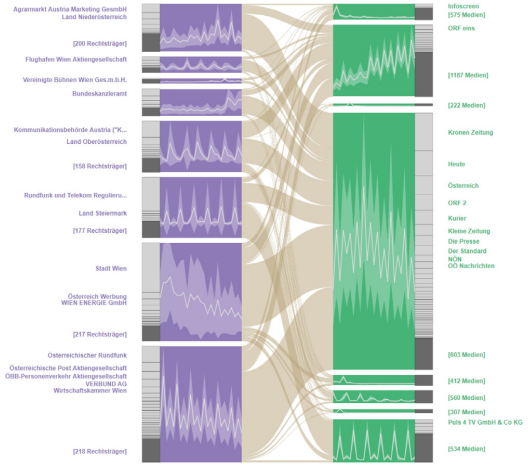
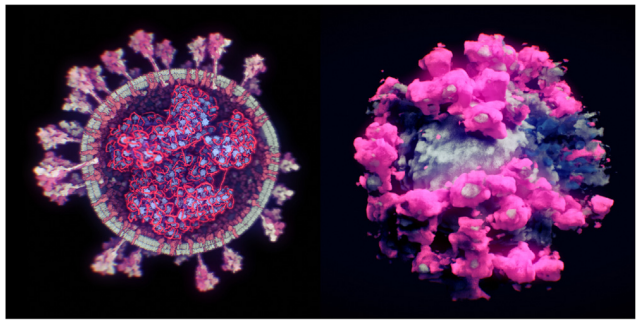
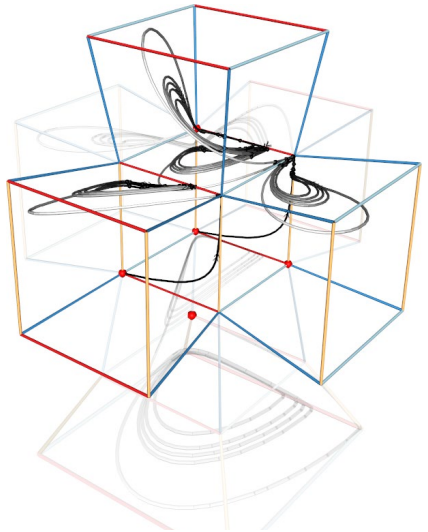
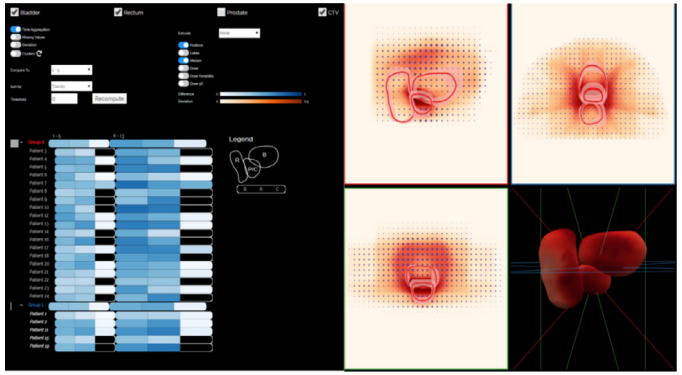






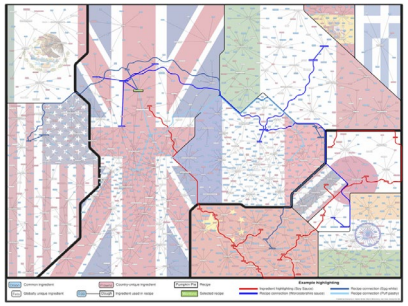
Research and How it Works

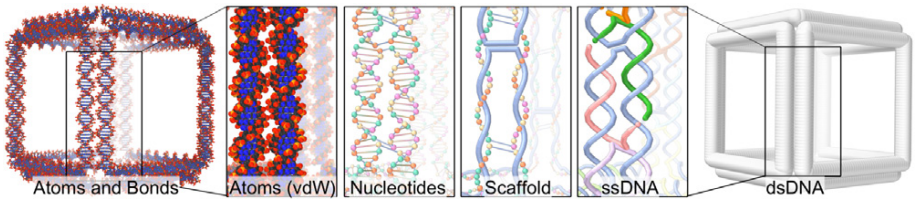


Eduard Gröller

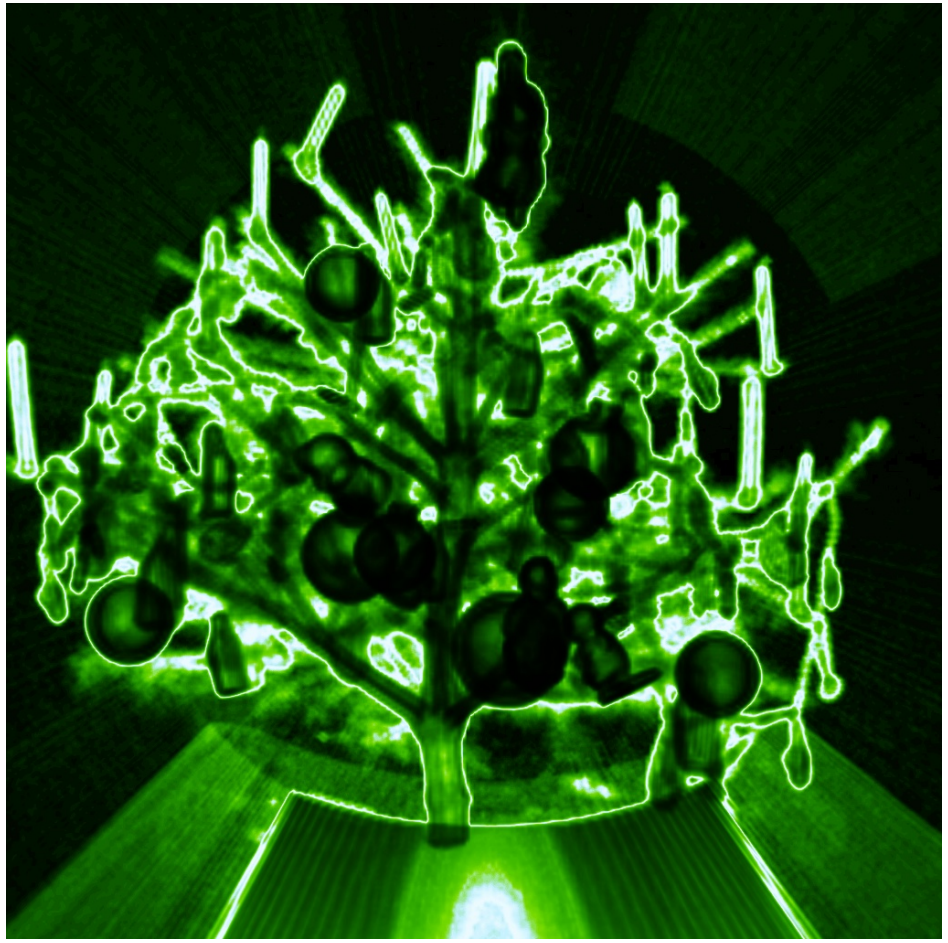
Institute of Visual Computing & Human-Centered Technology,

TU Wien, Austria





What is Research?



- Nibble on the tree of knowledge
- Driving force: human curiosity

Knowledge Gain

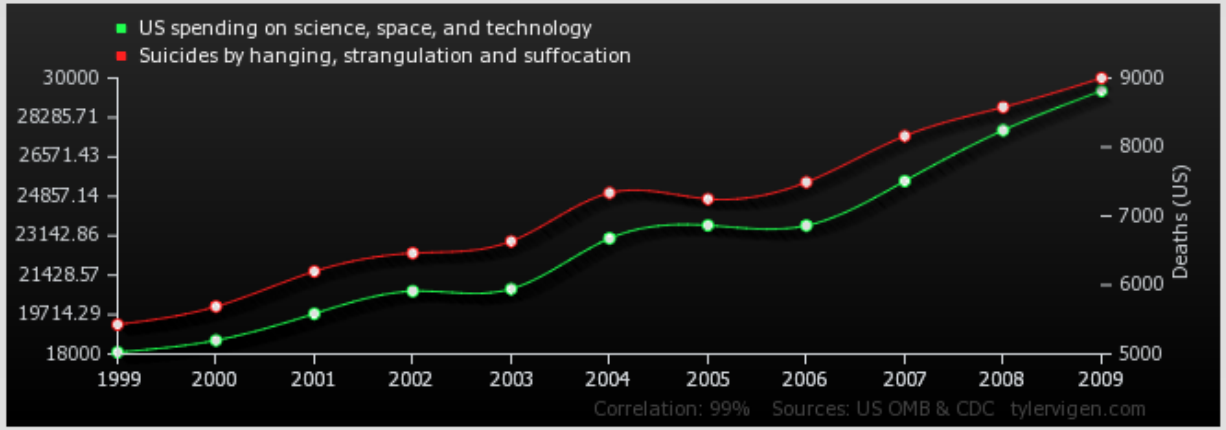
- Observations, measurements, trials
- Axioms, hypotheses, models
- Validation, verification, falsification
  - Proof (theoretical sciences)
  - Experiment (applied sciences)
  - Empirical study, survey (social sciences)

Research Aspects (1)

- Objectifiable, rational
- Reproducible, verifiable
- Principle of causality
- Reductionism - holism
- Paradigm shift

Spurious Correlations

US spending on science, space, and technology
correlates with
Suicides by hanging, strangulation and suffocation



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
US spending on science, space, and technology *Millions of todays dollars (US OMB)*	18,079	18,594	19,753	20,734	20,831	23,029	23,597	23,584	25,525	27,731	29,449
Suicides by hanging, strangulation and suffocation *Deaths (US) (CDC)*	5,427	5,688	6,198	6,462	6,635	7,336	7,248	7,491	8,161	8,578	9,000

Correlation:
0.992082

Permalink - Mark as interesting (5,147) - Not interesting (2,370)

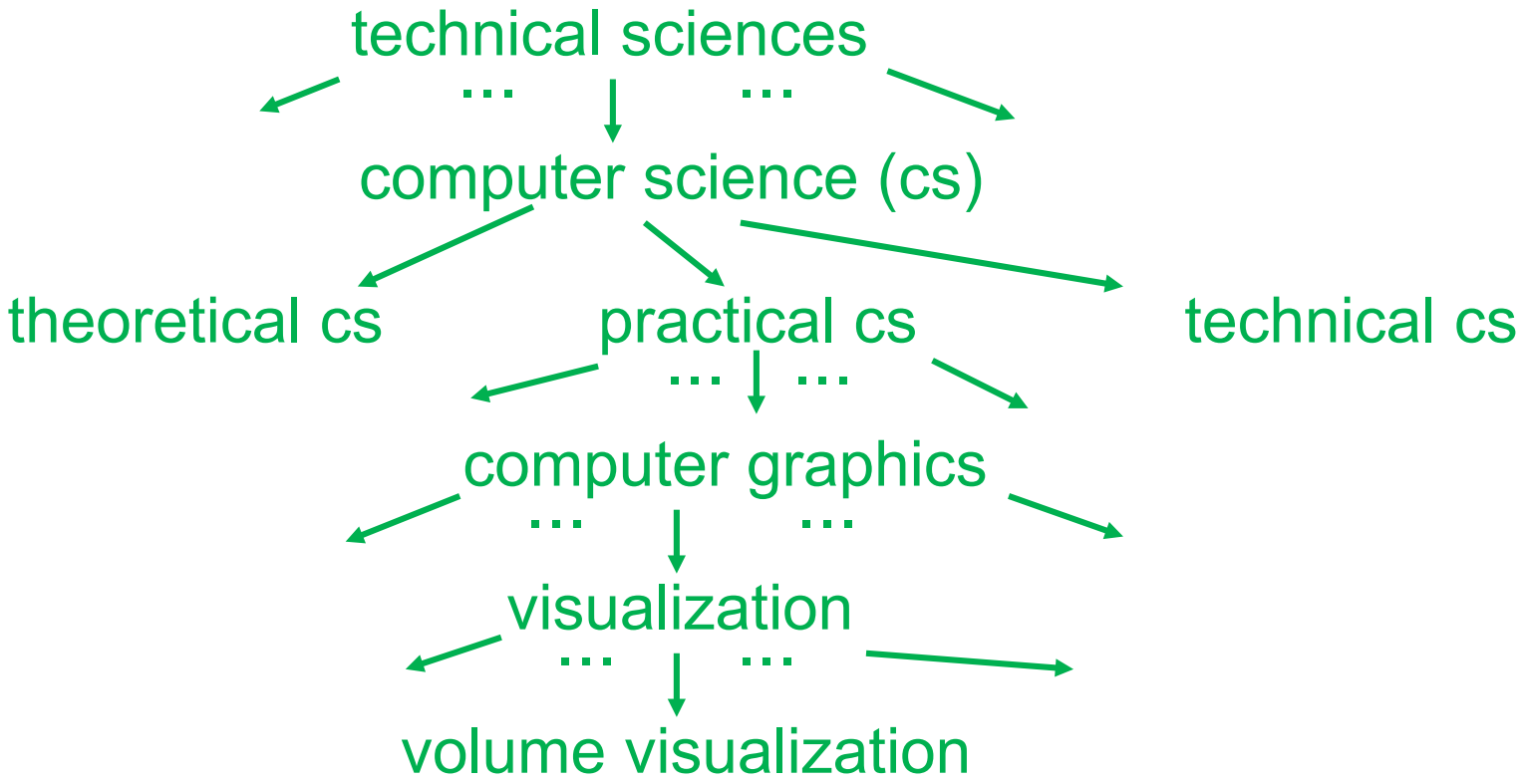
http://www.tylervigen.com/

Research Aspects (2)

- Society and Science
  - Scientism
  - Anti-scientism
- Science – research - development
- Basic research – applied research
- Research is very costly (even more costly is not doing research)

Research Aspects (3)

- Very strong differentiation



- Exponential data growth

Research Paradigms

- Experimental sciences (observations, experiments)
- Theoretical sciences (modelling to describe and explain natural phenomena)
- Scientific computing (computer simulation of mathematical models)
- Data science (big data, smart data)

Where does Research happen?

- Universities: “Unity of Teaching and Research” [https://www.bmbwf.gv.at/]
- Extra-mural research institutes
  - IST Austria, AIT, Joanneum Research, Oefai
- Academy of sciences
- Public – private research partnerships
  - K+ Centres (VRVis, http://www.vrvis.at/)
- Commercial companies
  - typically in large companies
  - (Research and) development

Research at Universities

- What is a university teacher doing?
  - He/she is teaching (4 - 12 weekly hours each term)
  - He/she is doing administrative work (study curriculum, ...)

- What is he/she doing during the breaks?
  - He/she is going on vacation

And then he/she is doing research

Research Groups

- Institute subdivided into several research groups
- Joint research interests
  - VC&HCT: CV, CG, Prip, …
- Members of a research group
  - University teachers
  - Research associates, PhD students
  - Master students, interested students
- Carrying out research projects

Research Projects (1)

- Single projects – joint projects
- Problem, goal, approach, outcome, costs
- Processing in several phases (milestones)
- In each phase defined
  - Desired goals and results
  - Actions, implementation measures
  - Evaluation
  - Duration

Vis-Group: Funding and Projects

WWTF

FWF

FFG

General Hospital Vienna

imagination at work

The Scripps Research Institute

Allen Institute for Cell Science

Inria

AIT Austrian Institute of Technology

King Abdullah University of Science and Technology

Czech Technical University in Prague

Universitas Masarykiana Brunensis

fhwels

Universitas Bergensis

vrvis

LIVERPOOL JOHN MOORES UNIVERSITY

TU Delft

UC San Diego School of Medicine

Aarhus University Hospital

Research Career

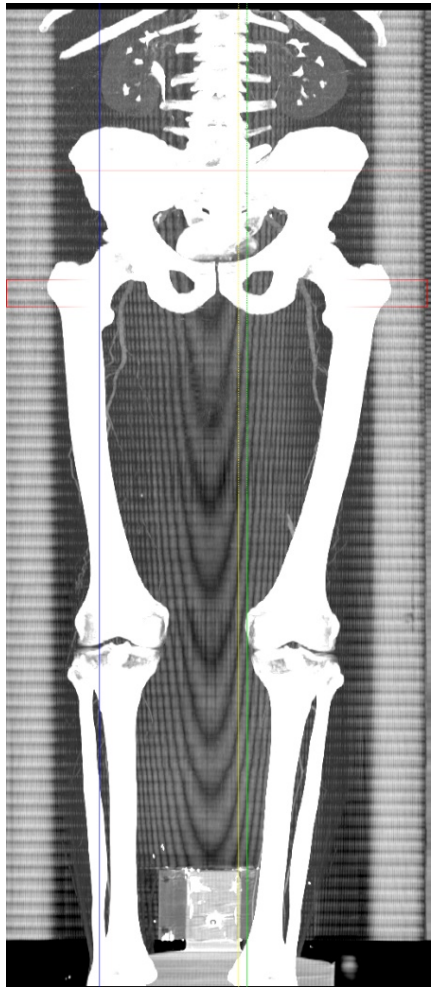
- Professional career
  - Tutor (teaching/research assistant)
  - Doctorate (university assistant, research assistant, ...)
  - PostDoc
  - Habilitation (tenured position), Professorship
- Qualities of a good scientist
  - Curiosity (why, why, why, ...)
  - Creativity
  - Excellent command of tools
  - Analytical thinking
  - Perseverance, tenacity, thoroughness, frustration tolerance

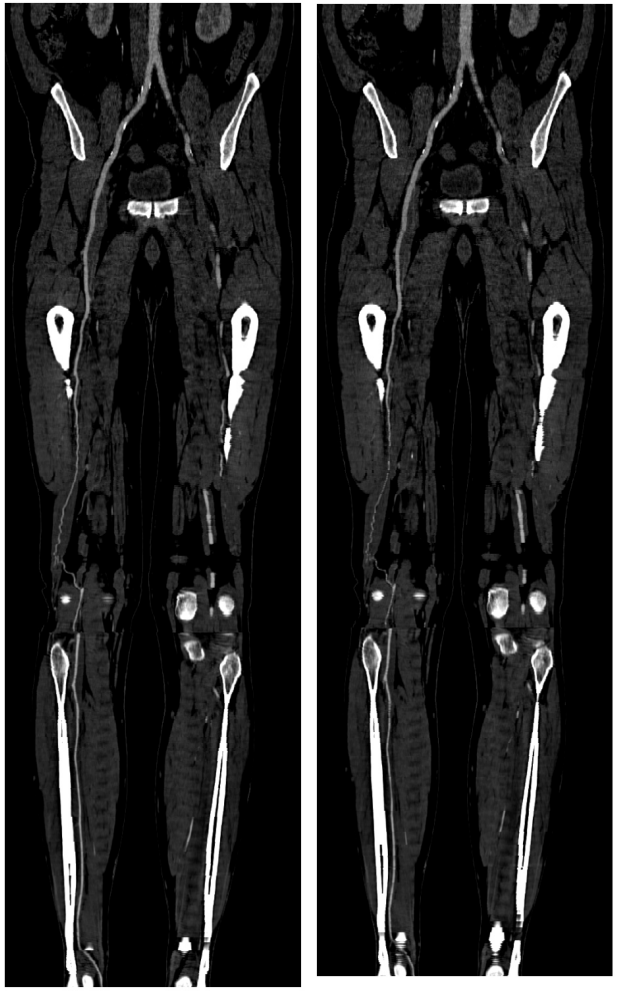
Research Projects - Milestones

- Project start
- State-of-the-art survey
- Formulation of ideas and goals
- Implementation, realization
- Testing, evaluation
- Publishing (write a scientific paper)
- Project end with debriefing

Research Project - Example

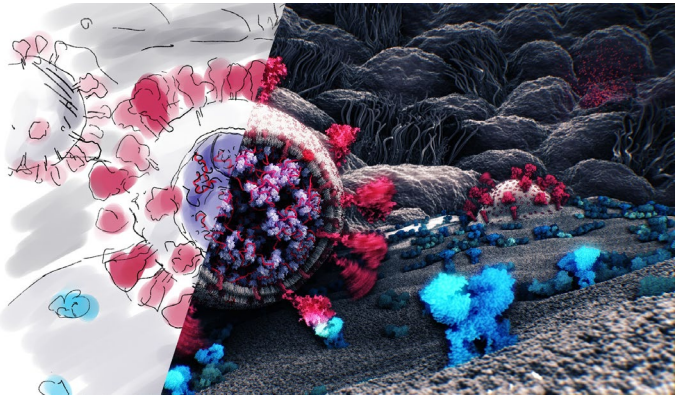
CT - Angiography





Research Results

- Master theses
- PhD theses
- Publications (https://www.cg.tuwien.ac.at/research/publications/)
  - At conferences
  - In scientific journals
- Software prototypes
- Patents, licenses
- Spin-off companies

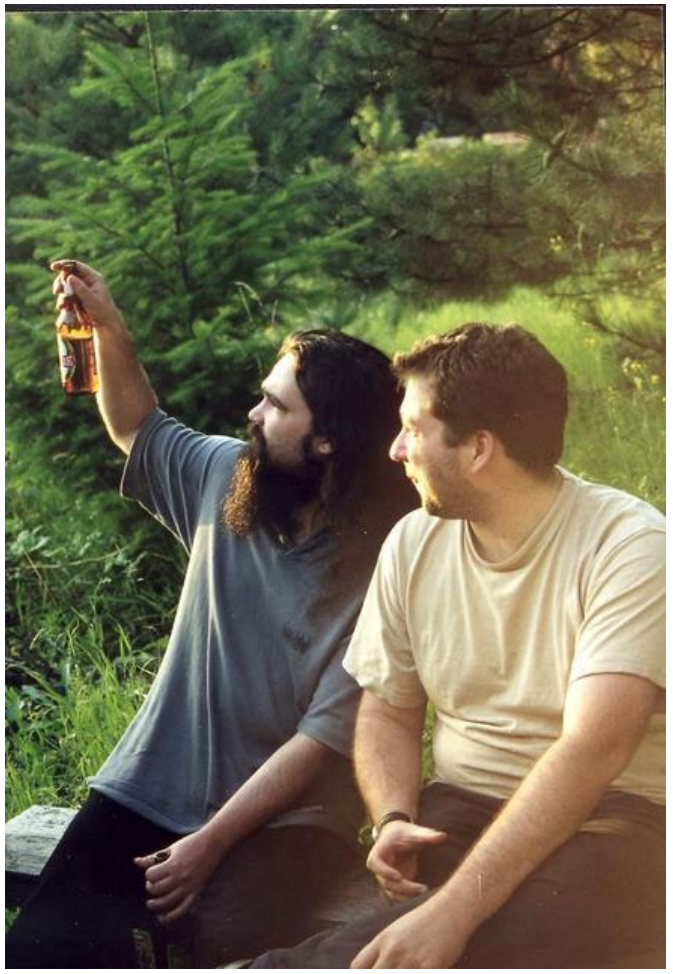


nanographics

VISUAPPS
the visual application company

Research Groups (1)

- Internal Communication
  - Individual meetings
  - Organisational meeting
  - Scientific meeting
  - Colloquy cycle
  - Yearly closed meetings
  - Social interaction



Research Groups (2)

- External Communication
  - Colloquy cycle, guest lecturer
  - Guest researcher
  - External research stays
  - Conference attendance
  - Publications (papers, posters)
    - Scientific
    - Popular science
  - Trade fairs

Publications - Conferences

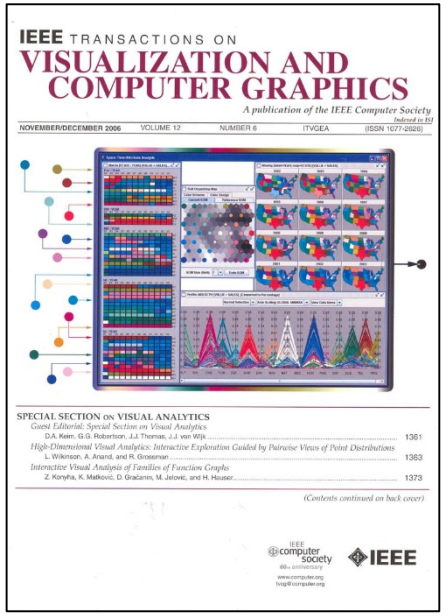
- Organized by scientific associations
- Local organizers
- Conference chair, program committee
- Call-for-papers
- Submission of scientific papers (technical reports)
- Peer reviewing
- Conference attendance, giving a talk
- Article published in conference proceedings

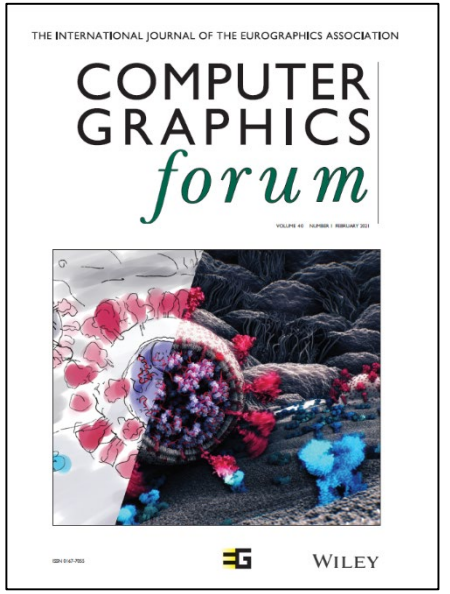
VIS 2021

the premier forum for advances in visualization and visual analytics

Publications - Journals

- Published by commercial publisher or scientific association
- Editor-in-chief, editorial board
- Submission of scientific papers (technical reports)
- Peer reviewing
- Major revision with second review cycle
- Article published in journal
- Duration: half a year and longer





Scientific Associations

- Advancement of scientific area, members
- Ethical guidelines
- Publishing of journals
- Organization of scientific events
- Examples of scientific associations
  - OCG (http://www.ocg.at/)
  - GI (http://www.gi-ev.de/),
  - Eurographics (http://www.eg.org/)
  - IEEE (http://www.ieee.org/)
  - ACM (http://www.acm.org/)

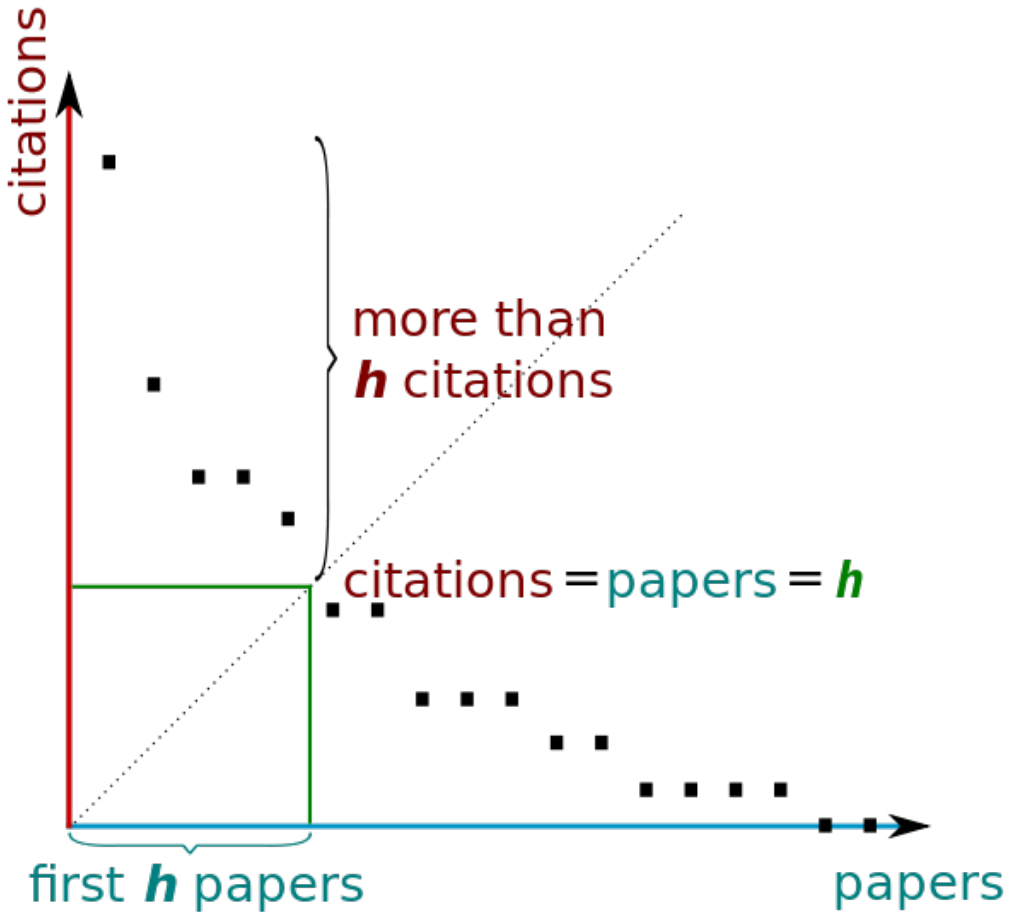
Journals on Academic Establishment

- Austrian University Journal

- German University Journal

Research Activities - Evaluation

- #Publications
- #Patents
- #Talks
- Acquired research fundings
- #PhD students, #Master students
- Member in scientific associations
- Member in program committees
- Member in editorial boards
- #citations
  - Science Citation Index
  - http://scholar.google.com/
  - http://citeseer.ist.psu.edu/
  - http://www.scopus.com/scopus/home.url
  - http://www.vs.inf.ethz.ch/publ/slides/Citation-Index-Unsinn.pdf



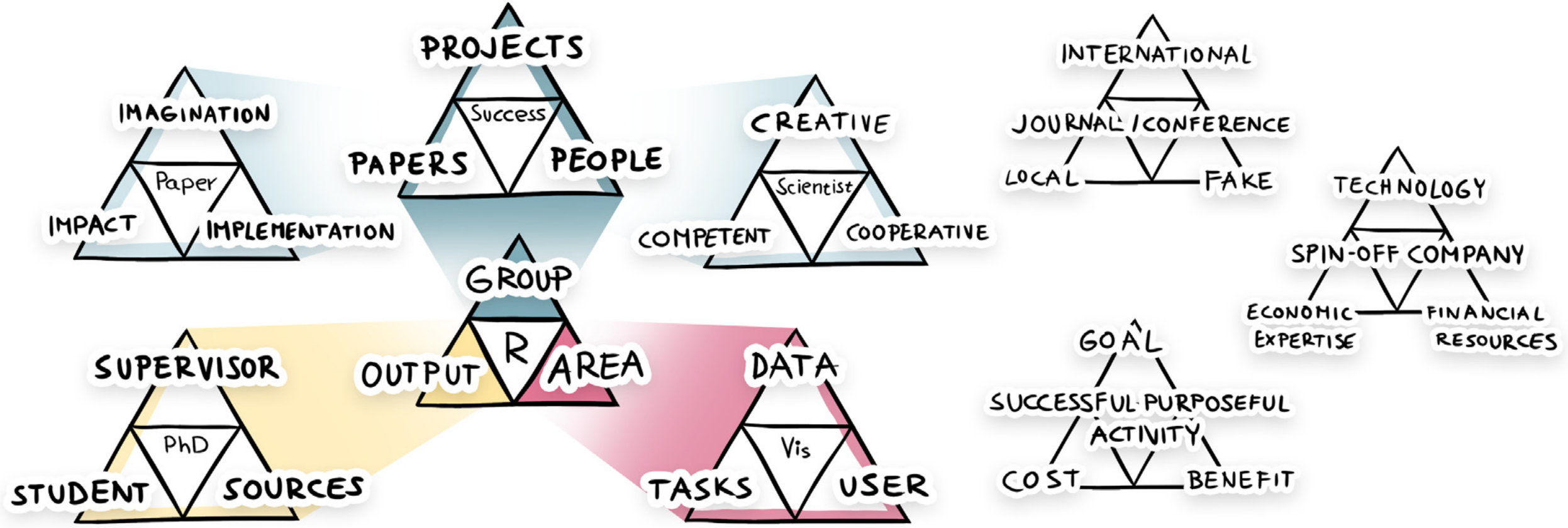
[https://en.wikipedia.org/wiki/H-index]

Research Funding

- University, science funds, company funding
- Science funds
  - FWF – basic research fund (http://www.fwf.ac.at/)
  - FFG – applied research fund (http://www.ffg.at/)
  - EU – funding programs
    - Horizon 2020
    - ERC grants

European Research Council
Established by the European Commission

How to Run a Successful Research Group?

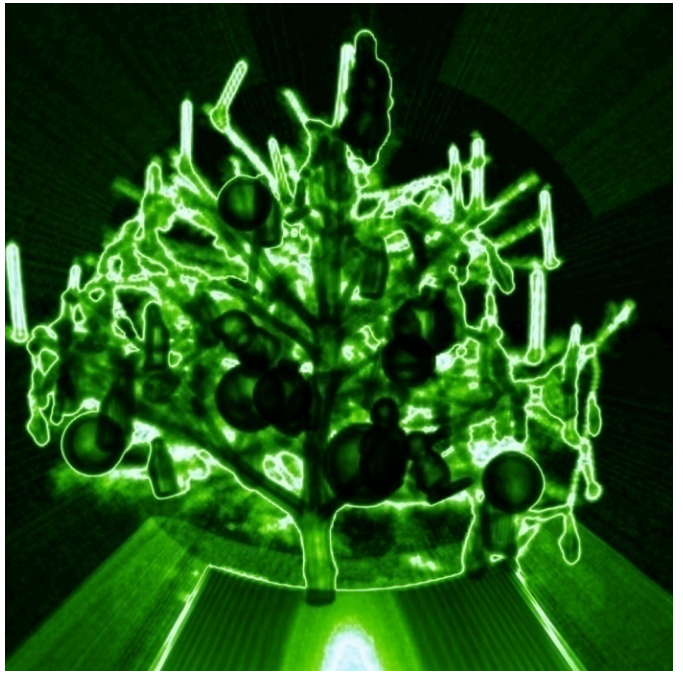


https://www.cg.tuwien.ac.at/research/publications/2021/wu-2021-vi/

Study and Research

- Unity of teaching and research
- Scientific topics dealt with in
  - Proseminars, Seminars
  - Programming assignments, computer science projects
  - Bachelor thesis
  - Master thesis
  - PhD thesis

Research is fascinating
Join in nibbling!



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- http://www.cs.usyd.edu.au/~peter/howtogetphdusyd.pps
- http://www.informatics-europe.org/images/documents/informatics-doctorate-europe_2013.pdf