Free Software and Open Hardware in the Service of Open Science
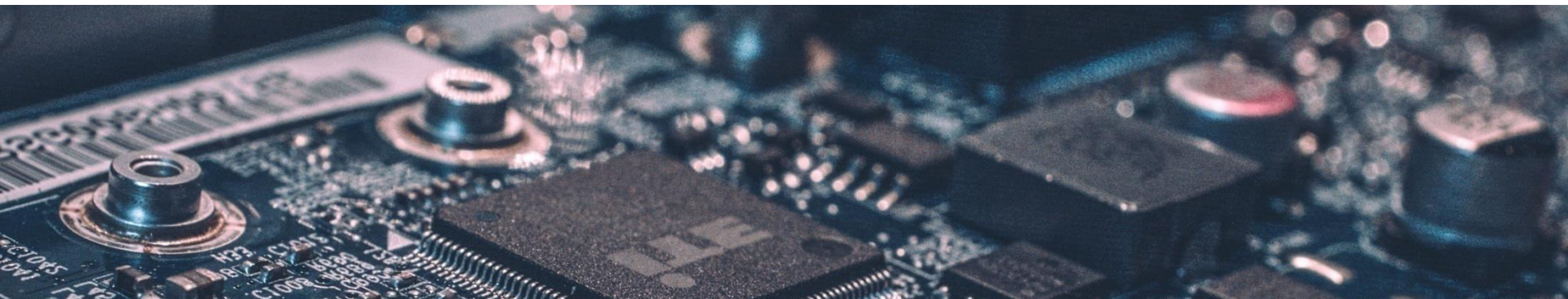
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Modified photo by Infralist.com on Unsplash

I am

- Assoc. Prof. in Biomedical Engineering at ETF

- Visiting Researcher at Faculty of Electrical Engineering, University of Ljubljana

- Guest Assoc. Prof. at the Military Academy, University of Defence in Belgrade

- Having >6 years of industry experience

- Sharing data and software

- Since 2018 involved in numerous Open Science and Open Research Data Initiatives:
  - One of the Founders of Open Science Community Serbia
  - Led one EOSC Co-creation activity
  - Active RDA member and Chair of FAIR4RH group
  - Member of Open Science Group at the Ministry of Education, Science, and Technological Development in Republic of Serbia
  - Organized and participated at numerous local and regional workshops
  - Etc.

"Basic idea of Open Science (OS) is that all knowledge should be freely shared and disseminated."

Lazarević B., Ljiljana, & Žeželj, Iris. (2018). How open science norms improve scientific practices. 13–15. https://doi.org/10.5281/zenodo.1469802
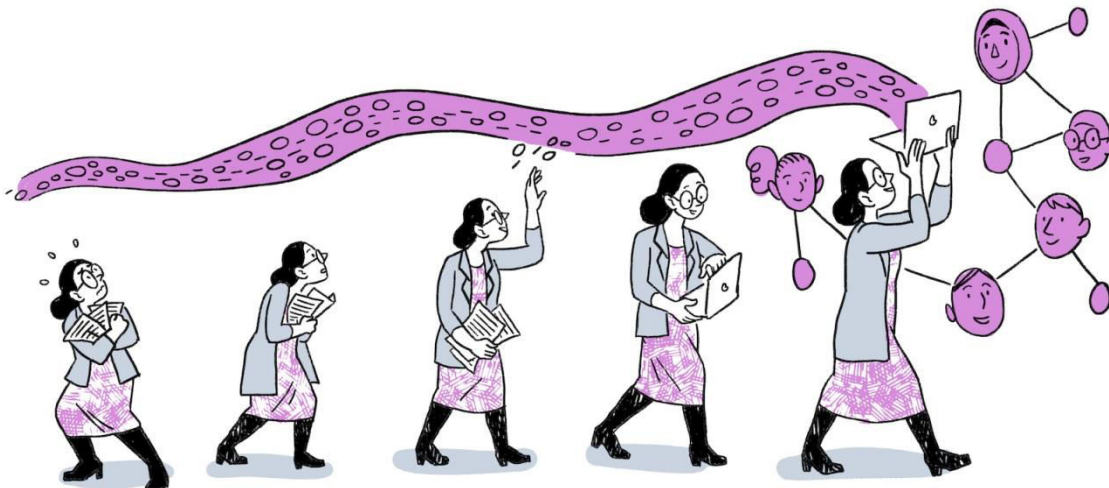
Open Science (OS)

- Usually connected exclusively to the main focus of Open Access (OA) "peer-reviewed journal articles"

  - Swan, Alma. *Policy guidelines for the development and promotion of open access*. UNESCO, 2012, https://unesdoc.unesco.org/ark:/48223/pf0000215863

  - Hunt, Meg, and Alma Swan. *Briefing paper: Open Access*, 2015, http://www.pasteur4oa.eu/resources/135#.YTFLNM_RaUl

- Even to APC (Article Processing Charges)

- This is a mistake

  - Surely, there are economical models, but they are not OS per se

- OS also relates to the research compendium and OA in general as well

  - " A research compendium accompanies, enhances, or is a scientific publication providing data, code, and documentation for reproducing a scientific workflow." https://research-compendium.science/, Accessed on October 28, 2022.

  - To open research data, open methodology, software, hardware, etc.

  - For more thorough discussion on OA definition see recent article https://library.harvard.edu/about/news/2022-10-28/what-does-open-access-mean-you-free-research-outputs-and-beyond

Why is research compendium important?

- " The ability to independently regenerate published computational claims is widely recognized as a key component of scientific reproducibility."

  - Stodden, Victoria, Matthew S. Krafczyk, and Adhithya Bhaskar. "Enabling the verification of computational results: An empirical evaluation of computational reproducibility." *Proceedings of the First International Workshop on Practical Reproducible Evaluation of Computer Systems*. 2018. https://doi.org/10.1145/3214239.3214242

- Strictly speaking, being open and accessible, does not mean bringing more quality and being related to the rigor research design/methodology, etc.

The Turing Way project modified illustration by Scriberia. Used under a CC-BY 4.0 licence. https://doi.org/10.5281/zenodo.3332807.

"Preserving digital artifacts that support scientific claims is necessary for reproducibility"

Stodden, Victoria. "Beyond open data: a model for linking digital artifacts to enable reproducibility of scientific claims." *Proceedings of the 3rd International Workshop on Practical Reproducible Evaluation of Computer Systems*. 2020.
https://doi.org/10.1145/3391800.3398172

The Turing Way project illustration by Scriberia. Used under a CC-BY 4.0 licence. https://doi.org/10.5281/zenodo.3332807

Practicaly

- To publish reproducible research that complies with OS principles, along with manuscript, we should share/open research data with other artifacts such as software and hardware.

    – Benefits: transparency, scientific validation, enhancement of trustworthiness in science, reusability, reduction of research expenses, collaborative, accessibility, etc.

- It should be noted that in some cases sharing is not possible

    – For example, if sharing data means violating praticipant's privacy.

Kidwell, Mallory C., et al. "Badges to acknowledge open practices: A simple, low-cost, effective method for increasing transparency." *PLoS biology* 14.5 (2016): e1002456.
https://doi.org/10.1371/journal.pbio.1002456
Image: https://www.cos.io/hs-fs/hubfs/badges_stacked.original.png?width=417&name=badges_stacked.original.png

Open Hardware and Free Software

Free/Libre Open-Source Software

- A program is free software if the program users have the four essential freedoms:

  - The freedom to run the program as you wish, for any purpose (freedom 0).

  - The freedom to study how the program works, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.

  - The freedom to redistribute copies so you can help others (freedom 2).

  - The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

- Source: Free Software Foundation, https://www.gnu.org/philosophy/free-sw.html#four-freedoms, Accessed on October 29, 2022.

- FS, FOSS/FLOSS, and OSS are now considered synonyms.

  - Pejović, Predrag, et al. Licence slobodnog softvera i otvorenog hardvera — kratko uputstvo za nestrpljive —. 2, Belgrade, Serbia: University of Belgrade - School of Electrical Engineering and Academic Mind, 2021, pp.7–14, https://doi.org/10.5281/zenodo.4210351

FREE SOFTWARE FOUNDATION

Open Hardware (OH)

- "OH is a thing – a physical artifact, either electrical or mechanical, whose design information is available to, and usable by, the public in a way that allows anyone to make, modify, distribute, and use thing".

  - Tomorrow's Ham Radio Technology Today, https://tapr.org/the-tapr-open-hardware-license/, Accessed on October 29, 2022.

- We do not share hardware per se, but its design information, which is digital.

- "Then we can refer to hardware made from a free design as "free hardware," but "free-design hardware" is a clearer term since it avoids possible misunderstanding."
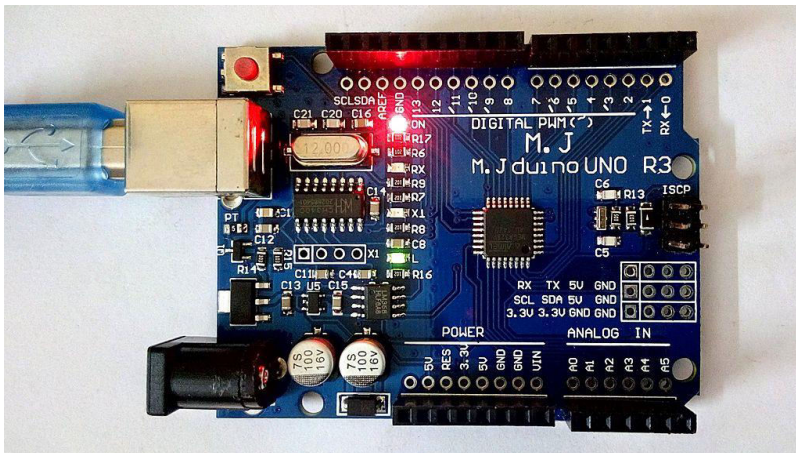
  - Free Hardware Designs by Free Software Foundation, https://www.gnu.org/philosophy/free-hardware-designs.en.html, Accessed on October 29, 2022.

Logo by OSHWA (Open Source Hardware Association) By Mateo Zlatar - http://www.oshwa.org/open-source-hardware-logo, Public Domain, https://commons.wikimedia.org/w/index.php?curid=39210195

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Selected Implications

- Sharing software by FLOSS licenses (Free/Libre and Open Source) matters a lot (for more information see "Public Money, Public Code" campaign by Free Software Foundation Europe)!

- Open hardware initiatives are naturally related to Open Science Practices and Academia, as well as to Education!

  – Some of them started with the education, but were then applied in science too.

- Nüst, Daniel, Carl Boettiger, and Ben Marwick. "How to read a research compendium." *arXiv preprint arXiv:1806.09525* (2018). https://doi.org/10.48550/arXiv.1806.09525
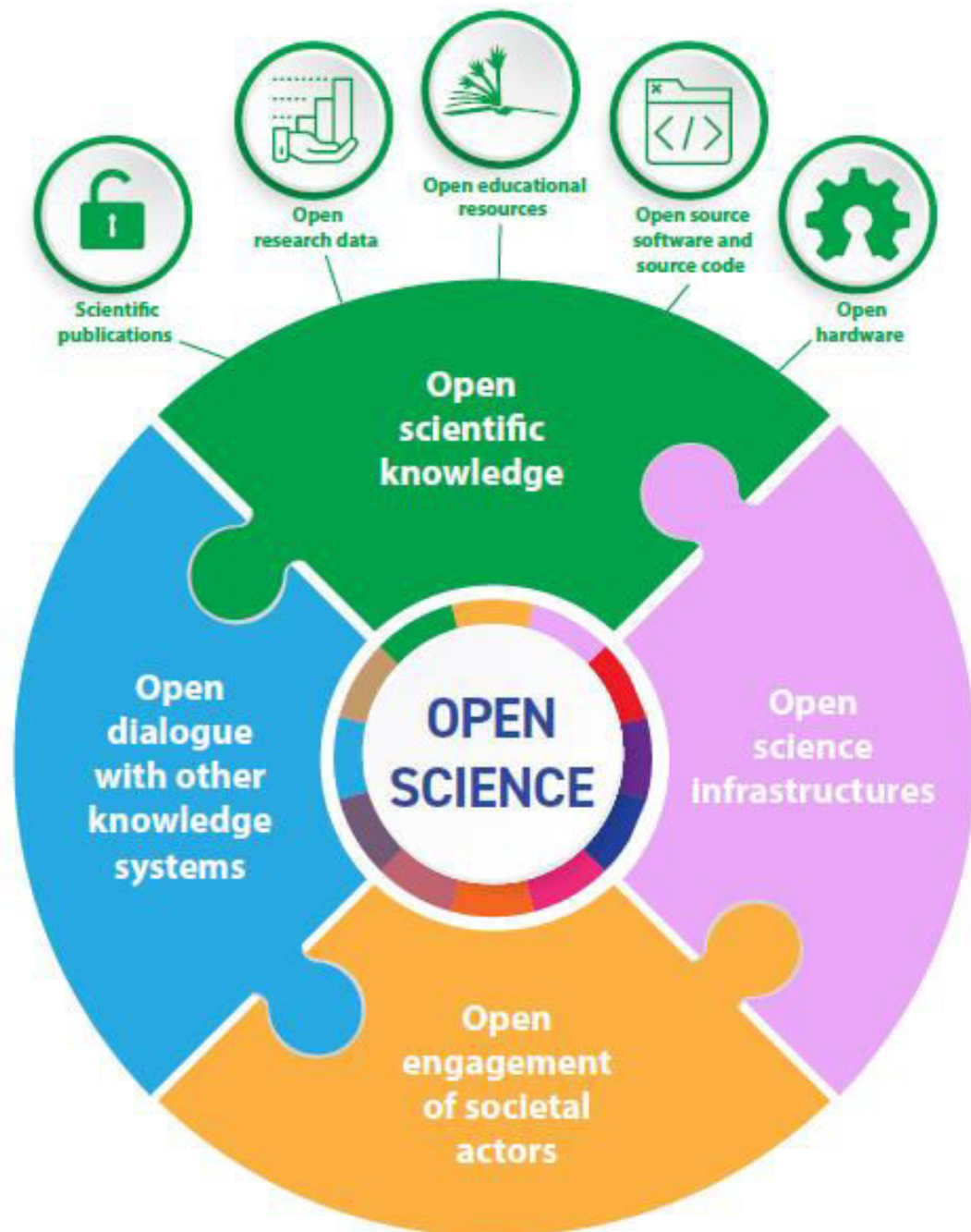

By Rajib Ghosh - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=41748470

NASA*Open Source Rover* powered by a Raspberry Pi 3 https://en.wikipedia.org/wiki/File:NASAJPLOpenSourceRover.webp

UNESCO Recommendation on Open Science adopted by the General Conference of UNESCO at its 41st session, on 23 November 2021. https://unesdoc.unesco.org/ark:/48223/pf0000379949

OS Ecosystem

FAIR

- FAIR (Findable, Accessible, Interoperable, and Reusable) principles.

  - Wilkinson, Mark D., et al. "The FAIR Guiding Principles for scientific data management and stewardship." *Scientific data* 3.1 (2016): 1-9. https://doi.org/10.1038/sdata.2016.18

- Introduced for improving supporting infrastructure.

F and A are related to the place where materials are stored (repositories).

I and R focus on data and metadata formats.

Source: https://forrt.org/glossary/fair-principles/

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FAIR for Software and Hardware

- Selected publications/projects:
  - Hong, Neil P. Chue, et al. "FAIR principles for research software (FAIR4RS principles)." *Research Data Alliance*, (2022). https://doi.org/10.15497/RDA00065
  - Barker, Michelle, et al. "Introducing the FAIR Principles for research software." *Scientific Data* 9.1 (2022): 1-6. https://doi.org/10.1038/s41597-022-01710-x
  - Miljković, Nadica, et al. "Towards FAIR Principles for Open Hardware." 3, *PSSOH Conference*, University of Belgrade - School of Electrical Engineering and Academic Mind, Belgrade, Serbia, (2022): 90–101. https://doi.org/10.5281/zenodo.5524414
  - The FAIR-Battery project, https://github.com/SanliFaez/FAIR-Battery
- Groups within the RDA (Research Data Alliance) you can join:
  - FAIR for Research Software, FAIR4RS WG, https://www.rd-alliance.org/groups/fair-research-software-fair4rs-wg
  - FAIR for Research Hardware, FAIR4RH IG, https://www.rd-alliance.org/groups/fair-principles-research-hardware
  - NEW: FAIR for Machine Learning, FAIR4ML IG, https://www.rd-alliance.org/groups/fair-machine-learning-fair4ml-ig
- RDA will celebrate 10th birthday in 2023 "A Decade of Data"
  - February 2023 will be devoted to FAIR data, software, and hardware
  - More at https://www.rd-alliance.org/plenaries-events/events/%E2%80%98-decade-data%E2%80%99-celebrating-10-years-research-data-alliance

Why not "just FAIR"?

- FAIR data are not necessarily FAIR open research data!

- FAIR software is not necessarily FLOSS!

- "Mouse-operated point-and-click interface with commercial software… cannot be available for inspection due to… proprietary code of the software"

  - Marwick, Ben. "Computational reproducibility in archaeological research: Basic principles and a case study of their implementation." *Journal of Archaeological Method and Theory* 24.2 (2017): 424-450, https://doi.org/10.1007/s10816-015-9272-9

- Although, FAIR is highly important and brings good practices, it is not a guarantee of data/software/hardware quality and (computational) reproducibility.

Practices and Experiences in Serbia

- OS practitioners, both researchers and librarians, with the support of decision makers provided web portals with resources on:

  - DMP, FAIR principles, Open Research Data, licenses, etc.

  - https://open.ac.rs/

  - https://rdm.open.ac.rs/

- Establishment of Community that is part of a larger INOSC network to

  - Raise awareness

  - Create a vivid OS local Community

  - Boost collaboration

  - https://oscs.open.ac.rs/

- Conferences/Events in Serbia

  - Open Science Days, http://www.open.ac.rs/index.php/osd2022

  - Conference on application of free software and open hardware at ETF, PSSOH

  - Etc.

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This presentation is partly based on the Miljković, Nadica. Open Research Data Practices and Experiences in Serbia. 1, Zenodo, https://doi.org/10.5281/zenodo.6860344