

Mapping scientific communities at scale

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1. Motivation

Analysing and mapping scientific communities provides an insight into the structure and evolution of academic disciplines. This involves providing an analytical and visual representation of the relationships between entities (e.g. researchers, research laboratories, research themes), with the aim, in particular, of understanding the networks and dynamics of scientific collaboration, and identifying collaborative groups and their influences. From the point of view of decision-makers, this type of tool is useful for strategic decision-making with a view to public policy and funding.

These maps are generally deduced from data in bibliographic databases (open or proprietary), based on co-publication or citation information. In the case of co-publications, two entities (authors, for example) will be linked if they have collaborated (co-published) on a piece of research. These links are then symmetrical. In the case of citation links, two authors will be linked if one cites the research work of another, in the list of references. This is a directed link, as one author may cite another without this being reciprocal. A lot of recent work uses this second approach, for example by trying to calculate composite indicators of novelty (or innovation) based on citation links.

The quality and completeness of the bibliographic metadata used are, of course, essential if we are to produce a relevant map. Today, the quality of open citation data still needs to be improved, cf (Alperin et al. 2024). On the other hand, it is possible to obtain quality metadata on publications (and therefore links to co-publications). For example, the French Open Science Monitor (BSO) has compiled a corpus of French publications with good coverage cf (Chaignon and Egret 2022). This corpus is exposed in the French research portal scanR (Jeangirard 2024). This is a corpus containing about 4 millions publications in all disciplines. These publications have been enriched with disambuation persistent identifier (PID) on authors, affiliations and topics. For authors and affiliations, French-specific PID have been used (idref for authors and RNSR for laboratories) because they have the best coverage, even if not perfect. For topics, wikidata identifiers has been used cf (Foppiano and Romary 2020). Other enrichments, like software detection are also present, and thus usable as entities to map.

1.1 Previous limits of the scanR application

Launched in 2016, the scanR portal used to be a search engine. Its scope first focused on research entities (institutions, laboratories and private companies) and was extended in 2020 to cover fundings, publications, patents and authors. Two main use cases were covered. Firstly, the ability to generate a list of search results corresponding to a user query. A list of laboratories, authors, funding or publications could be generated. Secondly, for each institution (or laboratory), a unified view of all the

data concerning it was grouped together on a dedicated page in scanR (administrative information, list of publications, list of funding, main partners, etc.).

However, these functions only gave a flat view of the different dimensions, without providing any insights into the interactions between laboratories or authors. For a user interested in a research theme, for example, the list of the main contributors (those who have co-authored the most publications) does not give a clear idea of which research communities are at work and how they interact with each other. A network analysis tool to describe these interactions and attempt to detect research communities could therefore enable us to go further in creating tools to help explore fields of research and innovation.

1.2 Network analysis limits

Network analysis tools for bibliographic studies are used to study the relationships between entities in a corpus. In general, the size of this corpus is limited because the calculations to determine the nodes, links and their positions for very large networks require too many resources, in addition to being very difficult to interpret. As a result, tools such as VOSViewer offer options for limiting the size of networks. The first option is to filter publications with too many authors. This is particularly true of publications in particle physics, which can list several thousand authors. As well as generating very large networks, this hyperauthorship can also be seen as reducing the relevance of the information conveyed by the co-authorship links. The second option offered by VOSViewer is to set thresholds to limit the number of nodes directly (minimum number of publications or minimum number of citations for a node). However, this approach of retaining only the largest nodes in the network can be an obstacle to scaling up to very large corpora of several million documents. Indeed, if we wish to concentrate on a few hundred nodes, the threshold will be very high and the resulting network risks being just a constellation of single nodes with no links between them, the other nodes with which they are linked being in fact made insignificant by the threshold set in terms of the number of publications (or citations) per node. In addition, the processing time for a very large corpus of publications can be very long, making such a tool unusable in a web application where the user expects rapid interaction with the application.

2. Network analysis at scale

We propose a method for overcoming the limitations set out above. We also use a filtering technique to reduce the size of the network, but with a dual approach: instead of filtering the nodes, we filter the links.

2.1 Focusing on strongest interactions

One of the added values of mapping with a network view is to show the interactions between entities, i.e. the links between the nodes in the graph. These links provide crucial information that can be used to structure communities. If the size of the network needs to be reduced (for reasons of computation, speed, legibility and interpretability), it is vital to preserve the links that carry the most information, i.e. the strongest interactions. With this reasoning, it seems logical to reduce the size of the network by only affecting the strongest links.

Thus, from a given corpus, however large, we seek to extract the pairs of entities with the strongest interactions, for example the most co-signatures per pair of authors. From this list of pairs, we can naturally find the nodes of the graph and deduce a new graph. If the graph has several independent components, i.e. several unconnected sub-graphs, we can decide to keep only the main component(s).

2.2 Elasticsearch implementation

2.3 VOSviewer implementation

2.4 LLM trick

3. Making insightful maps

3.1 Citation / hot topics

3.2 User interaction

References

- Alperin, Juan Pablo, Jason Portenoy, Kyle Demes, Vincent Larivière, and Stefanie Haustein. 2024. “An Analysis of the Suitability of Openalex for Bibliometric Analyses.” <https://arxiv.org/abs/2404.17663>.
- Chaignon, Lauranne, and Daniel Egret. 2022. “Identifying Scientific Publications Countrywide and Measuring Their Open Access: The Case of the French Open Science Barometer (Bso).” *Quantitative Science Studies* 3 (1): 18–36. https://doi.org/10.1162/qss_a_00179.
- Foppiano, Luca, and Laurent Romary. 2020. “Entity-Fishing: A Dariah Entity Recognition and Disambiguation Service.” *Journal of the Japanese Association for Digital Humanities* 5 (1): 22–60.
- Jeangirard, Eric. 2024. “scanR - Explore public data on French research and innovation.” In *euroCRIS SMM 2024*. Paris, France: euroCRIS. <https://hal.science/hal-04813230>.