# Clustering of scientific citations in Wikipedia

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# Science in Wikipedia!?

Danish librarian:

"[...] pupils up to high school, who need to get an overview about a topic, can use [Wikipedia]. But if you are working on a doctoral thesis, then you will not be able to use it [...]"

— from (Brand, 2005).

...but now there very much science in Wikipedia is written and read by people working on a doctoral thesis ...

# Structured content in Wikipedia

The content in Wikipedia may contain structured information in templates, e.g., for scientific citations:
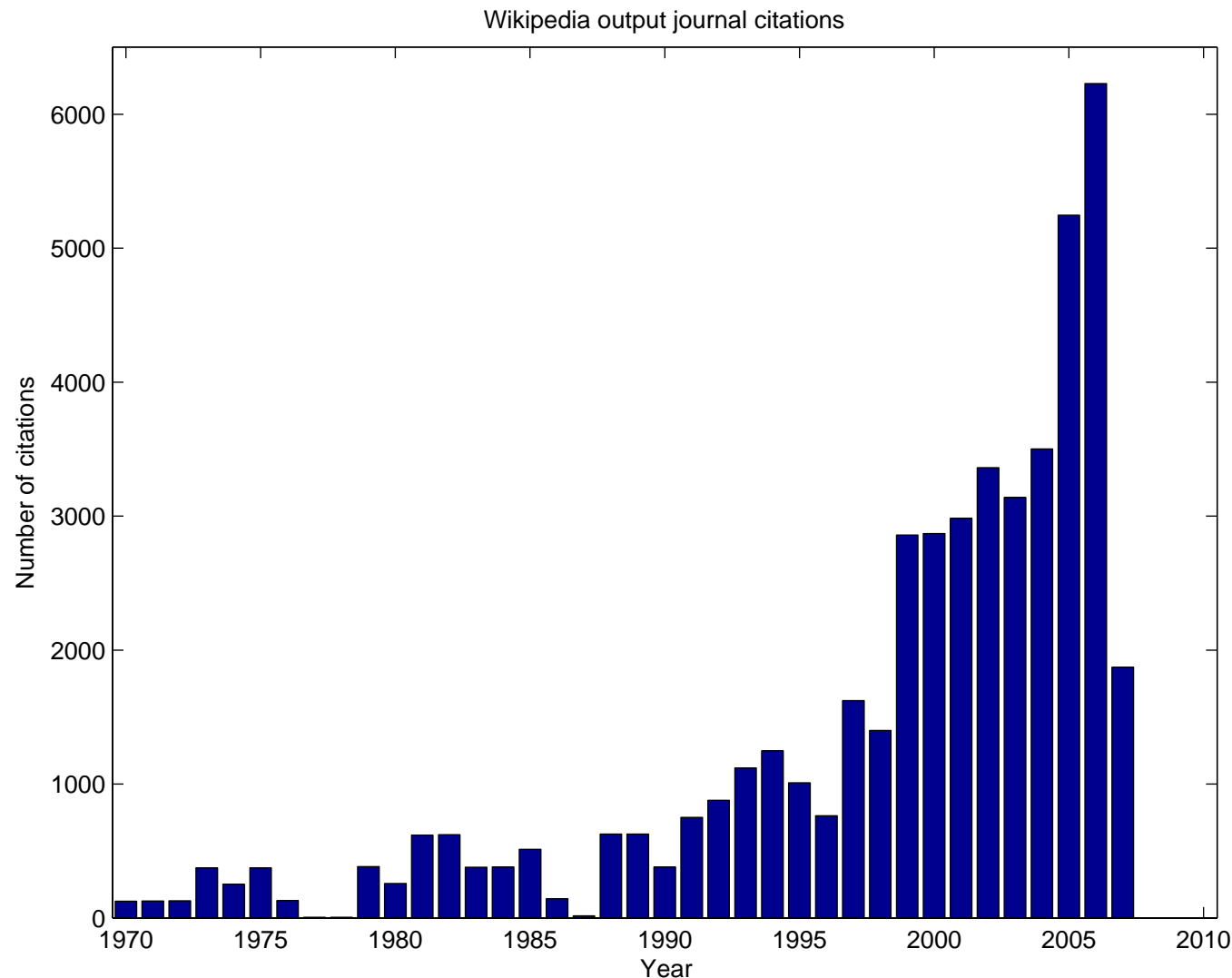
```
{{cite journal|author=Filipek PA, Accardo PJ, Baranek GT ''et al.''
|title=The screening and diagnosis of autistic spectrum disorders
|journal=J Autism Dev Disord |date=1999 |volume=29 |issue=6
|pages=439--84
|doi=10.1023/A:1021943802493|pmid=10638459}}
```

It is reasonably easy to extract the fields and values of templates in Wikipedia articles (Auer et al., 2008; Isbell and Butler, 2007) ☺ .

Focus on the `journal` field of the `Cite journal` template, where the first edit on the template was 4 February 2005.

Download XML dump → Perl → Matlab → HTML

# Year of publication of cited journal article



Wikipedia output journal citations

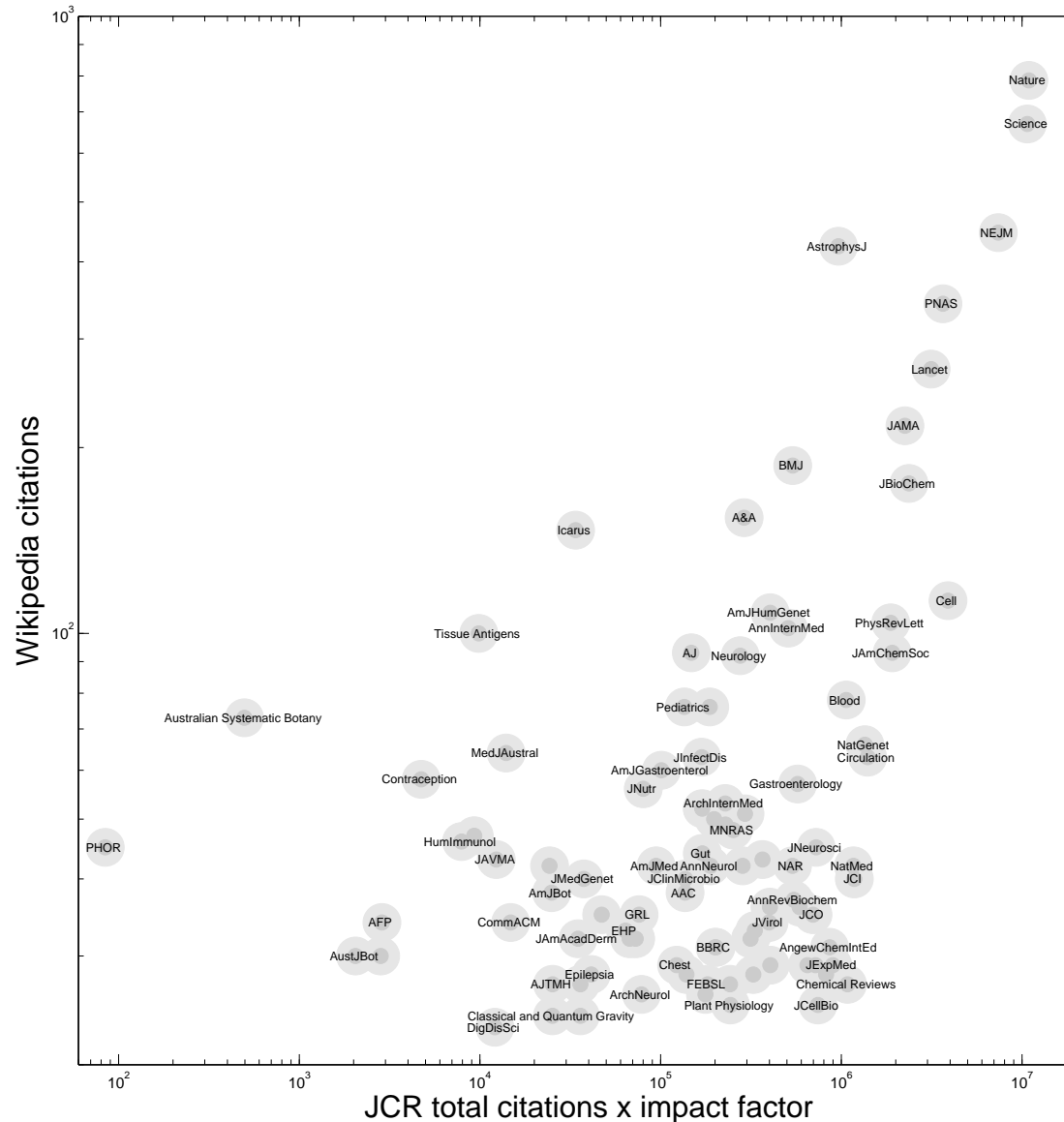# Manually built XML file for journals

```
<Jou>
    <wojou>7</wojou>
    <name>The Journal of Neuroscience</name>
    <abbreviation>JNeurosci</abbreviation>
    <namePubmed>J Neurosci</namePubmed>
    <type>jou</type>
    <variation>Journal of Neuroscience</variation>
    <variation>j. neurosci.</variation>
    <variation>J Neurosci</variation>
    <wikipedia>Journal of Neuroscience</wikipedia>
</Jou>
```
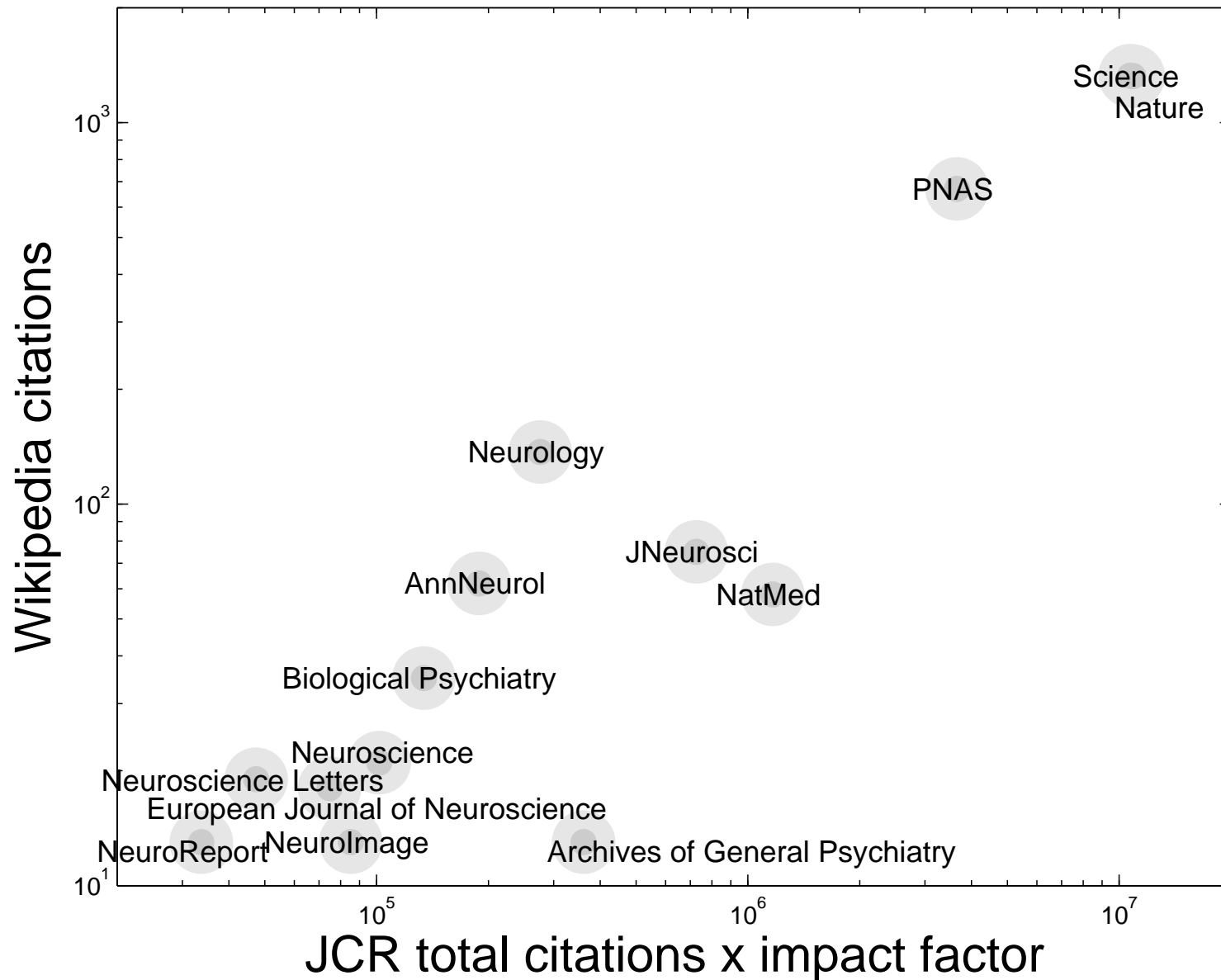
# Analysis of scientific citations



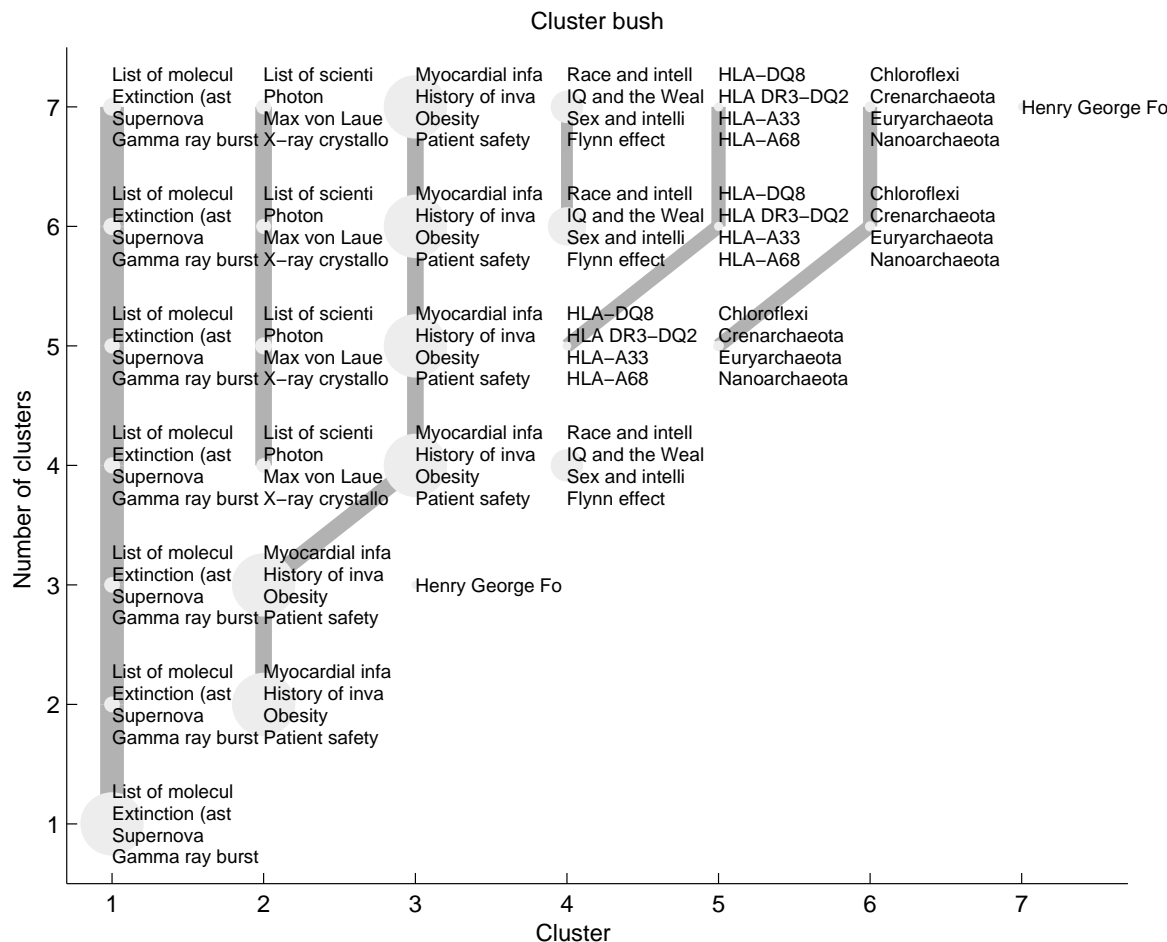Scientific citations from Wikipedia to journals

Comparison against *Journal Citation Reports* from *Thomson Scientific*

The *Nature* and *Science* journals are the most cited from Wikipedia.

The product between total citations and impact factor showed good correlation with the Wikipedia citation count (Nielsen, 2007) ☺ .

# Clustering of Wikipedia data



Cluster bush

Clustering of citations from Wikipedia articles to scientific journals from a October 2007 dump.

Data matrix (Wikipedia article × journal)

Non-negative matrix factorization with increasing number of clusters (components) (Nielsen et al., 2005)

Clusters in this dump related to astrophysics, medicine, intelligens, immunology, bacteria, ...

# Non-negative matrix factorization

|           | Science | Nature | JBC | JAMA | AJ | ... |
|-----------|---------|--------|-----|------|----|-----|
| Evolution | 3 | 1 | 1 | 0 | 1 | ... |
| Bacteria | 1 | 3 | 0 | 1 | 0 | ... |
| Sertraline | 0 | 0 | 4 | 2 | 0 | ... |
| Autism | 0 | 0 | 0 | 2 | 0 | ... |
| Uranus | 1 | 0 | 0 | 0 | 3 | ... |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋱ |

Begin with (Wikipedia articles $\times$ journals)-matrix $\mathbf{X}$

Paatero, ..., (Lee and Seung, 1999): Non-negative matrix factorization (NMF) of a data matrix $\mathbf{X}$ into two other matrices $\mathbf{X} = \mathbf{WH} + \mathbf{U}$.

In Wikipedia contexts: (Buntine, 2005; Bellomi and Bonato, 2005)
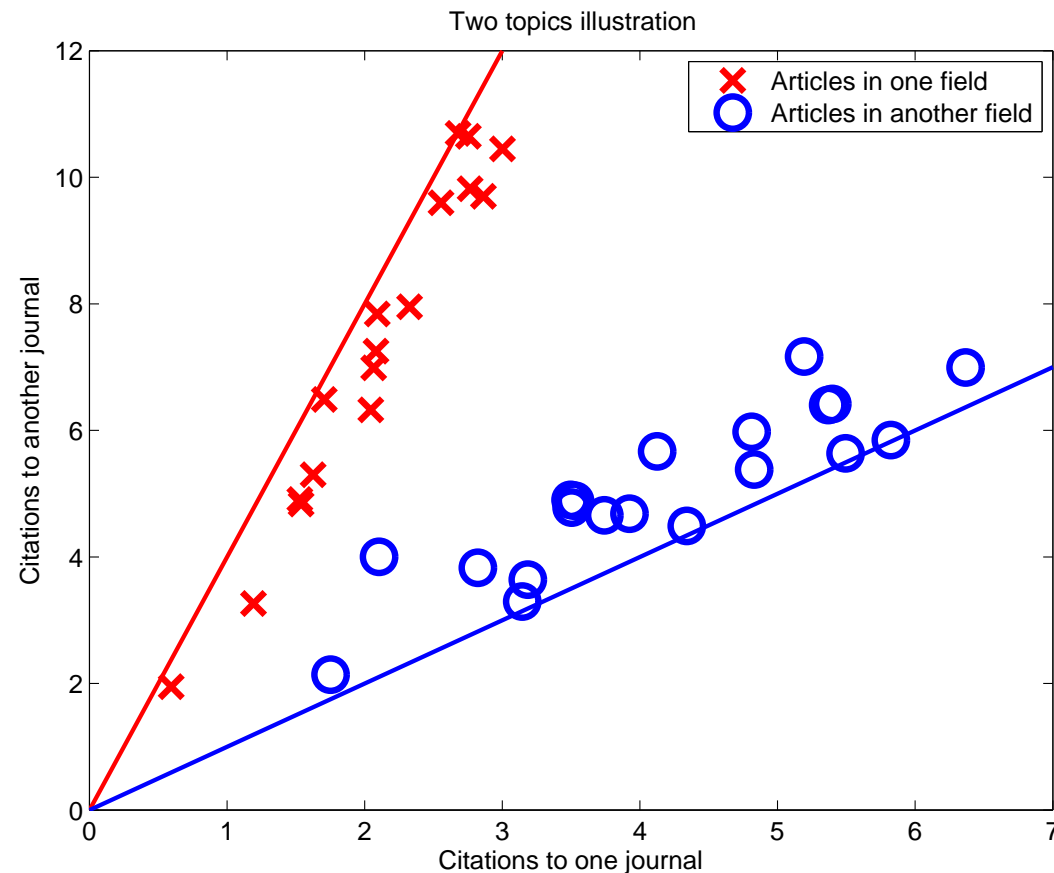
# ...Non-negative matrix factorization



Figure 1: Illustration of non-negative matrix factorization where each point is a Wikipedia article and the lines are representing the loadings in the **H** matrix.
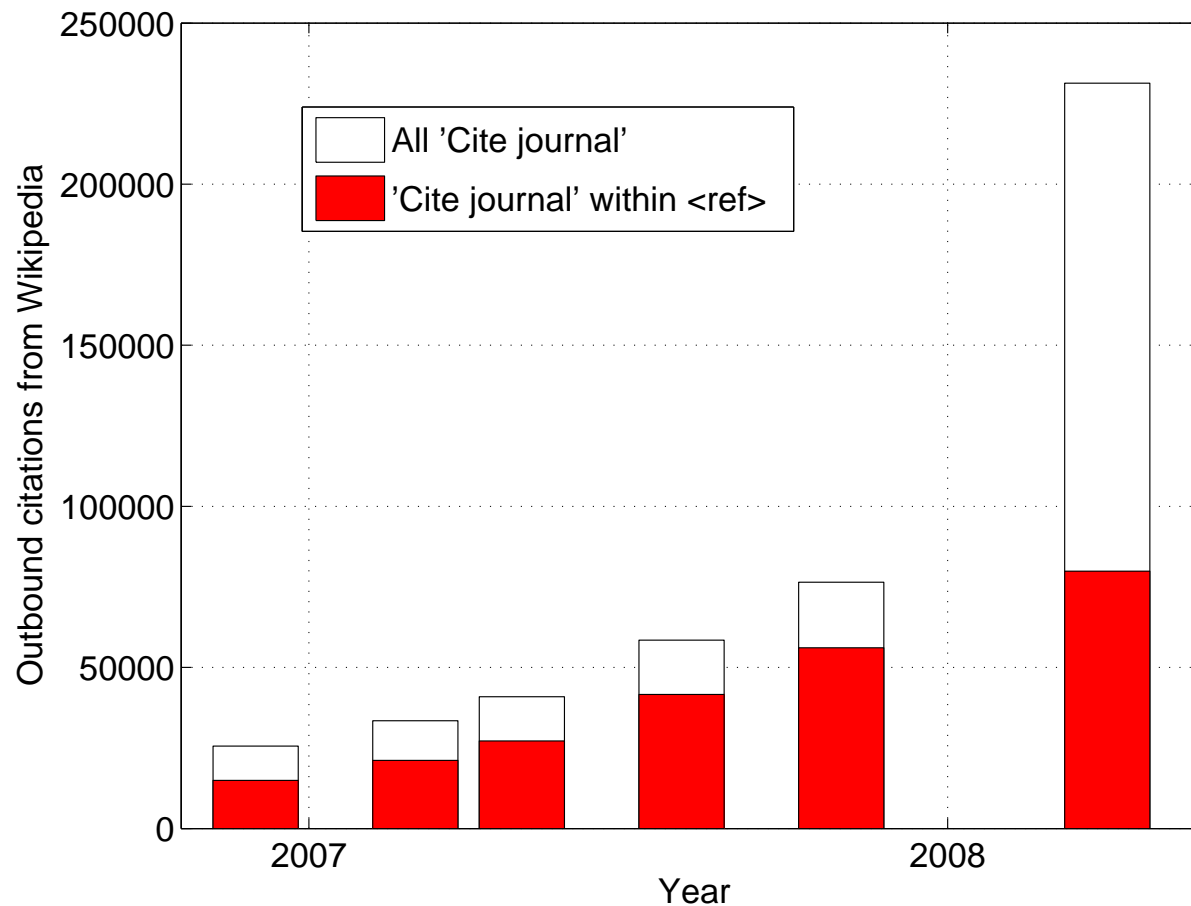
Compared to singular value decomposition ("latent semantic indexing"):

— Clusters are not constraint to be orthogonal ☺

— Only one "interpretable" end for NMF ☺

— Seemingly more difficult estimation ☹ , but active research area ☺ and new fast algorithms are available, e.g., Mikkel N. Schmidt's fast NMF ☺

# Growth in citations from Wikipedia . . .



The use of the `cite journal` template has increased since 2006 ☺ .

Over the new year 2007/08 a bot adds numerous pages for proteins with a lot of scientific citations expanding the number of citations from 74,776 citations in the October 2007 dump to 228,593 in the March 2008 dump (Huss, III et al., 2008).

# Most cited journals in March 2008

| Citations | Journal name |
|---:|:---|
| 16739 | The Journal of Biological Chemistry |
| 12779 | PNAS |
| 8772 | Genome Research |
| 7561 | Nature |
| 4007 | Nature Genetics |
| 3928 | Genomics |
| 3689 | Science |
| 3511 | Gene |
| 3380 | Biochemical and Biophysical Research Communications |
| 3043 | Molecular and Cellular Biology |
| 2975 | Cell |
| 2261 | The EMBO Journal |

Table 1: Most cited journals from Wikipedia in the 12th March 2008 dump.

# Clusters in the new dump

| Cluster | Wikipedia hub articles | Authoritative journals |
|---|---|---|
| 'Cancer' | RBL2 | Oncogene |
| | MYB | Cancer Research |
| | ERG (gene) | Int. J. Cancer |
| | EPS8 | Gene & Development |
| 'Immunology' | DNA vaccination | The Journal of Immunology |
| | CCL21 | The Journal of Experimental Medicine |
| | HLA-DQ8 | Tissue Antigens |
| | HLA-DQA1 | Eur. J. Immunol. |
| 'Blood' | Acute myeloid leukemia | Blood |
| | Serpin | British Journal of Haematology |
| | CEBPE | The Journal of Clinical Investigation |
| | CD34 | The Journal of Experimental Medicine |
| 'Virology' | Papillomavirus | The Journal of Virology |
| | HHV Infected Cell . . . | Virology |
| | Poliovirus | Journal of Molecular Biology |
| | RELB | AIDS Res. Hum. Retroviruses |

Table 2: The top Wikipedia hubs articles and authoritative journals with respect to clusters from a non-negative matrix factorization with twenty clusters.

The newly added protein pages have a large impact on the clusters of the result of the non-negative matrix factorization ☺/☹ .

# Cluster example with only in-line references

## Cluster 2

| # | Cites | Load | Wikipedia hub article | # | Cites | Load | Authoritative journal |
|---|-------|------|----------------------|---|-------|------|----------------------|
| 1 | 106 | 5.857 | List of molecules in interstellar space | 1 | 794 | 8.076 | The Astrophysical Journal |
| 2 | 41 | 1.665 | Supernova | 2 | 300 | 2.946 | Astronomy & Astrophysics |
| 3 | 38 | 1.623 | Vega | 3 | 51 | 1.609 | The Astrophysical Journal Letters |
| 4 | 30 | 1.511 | Gamma ray burst | 4 | 181 | 1.197 | Monthly Notices of the Royal Astronomical Society |
| 5 | 21 | 1.488 | Extinction (astronomy) | 5 | 315 | 0.729 | The Astronomical Journal |
| 6 | 27 | 1.318 | Andromeda Galaxy | 6 | 44 | 0.368 | The Astrophysical Journal Supplement Series |
| 7 | 24 | 1.268 | AU Microscopii | 7 | 49 | 0.298 | Bulletin of the American Astronomical Society |
| 8 | 33 | 1.131 | Star | 8 | 56 | 0.298 | Publications of the Astronomical Society of the Pacific |
| 9 | 31 | 1.110 | Galaxy | 9 | 26 | 0.202 | annual review of astronomy and astrophysics |
| 10 | 25 | 1.022 | Sombrero Galaxy | 10 | 17 | 0.195 | astrophysics and space science |

# Another cluster example

## Cluster 21

| # | Cites | Load | Wikipedia hub article | # | Cites | Load | Authoritative journal |
|---|---|---|---|---|---|---|---|
| 1 | 67 | 2.561 | Multiple sclerosis signs and symptoms | 1 | 232 | 5.036 | Neurology |
| 2 | 119 | 1.937 | Alzheimer's disease | 2 | 72 | 1.292 | Archives of Neurology |
| 3 | 65 | 1.936 | Multiple sclerosis | 3 | 79 | 1.063 | Annals of Neurology |
| 4 | 44 | 1.596 | Familial hemiplegic migraine | 4 | 24 | 0.834 | j neurol |
| 5 | 33 | 0.986 | Episodic ataxia | 5 | 61 | 0.773 | Brain |
| 6 | 56 | 0.961 | Parkinson's disease | 6 | 24 | 0.695 | j neurol sci |
| 7 | 23 | 0.892 | Restless legs syndrome | 7 | 19 | 0.689 | mult scler |
| 8 | 43 | 0.890 | Migraine | 8 | 42 | 0.675 | j neurol neurosurg psychiatr |
| 9 | 25 | 0.769 | Benign familial neonatal convulsions | 9 | 8 | 0.358 | european archives of psychiatry and clinical neuroscience |
| 10 | 24 | 0.666 | Therapies under investigation for multiple sclerosis | 10 | 12 | 0.318 | lancet neurology |

# A third cluster example

## Cluster 6

| # | Cites | Load | Wikipedia hub article | # | Cites | Load | Authoritative journal |
|---|-------|------|-----------------------|---|-------|------|----------------------|
| 1 | 48 | 4.157 | HLA-DQ8 | 1 | 254 | 6.737 | Tissue Antigens |
| 2 | 57 | 4.151 | HLA DR3-DQ2 | 2 | 102 | 2.833 | Human Immunology |
| 3 | 37 | 2.748 | HLA-A33 | 3 | 24 | 0.979 | International Journal of Immunogenetics |
| 4 | 19 | 1.524 | HLA-A68 | 4 | 41 | 0.227 | American Journal of Physical Anthropology |
| 5 | 14 | 1.159 | HLA-A69 | 5 | 7 | 0.184 | Experimental and Clinical Immunogenetics |
| 6 | 40 | 1.050 | HLA-DR4 | 6 | 37 | 0.173 | Human Genetics |
| 7 | 11 | 0.690 | HLA-A3 | 7 | 14 | 0.156 | immunogenetics |
| 8 | 26 | 0.675 | HLA-DQ1 | 8 | 70 | 0.154 | Arthritis & Rheumatism |
| 9 | 15 | 0.636 | HLA-DR16 | 9 | 7 | 0.126 | transplant proc |
| 10 | 17 | 0.632 | HLA-DQ4 | 10 | 29 | 0.126 | Annals of the Rheumatic Diseases |

# Another data set



Construct binary matrix $\mathbf{X}$(articles $\times$ authors) from the revision history with one indicated an edit.

Excluding usernames matching "bot" and documents beginning with "Wikipedia". Exclude articles with less than three different authors.

Non-negative matrix factorization clusters in Danish 2006 dump: Danish Kings, countries, Danish munipalities and counties, years, . . .

# Summary

Wikipedia structured content can be extracted and subjected to multivariate analysis: Wikipedia templates are not just for formatting!

Analysis of the citation pattern in Wikipedia reveals scientific themes.

Future: An online real-time application!?

http://www.imm.dtu.dk/~fn/Nielsen2008Clustering.html

http://hendrix.imm.dtu.dk/services/wikipedia/

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