
  - How?

Structure

Title

Authors and affiliations

Abstract

Keywords

Introduction

Background

Methods

Results

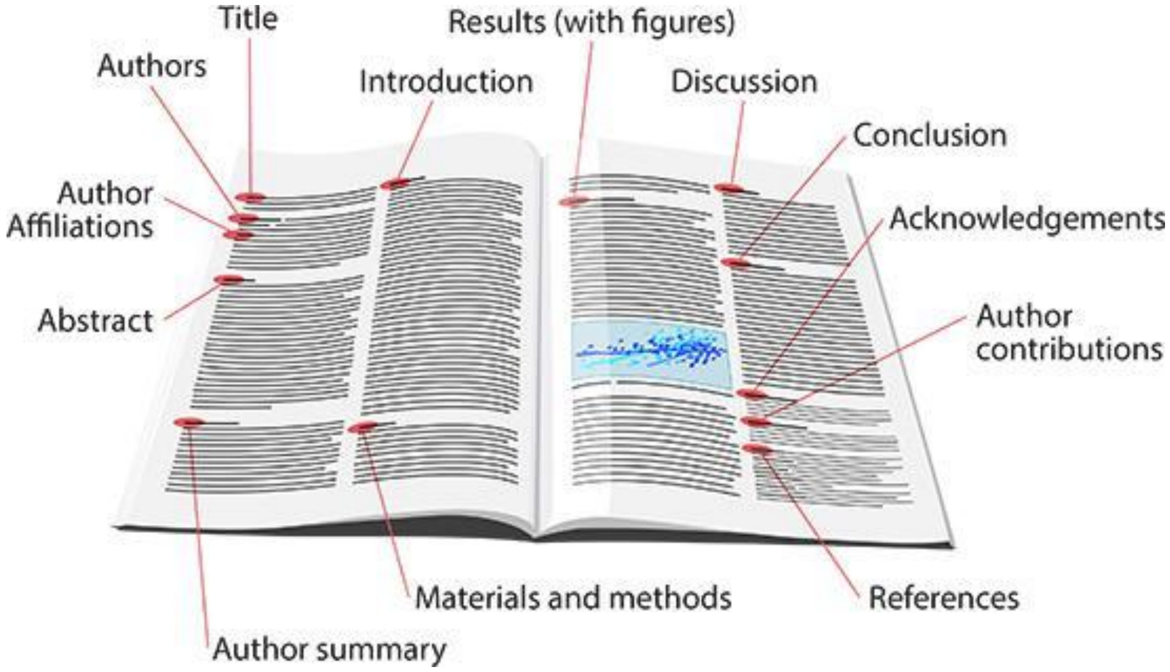
Discussion

Future work

Conclusion

Acknowledgements

References



How to *actually* do it?

The result-oriented

1. Invent a method and get as many good results as possible
2. Document the results
3. Describe the method in great detail
4. Finally, wrap the rest of the paper around it: introduction, conclusion and abstract

The concept-oriented

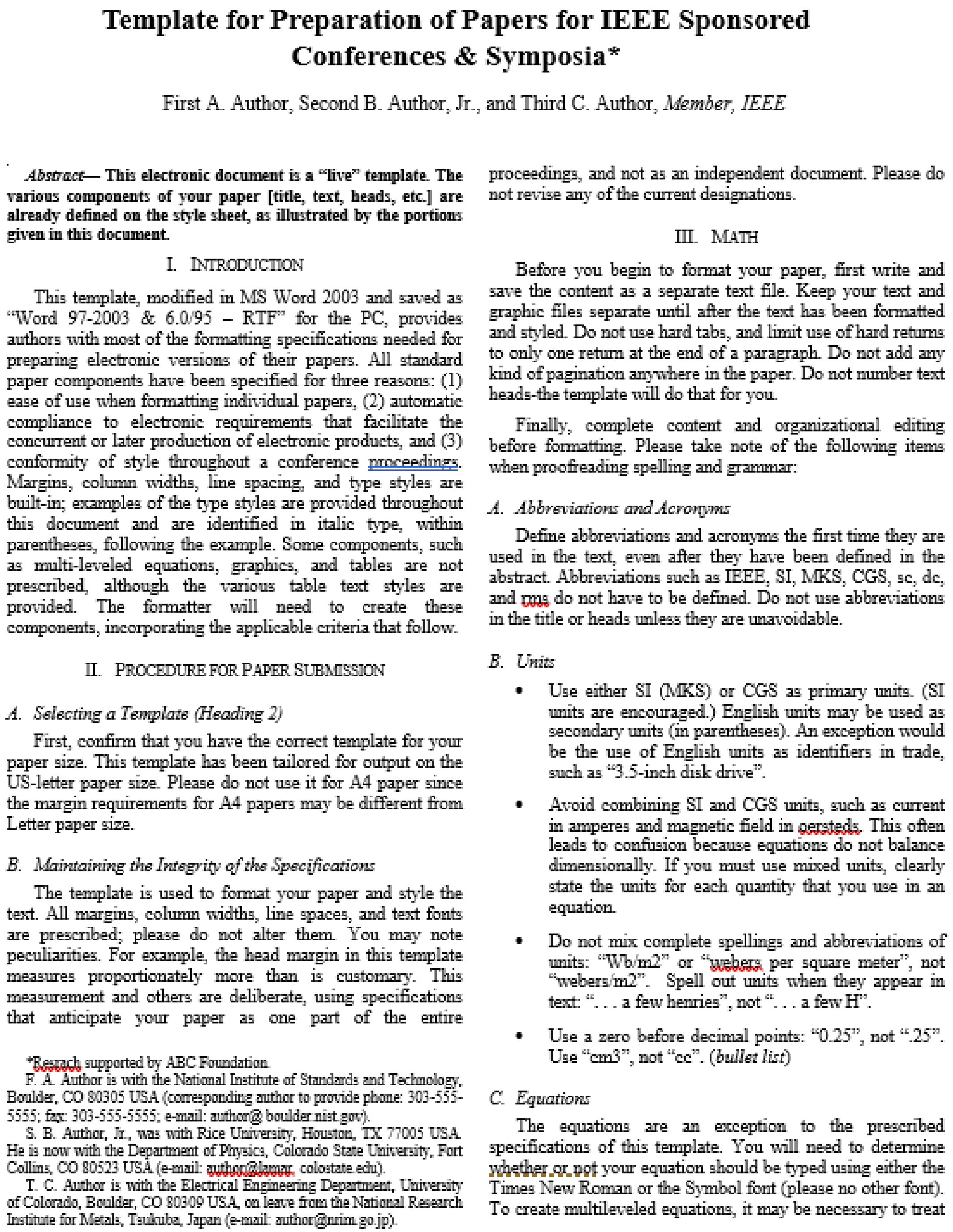
1. Based on a hypothesis, spend time thinking about how to prove it
2. Start immediately the introduction in order to develop a good story
3. Get as many results as you can within the time left
4. Conclude and write an abstract

Writing style

- Don’t overcomplicate your sentences
- But be well worded (however, although, nevertheless)
- Best way to learn is to read many papers
- Pay attention to syntax: “a solutions”, “three solution”
- Acronyms – must be defined at first use
- Use standard abbreviations instead of “secs”, “millis”, “millisec”
- Consistent use of terms “human-robot interaction”, “human robot interaction”
- Run spell-checker
- Tell a story but don’t make it sound like an essay
- No emotional content – everything expressed need to be based on other scientific assertions

Document style

- Depends on the publisher
- Consistency!
  - Figure numbers and names
  - Headings
  - Tables
- Italics for independent variable levels *treatmentA* vs. *treatmentB*
- Follow the style selections from the template



Template for Preparation of Papers for IEEE Sponsored Conferences & Symposia*

First A. Author, Second B. Author, Jr., and Third C. Author, *Member, IEEE*

Abstract— **This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document.**

I. INTRODUCTION

This template, modified in MS Word 2003 and saved as "Word 97-2003 & 6.0/95 – RTF" for the PC, provides authors with most of the formatting specifications needed for preparing electronic versions of their papers. All standard paper components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout a conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

II. PROCEDURE FOR PAPER SUBMISSION

A. Selecting a Template (Heading 2)

First, confirm that you have the correct template for your paper size. This template has been tailored for output on the US-letter paper size. Please do not use it for A4 paper since the margin requirements for A4 papers may be different from Letter paper size.

B. Maintaining the Integrity of the Specifications

The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

III. MATH

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: "Wb/m2" or "webers per square meter", not "webers/m2". Spell out units when they appear in text: ". . . a few henries", not ". . . a few H".
- Use a zero before decimal points: "0.25", not ".25". Use "cm3", not "cc". (*bullet list*)

C. Equations

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat

*Resrach supported by ABC Foundation.

F. A. Author is with the National Institute of Standards and Technology, Boulder, CO 80305 USA (corresponding author to provide phone: 303-555-5555; fax: 303-555-5555; e-mail: author@ boulder.nist.gov).

S. B. Author, Jr., was with Rice University, Houston, TX 77005 USA. He is now with the Department of Physics, Colorado State University, Fort Collins, CO 80523 USA (e-mail: author@lamar. colostate.edu).

T. C. Author is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp).

Title

- Try to motivate potential readers to at least read your abstract – can try to be catchy
- You can use a message, e.g. your conclusion
- Short titles
  - Easy to understand
  - Generic, will catch many non-intended readers
- Long titles
  - Very topic-specific
  - Search engine friendly
  - Will scare some readers

Title examples

The Global Patch Collider

Latent Embeddings for Zero-Shot Classification

A New Finsler Minimal Path Model With Curvature Penalization for Image Segmentation and Closed Contour Detection

If looks could kill: Humanoid robots play a gaze-based social game with humans

What is your project's title?

- Make a catchy one
- Make a short one
- Make a long one

Author list

- Order matters!
- First author
    - The person (e.g. student) who carried most of the practical/writing workload
- Intermediate authors
- Last author
    - Typically an assistant, associate or full professor
    - Led the work
    - Maybe developed the early concepts or prior works
- Equal contributions?
- Corresponding author?

Transportation Research Part C 74 (2017) 113–125

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Estimation of driving style in naturalistic highway traffic using maneuver transition probabilities

Guofa Li [a,1], Shengbo Eben Li [b,*,1], Bo Cheng [b], Paul Green [c]

[a] *Institute of Human Factors and Ergonomics, College of Mechatronics and Control Engineering, Shenzhen University, Shenzhen 518060, China*
[b] *State Key Laboratory of Automotive Safety and Energy, Department of Automotive Engineering, Tsinghua University, Beijing 100084, China*
[c] *University of Michigan Transportation Research Institute (UMTRI) & Department of Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI 48109, USA*

A R T I C L E   I N F O

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Keywords:
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Driving safety
Driving risk
Transition probability
Maneuver frequency
Highway driving

A B S T R A C T

Accurately estimating driving styles is crucial to designing useful driver assistance systems and vehicle control systems for autonomous driving that match how people drive. This paper presents a novel way to identify driving style not in terms of the durations or frequencies of individual maneuver states, but rather the transition patterns between them to see how they are interrelated. Driving behavior in highway traffic was categorized into 12 maneuver states, based on which 144 (12×12) maneuver transition probabilities were obtained. A conditional likelihood maximization method was employed to extract typical maneuver transition patterns that could represent driving style strategies, from the 144 probabilities. Random forest algorithm was adopted to classify driving styles using the selected features. Results showed that transitions concerning five maneuver states – free driving, approaching, near following, constrained left and right lane changes – could be used to classify driving style reliably. Comparisons with traditional methods were presented and discussed in detail to show that transition probabilities between maneuvers were better at predicting driving style than traditional maneuver frequencies in behavioral analysis.

1. Introduction

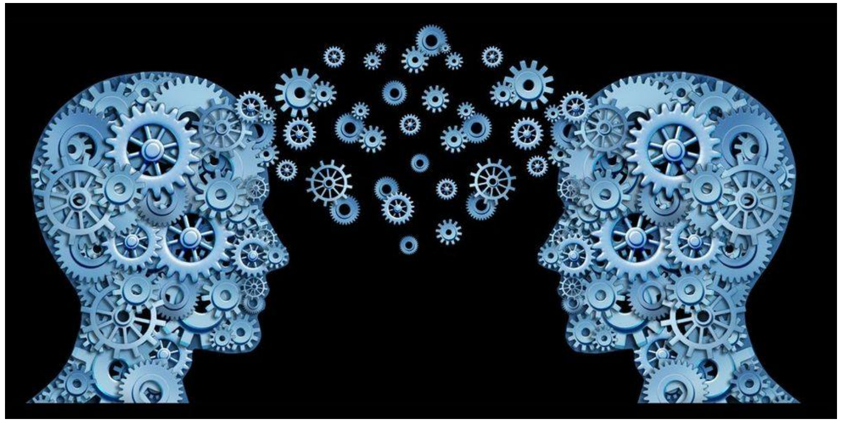
Driving style is generally defined as the habitual ways drivers choose to drive, *i.e.*, the way individuals choose to drive or driving preferences that have developed over time (Elander et al., 1993; Lajunen and Özkan, 2011). Some definitions tend to emphasize ways of thinking (Ishibashi et al., 2007) or decision-making (Deery, 1999) rather than observable behavior. Despite the differences, these definitions are very much in accordance with each other in terms of their contents (Sagberg et al., 2015).

Driving style refers broadly to all activities performed by a driver, including strategic planning, tactical maneuvering, vehicle operation, as well as maintaining situation awareness and engaging in secondary tasks (Rasmussen, 1983; Cheng and Fujioka, 1997; Toledo et al., 2007). Fig. 1 summarizes the framework of driving style analysis. Strategic planning refers to knowledge-based activities, including the determination of route choice, the evaluation of the costs and risks involved, etc.

* Corresponding author.
E-mail addresses: hanshan198@gmail.com, guofali@szu.edu.cn (G. Li), lishbo@tsinghua.edu.cn (S.E. Li), chengbo@tsinghua.edu.cn (B. Cheng), pagreen@umich.edu (P. Green).
[1] These authors have equally contributed to this research work.

http://dx.doi.org/10.1016/j.trc.2016.11.011

What qualifies a person to become author?



- **Intellectual work**

- Practical work?
- Funding work behind the authors?
- Equipment owners?
- High-profile friends who can “help” you with a name?

Abstract

- A short intro to the field
- A short problem statement
- A short overview of your approach
- Results in short
- Implications of your results
- Sprinkle with significance, relevance, originality claims
- It’s the “selling point” or “elevator pitch” of your paper
- Most people will only read your abstract
- Readeres will: read title >> read abstract >>>>> read paper

Very likely Likely Very unlikely

SDU

Example abstract

A Robot Reading Human Gaze: Why Eye Tracking Is Better Than Head Tracking for Human-Robot Collaboration

Oskar Palinko, Francesco Rea, Giulio Sandini, Alessandra Sciutti

motivation
problem
hypothesis
approach
results
conclusion

***Abstract* — Robots are at the position to become our everyday companions in the near future. Still, many hurdles need to be cleared to achieve this goal. One of them is the fact that robots are still not able to perceive some important communication cues naturally used by humans, e.g. gaze. In the recent past, eye gaze in robot perception was substituted by its proxy, head orientation. Such an approach is still adopted in many applications today. In this paper we introduce performance improvements to an eye tracking system we previously developed and use it to explore if this approximation is appropriate. More precisely, we compare the impact of the use of eye- or head-based gaze estimation in a human robot interaction experiment with the iCub robot and naïve subjects. We find that the possibility to exploit the richer information carried by eye gaze has a significant impact on the interaction. As a result, our eye tracking system allows for a more efficient human-robot collaboration than a comparable head tracking approach, according to both quantitative measures and subjective evaluation by the human participants.**

One reason for this lack of gaze tracking in robots might be the need for specific camera properties to calculate eye gaze direction. In particular, high resolution, narrow field-of-view images are ideally required for such a computation, while robots are in general equipped with wide field-of-view cameras to be able to move and interact in a large environment. Some robots are also limited to lower resolution cameras for different reasons and for example network bandwidth utilization is prioritized for real time behavior (walking, balancing, etc.), and not for visual processing. Light and shadow can affect this calculation as well. An alternative possibility is to use ad hoc hardware. However, standard gaze tracking devices are usually designed to be static, observing just one spot in space, while robots often need a solution that can deal with agents moving in space. The common solution adopted in experimental settings is then the use of head-mounted systems worn by the human partner. These are moving with the subject, but are intrusive and require that anyone wanting to interact with a

Keyword section

- Don’t have to be single words – key phrases
- Reverse engineering: which words do you want people to search for to find your paper?
- Sometimes categories are required (IEEE)

Abstract

We report on the results of a study in which pairs of subjects were involved in spoken dialogues and one of the subjects also operated a simulated vehicle. We estimated the driver’s cognitive load based on pupil size measurements from a remote eye tracker. We compared the cognitive load estimates based on the physiological pupillometric data and driving performance data. The physiological and performance measures show high correspondence suggesting that remote eye tracking might provide reliable driver cognitive load estimation, especially in simulators. We also introduced a new pupillometric cognitive load measure that shows promise in tracking cognitive load changes on time scales of several seconds.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces

Keywords: eye tracking, pupillometry, cognitive load

What’s you paper’s abstract?

- Spend 10 minutes with your group members to write an abstract to your project
- Share your writing afterwards
- If you are not there yet with your own project, write an abstract to the “kayak experiment” discussed in previous classes

Introduction

- Introduce the field – *context*
- Motivation for doing this work
- State the importance of your work - *need*
  - What was missing before you came around?
  - What were the (poor) alternatives before?
- State what you contribute - *task*
- State concisely what the actual paper is about to address – *object*
- Start from general, go to specific:
  - Robots are making their way from factory floor to our living environments.
  - They are equipped with different interaction modalities.
  - One of the modality is gaze that we don’t know much about.
- Another approach: problems – hypotheses - goals

Background

- Literature review
- Visit all relevant areas for your paper from general to specific
    - Gaze tracking for robots
    - Robots interacting with multiple humans
    - Robots playing social games
- Find the niche your paper fits in
- Ideally, in each section you analyze the most important papers and say how your research is different (originality)

If Looks Could Kill: Humanoid Robots Play a Gaze-based Social Game with Humans

Oskar Palinko, Alessandra Sciutti, Yujin Wakita, Yoshio Matsumoto, Giulio Sandini

***Abstract*— Gaze plays an important role in everyday communication between humans. Eyes are not only used to perceive information during interaction, but also to control it. Humanoid robots on the other hand are not yet very proficient in understanding and using gaze. In our study we enabled two humanoid robots to perceive and exert gaze actions. We then performed a pilot experiment with the two android robots playing the "Wink Murder" game with human players. We demonstrate that the designed framework allows the robots to complete the game successfully, validating the efficacy of our gaze tracking system. Moreover, human participants exhibited a rich variety of natural behaviors in the game, suggesting that it could represent a valid scenario for a more in-depth investigation of human-humanoid interaction.**

I. Introduction

Gaze is one of the basic ways people communicate with each other. Often times gaze interaction is not explicit but rather implicit: we are not always aware that besides acquiring visual information (sensing) we are also transmitting information with our eyes (acting). An observer could for example tell what we are interested in by noticing where we look.

Robots, especially humanoid robots, could become more natural by being able to understand the gaze of humans. This way they could become more aware of the intention of people during interaction. Due to their resemblance to people, humanoids might even be expected to understand the gaze of others, as this is something humans are able to do naturally.

The general problem we are addressing is that human-humanoid interaction is not as natural as human-human interaction. We hypothesize that naturalness could be improved by exploiting gaze reading by the robot. Our goal was to improve our gaze tracking algorithms and to design a gaze tracking scenario in which we could employ this eye tracking solution. The requirements for this scenario were: a) to include multiple humans and multiple robots and b) to be engaging enough for human so they would not become bored quickly. These criteria would ensure a wealth of diverse gazing behavior. We decided that a social game would be the ideal scenario which would fulfill the requirements. Therefore we chose the so-called "Wink Murder" party game as the basis for our experiments. This game can be played by multiple humans and multiple robots, thus it can produce complex gazing behavior. This game also employs gaze detection as well as gaze actions (selection with gaze, mutual gaze) which is an added benefit. For the most part the game does not require verbal communication, thus it is easy to port it to different cultural groups. To the best of our knowledge, such a complex game with multiple humans and multiple humanoid robots was not yet implemented anywhere, thus using this setup could generate novel results, as we also show in our pilot experiment. Our main goals were to create a natural gazing scenario to validate our gaze tracking system and to explore human gazing behavior in interaction with androids.

* Research supported by the European Project CODEFROR (PIRSES-2013-612555).

Oskar Palinko, Alessandra Sciutti and Giulio Sandini are with the Robotics, Brain and Cognitive Sciences Department, Istituto Italiano di Tecnologia, Genova, Italy (e-mail: [firstname].[lastname]@iit.it).

Yujin Wakita and Yoshio Matsumoto are with the Robot Innovation Research Center, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan (e-mail: yoshio.matsumoto@aist.go.jp).

II. Background

As mentioned before gaze recognition is particularly interesting for humanoid robots, as it is a natural human ability that might be expected from human-like robots. There are two aspects of gaze behavior considering robots: gaze generation and gaze understanding. The first approach deals with how robots should display their own gazing. A good overview of this field can be found in [1]. Our work focuses both on humans reading the robot's gaze but more importantly on how robots could understand people's gaze in order to improve their natural behavior. In this field there is a number of observed phenomena which are closely related to observing the eye: mutual gaze [2], joint attention [3], gaze aversion [4], etc. Mutual gaze happens when the gaze of two agents interlock, which has a special importance in human communication. Joint attention is when two people focus their on attention on a single object, which might be an important interaction cue. Gaze aversion happens when the agent diverts its gaze to gain time in a conversation.

Many authors in the field of human-robot interaction have substituted eye gaze with its closest proxy, head orientation, because of technical limitations [5]. Gaze was deemed difficult to calculate or just not available to the authors [6]. Indeed, often times the head and eye orientations are in line, but not always. The eyes definitely carry additional information that head direction does not possess [7].

Furthermore a number of authors did use actual eye tracking devices to analyze the humans' gaze, most of them used head-mounted systems. Broz et al. looked at human-human interaction for designing more natural human-robot interaction [8]. Sciutti et al. studied how humans follow movements of the robot and compared it to following human movements [9]. Although, as mentioned before, these systems provide high accuracy results, their drawback is in the fact that they are obtrusive for everyday interaction, thus

Methods - Approach - Experiments

- It varies from discipline to discipline what this section is called
- Overall goal
  - Make the methods (your experiment, algorithm, etc.) and the results **reproducible**
  - If you use materials, include relevant info for it also (product codes, part numbers, etc.)
- Start with description of used/developed hardware – UR robot modified with…
- Then what experimentation method you used
- Describe procedure for experimentation – how you gathered data

Results

- Make clear from the beginning (maybe first sentence) what each result shows
- Then explain in more detail
- Provide figures
    - **Make sure that figure legends and/captions are self-explanatory**
- Report only factual results, discussion comes afterwards
- How to report on results using e.g. ANOVA?
    - Standard way
    - F number, degrees of freedom, p value
    - Post hoc comparisons
- Google: how to report on XYZ method in a scientific paper

We performed a series of repeated measured ANOVAs for the first three dependent variables with *st_part* as the independent variable (Figures 3 and 4). We found statistically significant differences in steering wheel variance (F(2,30)=25.0, p<.001) while performing different parts of the spoken tasks (TQ1, LL and TQ2). Post hoc pair-wise comparisons also show differences between all levels (p<.006). The differences in lane position variance are also statistically significant (F(2,30)=10.0, p<.001). Post hoc comparisons show significance between TQ1 and LL (p<.002), TQ1 and TQ2 (p<.007) but not between LL and TQ2 (p<.175). Note that on average TQ1, LL and TQ2 took about 22, 30 and 45 seconds to complete respectively.

Figure examples

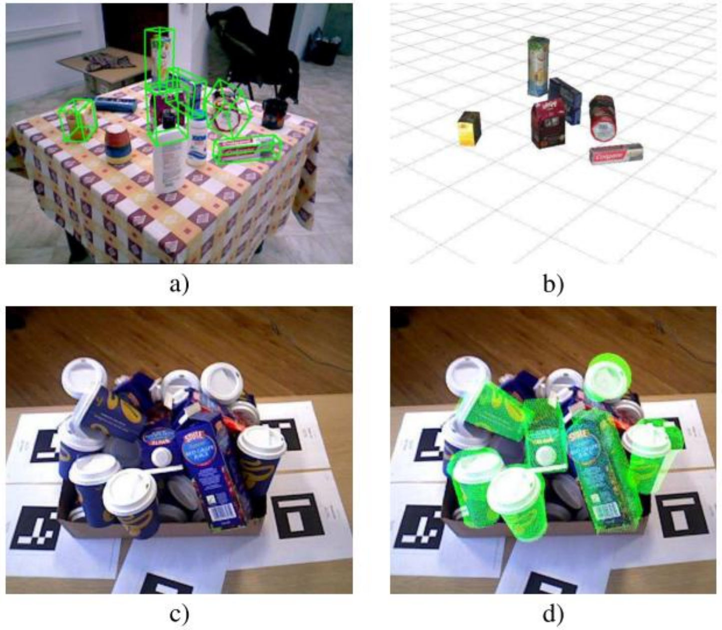
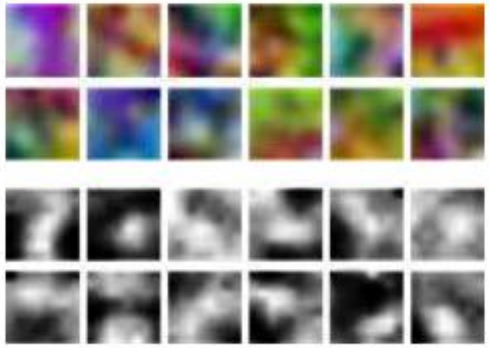


Figure 1: Sample photos from our dataset. a) Scene containing objects from a supermarket, b) our system's evaluation on a), c) Bin-picking scenario with multiple objects stacked on a bin, d) our system's evaluation on c).



(d) 1st layer filters

A. Doumanoglou et al., "Recovering 6D Object Pose and Predicting Next-Best-View in the Crowd", In *CVPR*, 2016.

Discussion

- Discusses the results
- Gives explanation of results
- Aligns results with models, theories, hypotheses
- Explanation of unexpected results
- Limitations of your approach – defense from reviewers
    - What you know but neglected
    - Neglected independent variables
    - What you figured out later
- Don’t overreach with implications

Conclusions

- The **take home message** of your paper
  - Provide a high-level interpretation of your main results
  - Focus on what the implications are to the reader
  - Do not just restate the whole paper in a couple of sentences
- Now put your work into **perspective**
  - Dwell on and speculate a bit on potential future implications
  - Be open to future endeavors, but not speculative
  - If possible, provide specific future plans for yourself

Future Work

- Overlooked but important
- Defend yourself from criticism
  - You state how your research can be extended or improved before reviewers do
- State in which directions your research could go in
- You are not committing yourself

Acknowledgements

- Funding bodies
- People providing helpful inputs
- People who did technical work without providing intellectual input
- Providers of materials, test data, etc.

Acknowledgments. We wish to thank Selina Sara Eisenberger and Matous Jelinek for their help during the experiments. This project was supported by the Innovation Fund Denmark in the framework of the SMOOTH project, which we gratefully acknowledge.

*Research supported by the European Project CODEFROR (PIRSES-2013-612555)

2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
Daejeon Convention Center
October 9-14, 2016, Daejeon, Korea

A Robot Reading Human Gaze: Why Eye Tracking Is Better Than Head Tracking for Human-Robot Collaboration

Oskar Palinko, Francesco Rea, Giulio Sandini, Alessandra Sciutti

***Abstract* — Robots are at the position to become our everyday companions in the near future. Still, many hurdles need to be cleared to achieve this goal. One of them is the fact that robots are still not able to perceive some important communication cues naturally used by humans, e.g. gaze. In the recent past, eye gaze in robot perception was substituted by its proxy, head orientation. Such an approach is still adopted in many applications today. In this paper we introduce performance improvements to an eye tracking system we previously developed and use it to explore if this approximation is appropriate. More precisely, we compare the impact of the use of eye- or head-based gaze estimation in a human robot interaction experiment with the iCub robot and naïve subjects. We find that the possibility to exploit the richer information carried by eye gaze has a significant impact on the interaction. As a result, our eye tracking system allows for a more efficient human-robot collaboration than a comparable head tracking approach, according to both quantitative measures and subjective evaluation by the human participants.**

I. Introduction

Humans are very efficient collaborators, able to rapidly coordinate with each other, often with no need of detailed verbal instructions. This efficiency derives from the use of a wealth of communication cues to guide interaction, both explicit, as for instance gestures or speech, and implicit, as gaze. Implicit communication signals are those, which are not intended to carry information, but they do anyways and are fundamental for effective communication. For instance, when humans want to reach for an object, their gaze anticipates their hand on target. This implies that keen observers can predict the goal of their partner even before the beginning of the hand motion, just by looking at their eyes. When people turn their gaze to gather information, their eyes immediately give off where their visual attention is focused at and hence which object they want to take.

Recently the importance of communication through gaze has been acknowledged also in robotics, even beyond the boundaries of purely social applications. For instance, in the field of small manufacturing, one of the key selling points of Baxter (Rethink Robotics) is its ability to seamlessly communicate its focus of attention thanks to its "eyes", which make it easily understandable by non-trained collaborators. However, while the opportunity of using robot eyes to communicate has been already applied in the market, the possibility for a robot to observe humans' eyes to anticipate their needs and intentions has not been widely used yet.

One reason for this lack of gaze tracking in robots might be the need for specific camera properties to calculate eye gaze direction. In particular, high resolution, narrow field-of-view images are ideally required for such a computation, while robots are in general equipped with wide field-of-view cameras to be able to move and interact in a large environment. Some robots are also limited to lower resolution cameras for different reasons and for example network bandwidth utilization is prioritized for real time behavior (walking, balancing, etc.), and not for visual processing. Light and shadow can affect this calculation as well. An alternative possibility is to use ad hoc hardware. However, standard gaze tracking devices are usually designed to be static, observing just one spot in space, while robots often need a solution that can deal with agents moving in space. The common solution adopted in experimental settings is then the use of head-mounted systems worn by the human partner. These are moving with the subject, but are intrusive and require that anyone wanting to interact with a robot wear special glasses or a helmet. This approach often limits the adoption of eye tracking in open environments (e.g. airports, shopping malls, hospitals, etc.) where robots could be required to interact with people with no prior preparation of the human partners.

Because of the above problems concerning retrieving gaze in human robot interaction (HRI) a number of authors (see Chapter II) have resorted to using the so called "head gaze" instead of eye gaze. This choice was mostly made because head orientation is easier to compute. But the problem is that eye gaze does not always coincide with head gaze. People can make short glances at objects without moving their heads (e.g. checking the time or a wrist watch or glancing at a secondary screen). Indeed, eye gaze contains more information than head orientation only. Also for humans it has been proved that actual gaze direction estimation is significantly more precise when it is based also on eyes with respect to head only [1]. Moreover, in natural collaborative scenarios the objects are often close to each other and people tend to switch their focus of attention just by moving their eyes, yielding to minor or null head movements. The inability to read actual eye movements could then make the robot miss important information for an efficient interaction, like which object the human collaborator attends to.

In this work we add performance improvements to our calibration-free, visual light, monocular eye gaze tracking algorithm designed to work on humanoid robots. This system enables a robotic platform to catch the subtle communication signals associated with human eye motion during collaboration with no need of ad hoc hardware or high resolution, narrow field-of-view cameras. Using this system

*Research supported by the European Project CODEFROR (PIRSES-2013-612555)

All authors (members of IEEE) are with the Robotics, Brain and Cognitive Sciences Department of the Fondazione Istituto Italiano di Tecnologia, Genova, 16163, Italy (corresponding author's e-mail: oskar.palinko@iit.it).

References

- The format is always dictated by the journal/conference
- In-text citations
- Reference list

clusions. When objects have sufficient texture, techniques based on key-point matching [22, 30] demonstrate good results, yet when there is a lot of clutter in the scene they

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SDU

A. Doumanoglou et al., "Recovering 6D Object Pose and Predicting Next-Best-View in the Crowd", In *CVPR*, 2016.

In-text citations (Science)

Using flapping wings and tiny nervous systems, flying insects are able to perform sophisticated aerodynamic feats such as deftly avoiding a striking hand or landing on flowers buffeted by wind. How they perform these feats—from sensorimotor transduction to the unsteady aerodynamics of their wing motions—is just beginning to be understood (*1*–*3*), aided in part by simulation (*4*) and scaled models (*5*). Motivated by a desire for tiny flying robots with comparable maneuverability, we seek to create a robotic vehicle that mirrors these basic flight mechanics of flies. At the scale of flies, no such vehicle has been demonstrated to date because of the severe miniaturization challenges that must be overcome for an insect-sized device (*6*). Con-

School of Engineering and Applied Sciences and the Wyss Institute for Biologically Inspired Engineering, Harvard University, Cambridge, MA 02138, USA.

*Corresponding author. E-mail: kevinma@seas.harvard.edu
†These authors contributed equally to this work.

K. Y. Ma et al., "Controlled flight of a biologically inspired, insect-scale robot", *Science*, 2013.

In-text citations (Sage)

1. Introduction

The robotic motion planning problem has received a considerable amount of attention, especially over the last decade, as robots started becoming a vital part of modern industry as well as our daily life (Latombe 1991; Choset et al. 2005; LaValle 2006). Even though modern robots may possess significant differences in sensing, actuation, size, workspace, application, etc., the problem of navigating through a complex environment is embedded and essential in almost all robotics applications. Moreover, this problem is relevant to other disciplines such as verification, computational biology, and computer animation (Finn and Kavraki 1999; Latombe 1999; Liu and Badler 2003; Bhatia and Frazzoli 2004; Branicky et al. 2006; Cortes et al. 2007).

Informally speaking, given a robot with a description of its dynamics, a description of the environment, an initial state, and a set of goal states, the motion planning problem is to find a sequence of control inputs so as the drive the robot from its initial state to one of the goal states while obeying the rules of the environment, e.g. not colliding with the surrounding obstacles. An algorithm to address

S. Karaman & E. Frazzoli, "Sampling-based algorithms for optimal motion planning", *IJRR*, 2011.

In-text citations (IEEE)

I. INTRODUCTION

A surgical procedure may be decomposed into subtasks including dissection, suturing, and tissue manipulation. Suturing is one of the most challenging and time consuming of all surgical subtasks [1]. In minimally invasive surgery (MIS), deficiencies such as reduced surgeon dexterity or limited visual feedback make this task even more challenging. Surgical robotic systems, such as the Raven II (see Fig. 1), have solved many of these deficiencies by providing additional degrees of freedom and leveraging sophisticated vision systems [2], [3], [4]. However, suturing with these systems, in which the surgeon serves as both the decision maker and the operator, is still difficult. For example, it is challenging for the surgeon to estimate distances and angles through an endoscope. Additionally, with limited vision and/or haptic feedback, extracting the needle from the desired point often requires multiple attempts, resulting in increased tissue trauma and extended operation time [5]. The limitations associated with the human operator along with the repetitive nature of suturing make it a candidate subtask for automation. The framework of automating suturing relies on the surgeon for high level decision making while delegating the execution of low-level motions to the robot, potentially leading to improved surgical outcome.

Previous studies have focused on different parts of fully automated suturing including knot tying [6], [7], [8], thread tracking [9], [10], and dexterous needle manipulation [11], [12], [13]. In particular, many research efforts focused on generating an initial needle path which can be updated in real time to adjust to environment changes. In [14], needle path planning has been formulated as a non-convex optimization problem subjected to kinematic constraints. This algorithm is designed to minimize the suture length and maintain orthogonal needle angle at the tissue entry point. Some studies [15], [16] have proposed constant curvature path (CCP) planning in which the needle only rotates around its geometric center to pierce the tissue (see Fig. 2a-Fig. 2c). It was argued in these studies that the CCP algorithm will result in minimal tissue trauma. However, due to the constrained motion, important suturing requirements such as adequate suture depth may not be satisfied [17], [18]. Needle reorientation inside the tissue is proposed in other studies [11], [14], [19], [20], [21], [22] to better follow suturing requirements yet it may impose tissue trauma [13].

Contribution: Despite the fact that surgeons select needle shape and diameter based on the wound/tissue geometry [23], [24], previous studies have largely ignored these variables in their path planning formulations. This study extends the current research effort by developing an algorithm that includes tissue/wound geometry as inputs, and needle shape/diameter

*This work is supported by the U.S. National Science Foundation award IIS-1227184: Multilateral Manipulation by Human-Robot.

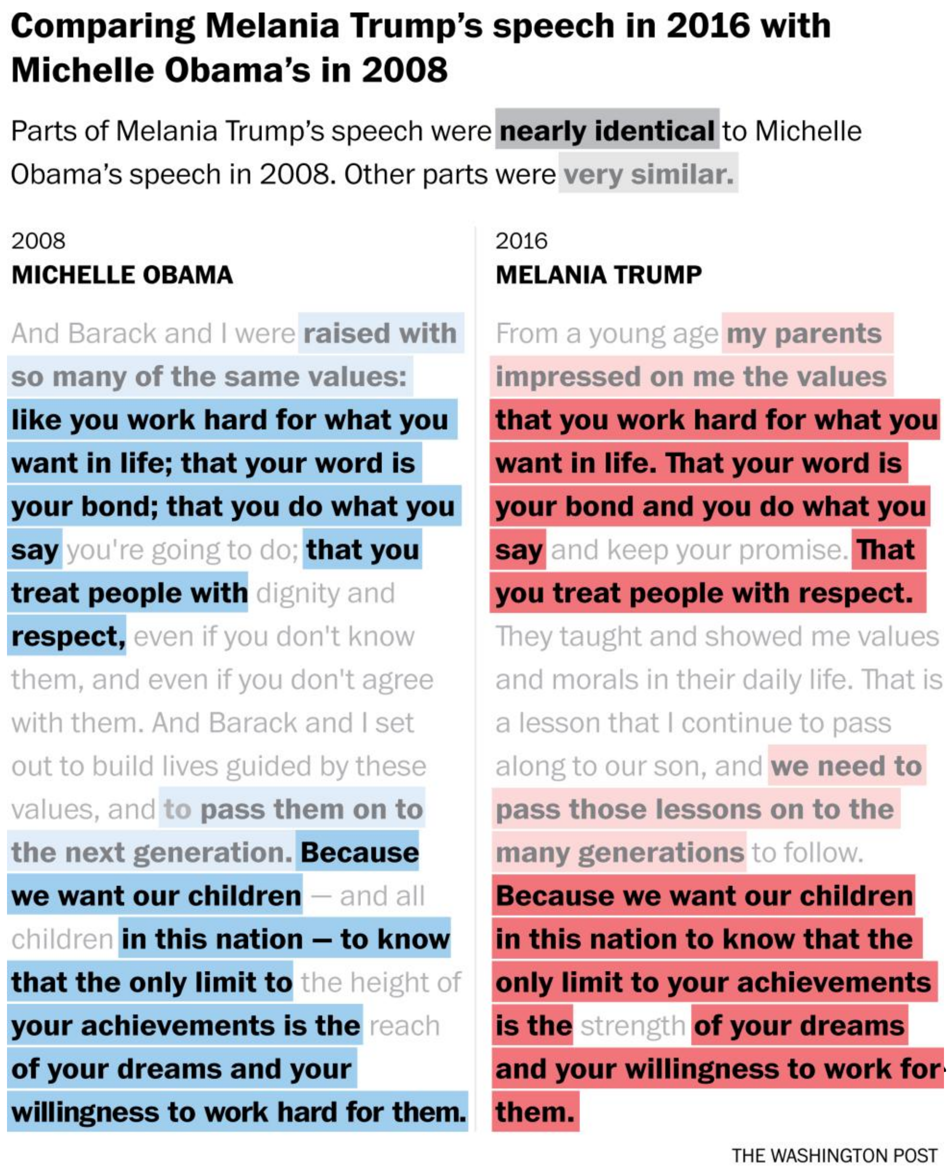
[1]Sahba Aghajani Pedram, Peter Ferguson, Ji Ma, and Jacob Rosen are with the Mechanical and Aerospace Engineering Department, University of California at Los Angeles, Los Angeles, CA, USA sahbaap@ucla.edu, pwferguson@ucla.edu, jima@ucla.edu jacobrosen@ucla.edu

[2]Erik Dutson is with the Department of Surgery, David Geffen School of Medicine, University of California at Los Angeles, Los Angeles, CA 90095, USA EDutson@mednet.ucla.edu

S. A. Pedram et al., “Autonomous Suturing Via Surgical Robot: An Algorithm for Optimal Selection of Needle Diameter, Shape, and Path”, In *ICRA*, 2017.

Plagiarism – famous examples

- Melania Trump vs. Michelle Obama
- Lord of the Rings vs. Ring of the Nibelung
- My Sweet Lord released by George Harrison
- Jerry Seinfeld over Comedians in Cars Getting Coffee
- Avatar vs Pocahontas vs Dances with Wolves
- Martin Luther King Jr.
- Joe Biden
- Any other?



Can one plagiarize themselves?

Plagiarism - definition

- The practice of taking someone else's work or ideas and passing them off as one's own – Oxford Dictionary

- Plagiarism is the representation of another author's language, thoughts, ideas, or expressions as one's own original work. - Wikipedia

Plagiarism vs copyright infringement

- Copyright infringement - is the use of works protected by copyright law without permission for a usage where such permission is required, thereby infringing certain exclusive rights granted to the copyright holder, such as the right to reproduce, distribute, display or perform the protected work, or to make derivative works. (Wikipedia)

Plagiarism vs copyright

Plagiarism	Copyright infringement
Not illegal but violation of academic norms	Illegal
Offense against an author	Offense against copyright holder
When ideas are copies	When specific fixed expressions are copied
About assigning intellectual credit	About maintaining revenue streams

- Adopted from [UIC]

Avoiding plagiarism

- Cite, cite, cite
- When to cite?
  - Using someone else's ideas
  - Using someone else's quoted text, images, graphs, etc.
  - Even when text is paraphrased (not quoted verbatim)
  - Even if you are borrowing from your own publication – self-plagiarism exists!

- Two ways of in-text citation: narrative and parenthetical
  - Narrative: Recarte and Nunes used monoscopic remote eye tracking in a naturalistic driving experiment [2000].
  - Parenthetical: Falsely balanced news coverage can distort the public's perception of expert consensus on an issue (Koehler, 2016).

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Why plagiarism is more important than copyright in academia and research for scientific papers?

- I’m not a lawyer – no legal weight to my opinion
- USA: Fair use act
  - Fair use is a doctrine in the United States copyright law that allows limited use of copyrighted material without requiring permission from the rights holders, such as for commentary, criticism, news reporting, research, teaching or scholarship. (Wikipedia)
- EU Copyright Law Exceptions 5.3 (a) Teaching and Research exception

Avoiding plagiarism - citations

- Citations are dependent on the publisher’s style
  - IEEE: [1]
  - APA: (Palinko, 2018)
- When using names of authors in narrative citation
  - One author: Palinko
  - Two authors: Ishiguro and Matsumoto
  - More than two authors: Kanda et al.

Citations and references

- When using citations there must be a References section at the end

In the field of human robot interaction it has become a common practice to replace eye gaze with its approximation, head gaze. Doniec et al. describe a method for learning joint attention by a robot [2]. In their approach the robotic agent observes the caregiver's gaze towards certain objects. However, eye gaze is replaced by head pose, because the authors claim that eye gaze was not possible to extract due to the low resolution of their cameras. Using a Radial Basis Function Network they were able to train the robot to recognize joint attention towards a number of objects on a table and then recognize the selection of objects based on head pose. They report a recognition rate of 95% when testing is done with the same person as training, but 62% when different people are used in training and testing.

Kim et al. reported on a robotic system capable of learning gaze following [3]. They used head pose estimation, because they did not have an eye gaze tracking system available. Their system was able to learn correct associations between the caregiver's head pose and corresponding motor actions using offline reinforced learning.

...

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Avoiding plagiarism

- If idea came from some other source, to be safe, cite it
- If it is a non-citable source, talk to person about it, but nothing to cite
- Paraphrasing
  - Here’s one technique:
    1. Read and *understand* related work
    2. Put it away for some time
    3. Paraphrase it
  - 4. Cite it

- Quoting
  - Sometimes, the words of the original author(s) are irreplaceable
  - Required even for sentence blocks (sometimes a few words)
  - Seldom seen in scientific works that I encounter

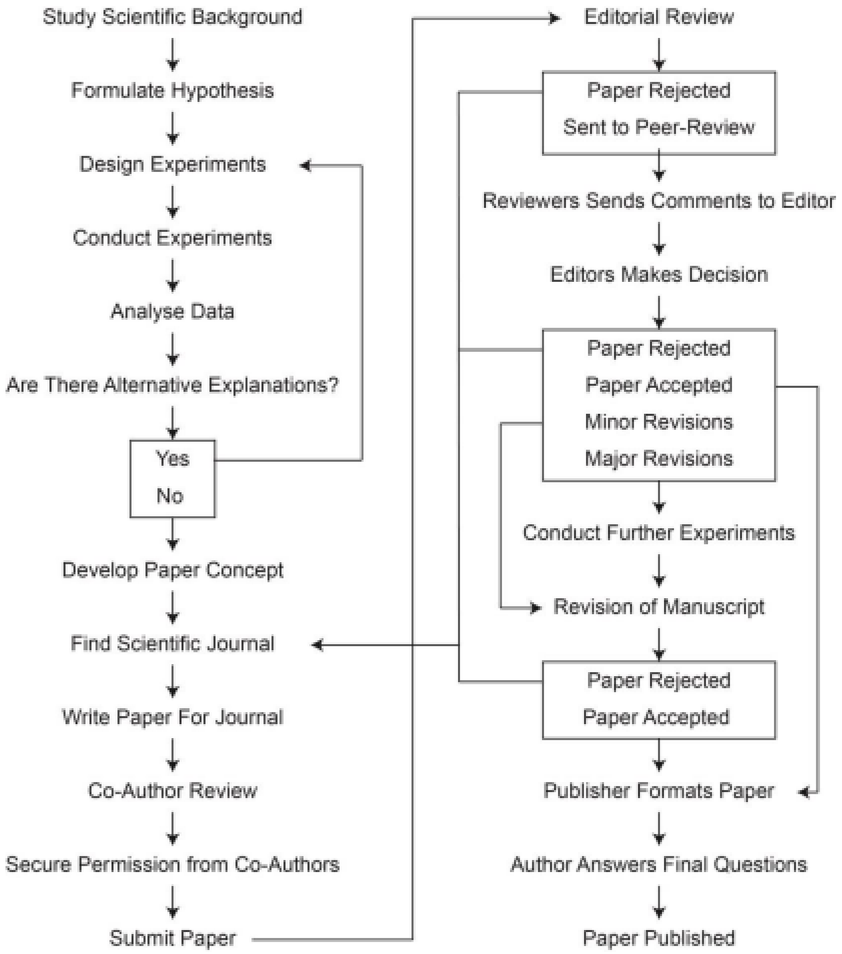
Protection of ideas

- “Stealing of ideas” quite common in academia as it is not illegal, only immoral
- If you have the idea
  - Best method that always works: shut up!
  - Second best solution: sign a non-disclosure agreement (NDA) – not too common in academia
- Someone else has the idea
  - Don’t be that guy who steals it
  - Talk to the person whose idea you want to use
- In industry
  - Money talks – less importance on morality
  - Legal issues most important
  - Patent (more on this next class)

Supplementary material

- Sometimes, 8 pages is just not enough!
- Supplementary can contain
  - A PDF that looks like the paper, but with additional details, results, figures, etc.
  - Video demonstrations
  - Code examples

Overview of the process



What tools to use

- MS Word or LaTex
- Word
  - Easiest way to go
  - Style and content interconnected
  - Mendeley citation plugin
- LaTex
  - Style and content separated
  - More like coding

How to collaborate online

- Google Docs
- Overleaf – working on LaTex together
- Microsoft Office 365

General advice

- Too speculative (or inductive)
  - Our results confirm that our method can solve virtually all future point cloud based pose estimation tasks in industrial bin picking
- Too conclusive
  - Based on our experiment, X is better than Y

General advice

- Always have others read (not necessarily correct) your paper
- Keep your co-authors up to date at all times
- Always be honest with results
- Beware of reasons for retraction
  - Non-repeatable results
  - Experimental errors
  - Wrong conclusions
  - Fraud
- Examples

nature International weekly journal of science

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News & Comment > News > 2019 > May > Article

NATURE | NEWS

Stem-cell scientist found guilty of misconduct

But Japanese researcher stands by her claim to be able to produce stem cells using an acid bath or mechanical stress.

David Cyranoski

01 April 2014 | Updated: 02 April 2014, 01 April 2014

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Eugene Hoshiko/AP/Press Association Images

RIKEN president Ryoji Noyori bows during a press conference in Tokyo, where investigators revealed the results of their investigation into Haruko Obokata's research.

A committee investigating problems in papers claiming a method to apply stress to create embryonic like cells has found the lead researcher guilty of scientific misconduct.

Journal retracts 16-year-old paper based on debunked autism-vaccine study

Andrew Wakefield

Better late than never? Or too little too late?

Those are two different ways to look at a recent retraction.

Eight years after one of the most infamous retractions in science — that of the 1998 paper in The Lancet in which Andrew Wakefield and colleagues in the UK claimed a link between vaccines and autism — the journal *Lab Medicine* is retracting a paper that relied heavily on the now-discredited work. The paper, by Bernard Rimland and Woody McGinnis, of the Autism Research Institute, in San Diego, California, begins:

Advices

- Your paper is not meant for boasting about your methods and results
- Learn from your own experience or even better from others’ experience (read as much as you can)
- Focus on *clarity*
- Tell a story!

Reproducible research

using tools from the tidyverse

Scientific Methods

Henrik Skov Midtiby, University of Southern Denmark

October 2025

Some papers are not reproducible!

A 2016 poll of 1,500 scientists reported that 70% of them had failed to reproduce at least one other scientist's experiment (50% had failed to reproduce one of their own experiments).

Source: Nature Video (28 May 2016). "Is There a Reproducibility Crisis in Science?". Scientific American. Retrieved 15 August 2019.

SDU

It is not even uncommon …

A 2016 study in the journal Science found that one-third of 18 experimental studies from two top-tier economics journals (American Economic Review and the Quarterly Journal of Economics) failed to successfully replicate.

Source:

My experience

I use reproducible methods in my daily work and when I work on the analysis part of a paper.

Look at the document with statistics from the midterm evaluation in EMAIP and RobtekMat 2023.

/home/hemi/Nextcloud/Work/06 Papers/2023-11-08 DUT Omkring BTC/midtvejsevaluering-kodet.Rmd

How can you benefit from using reproducible research?

It becomes much easier to look back at an old analysis and actually redo it from scratch.

It also allows you to modify the analysis, if an error is discovered or a new thing should be investigated.

Why is data visualisation important?

A good visualisation will show you things that you did not expect, or raise new questions about the data.

A good visualisation might also hint that you’re asking the wrong question, or you need to collect different data.

Visualisations can surprise you, but don’t scale particularly well because they require a human to interpret them.

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Anscombe’s quartet – four data sets

Mean x value of 9.

Sample variance of x: $s_x^2 = 11$

Mean of y 7.50 to 2 decimal places

Sample variance of y: $s_y^2 = 4.125 \pm 0.003$

Correlation between x and y: 0.816 to 3 decimal places

Linear regression line: y = 3.00 + 0.500x to 2 and 3 decimal places, respectively

Coefficient of determination of the linear regression: $R^2 = 0.67$ to 2 decimal places

Not all data visualizations work equally well

SDU

Tidy data

Data shapes

For `ggplot()` to work,
your data needs to be in a **tidy** format

This doesn't mean that it's clean—
it refers to the *structure* of the data

All the packages in the **tidyverse** work best with
tidy data; that why it's called that!

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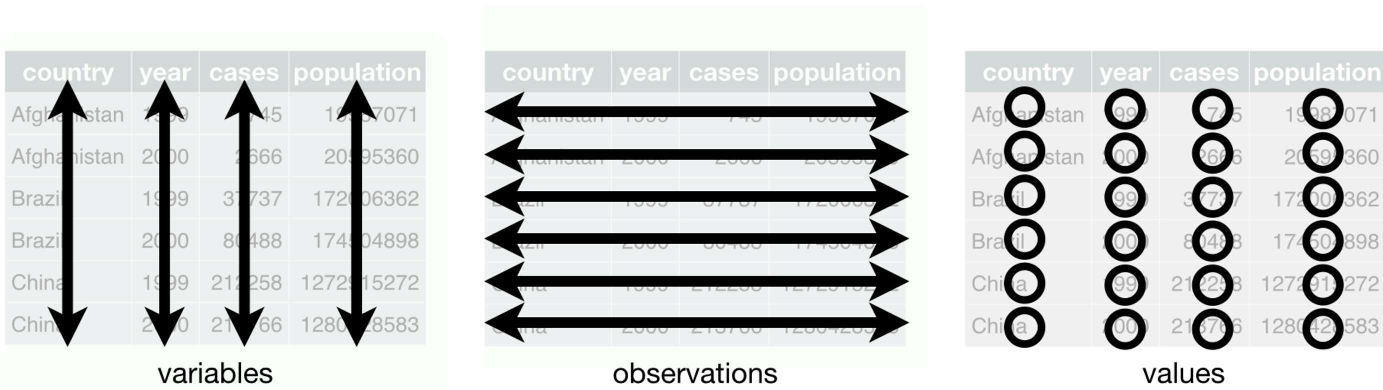
Tidy data

- Each variable has its own column
- Each observation has its own row
- Each value has its own cell



From chapter 12 of *R for Data Science*

Untidy data example

Real world data is often untidy, like this:

	A	B	C	D
1	Number of incidents			
2				
3	Office	2015	2016	2017
4	Utah County	134	145	**167**
5	Salt Lake County	**302**	334	331
6	Davis County	254	288	299
7	Juab County	78	**82**	87
8				
9	**bold = needs verification**			
10	yellow = compiled from different source			
11				

Tidy data example

Here's the tidy version of that same data:

	A	B	C	D	E
1	Office	Year	Incidents	Needs Verification	Different Source
2	Utah County	2015	134	FALSE	FALSE
3	Salt Lake County	2015	302	TRUE	FALSE
4	Davis County	2015	254	FALSE	FALSE
5	Juab County	2015	78	FALSE	FALSE
6	Utah County	2016	145	FALSE	TRUE
7	Salt Lake County	2016	334	FALSE	FALSE
8	Davis County	2016	288	FALSE	FALSE
9	Juab County	2016	82	TRUE	TRUE
10	Utah County	2017	167	TRUE	FALSE
11	Salt Lake County	2017	331	FALSE	FALSE
12	Davis County	2017	299	FALSE	TRUE
13	Juab County	2017	87	FALSE	FALSE

This is plottable!

Wide vs. long

Tidy data is also called “long” data

`wide`

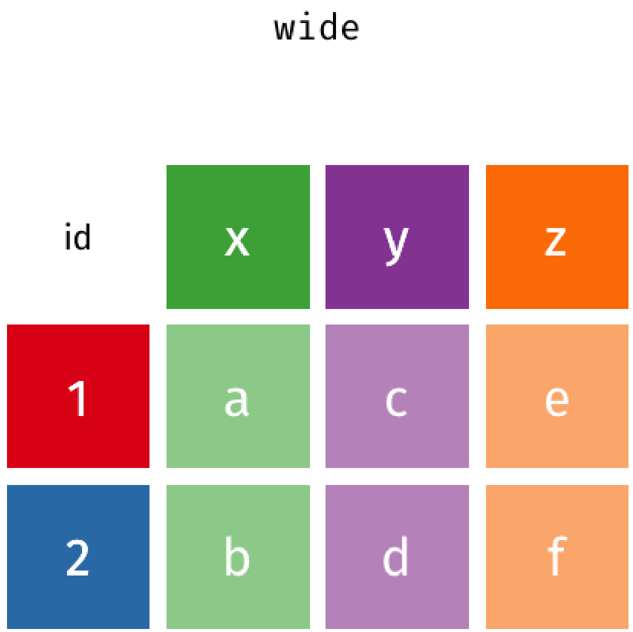
id	x	y	z
1	a	c	e
2	b	d	f

`long`

id	key	val
1	x	a
2	x	b
1	y	c
2	y	d
1	z	e
2	z	f

Moving from wide to long

Nowadays, `gather()` is called `pivot_longer()` and `spread()` is called `pivot_wider()`



Example of comparing two datasets

Vision based localization

Build a map from two images of the same scene.

Then estimate the position of the camera that acquired a third image of the same scene.

We would like to compare two different feature detector for this SIFT and ORB.

For a set of images we have the number of matches with the map and the number of inliers.

SDU RIO

An introduction to inventions, IP and IP protection as part of building a business

Jørgen Jakob Friis, RTTP Candidate
jjf@sdu.dk

Commercialisation SDU RIO

BUSINESS DEVELOPERS

We are specialists with a range of professional backgrounds and domain knowledge.

WE HAVE COMPETENCES AND EXPERIENCE IN:

- Intellectual Property
- Product development
- Seed investments
- Marketing
- Project management

What is IPR

We work with:

Inventions

Patentable (as such)

Consists of one or more of:

- Idea
- Concept
- Enablement

Copyright

Quite ofte in the form of software

On rare occasions:

Other less tangible IP

- Trademarks
- Know how

Deals include:

- Licenses
- Signing rights over to companies
- Collaboration agreements

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So, you are building a business based on an idea?

- 80 % of new knowledge is published as patent applications (epo.org)
- Does the company you create solutions for have “Freedom to operate”?
- Is this idea so good that I should file a patent application?
- “But, we had an NDA!!!”

What is IPR?

SDU

What is Intellectual Property?

- Intellectual Property refers to creations of the mind: inventions
- literary and artistic works
- symbols, names and images used in commerce

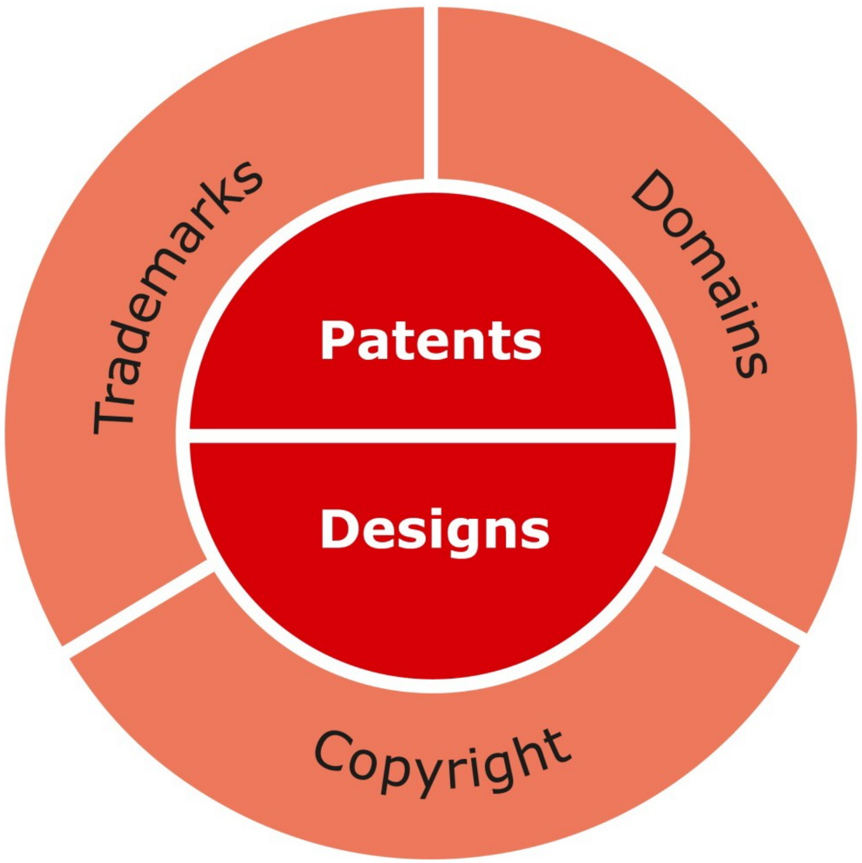
Why promote and protect Intellectual Property?

1. The progress and well-being of humanity rest on its capacity to create and invent new works in the areas of technology and culture.
2. The legal protection of new creations encourages the commitment of additional resources for further innovation.
3. The promotion and protection of intellectual property spurs economic growth, creates new jobs and industries, and enhances the quality and enjoyment of life.

Source: WIPO, World Intellectual Property Organization, wipo.int

What is IPR

The Danfoss Intellectual Property Wheel



Product-oriented rights

The hub is the product with functional features (patent) and visual features (design)

Supporting rights

The rim is supporting rights. E.g. brand, texts, others

Source: Presentation on IP from Danfoss, 2015

SDU

What is an invention?

An invention is a technical solution to a problem which is both novel and have inventive step

"An invention is a unique or novel device, method, composition or process. […] It may be an improvement upon a machine or product or a new process for creating an object or a result. An invention that achieves a completely unique function or result may be a radical breakthrough. Such works are novel and not obvious to others skilled in the same field."

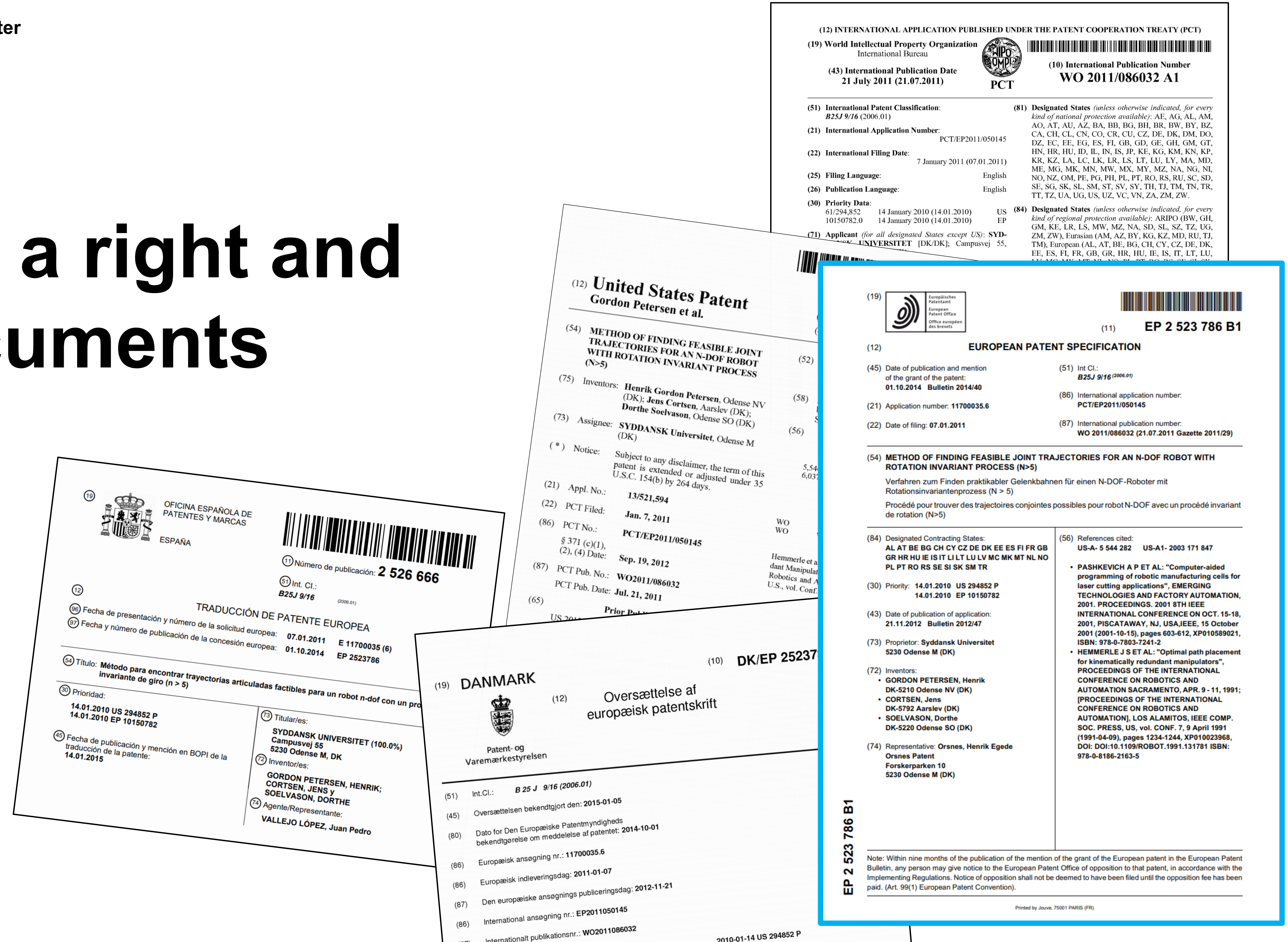
"Some inventions can be patented. The system of patents was established to encourage inventors by granting limited-term, limited monopoly on inventions determined to be sufficiently novel, non-obvious, and useful."

Source: https://en.wikipedia.org/wiki/Invention

What is a patent?

Technical solution to a Technical problem

It is a right and documents



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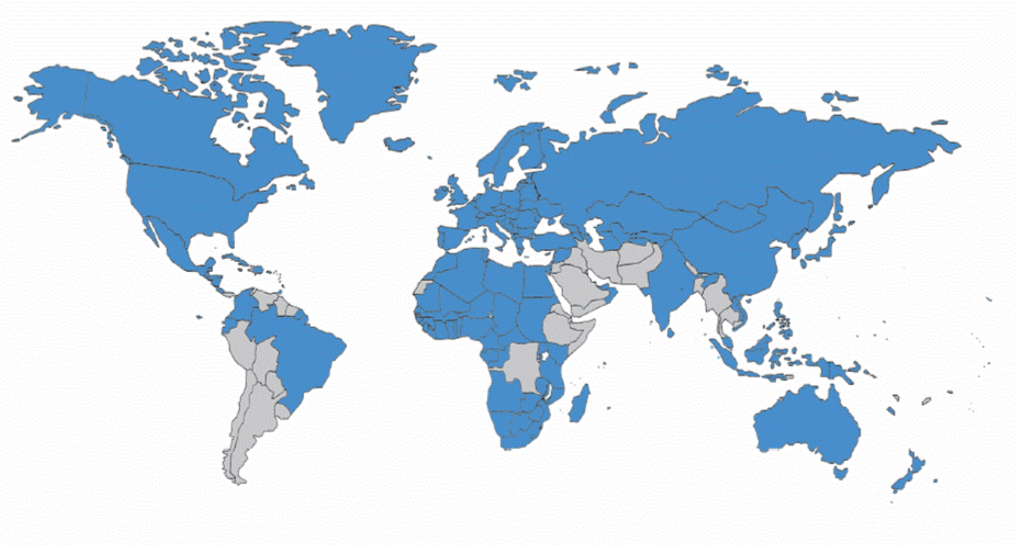
October 2020

The right

For a given *territory*
20 years

A patent is a legal title granting its proprietor the right to prevent third parties from commercially using an invention without authorisation.

An invention is usually a product or a process.

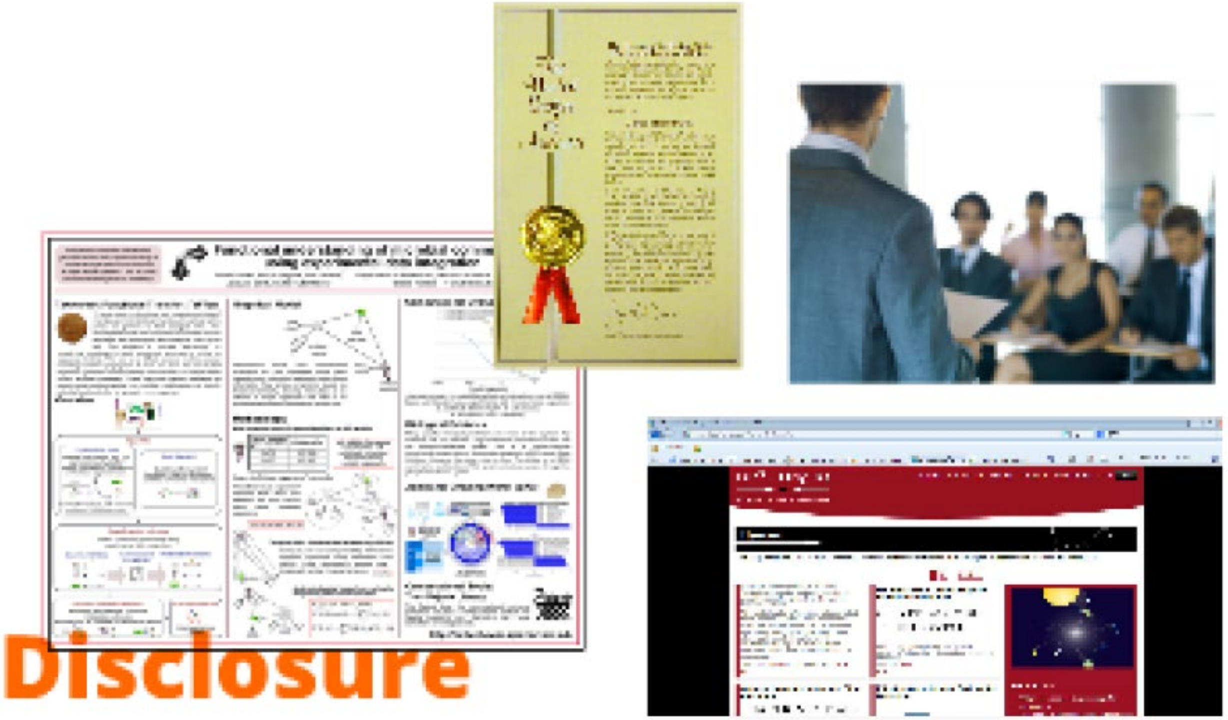


A patentable invention must be:

New

- Over other patents
- Articles
- News papers (anywhere!)
- Donald Duck Catons, etc..

A PATENTABLE INNOVATION
NOVELTY



Summary:
Invention disclosure is ANY form of communication about the details (technology and especially the inventive step) of your invention, which is done in public, or in any publicly available media.

A patentable invention must be:

New

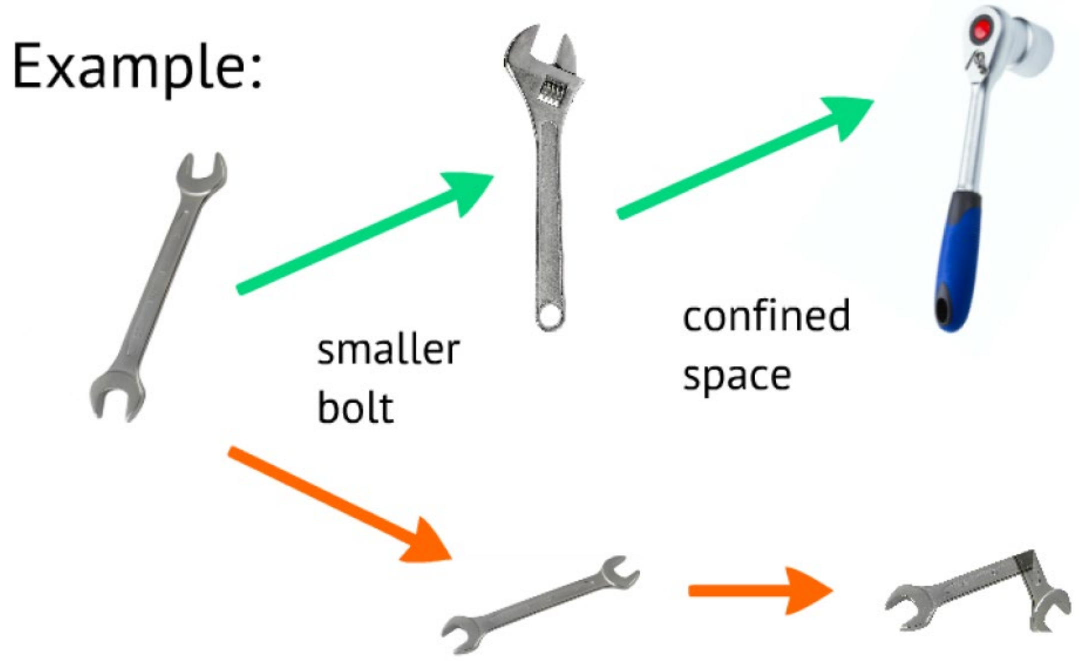
- Over other patents
- Articles
- News papers (anywhere!)
- Donald Duck Catons, etc..

Inventive step

- Surprising to expert in the field of art.

A PATENTABLE INNOVATION
INVENTIVE STEP

Inventive step (EU) or non-obviousness (USA)



Summary: the criteria of non-obviousness means that given the same problem and the same training, a peer should not be able to immediately come up with the same solution

A patentable invention must be:

New

- Over other patents
- Articles
- News papers (anywhere!)
- Donald Duck Catons, etc..

Inventive step

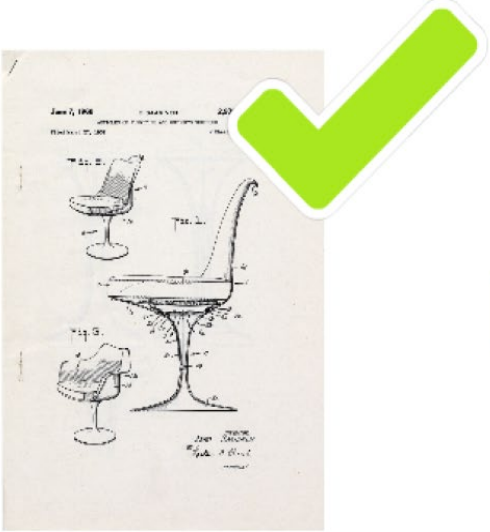
- Surprising to expert in the field of art.

AND: have an Industrial application

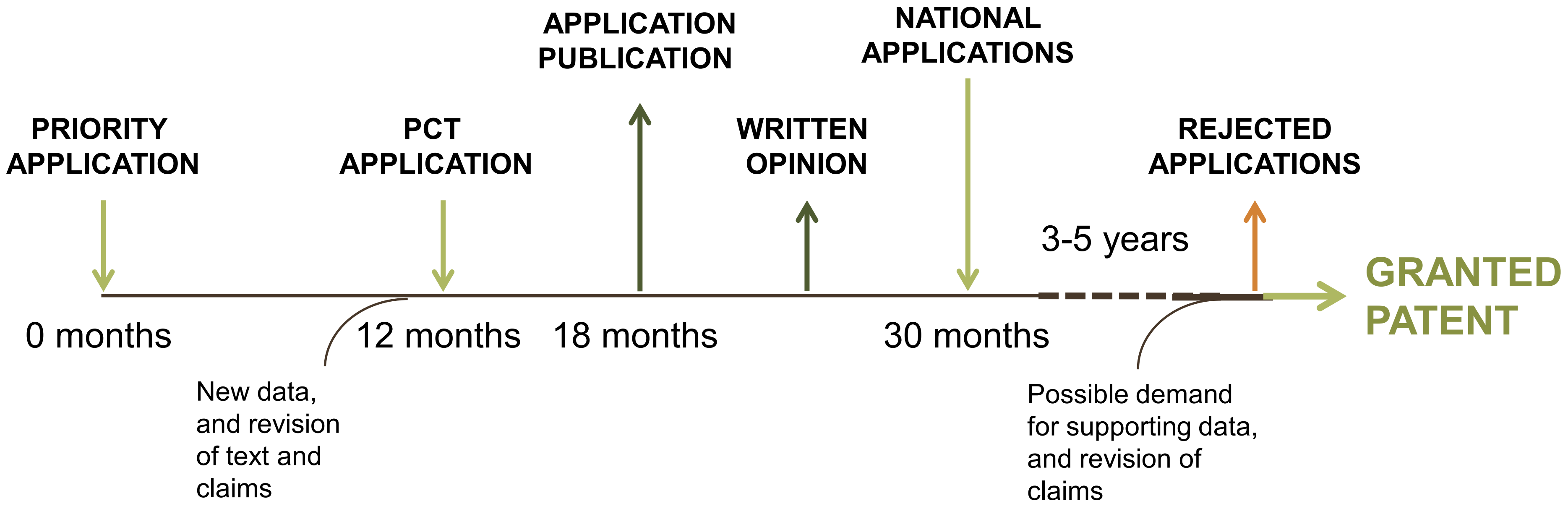
A PATENTABLE INNOVATION
INDUSTRIAL APPLICATION

What does that mean?:

- ✓ It can be reproduced by others
- ✓ It can be produced, marketed and sold
- ✓ It meets a specific unmet need in society



IP PROTECTION PROCESS



- Note that upon entering national phase the process branches out with one branch per country

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PATENT PROTECTION COSTS

Example of patent costs and timing

- US patent only
- No complications

IP Cost description	DKK	In Year
Patent assessment cost	kr. 15.000	-0,3
Priority application cost	kr. 60.000	0,0
PCT application cost	kr. 50.000	1,0
WO/ISR	kr. 45.000	1,3
National application	kr. 20.000	2,5
Patent prosecution	kr. 40.000	3,3
Maintenance fee	kr. 10.960	3,5
Maintenance fee	kr. 24.660	7,5
Maintenance fee	kr. 50.690	11,5
Total	kr. 310.096	20,0

How to find patent?

- Google “drone” does not work, but may get you started
- Classification and Synonyms

- Databases:
  - https://patents.google.com/
  - https://worldwide.espacenet.com/patent/cpc-browser
  - https://worldwide.espacenet.com/patent/search

- Patent advisors are expensive specialists

Good sources of information

IP in general

World Intellectual Property Organization, WIPO: http://www.wipo.int/portal/en/index.html

European Patent Organization, EPO: http://www.epo.org/

National Patent and Trademark Offices, e.g. DKPTO: http://www.dkpto.dk/

US Patent and Trademark Office: http://www.uspto.gov/

Patents

Google

Espacenet (European Patent Office patent search site): http://www.epo.org/searching/free/espacenet.html?hp=stages

Google patents: https://www.google.dk/?tbm=pts&gws_rd=cr,ssl&ei=pYgjVYabloaVsAGuhISQDQ

US patents (USPTO patent search site): http://www.uspto.gov/patents-application-process/search-patents

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An annoying patent

Invention:

A wheel that will lock itself, if a shopping cart is removed from the store carpark area

Existing patent:

US20080074260A1

NAVIGATION SYSTEMS FOR WHEELED CARTS

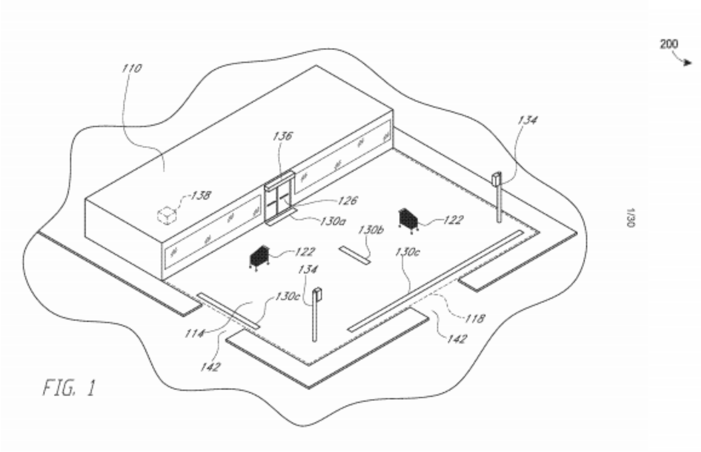


FIG. 1

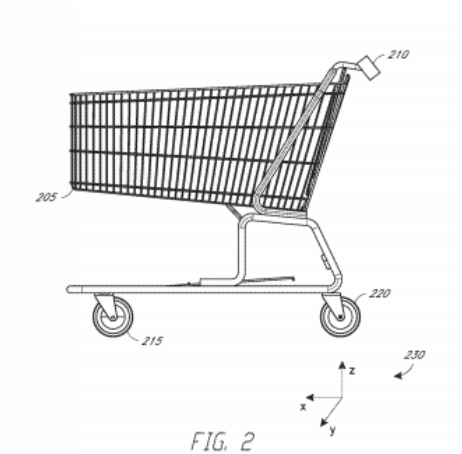


FIG. 2

Source:
https://patentimages.storage.googleapis.com/2e/4a/66/2459ccc580b4f1/WO2018165178A1.pdf

"keeping with the invention, processor/controller assembly 126 may comprise any suitable device for generating the aforementioned trigger and reset signals upon detection of corresponding user attempts to breach a designated use area and appropriate corrective action, respectively.

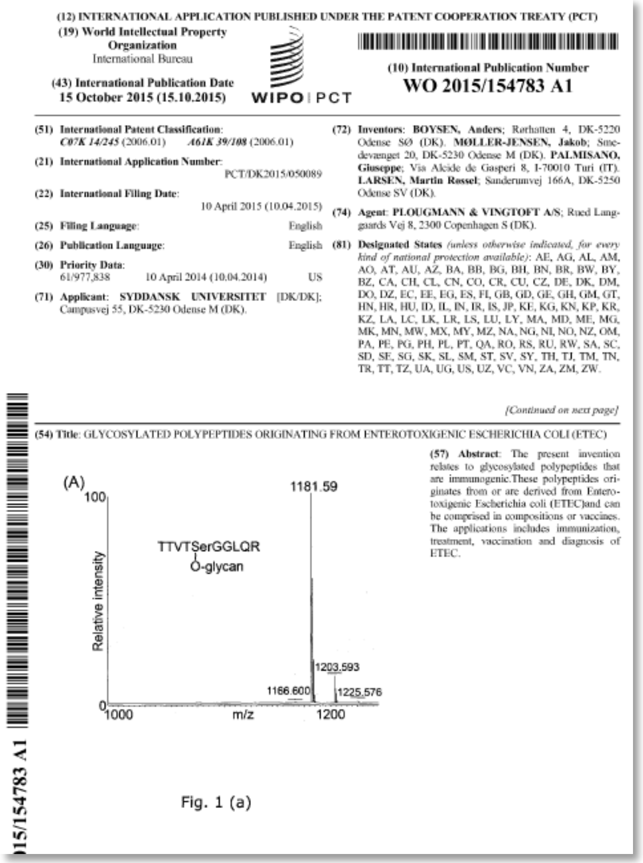
*For example, processor/controller assembly 126 may comprise an **infrared receiver** operative to receive signals from one or more infrared transmitters affixed in proximity to an exit area, a buried transmitter, etc. Similarly, processor/controller assembly 126 may comprise a **magnetic field sensor** operative to detect a magnetic field generated by a similarly positioned device or buried cable. Still further, processor/controller assembly 126 may comprise a **Radio Frequency Identification (RFID)** system such as a passive or active RFID tag or transponder in communication with one or more tag readers, edge servers, middleware and/or application software. Processor/controller assembly 126 may further comprise **Global Positioning System (GPS)** devices or components operative to determine the exact position of vehicle 10 or position relative to a reference point inside or outside the designated use are. Still further, assembly 26 may comprise **one or more devices for detecting a specific change in the direction of travel of the vehicle or a specific distance traveled in the activated mode (and thus an estimated change in direction of travel) for example, by counting wheel rotations.***

Each of the aforementioned systems (infrared transmitters/receivers, magnetic field sensors/transmitters, RFID tags/transmitters, GPS systems, gyroscopes, wheel rotation counting mechanisms, etc. are well know in the art and, accordingly, need not be discussed in detail."

THE PATENT (APPLICATION)

- Bibliographic data
- Abstract
- Description
- Claims
- Drawings

Often > 50 pages



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 October 2015 (15.10.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/154783 A1

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C07K 14/245 (2006.01) *A61K 39/108* (2006.01)

(21) International Application Number: PCT/DK2015/050089

(22) International Filing Date: 10 April 2015 (10.04.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/977,838 10 April 2014 (10.04.2014) US

(71) Applicant: **SYDDANSK UNIVERSITET** [DK/DK]; Campusvej 55, DK-5230 Odense M (DK).

(72) Inventors: **BOYSEN, Anders**; Rørhatten 4, DK-5220 Odense SØ (DK). **MØLLER-JENSEN, Jakob**; Smedevænget 20, DK-5230 Odense M (DK). **PALMISANO, Giuseppe**; Via Alcide de Gasperi 8, I-70010 Turi (IT). **LARSEN, Martin Røssel**; Sanderumvej 166A, DK-5250 Odense SV (DK).

(74) Agent: **PLOUGMANN & VINGTOFT A/S**; Rued Langgaards Vej 8, 2300 Copenhagen S (DK).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) Title: GLYCOSYLATED POLYPEPTIDES ORIGINATING FROM ENTEROTOXIGENIC ESCHERICHIA COLI (ETEC)

(57) Abstract: The present invention relates to glycosylated polypeptides that are immunogenic.These polypeptides originates from or are derived from Enterotoxigenic Escherichia coli (ETEC)and can be comprised in compositions or vaccines. The applications includes immunization, treatment, vaccination and diagnosis of ETEC.

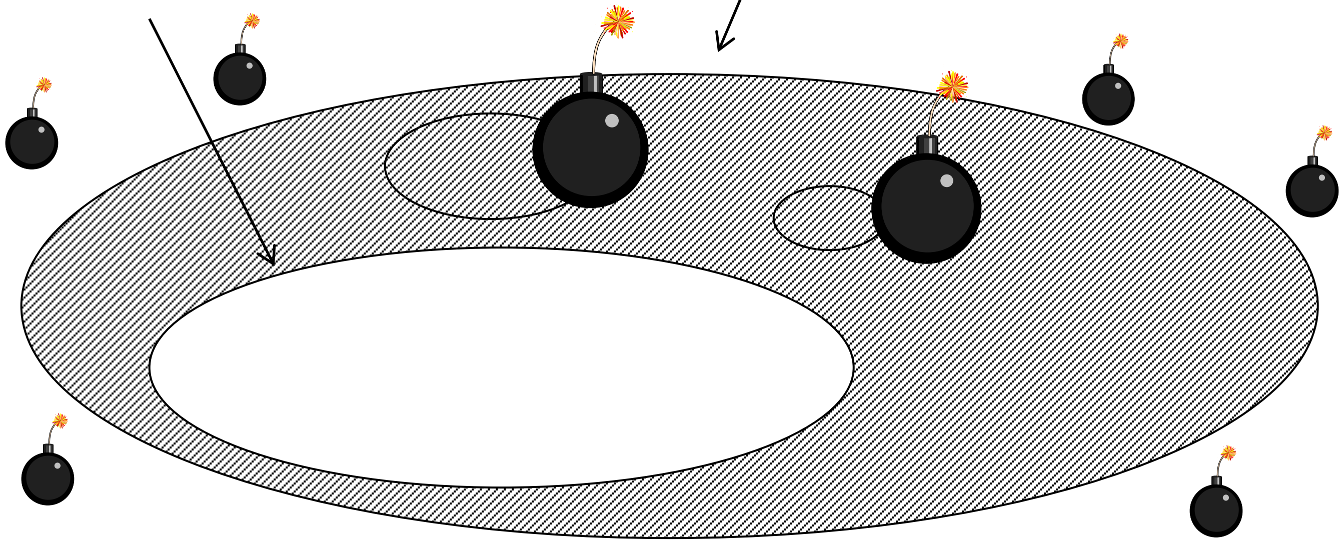
Fig. 1 (a)

WO 2015/154783 A1

CLAIMS
(THE VALUE OF THE PATENT)

- Clear and concise description of the matter for which protection is sought
- Independent claims. These must contain a ”prior art” part and a ”characterizing portion”
  - Main aspects
- Dependent claims ”fold” out the invention to more an more specific descriptions
  - Sub-aspects
  - Embodiments

CLAIMS
(A NEGOTIATION)



H-8 as example

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Who is the inventor?

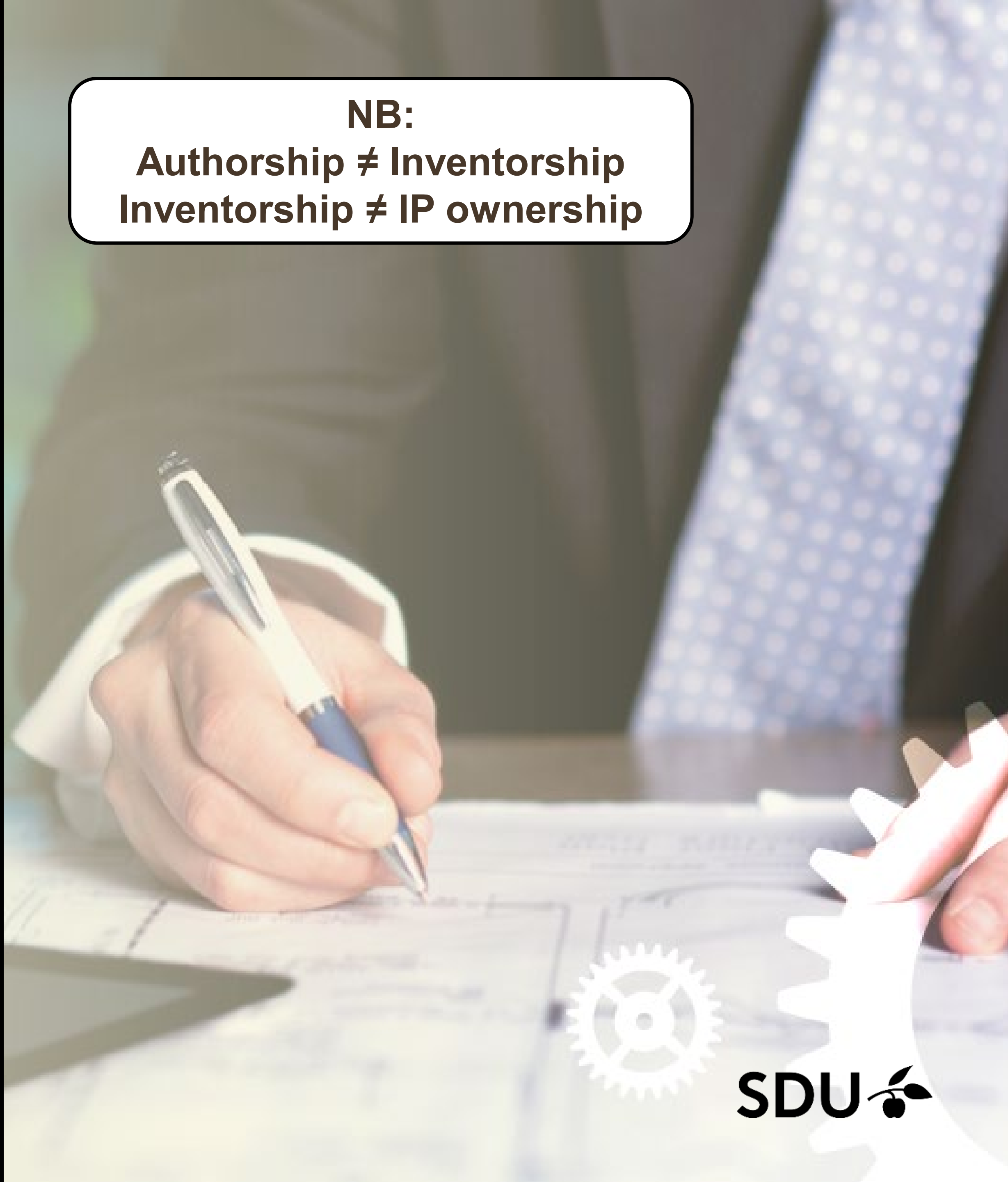
*"Bringing an invention to physical fruition is **"reduction to practice."** It can be "actual" or "constructive." Actual reduction to practice occurs when an inventor or someone working under the inventor's authority*

(1) constructs an embodiment or performs a process that meets all of the limitations of the claim; and

(2) determines that the invention works for its intended purpose. Constructive reduction to practice occurs when a patent application directed to the invention is filed.

*Reduction to practice, without more, is not enough to establish an inventive role **[…]** However, if during reduction to practice, a person (i) encounters a problem that requires more than ordinary skill to overcome; (ii) comes up with a defined way to resolve that problem; and (iii) that specific defined resolution is reflected in a claim, then that person could also be an inventor."*

Source: https://www.mintz.com/insights-center/viewpoints/2231/2017-03-30-five-things-academic-scientists-should-know-when



How to plan?

Consider the timing carefully

You need to factor in:

1. **Time to market**
2. **Cashflow**
3. **Need for investors**

And remember:

PLANS ARE MADE TO BE CHANGED!!!

- **What is the idea?**
- **What makes it unique?**
- **Does it have anything protectable?**
  - Software
  - Patentable idea
  - Database / AI / qualified data
  - Know how
- **What is your (current) business model?**
  - Customers
  - Sales channels
  - Capital need
  - Investors
- **What kind of protection would be useful?**
- **How should the timing be?**

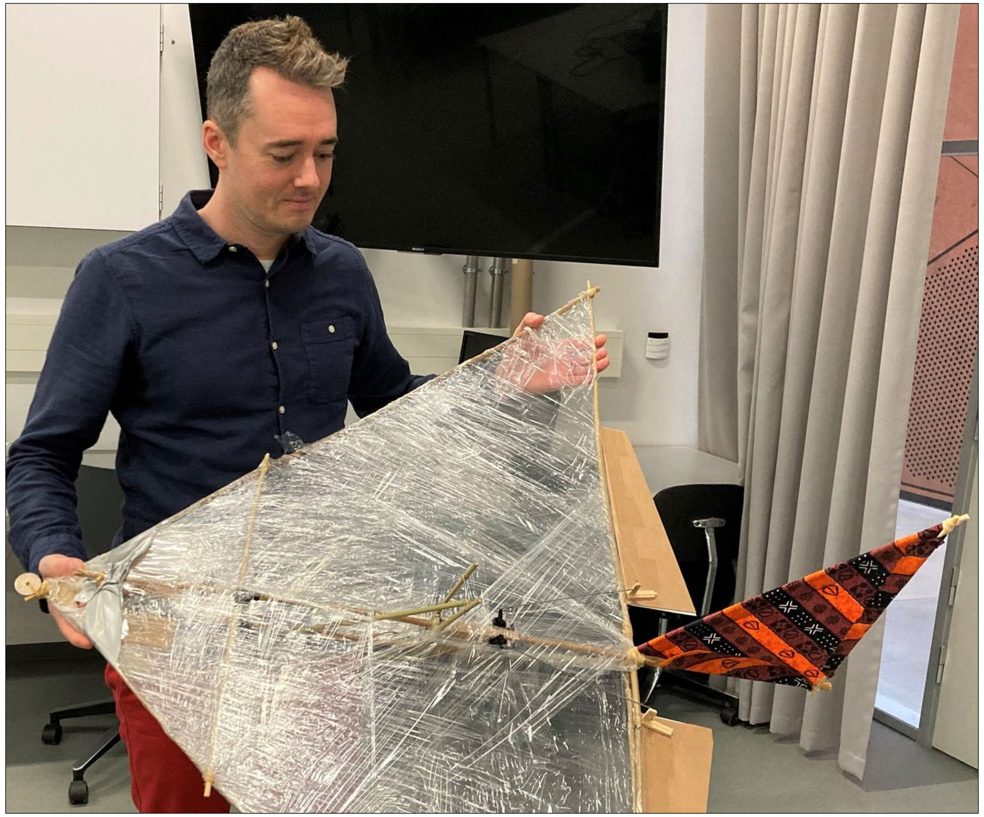
Questions?

Case specific is quite okay

Scientific Methods

Ethics & Engineering

Fall 2022



Dylan Cawthorne

PhD, MSc, BSME

University of Southern Denmark

Unmanned Aerial Systems Center

dyca@sdu.dk

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Who am I?

'FLOURISHING THROUGH ETHICS AND TECHNOLOGY'

My name is Dylan Cawthorne, and I am an Associate Professor at the Drone Center at the University of Southern Denmark in Odense. My personal mission statement is to support the "flourishing of humans and other life on the planet forever" (Ehrenfeld, 2009). I do so using the tools available to me, including ethics, technology, art, and craft. I see myself as a champion for the use of ethics and human values in engineering, and as an activist engineer, and received the honor of winning the 2021 Inspiration Prize from my colleagues at the university. My main area of research is using value sensitive design methods and ethical principles to design and build prototype drones. These drones are used in humanitarian and public healthcare contexts in Denmark and abroad. I am interested in utilizing art, craft, and creativity to enhance engineering (and engineering to enhance art!) A common theme in my work is the support of de-centralized technologies and democratic, grassroots organizations and methods. You can read more about my background at this link, see an overview of my projects below, and read about my future work at the bottom of this page.

-Dylan

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Engineering is not ethically neutral

Abstract A core issue in the philosophy of technology has been the non-neutrality of technology. Most scholars in the field agree that technologies actively help to shape culture and society, rather than being neutral means for realizing human ends. How to take seriously this non-neutrality of technology in ethics? Engineering ethics mainly focuses on the moral decisions and responsibilities of designers, and remains too external to the moral significance of technologies themselves. Yet, analyses of the non-neutrality of technology make it plausible to ascribe some morality to artifacts. First of all, technologies substantially contribute to the coming about of actions and of decisions about how to act. Second, their role cannot be entirely reduced to the intentions behind their design and use. This paper investigates what these observations imply for ethical theory, and for the ethics of design.

Verbeek, Peter-Paul. "Design ethics and the morality of technological artifacts." *Vermaas, PE and alii (eds) Philosophy and Design: From Engineering to Architecture* (2007).

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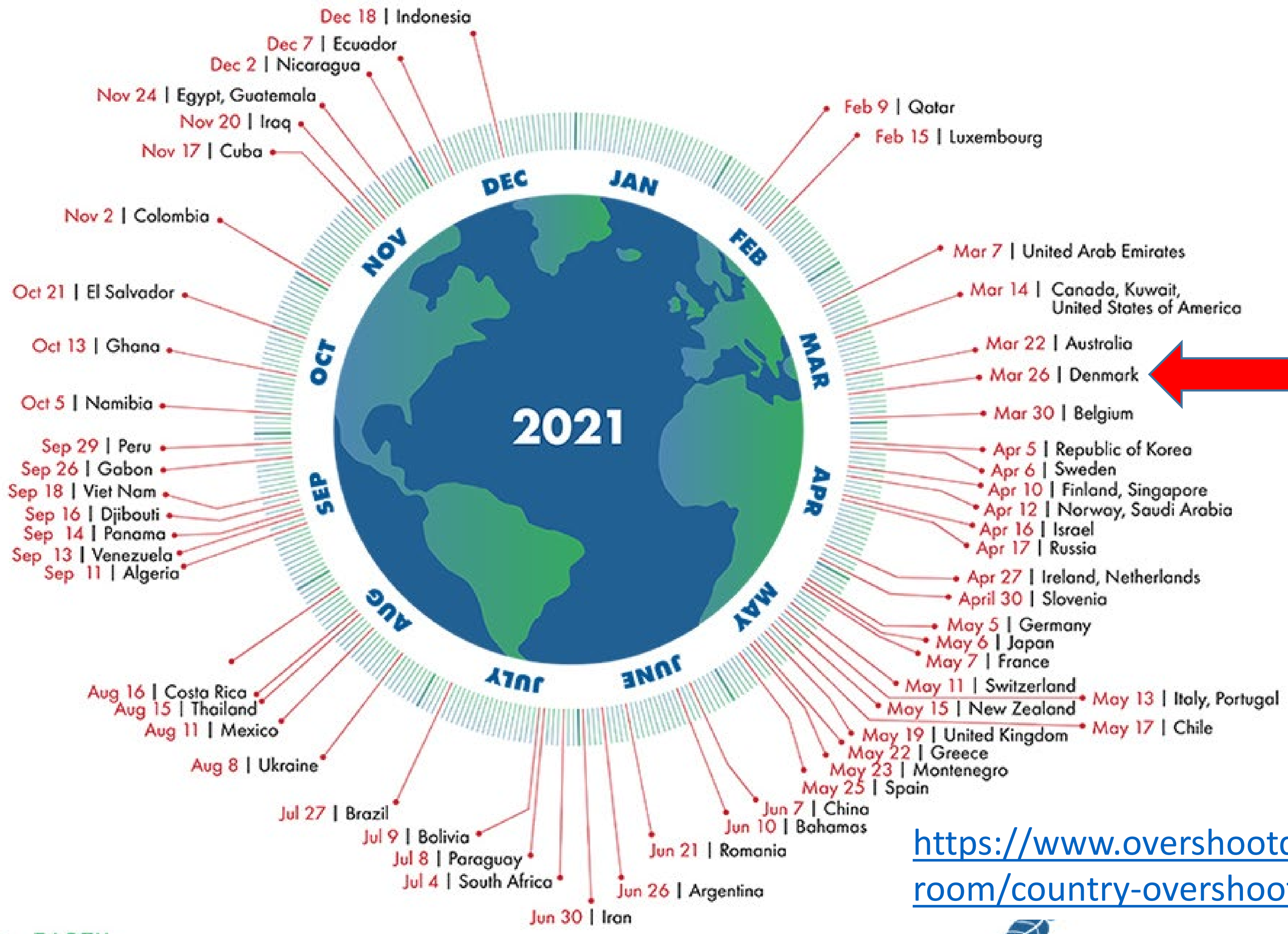
Engineering and the environment



https://www.overshootday.org/newsroom/country-overshoot-days/

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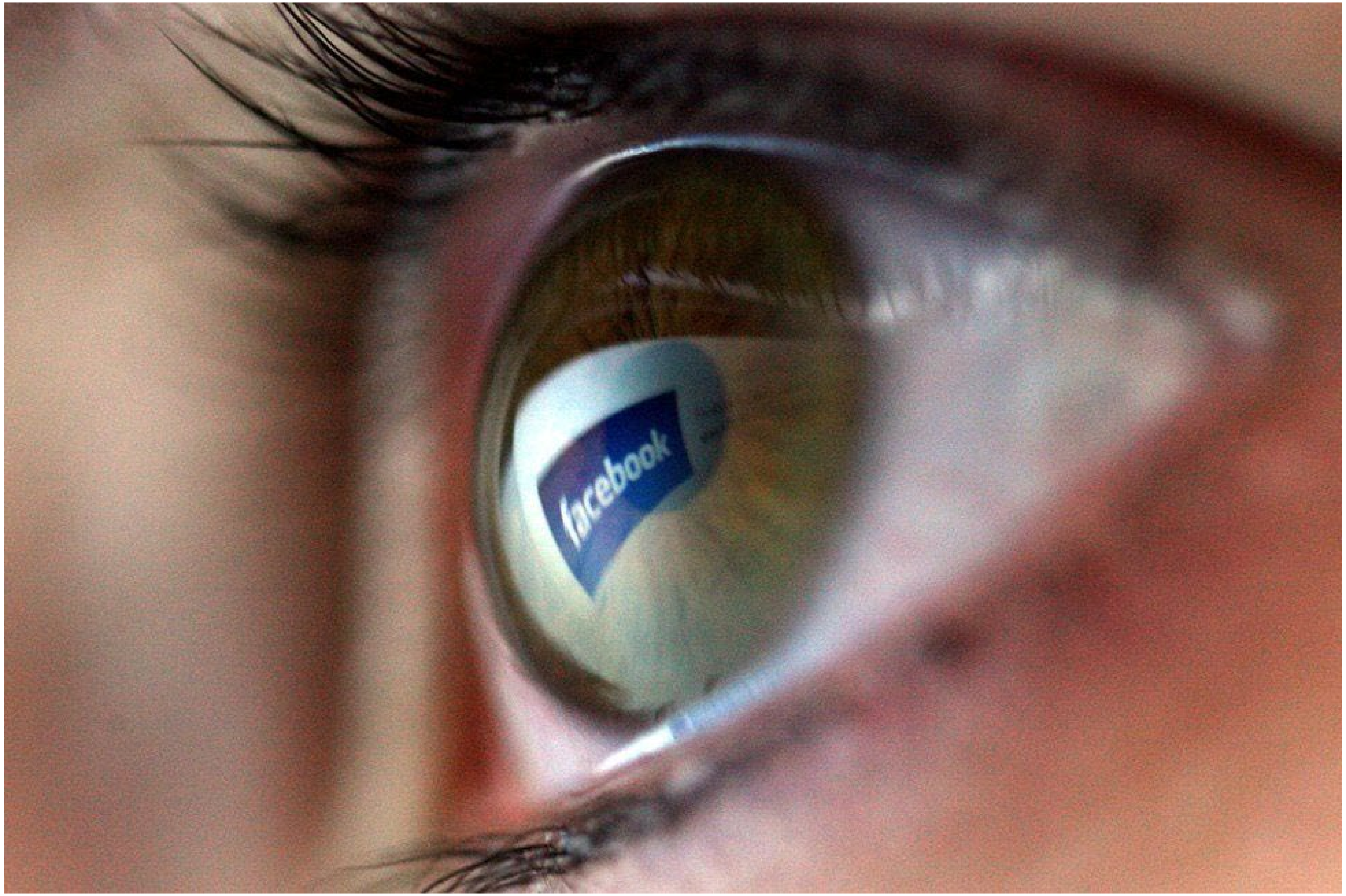
Engineering and democracy



"Christopher Wylie, who worked with Cambridge Analytica, alleges that because 270,000 people took the quiz, the data of some 50 million users, mainly in the US, was harvested without their explicit consent via their friend networks.

Mr Wylie claims the data was sold to Cambridge Analytica, which then used it to psychologically profile people and deliver pro-Trump material to them."

https://www.bbc.com/news/technology-43465968

Engineering and privacy

SECURITY

TikTok a privacy threat? Sure, but so are most of your smartphone apps

Analysis: The reality of TikTok's threat is far more mundane and not particularly unique, experts say.

https://www.nbcnews.com/tech/security/tiktok-privacy-threat-sure-so-are-most-your-smartphone-apps-n1233625

"The Federal Trade Commission (FTC) in the United States began to investigate Musical.ly before the merger as they received thousands of complaints from parents concerned about the data their children were sharing via the app. The app asked all users to provide a name, profile picture, email address, and phone number, without requiring underage users to get parental consent before sharing this data. "

https://www.avira.com/en/blog/privacy-and-security-concerns-surrounding-tiktok

Engineering and work

47% of jobs in the United States are at risk of being automated

C. B. Frey and M. A. Osborne, “The future of employment: How susceptible are jobs to computerisation?” Technological forecasting and social change, vol. 114, pp. 254–280, 2017.

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Engineering and violence

Just what the world needs: budget-friendly kamikaze drones

AK-47 maker Kalashnikov wants to sell the device to 'smaller armies.'

K. Holt
@krisholt
February 26th, 2019

In this article: drone, gear, kalashnikov, kamikaze drone, robots, security, suicide drone, transportation, weaponized

Kalashnikov

https://www.engadget.com/2019-02-26-kalashnikov-kamikaze-drone.html

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Engineering is not ethically neutral

"Guns kill people."

"Guns don't kill people. People kill people."

Verbeek, Peter-Paul. "Design ethics and the morality of technological artifacts." *Vermaas, PE and alii (eds) Philosophy and Design: From Engineering to Architecture* (2007).

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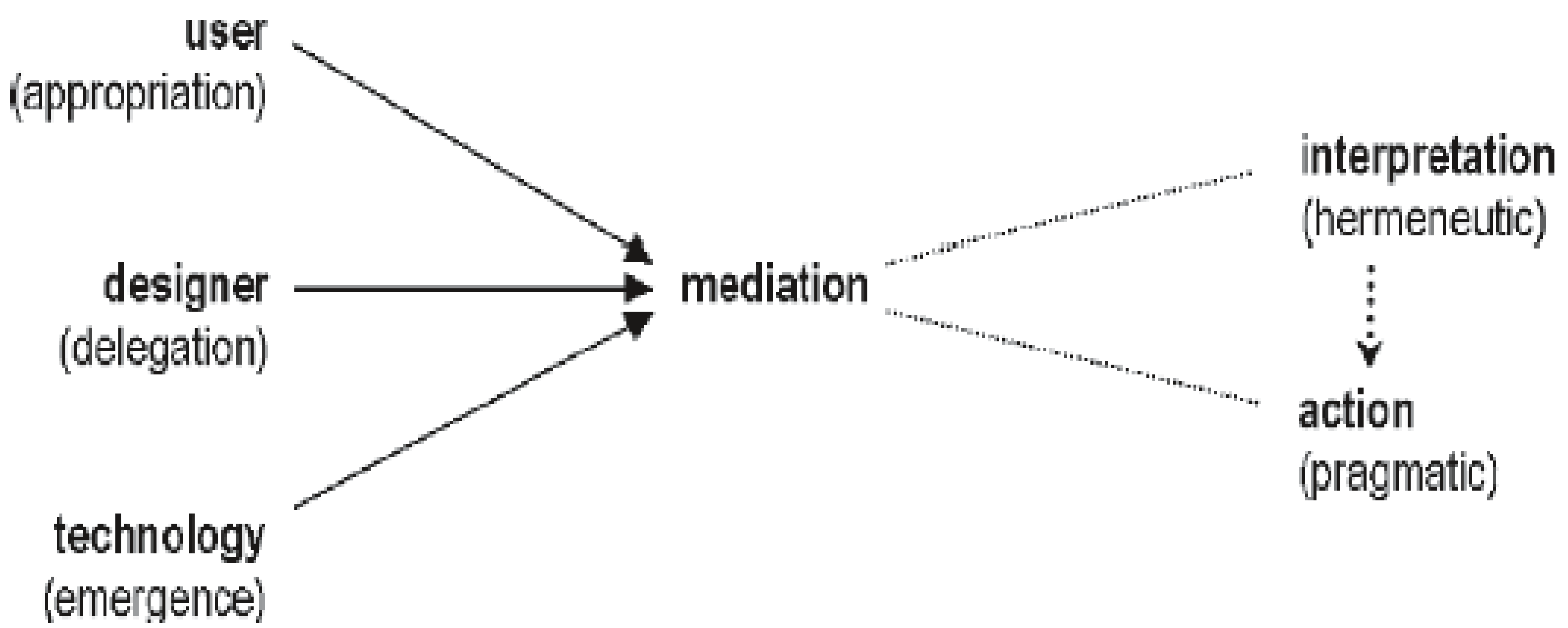
Engineering is not ethically neutral



Verbeek, Peter-Paul. "Design ethics and the morality of technological artifacts." *Vermaas, PE and alii (eds) Philosophy and Design: From Engineering to Architecture* (2007).

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In-class exercise

As engineers, what is our responsibility for the technologies we develop?

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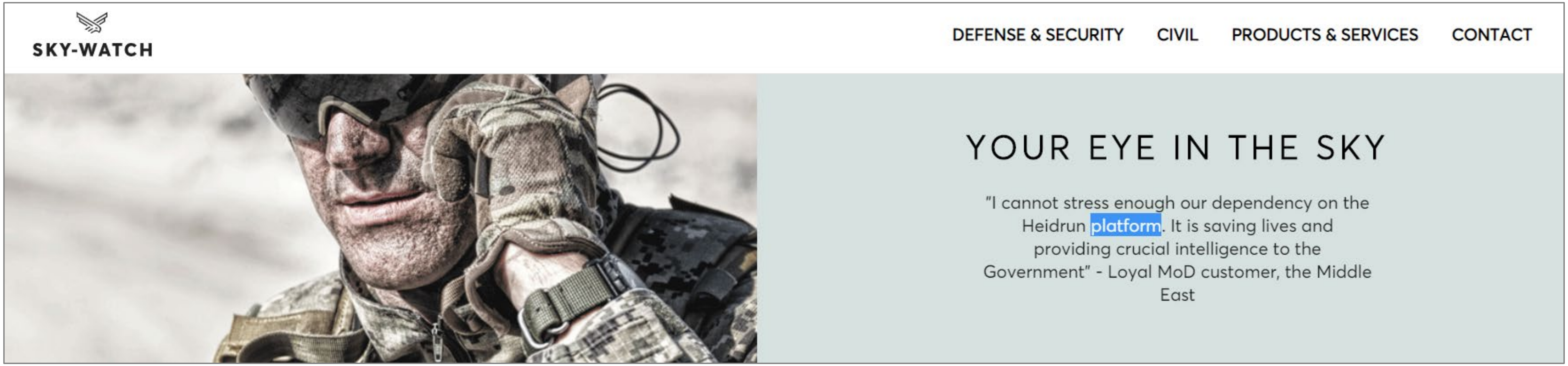
Technology as a “platform”

YouTube

Gillespie, Tarleton. "The politics of ‘platforms’." *New media & society* 12.3 (2010): 347-364.



Cawthorne, Dylan, and Arne Devos. “Capability caution in UAV design”. *2020 International Conference on Unmanned Aircraft Systems (ICUAS)*. IEEE, 2020.

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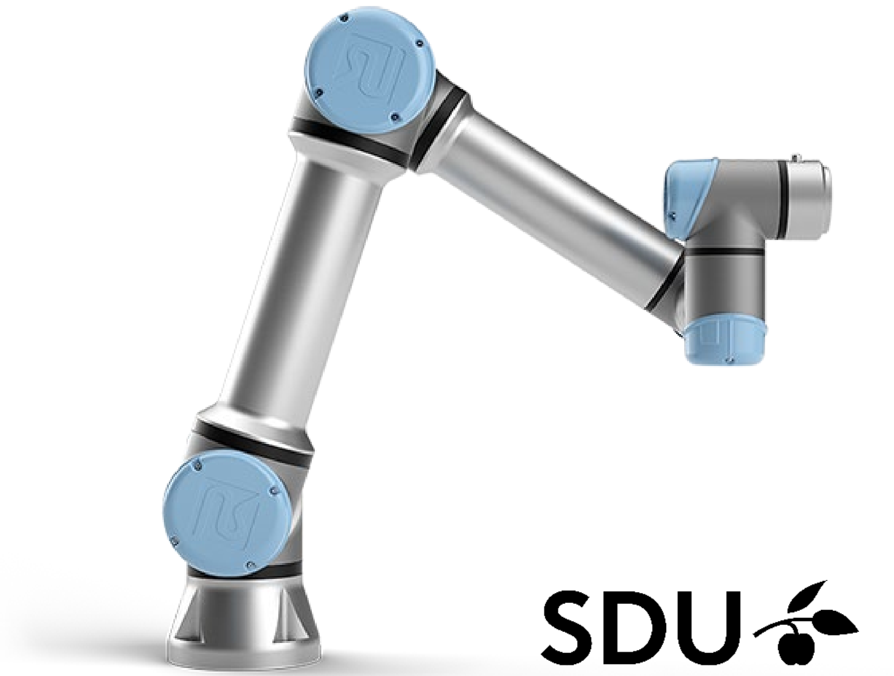
Technology does not "just happen"

- Multiple possible futures VS technological determinism



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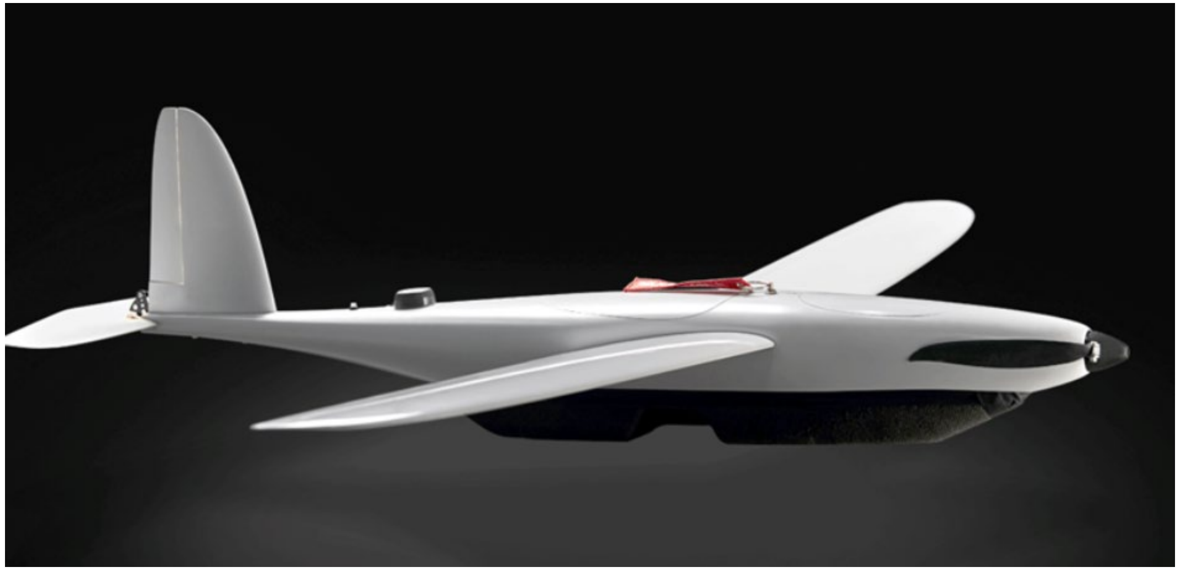
Dual-use technology

- Civil VS military
- Good VS bad



Cawthorne, Dylan, and Arne Devos. "Capability caution in UAV design". *2020 International Conference on Unmanned Aircraft Systems (ICUAS)*. IEEE, 2020.

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Now what?

- Given that ethics is relevant to engineering, what do we do about it?

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Methods – world view

- Positivism
  - There is one, objective reality
  - Value-free research
  - Researcher must be independent and objective
- Constructivism
  - Reality interpreted differently by different people
  - Research cannot be value-free
  - Researcher must accept they are not fully objective
- Pragmatism
  - Puts focus on the research problem
  - Not committed to any one system of reality

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Methods – research approach

1. Quantitative
   - Results expressed in numbers
2. Qualitative
   - Results expressed in words
3. Mixed methods
   - Combination of numbers and words

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Methods – research design

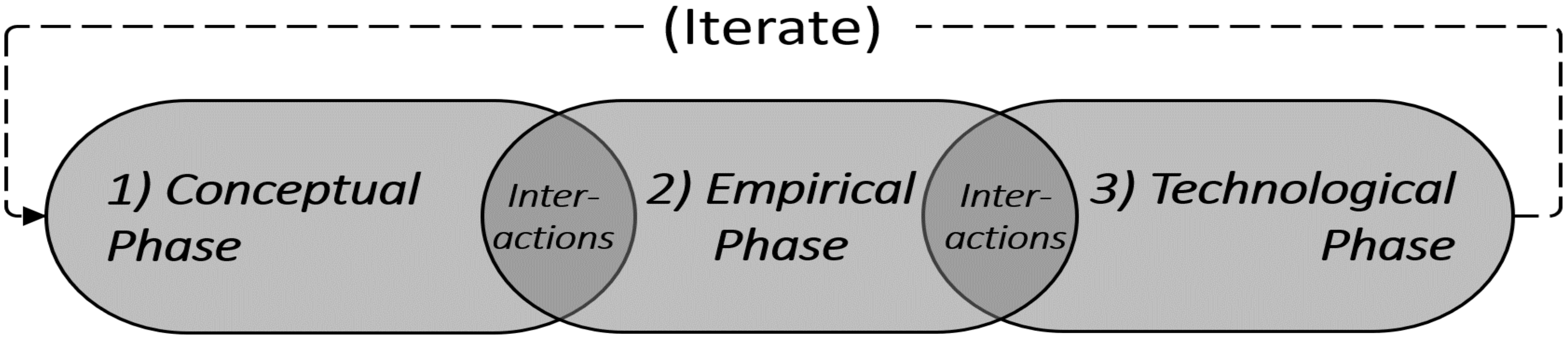
1. Deduction
2. Abduction
3. Induction

Three main normative ethical theories

1. Consequentialism – the result (consequence) of actions matter
   - Guide actions
   - Includes utilitarianism – the most "good" for the most people/lifeforms
2. Deontology – rule-based
   - Guide actions
3. Virtue ethics – focus on virtues/moral character
   - Guide the type of person one should be/become

References:
https://plato.stanford.edu/entries/consequentialism/
https://plato.stanford.edu/entries/ethics-deontological/
https://plato.stanford.edu/entries/ethics-virtue/

Value sensitive design: holistic and interdisciplinary



1) Conceptual phase: Relevant human values are identified and an ethical analysis can take place. Stakeholders engaged.

2) Empirical phase: Social impacts of the technology are taken into account.

3) Technological phase: Technical capabilities are explored, specifically, those which support the chosen human values/social impacts.

Graphic by the authors, based on:

Batya Friedman, Peter H Kahn, Alan Borning, and Alina Huldtgren. Value sensitive design and information systems. In Early engagement and new technologies: Opening up the laboratory, pages 55–95. Springer, 2013.

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Methodology: Human values relevant within technological design

Human welfare	Includes physical, material, and psychological well-being Physical well-being deals with bodily welfare, such as physical health Psychological welfare concerns mental health, such as stress Material welfare refers to physical circumstances, and is related to economics and employment
Ownership and property	The right to possess an object (or information)
Privacy	The ability to determine what information about one's self can be communicated to others
Freedom from bias	Systematic unfairness perpetrated on individuals or groups, including preexisting social bias, technical bias, and emergent social bias
Universal usability	Technology that can be successfully used by all people

Trust	The expectation to experience goodwill from others
Autonomy	The ability to decide, plan, and act in ways that allow one to achieve their goals
Informed consent	Garnering voluntary agreement, such as in the use of information systems
Accountability	Ensure that actions may be traced uniquely to the person, people, or institution responsible
Calmness	A peaceful and composed psychological state
Identity	The understanding of who one is over time, embracing both continuity and discontinuity over time
Environmental sustainability	Sustaining ecosystems such that they meet the needs of the present without compromising future generations

Graphic by the authors, based on:

Batya Friedman, Peter H Kahn, Alan Borning, and Alina Huldtgren. Value sensitive design and information systems. In Early engagement and new technologies: Opening up the laboratory, pages 55–95. Springer, 2013.

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Ethics standards, certifications

- IEEE P7000 Standard – “Process for Addressing Ethical Concerns During System Design“
- IEEE - “Ethics certification program for autonomous and intelligent systems“ (71)
- Foundation for Responsible Robotics - “Ethical quality mark”
- Self-regulation (such as in AI) - “Trust label”
- Self-regulation – “Privacy by design” etc.

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Recommendations - Design

- Problem first! Then "solution"
- Pro-active design to minimize negative impacts of tech
  - Protect human welfare, safety, privacy, jobs etc.

Cawthorne, Dylan, and Arne Devos. "Capability caution in UAV design". *2020 International Conference on Unmanned Aircraft Systems (ICUAS)*. IEEE, 2020.

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Recommendations - Design

- Unique technologies for each context of use
  - VS generic/universal products

Image source

Cawthorne, Dylan, and Arne Devos. "Capability caution in UAV design". *2020 International Conference on Unmanned Aircraft Systems (ICUAS)*. IEEE, 2020.

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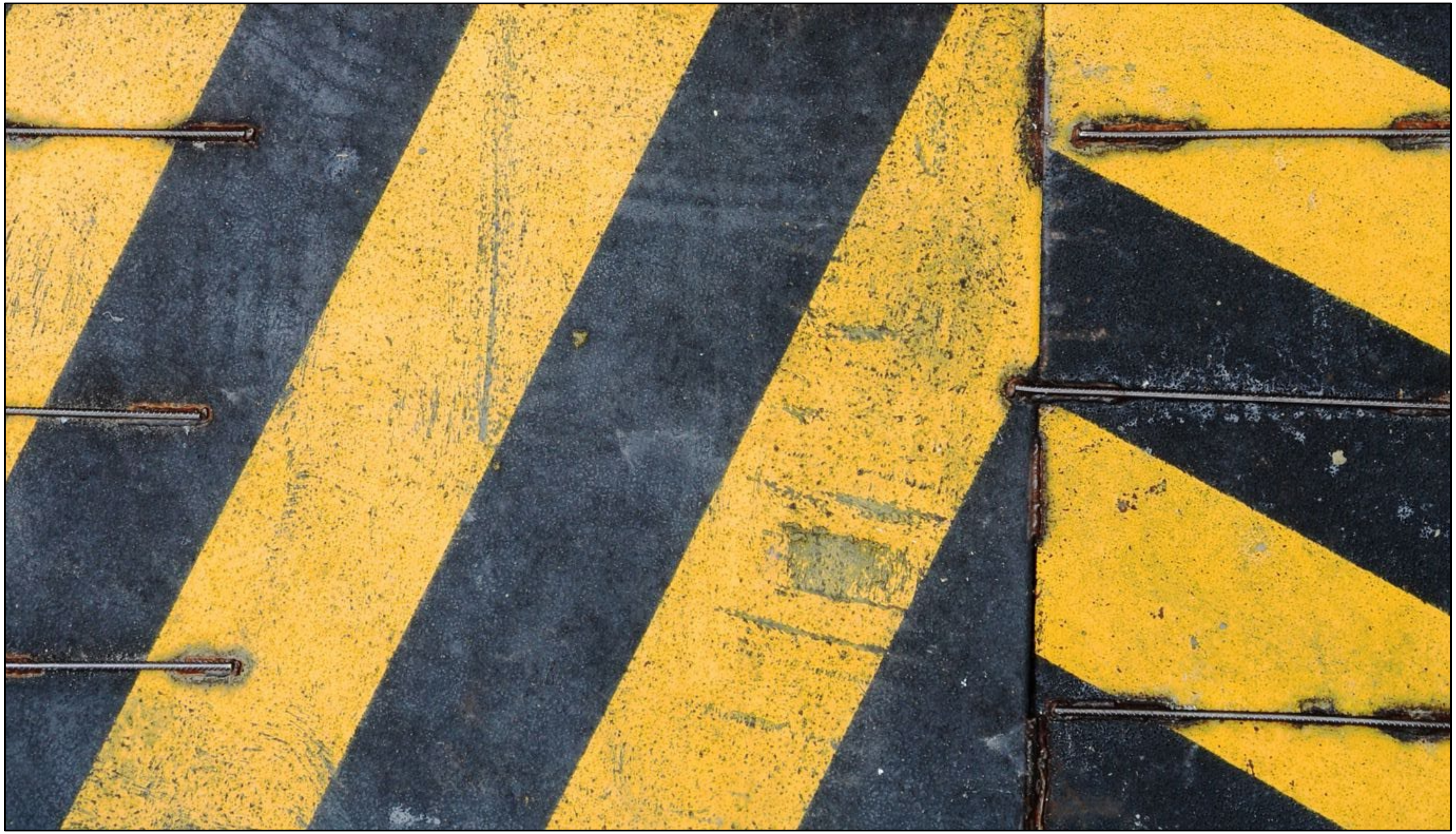
Ethics washing – the new greenwashing?



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Recommendations - responsibility

- *Engineers* should take more responsibility for the technology they develop
- *Companies* should self-regulate (VS “race to the bottom”)
- *Governments and policy makers* should reward responsible practices and restrict irresponsible practices
- *The public* should be actively involved in giving input to technology developers, governments, etc.

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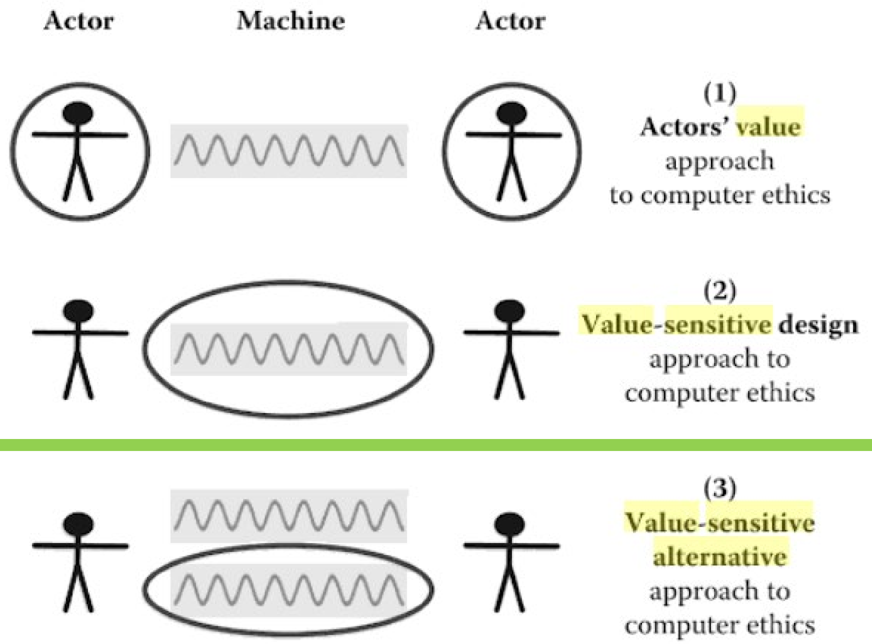
Value sensitive design alternative

- *We can always choose NOT to build a technology!*



=> Technology is fixed;
what is the impact on people?

=> Technology is variable;
design for ethical impact on people

=> Technology is not a given;
can chose *not* to develop it all together

Sarah Spiekermann. Ethical IT innovation: A value-based system design approach. CRC Press, 2015.

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Thanks to collaborators and supporters!

- The Danish taxpayers
- Aimee van Wynsberghe-Robbins
- Alessandra Cenci
- Marianne Harbo Frederiksen
- Arne Devos
- (And too many more to list!)

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