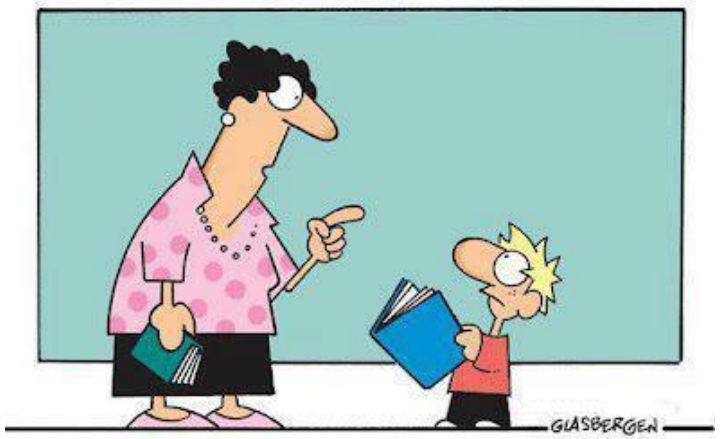
Scientific Method: Introduction and literature search

Oskar Palinko, Associate Professor, SDU Robotics



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

Autumn 2023

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/

About the course - activities

- Course activities
  - Weekly reading tasks
    - Each week one or more groups gets a reading task
    - Next week they report on it in the form of a 10min slide presentation
    - Discussion
  - Project in R on analyzing and reporting results
    - Henrik Skov Midtiby
  - Scientific Project
    - Plan, design, conduct, analyze, report on a scientific project
    - Must be robotics related
    - Write a 4-page paper about it
    - Present it at internal conference
    - New for this year: minimize effort by finding synergies with other projects on this semester
- Exam

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

About the course - exam

- Individual oral exam
- 7-point Danish grading scale
- Internal censor
- 15-20 min each
- Questions about project
- Questions about theory, classwork
- Prerequisite
  - Completed reading tasks
  - Completed R task
  - Completed scientific project

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

Learning objectives - knowledge

- Literature search and organizing the result
- Scientific methods used in different fields of research
- Hypothesis generation and testing
- How to choose and use statistical tests
- Real world applications

Learning objectives – skills and competences

- Independently find literature on a specific research topic.
- Begin to evaluate the scientific worth of a paper
- Generate alternative explanations for a set of results
- Propose a systematic approach for validating a research result by experimentation or by building simple prototypes.
- Understand why different branches of science use different methodologies.
- Understand the basics of some major methodologies.

- Be able to apply the correct methodology for their chosen topic

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Use of AI in class

- Always needs to be declared
- Should not be used for hand-ins as a general rule
  - Specific cases might be exempted upon previous approval by me
- We will explore using AI for SciMet topics – SDU policy

Expected practical outcomes

- Reviewing and presenting scientific work
  - Lectures 1-3
- Experiments
  - Setting up a hypothesis
  - Designing an experiment
  - Using proper statistics for data analysis
- Paper writing
  - Writing a scientific text over your scientific project

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Course outline

- **Literature**
  - Literature search
  - Scientific presentation
- **Experimental design**
  - Hypothesis and evidence
  - Descriptive and comparative statistics
  - Experimental design
- **Dissemination**
  - Avoiding plagiarism
  - Paper writing
- **Conference**
  - Your projects
- **Finalization**
  - Activity: project work

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Preliminary course schedule

Week	Date	Topic
W36	Sept 3	Intro to SciMet, Literature Search
W37	Sept 10	No class
W38	Sept 17	Scientific presentation
W39	Sept 24	Hypothesis and experimentation
W40	Oct 1	Basic and comparative statistics
W41	Oct 8	Experimental design
W42	Oct 16	Autumn break
W43	Oct 22	Paper writing and avoiding plagiarism
W44	Oct 29	Repeatable research using R - Henrik Skov Midtiby
W45	Nov 5	Patents, ethics, AI Guest presentation
W46	Nov 12	No classes – project work - consultations
W47	Nov 19	No classes – project work - consultations
W48	Nov 26	Conference (project presentations)
W49	Dec 4	Final project papers due

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Outline for today

- What is the Scientific Method
- Motivation for SCM
- Literature search
- Reading techniques
  - Case study: “Controlled Flight of a Biologically Inspired, Insect-Scale Robot”
- Citation metrics
- Activities
  - Make groups of 3 or 4 (**not < 3, not > 4**)
  - Think about an interesting topic for your project

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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**

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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 care about SciMet?

- I’m not going to become a scientist, but an engineer, why would I care?

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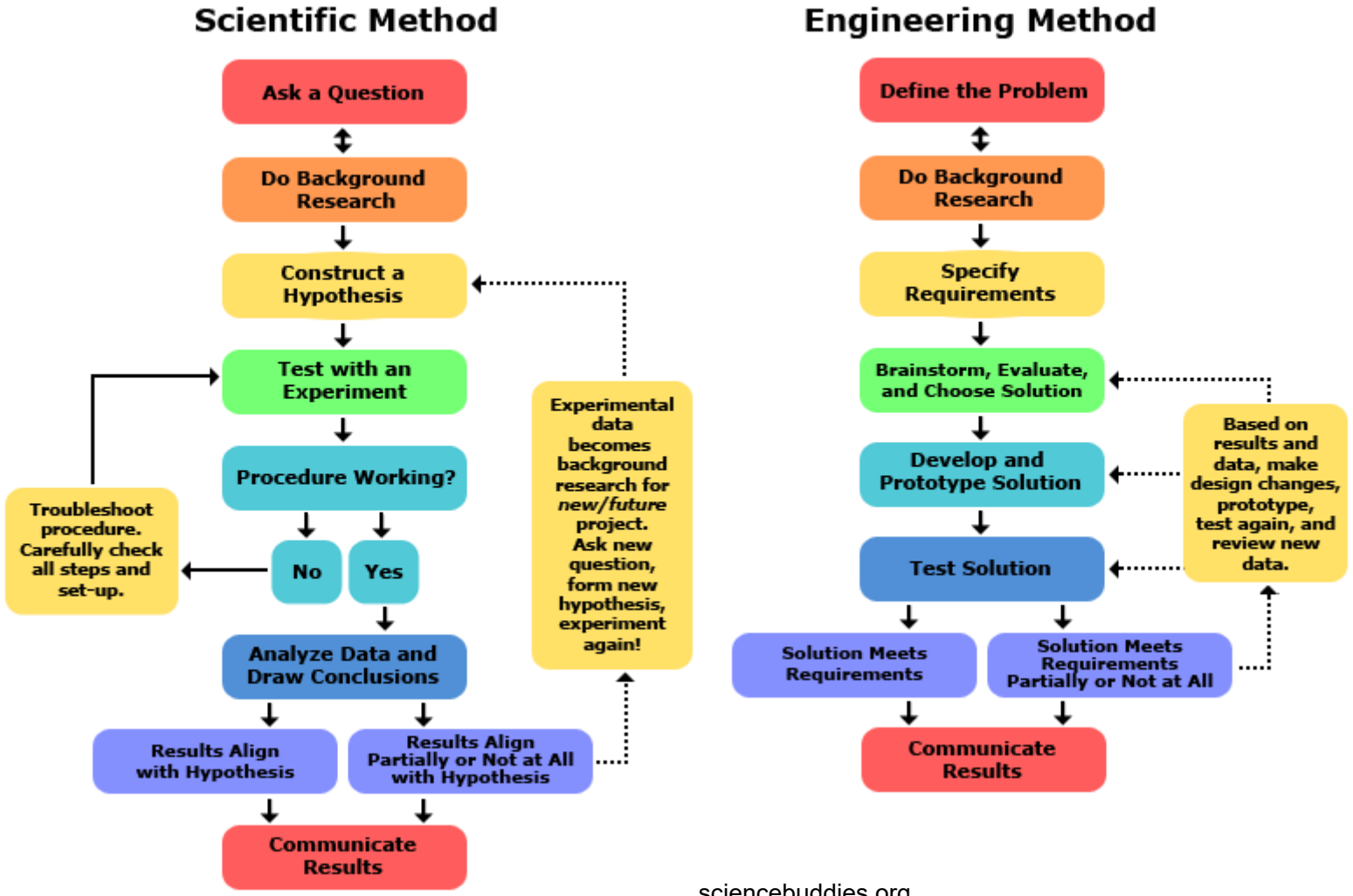
Why would I, an engineer, care about SciMet?



Literature search (W35)

Hypothesis and experimentations (W37)

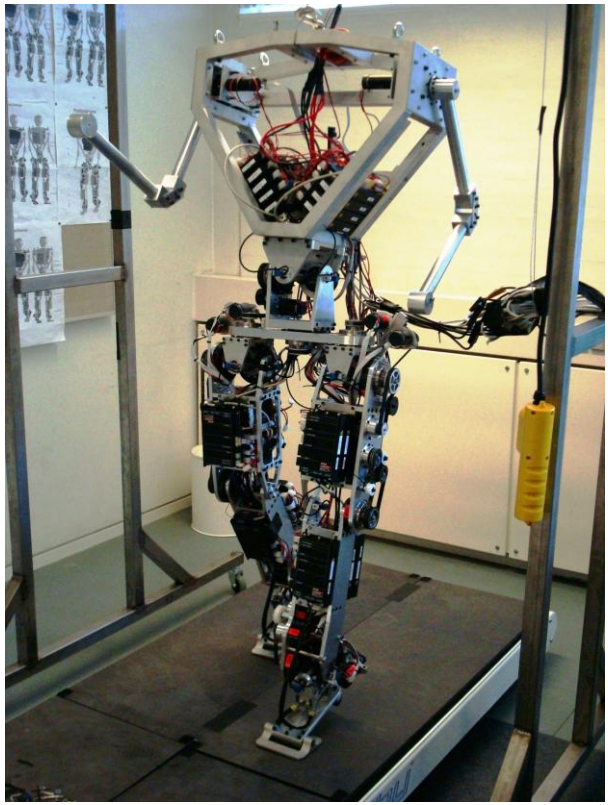
Statistics (W38, W39)

Presentation (W46), paper (W47)

sciencebuddies.org

Why SciMet in robotics?

- New field
- Focus on proof of concepts
- Focus on specific applications
- SCM needed to understand the science of robotics
- Need for standardization of methods



http://www.aaubot.aau.dk/

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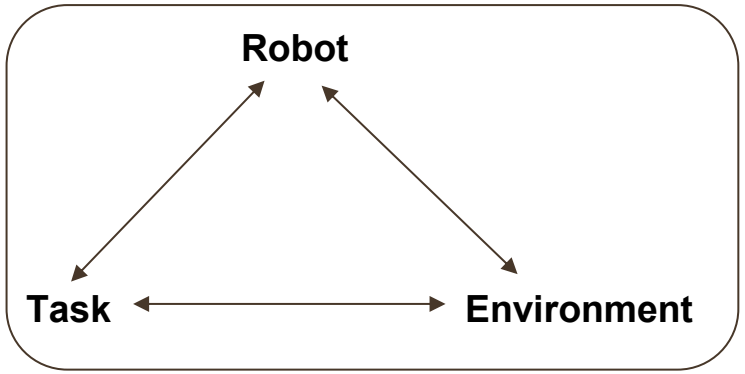
Why SciMet in robotics?

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



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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

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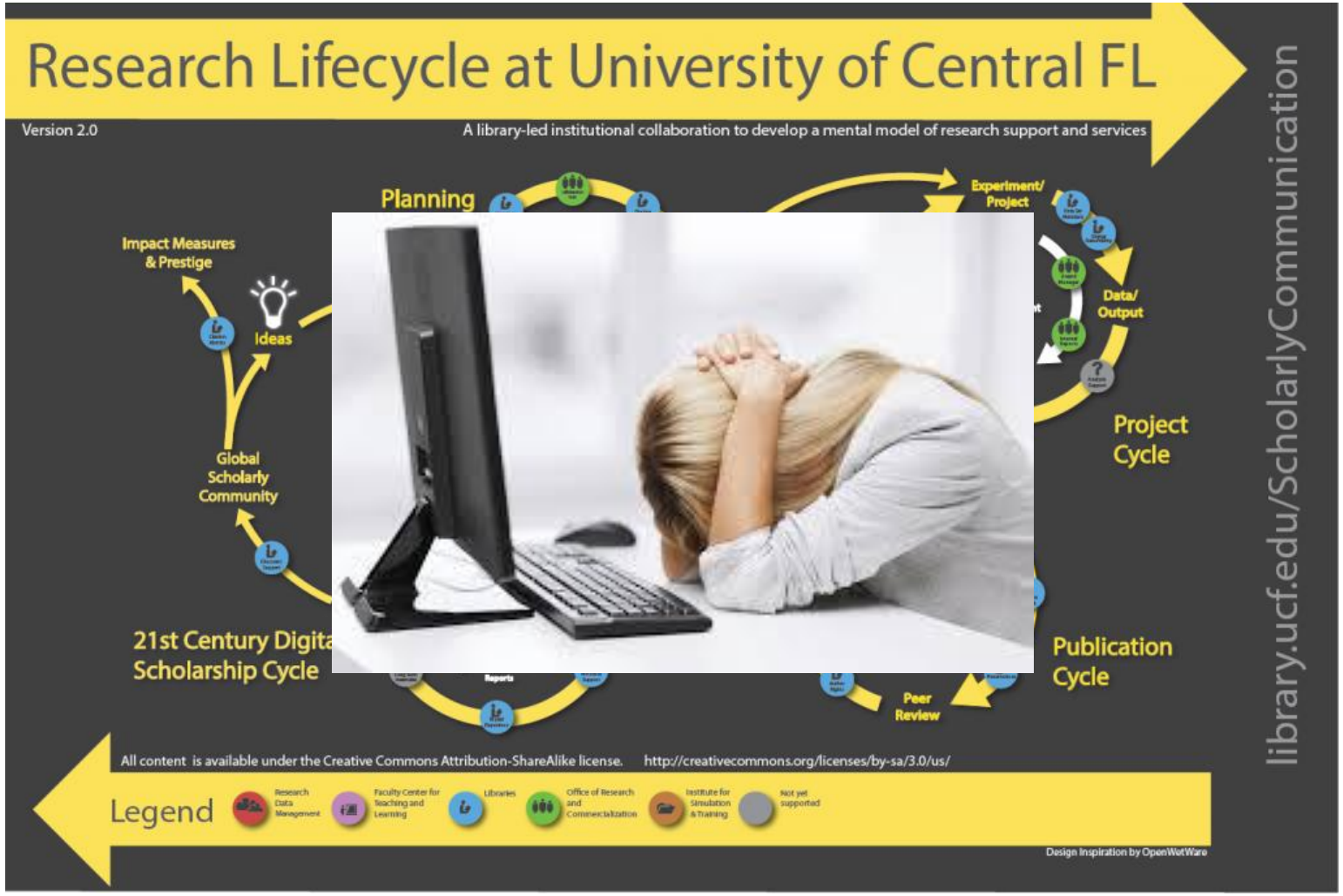
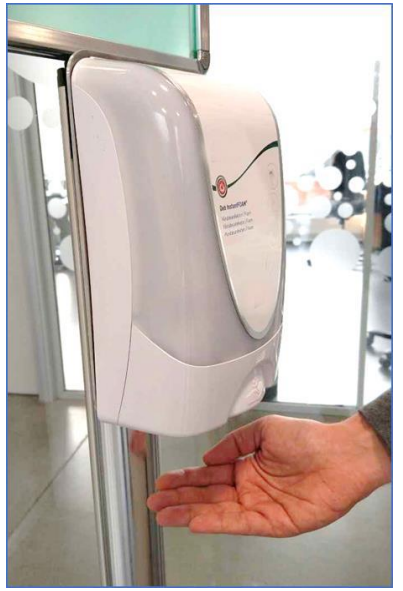
The realistic process

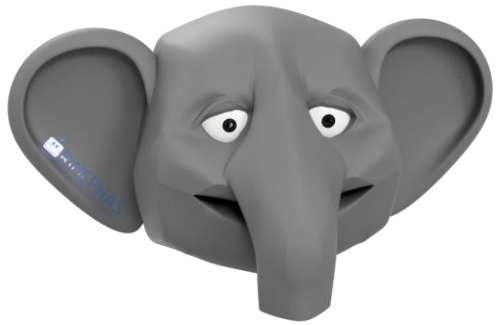


https://library.ucf.edu/about/departments/scholarly-communication/overview-research-lifecycle/

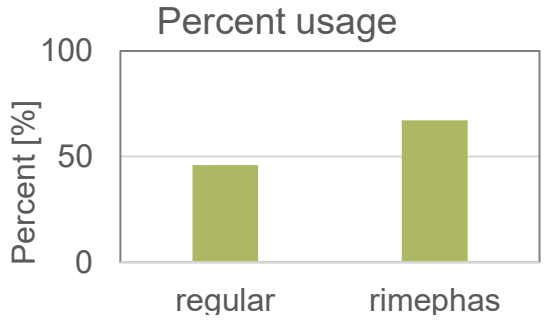
Example - RIMEPHAS

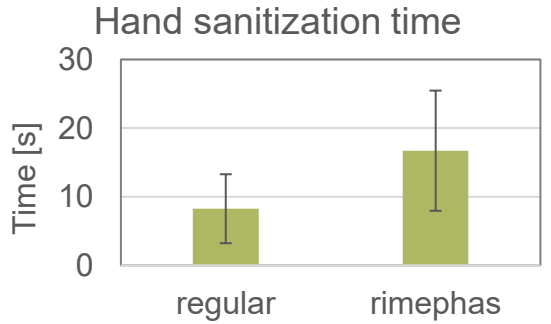


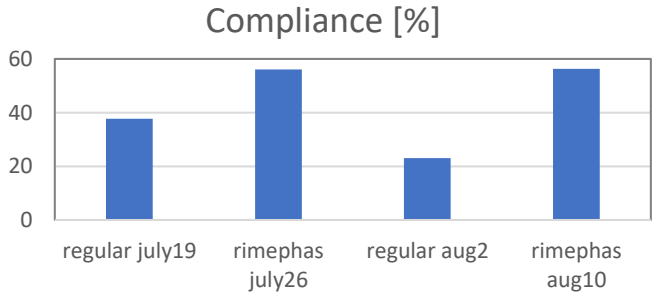
- InnovationFonden project
  - Robotic Interface for Motivating and Educating Proper Hand Sanitization
- Problem: People don’t sanitize their hands enough. When they do it, they don’t do in properly.
- Hypothesis: A robot interface can help with this.
- Method: Use affordable technology to build prototypes.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



Example - RIMEPHAS



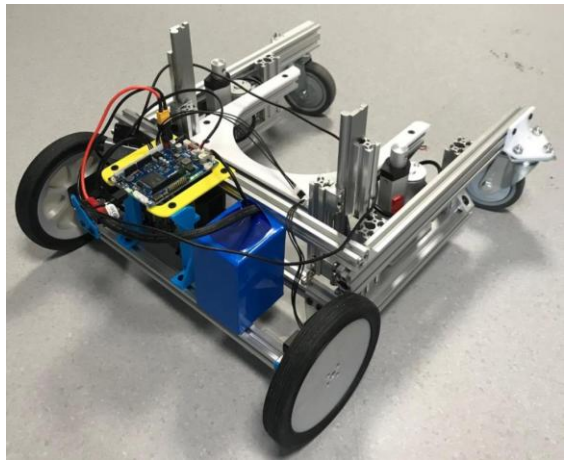




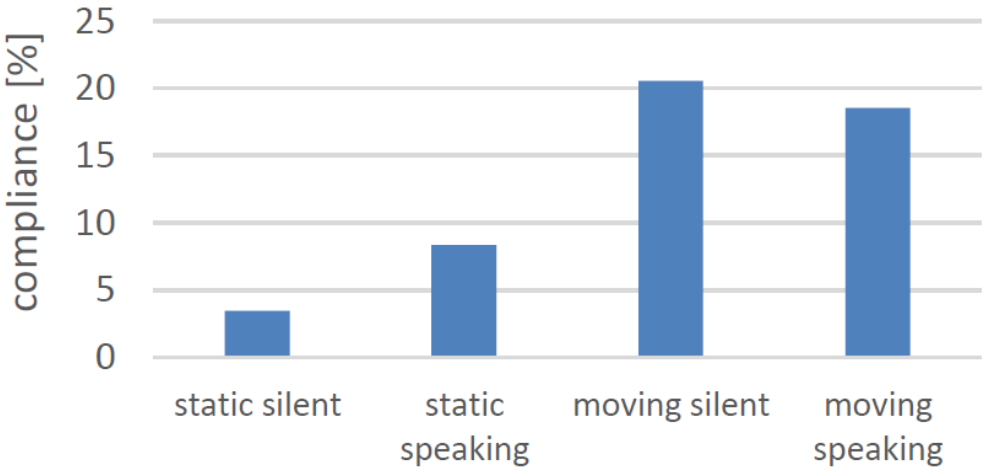
- The interface is compared to the regular automatic hand sanitizer
- Hand sanitization increased around 20% with the new interface (chi squared test)
- Hand sanitization duration increased significantly with RIMEPHAS (student's t-test)
- Testing was conducted at a university (SDU), a company (Abena) 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

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"

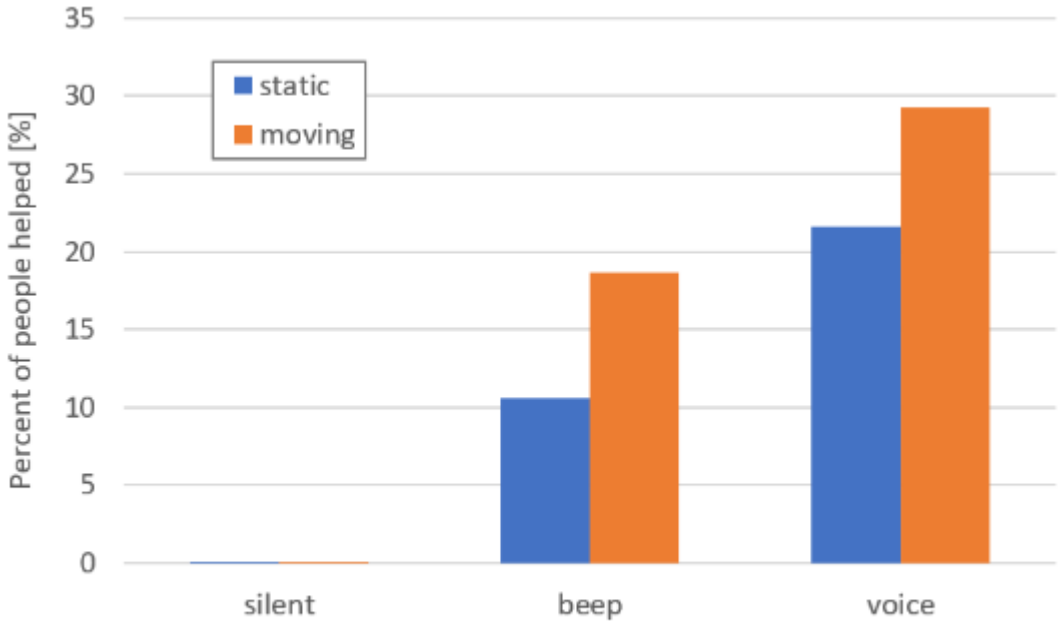
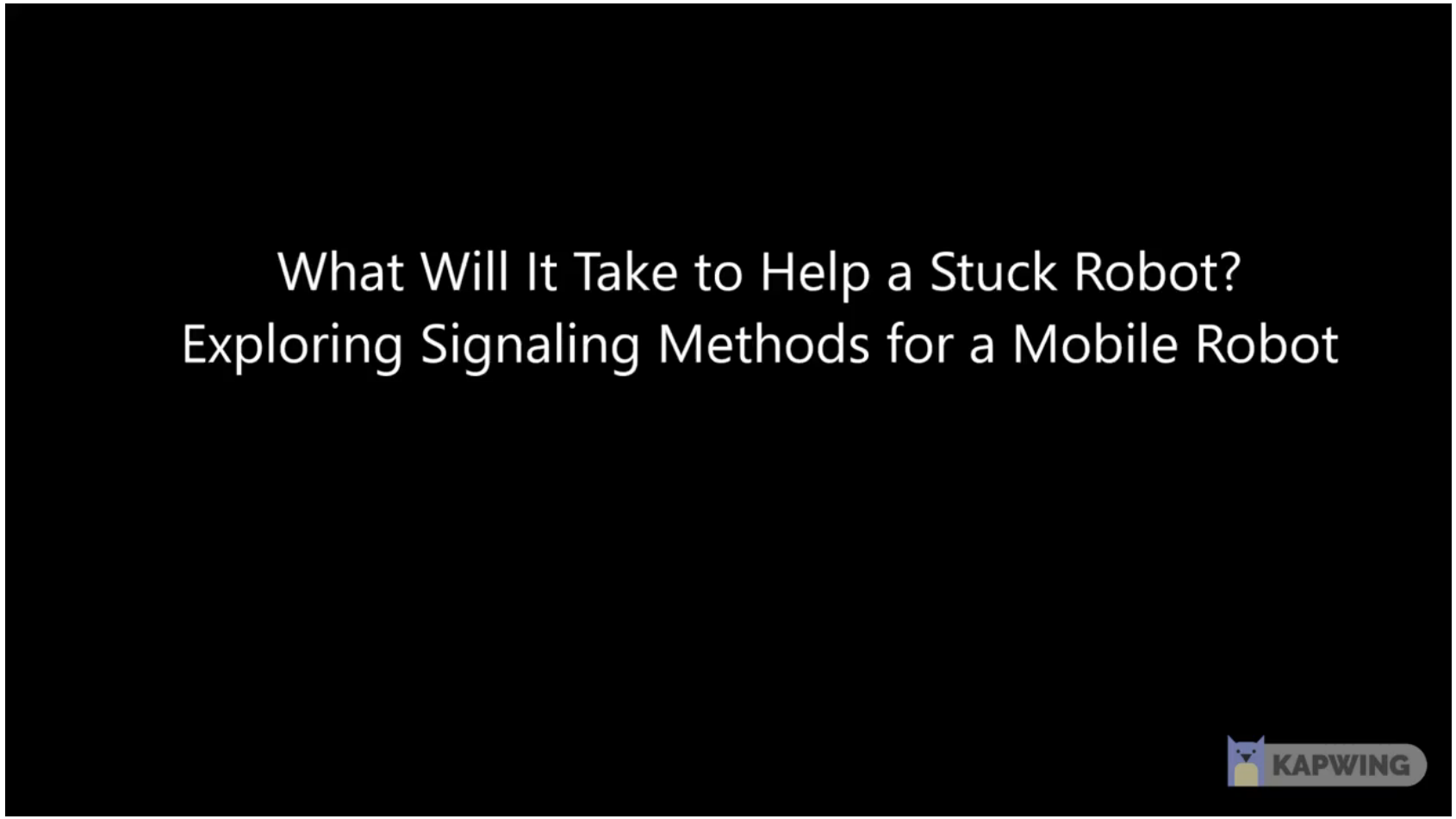


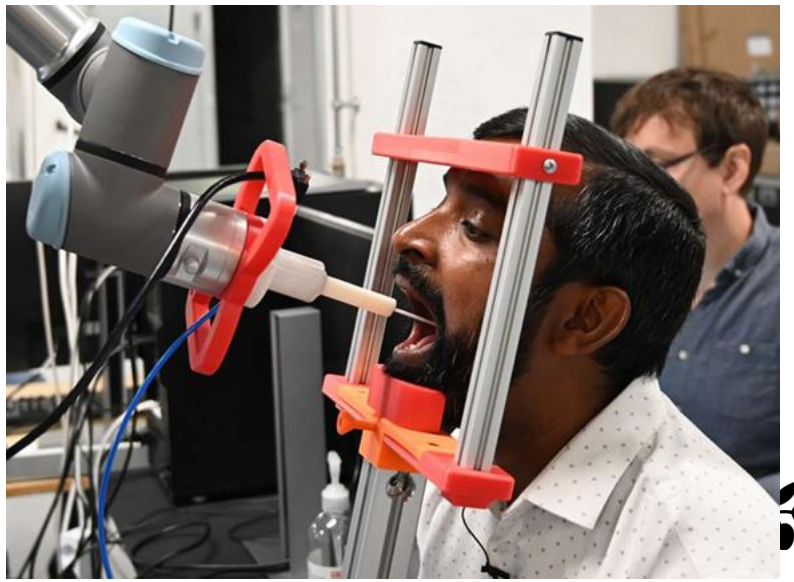
Fig. 2: Percent of people who helped the robot

Example – Stuck robot



Your task

- Using the scientific method design an experiment for:
  - Universal Robots (cobots)
  - Mobile Industrial Robots
  - Swabby
  - Atlas
  - HanDiRob



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

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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?

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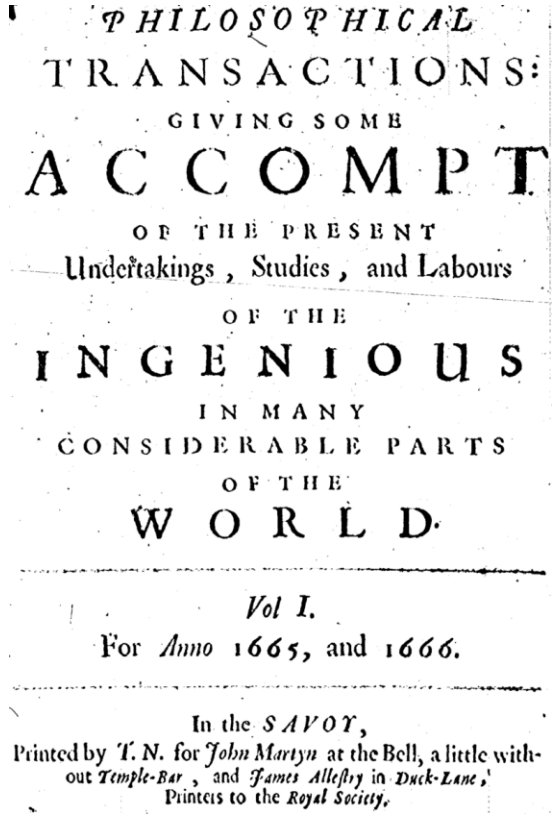
Scientific journals

- 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.

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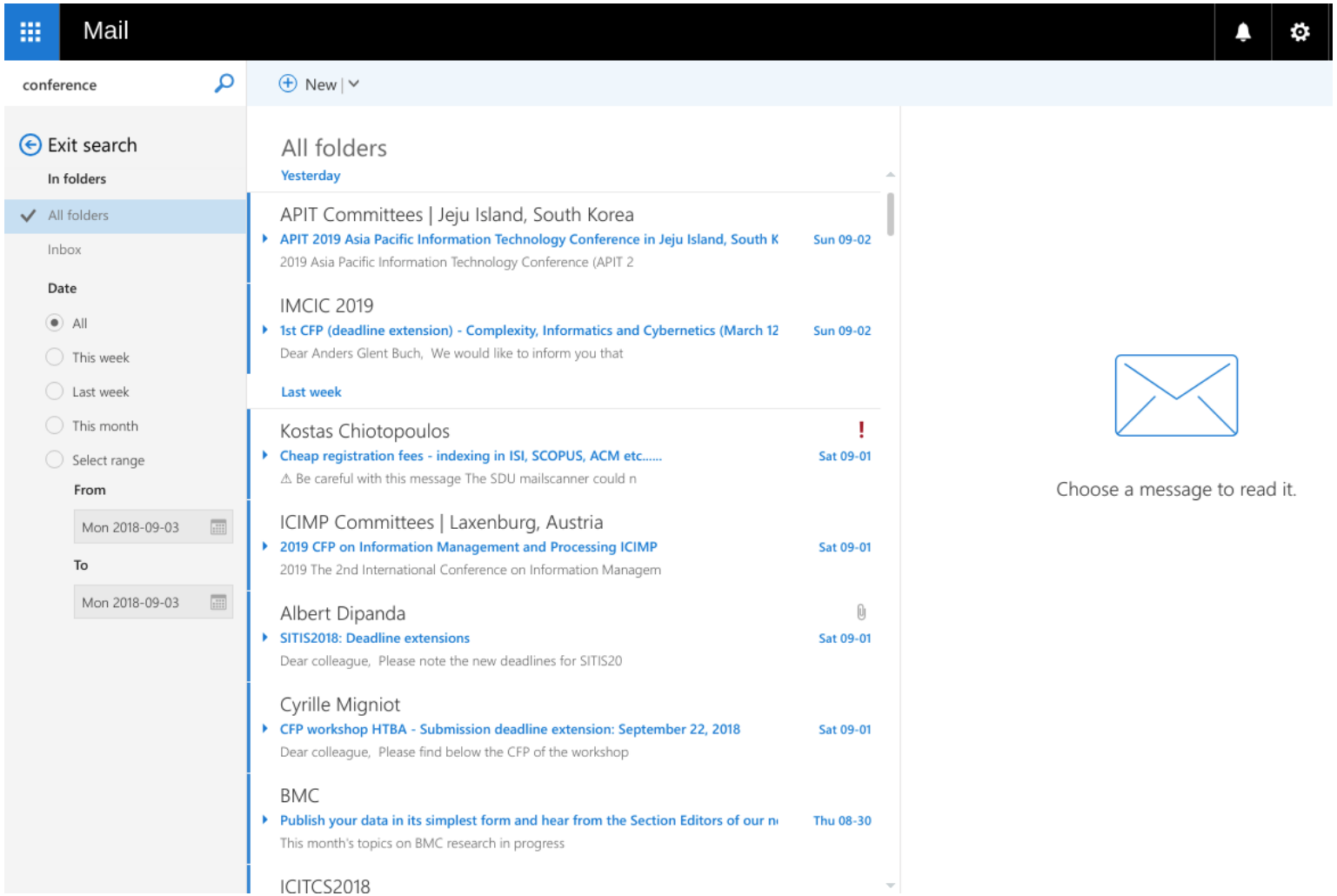
Scientific journals/conferences



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

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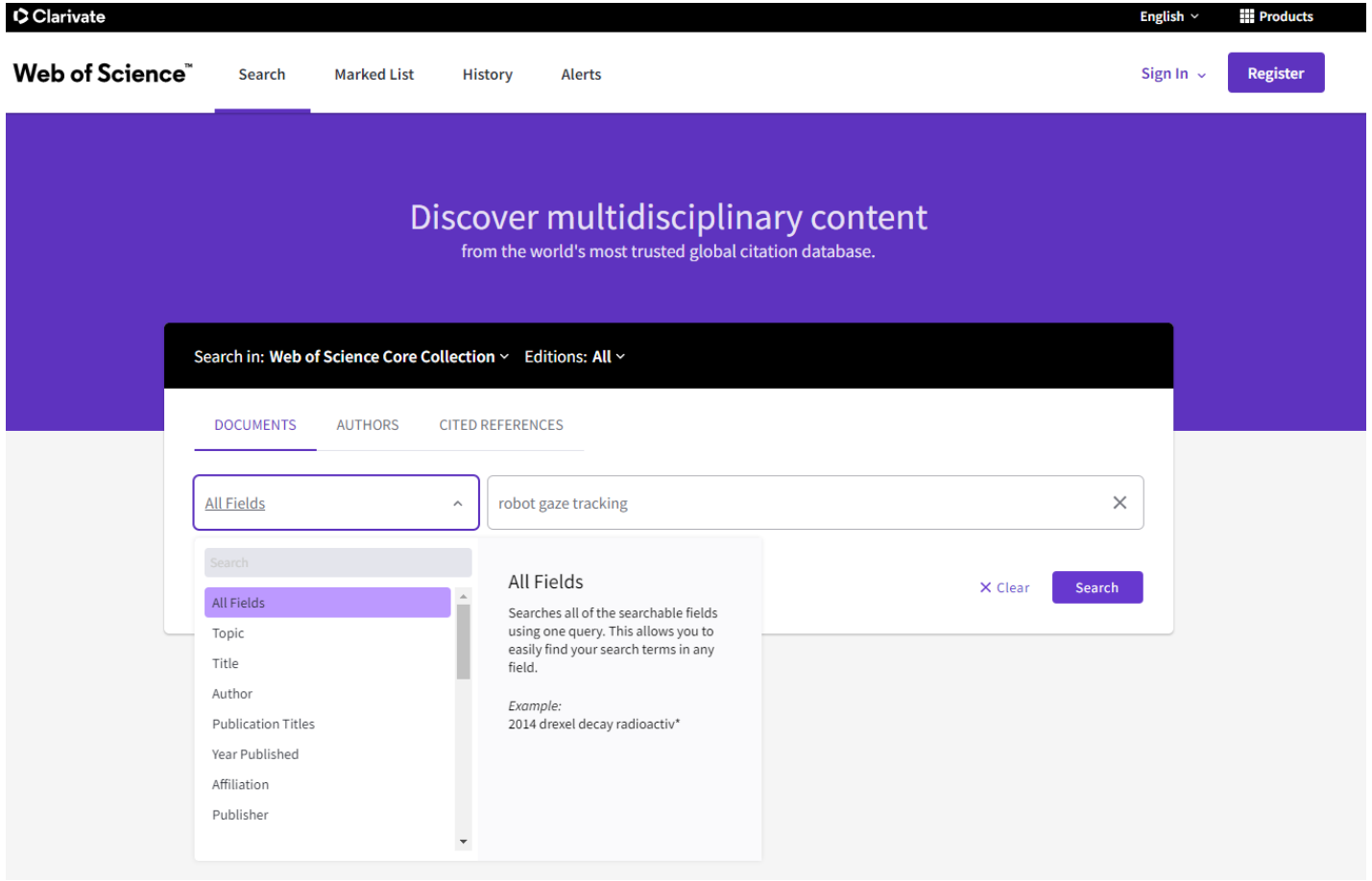
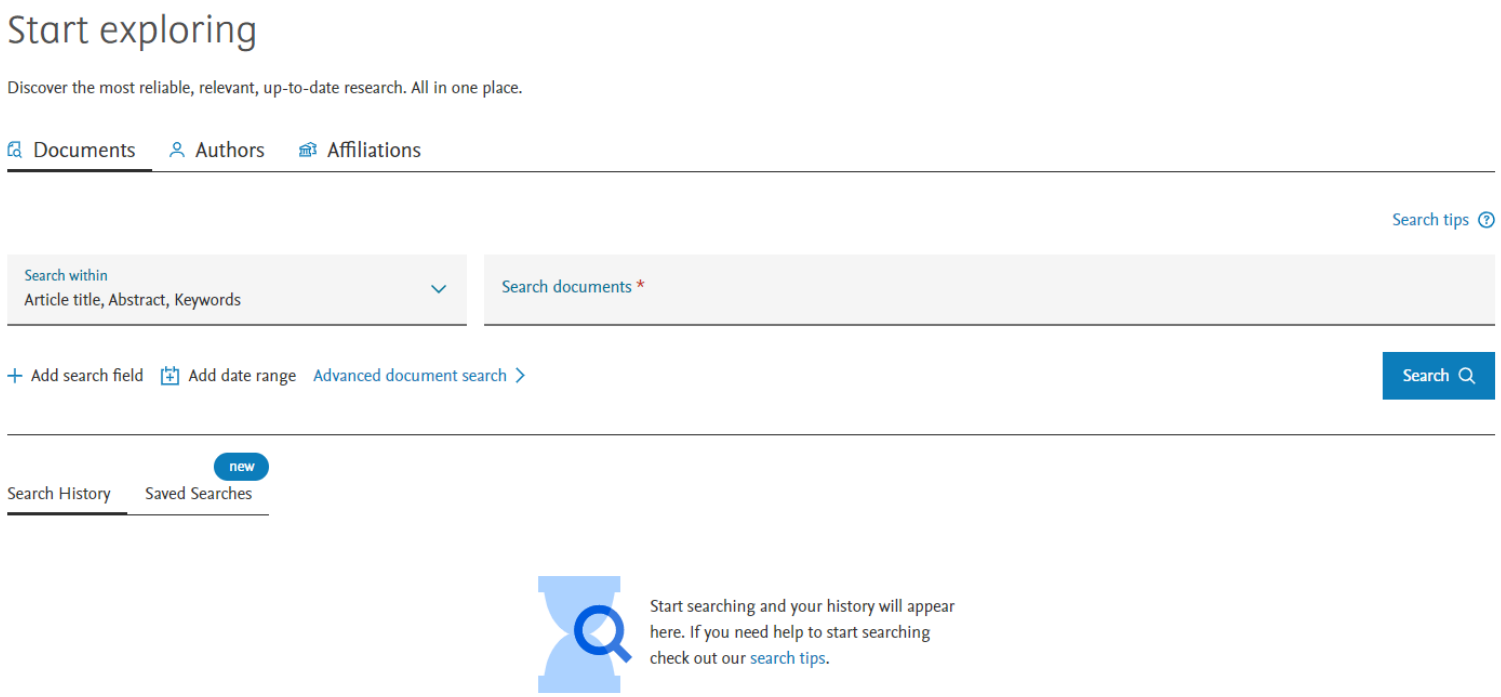
Search for papers – Web of Science

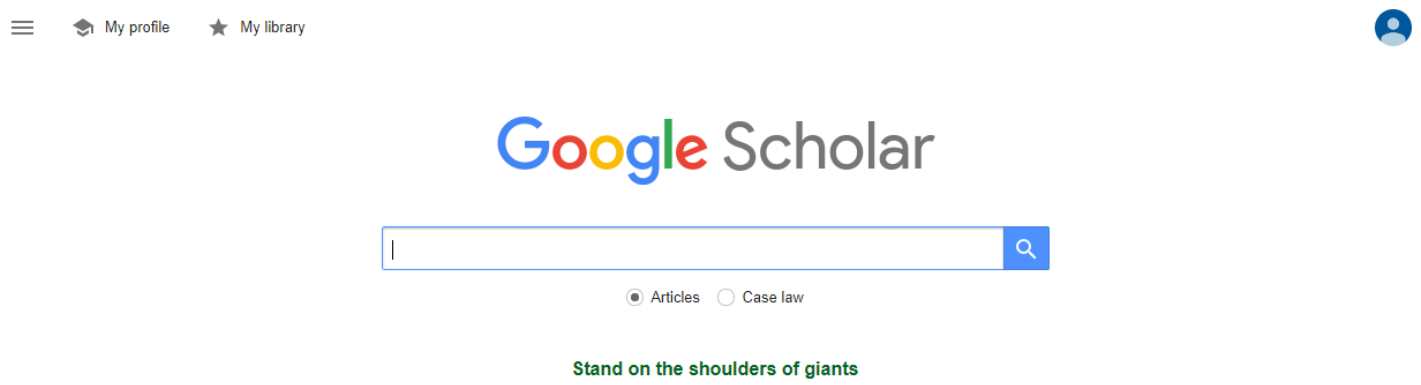


Search for papers – Scopus (Elsevier)



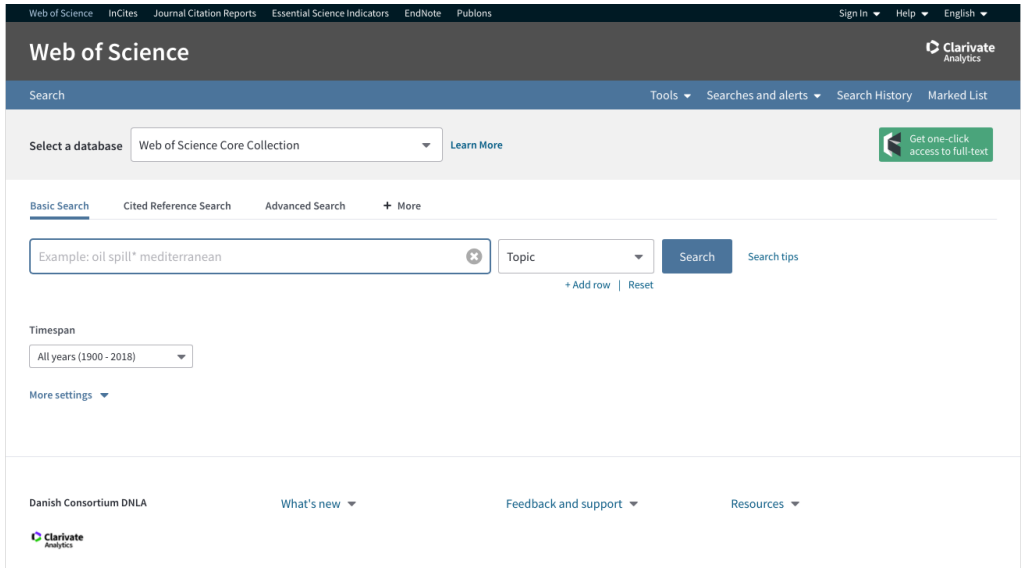
Search for papers (the Google way)

- scholar.google.com



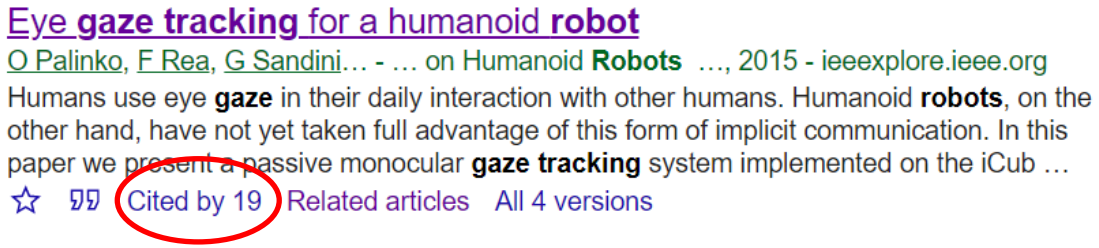
Wording

- 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



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Activity

- Let’s say you are interested in handshakes with robots.
- Do a literature search and find all the most relevant papers on it
- Put your results here

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Activity

- Prompt your generative AI of choice to write you a max 300-word literature review on handshakes with robots
- Put your results here
- Does it cite the most relevant papers which you found in the previous task?

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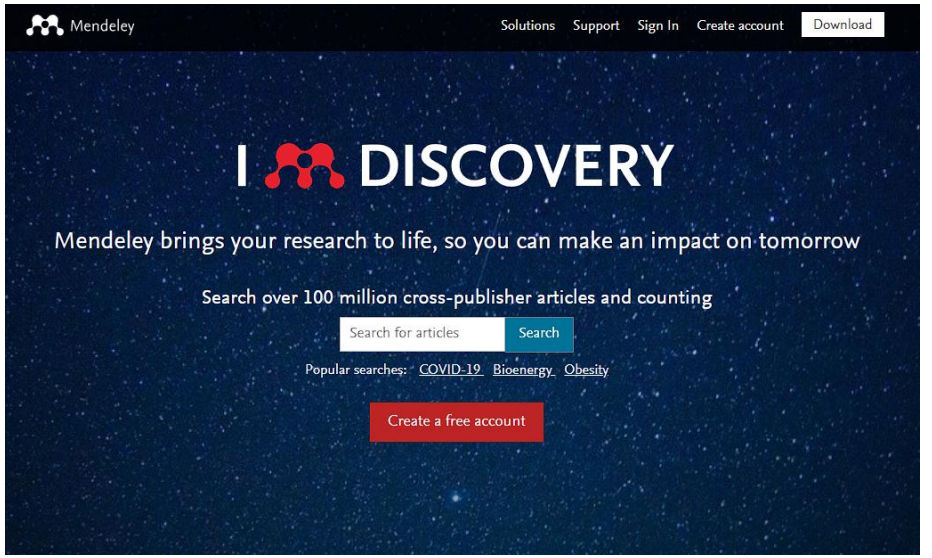
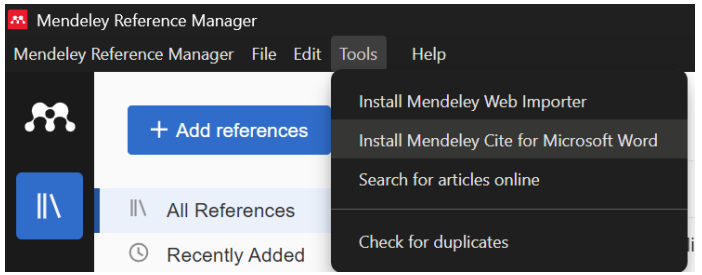
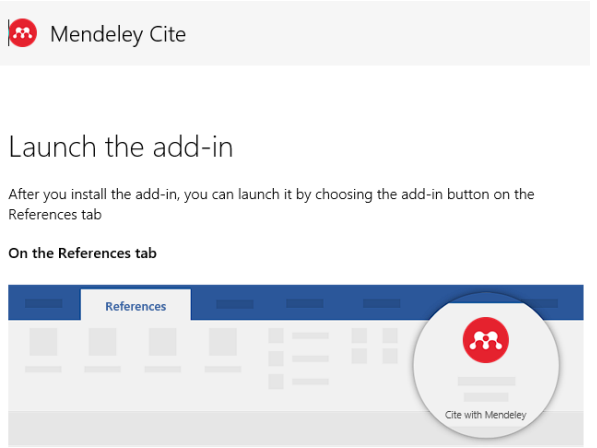
Tools for citing

- Word users
  - Bulit-in system of Word – not ideal
  - Zotero, Mendeley – better

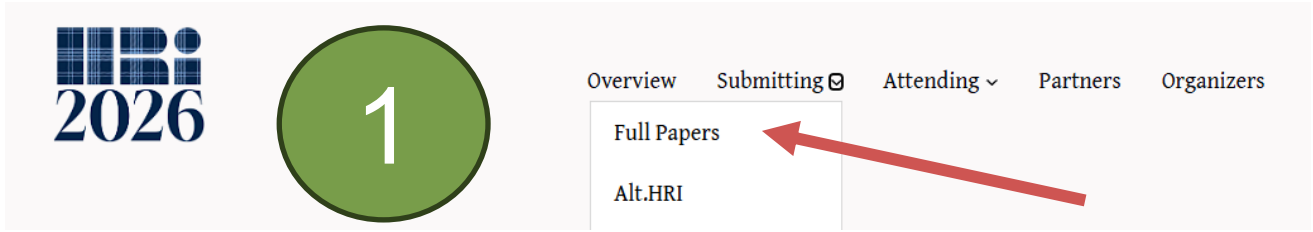
- Overleaf users
  - Find templates for your journal/conference on their website or Overleaf website
  - Example of HRI conference

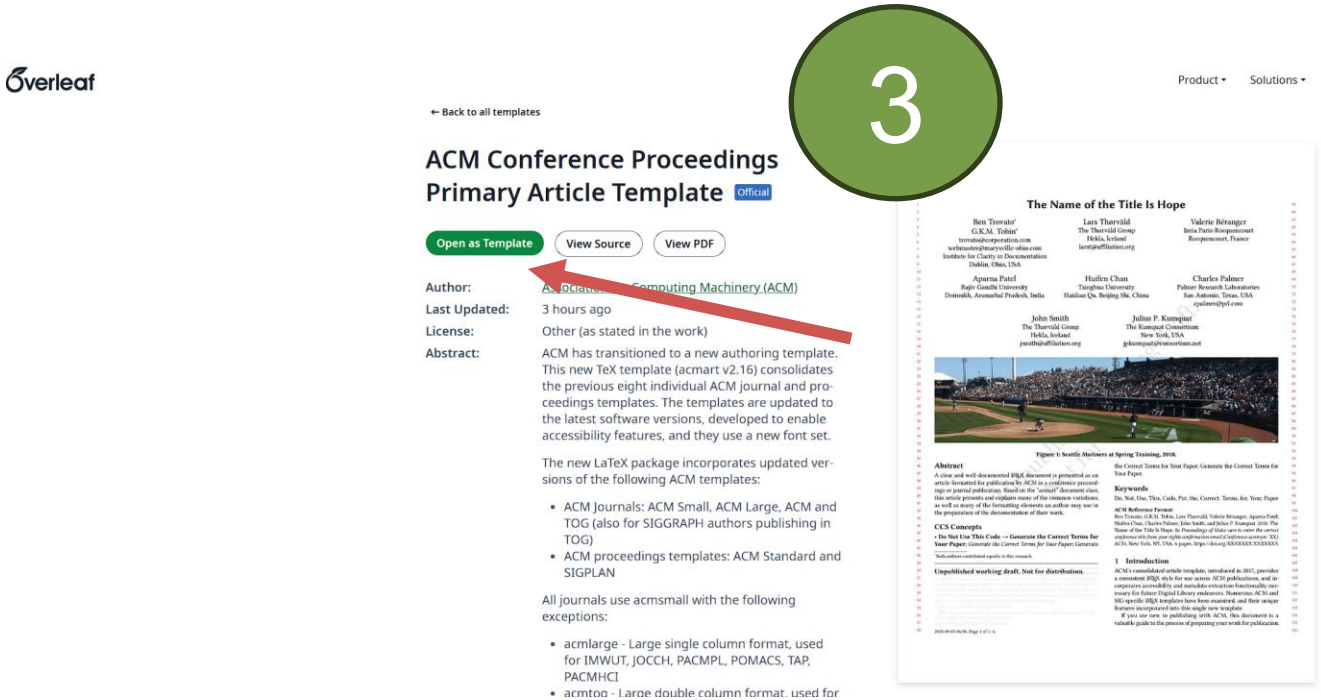






HRI conference example - Overleaf





Format and Submission

Full papers are up to eight camera-ready pages, including figures, but excluding references. Accepted full papers will be published in the conference proceedings and presented in an oral session. Submissions longer than eight pages of content excluding references will be desk rejected and not reviewed.

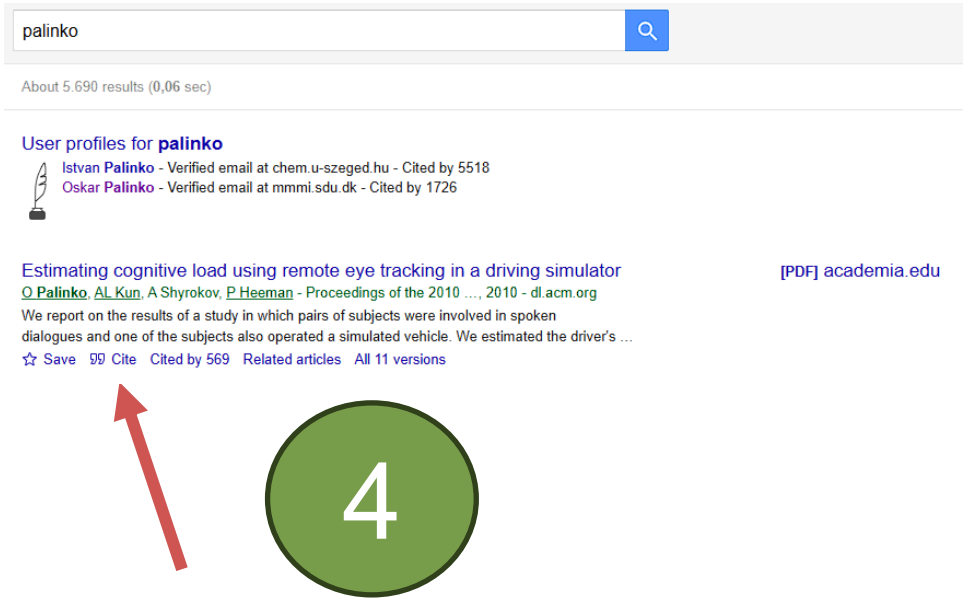
The HRI conference is highly selective with a rigorous, two-stage review model that includes an expert program committee meeting where papers are extensively discussed. As such, all submissions are expected to be mature, polished, and detailed accounts of cutting-edge research described and presented in camera-ready style. In cases of equal[ly] [qu]alified papers, positive consideration will be given to submissions that address thi[s] [I] Empowering Society".

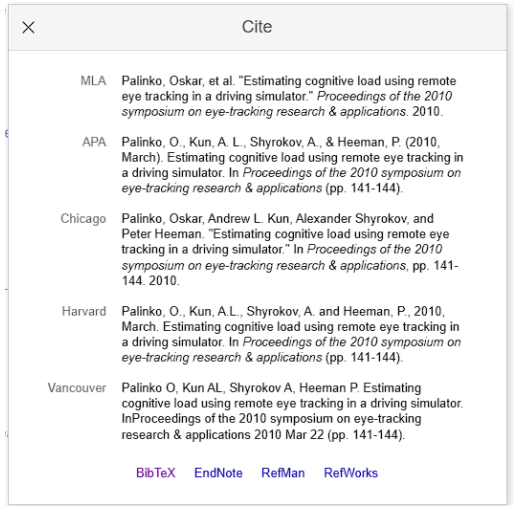
2

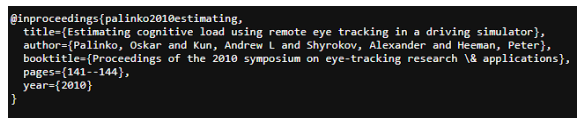
All papers for the conference must be submitted in PDF for[mat] [t]o **ACM Proceedings specifications**. Please note that we are following the general ACM [f]ormat ("sigconf", double column format), not the SIGCHI format. Templates are [a]vailable at this link (US letter).

In addition, ACM has partnered with Overleaf, where you can start writing using this link directly (note that this Overleaf document uses the new ACM workflow by default, which is not what HRI is using; to fix this, make sure the document uses the "sigconf" document class, rather than the "manuscript,screen,review" document class that is enabled in the Overleaf document by default).

HRI conference example - Overleaf







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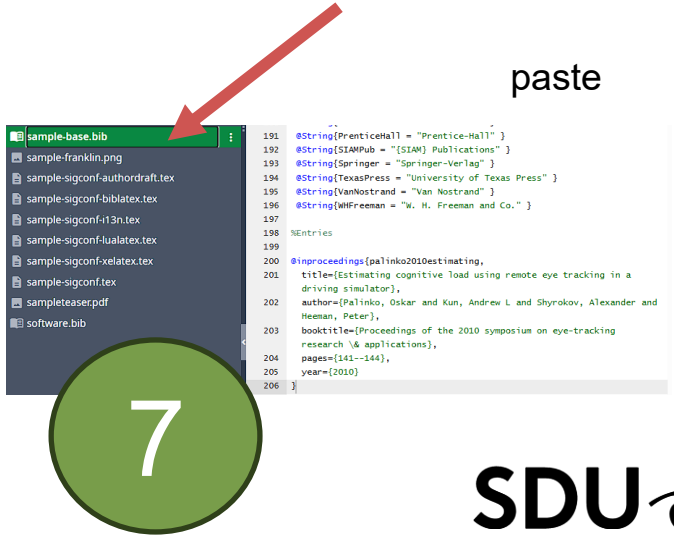
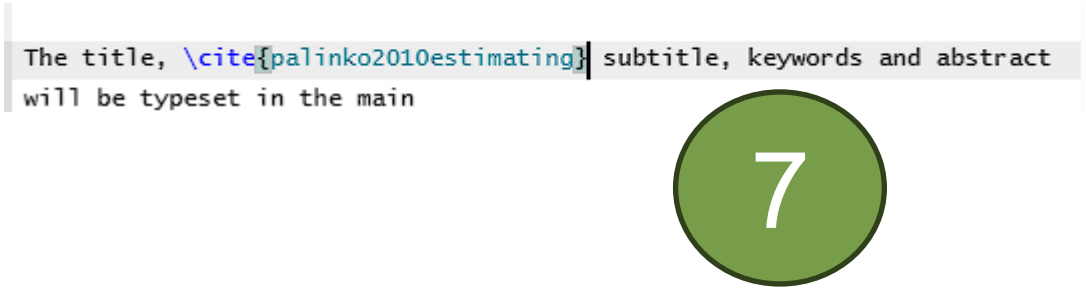
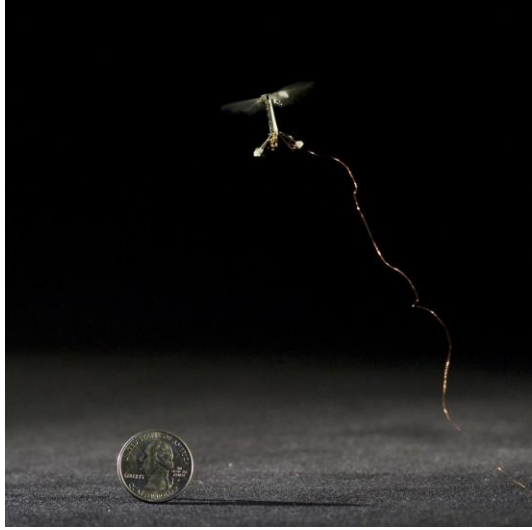




Activity



Use WoS and Scholar to locate today's paper:

Ma, Kevin Y., et al. "Controlled flight of a biologically inspired, insect-scale robot." *Science* 340.6132 (2013): 603-607.

1. using as few search words/characters as possible,
2. uniquely, i.e. without any other matches (still with as few words as possible)
3. Compare WoS to Scholar (easier to use, better results, etc)

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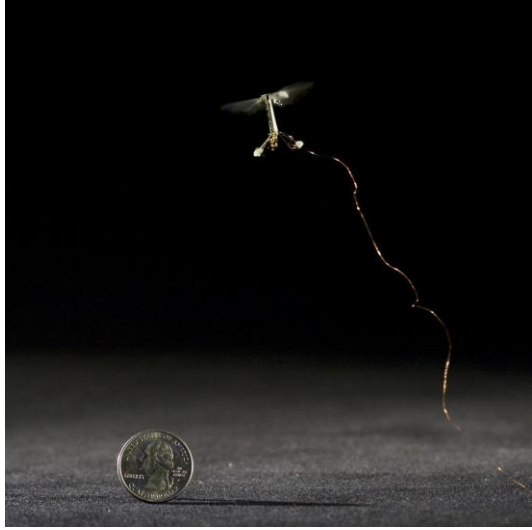
Reading techniques

Activity



Now read the paper:

Ma, Kevin Y., et al. "Controlled flight of a biologically inspired, insect-scale robot." *Science* 340.6132 (2013): 603-607.

1. Take notes, whatever comes to your mind about the content
2. Prepare *at least* one argument for and one argument against the paper
3. Spend 20 minutes

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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

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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-I%C3%A6rte-af-sagen

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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?

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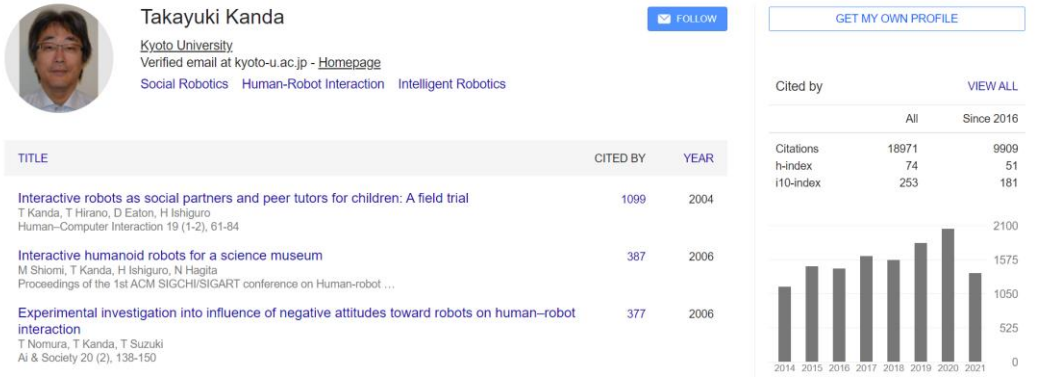
Citation metrics

Citation metrics



Takayuki Kanda

FOLLOW

GET MY OWN PROFILE

Kyoto University
Verified email at kyoto-u.ac.jp - Homepage
Social Robotics Human-Robot Interaction Intelligent Robotics

TITLE	CITED BY	YEAR
Interactive robots as social partners and peer tutors for children: A field trial T Kanda, T Hirano, D Eaton, H Ishiguro Human–Computer Interaction 19 (1-2), 61-84	1099	2004
Interactive humanoid robots for a science museum M Shiomi, T Kanda, H Ishiguro, N Hagita Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot …	387	2006
Experimental investigation into influence of negative attitudes toward robots on human–robot interaction T Nomura, T Kanda, T Suzuki Ai & Society 20 (2), 138-150	377	2006

Cited by VIEW ALL

	All	Since 2016
Citations	18971	9909
h-index	74	51
i10-index	253	181

- 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

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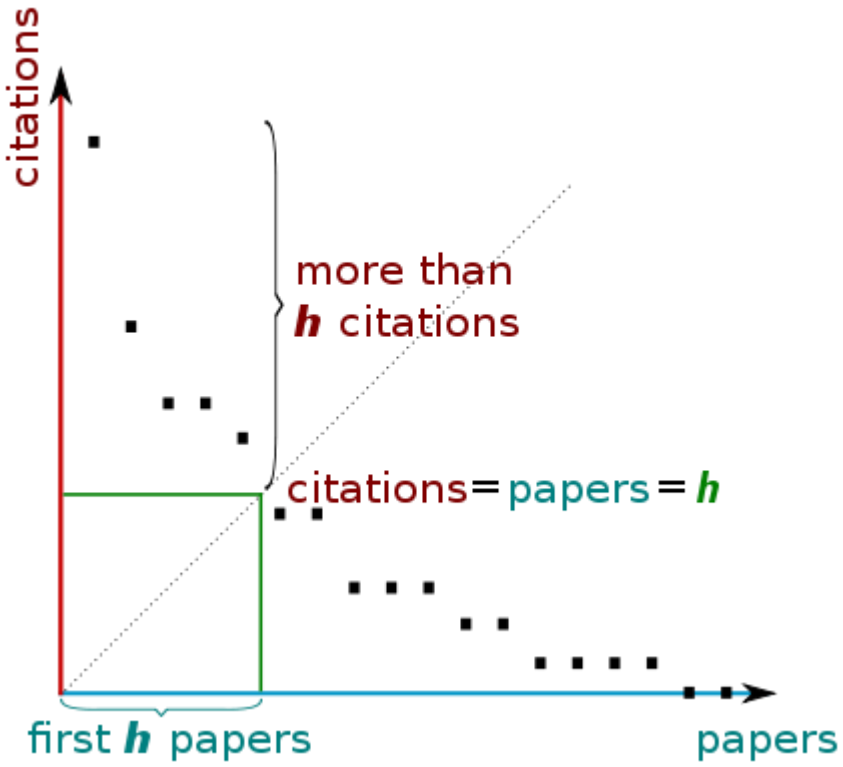
Citation count

- 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

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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

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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

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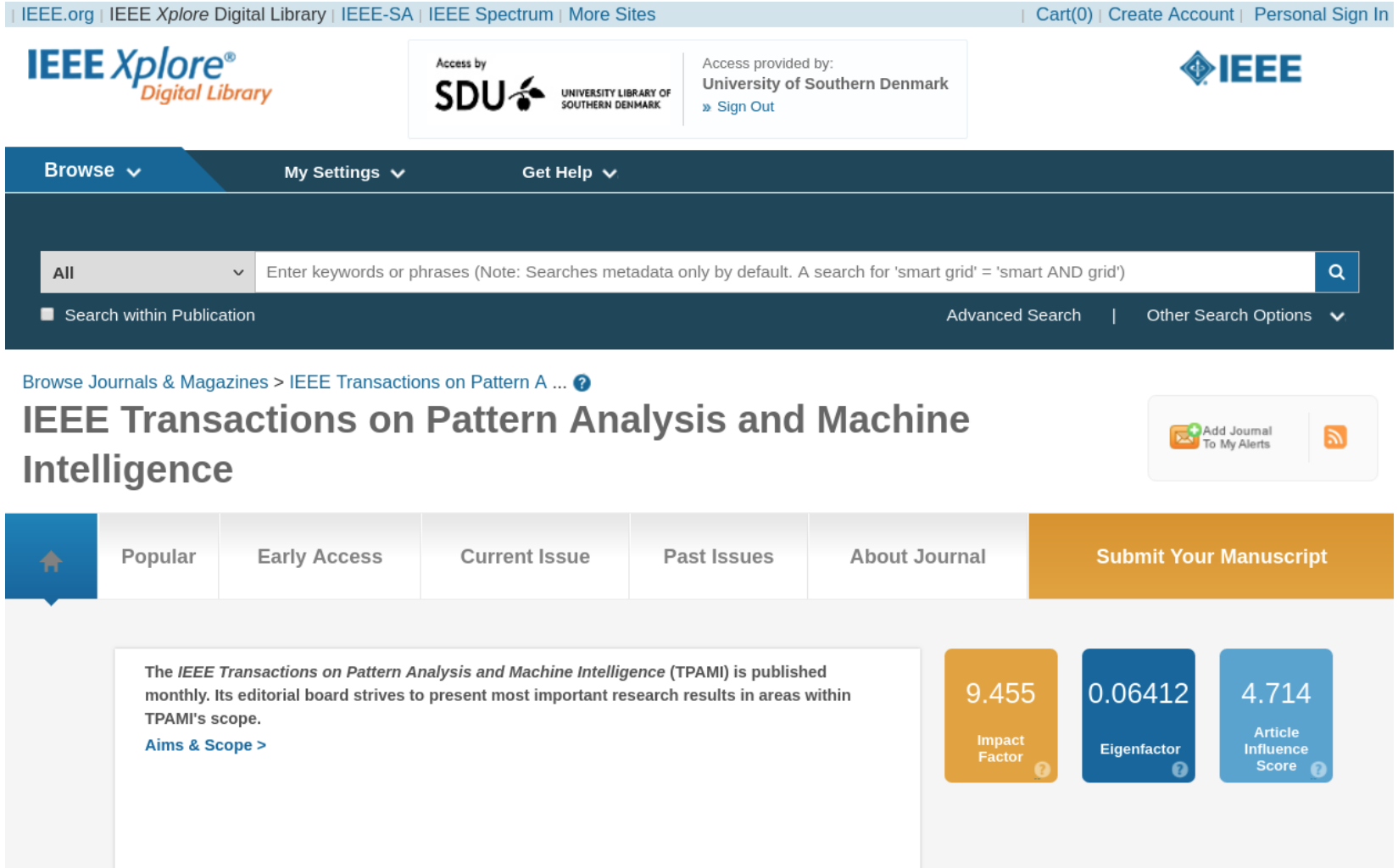
Article influence score

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

IF, EF and AIF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Access by SDU UNIVERSITY LIBRARY OF SOUTHERN DENMARK
Access provided by: University of Southern Denmark
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All
Enter keywords or phrases (Note: Searches metadata only by default. A search for 'smart grid' = 'smart AND grid')
Search within Publication
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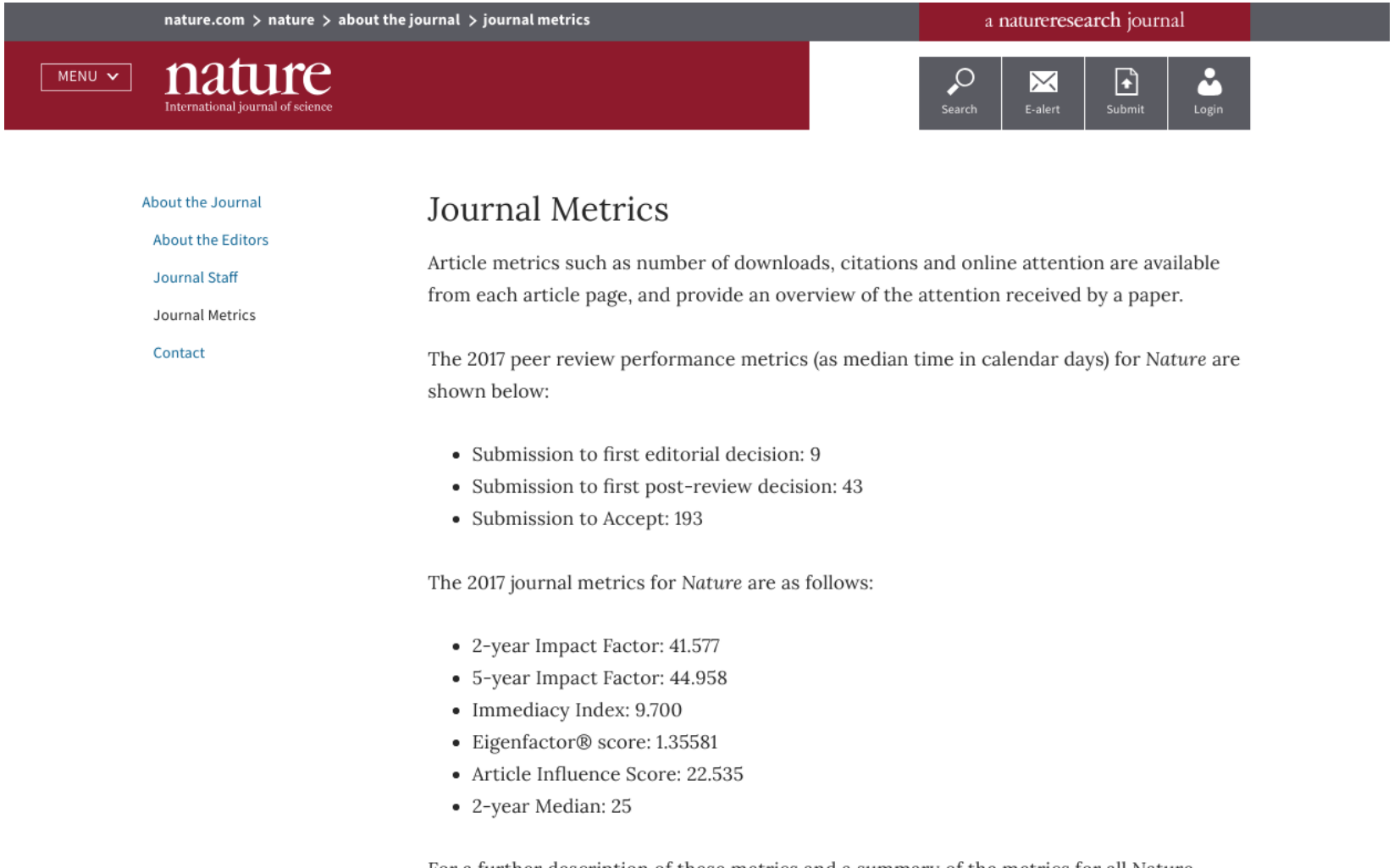
The IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI) is published monthly. Its editorial board strives to present most important research results in areas within TPAMI's scope.
Aims & Scope >
9.455
Impact Factor
0.06412
Eigenfactor
4.714
Article Influence Score

IF, EF and AIF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Journal Metrics
Article metrics such as number of downloads, citations and online attention are available from each article page, and provide an overview of the attention received by a paper.
The 2017 peer review performance metrics (as median time in calendar days) for Nature are shown below:
Submission to first editorial decision: 9
Submission to first post-review decision: 43
Submission to Accept: 193
The 2017 journal metrics for Nature are as follows:
2-year Impact Factor: 41.577
5-year Impact Factor: 44.958
Immediacy Index: 9.700
Eigenfactor® score: 1.35581
Article Influence Score: 22.535
2-year Median: 25

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!

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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?

Activities

- Create groups of 3 or 4 (NOT < 3 or > 4)
  - Put in your group info here: http://tiny.cc/scm25
  - Start thinking about a project
- Consider using a tool for shared papers, e.g. Overleaf, Google Docs, Teams

- **PAPER REQUIREMENTS**
  - Maximum 4 pages of content, excluding citations - non-negotiable!
  - You can have as many pages with citations as you wish
  - Ergo: your final PDF can have many more than 4 pages, but only the first 4 pages can contain the actual paper

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