Geographical Distribution of Biomedical Research in USA and China

Yingjun Guan, Jing Du, Vetle Torvik
School of Information Sciences, University of Illinois at Urbana-Champaign

School of Information Sciences
The iSchool at Illinois

Introduction

❑ **Research Questions** Using disambiguated and geocoded names of 19.4 millions author affiliations in PubMed, we address the following questions:

- What was the geospatial distribution of biomedical research in USA and China, and how has it changed over the past 30 years?
- To what degree are the publications concentrated in a few cities or in some regional hubs? Try analyze the clusters and measure of distances inside the publication clusters in both countries.

❖ ***Note:*** *In this research, USA refers to the lower 48 states and China stands for the mainland China.*

Data

❑ **Large but ambiguous PubMed affiliation records**

University, MS, USA	Harvard, MA, USA	Mexico, NY, USA
Usa, Oita, Japan	Cambridge, WI, USA	Sydney, NS, Canada
Institute, WV, USA	Carolina, PR, USA	Durham, CT, USA
York, NE, USA	Columbia, NJ, USA	King, NC, USA
London, KY, USA	Ontario, OR, USA	Melbourne, AR, USA
DE, USA; LA, USA;	Poland, ME, USA	Yale, MI, USA
IN, USA	Hopkins, MN, USA	Wales, WI, USA
Washington, TX, USA	Rochester, MO, USA	Indiana, PA, USA
Street, Somerset, UK	Florida, NY, USA	Athens, TN, USA
North, VA, USA	Oxford, IA, USA	etc.
Paris, IL, USA	Rome, NY, USA	

Figure 1. Low-Precision place names

MapAffil [1] geocoded and disambiguated 37M PubMed affiliations with 99.9% accuracy. The statistics results of ambiguity are shown in table 1. The top 20 countries with most publication are listed in Figure 2.

Table 1. Ambiguity of top most frequent place names

City	Precision	Recall	% of nation output	% of nation population
London, UK	91.8	91.5	29.2	13.7
New York, NY, USA	68.0	87.6	5.5	2.7
Boston, MA, USA	98.7	93.3	5.1	0.2
Paris, France	99.0	68.7	39.5	18.5
Tokyo, Japan	94.7	97.4	20.7	10.2
Beijing, China	99.4	99.1	18.2	1.6
Seoul, Korea	97.1	99.3	48.8	19.8
Baltimore, MD, USA	99.5	94.9	97.2	2.7
Philadelphia, PA, USA	99.5	95.1	97.2	2.7
Los Angeles, CA, USA	99.6	86.5	92.6	2.6

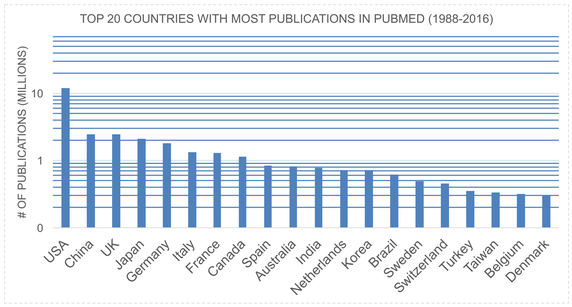


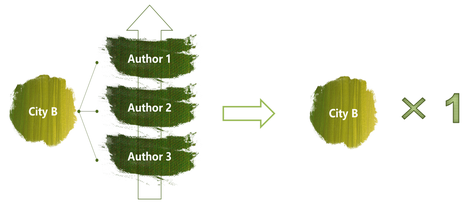
Figure 2. Top 20 countries with most authorships in the database

Method

❑ The spatial distribution of biomedical researches in USA and China, and its change over time.

Locality calculation: Each publication might have multiple affiliations involved, and each affiliation is counted towards its locality (city or suburb). When a publication connects to the same locality multiple times, it will only be counted once.

For example below, in a same paper, the affiliations of all three authors are City B. Then the locality of the publication is City B, whose count is only one.



❑ Centroid and average distance of the affiliations

Geographical centroid: The central point can be calculated by averaging the latitude and longitude of all the relevant localities. In this research both the overall centroid (treat as one cluster) and multiple cluster centroids are calculated and analyzed.

Average distance to a cluster centroid: The Rooted Mean Squared Vincenty Distance (RMSVD) is taken as shown below in Equation 1, where r_i is the distance from an individual affiliation to the centroid, n is the total number of localities in each calculation, $\bar{r}$ is the average distance (RMSVD).

$$\bar{r} = \sqrt{\frac{1}{n} * \sum_i r_i^2} \qquad \textit{(Equation 1)}$$

Vincenty Distance: Vincenty Distance is based on the assumption of the Earth being an oblate spheroid. Compared with Euclidean plane and great circle assumptions, the error is smallest and neglectable in the research. [However, it should be noticed that the distance here is the theoretical distance rather than travel distance]

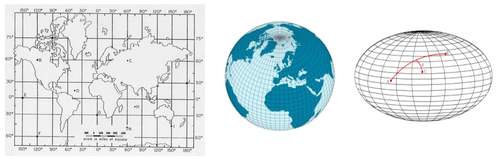


Figure 3. Model of Euclidean plane, great circle and vincenty model

❑ Clustering analysis in USA and China

K-Means clustering: the method aims to partition all observations into k clusters in which each observation belongs to the cluster with the nearest mean. As k increases, the RMSVD decreases. The method can help analyze research distributions.

Results

❑ **Geospatial distribution in USA and China, and overall centroid movement over time (1988 - 2016).**

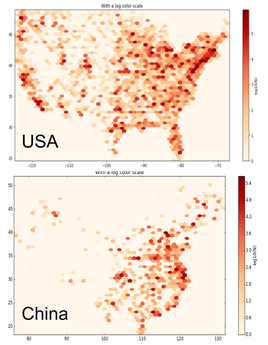


Figure 4. The overall geospatial distribution of USA (the lower 48) and China (mainland) are shown as left.
In the US, eastern and western coasts are the two main hubs of medical publication, the meddle part, like the the state of Nebraska and Utah, has fewer publications. The center of the lower 48 is in Illinois!
In China mainland, the eastern coast enjoy the most medical publications, there are obviously fewer publications in the middle and western sections. The center of the mainland of China is in Anhui Province.

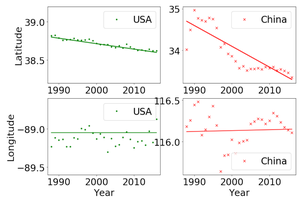


Figure 5. In the time period from 1988 to 2016, the overall centroid (averaged latitude and averaged longitude) in both USA and China moved southward.
For the US, the centroid slightly moved around 0.2 degree (20 miles); and for China, the centroid moved around 1.7 degree (175 miles).

❑ **Analysis of top cities in USA and China**

Top cities with most publications are analyzed in both countries. As shown in the figures and tables below, their behaviors are different: in USA, top 14 cities make up the 40% of all publications, where Boston contributes the most (6.5% of the publication); whereas in China, there are only four. Two super cities, Beijing and Shanghai, both contribute the majority (15.7% and 12.0%).

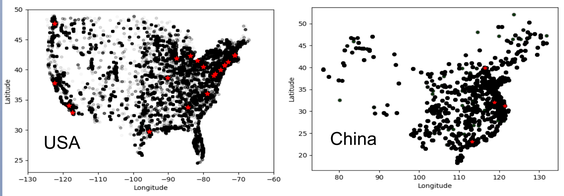


Figure 6. Top cities (contributing up to 40%) in both US and China have been marked above and listed in the table on the right.

Table 3. The top cities in the US and China during 1988 - 2017

Country	ranking	name	publication%	accumulated%	Population%
USA	1	New York	6.5	6.5	2.6
USA	2	Boston	5.6	12.1	0.2
USA	3	Los Angeles	3.2	18.9	1.2
USA	4	Philadelphia	3.1	22.1	0.5
USA	5	Baltimore	3	25	0.2
USA	6	Chicago	2.8	27.8	0.8
USA	7	Houston	2.6	30.4	0.7
USA	8	Bethesda	2.4	32.9	0
USA	9	San Diego	2.3	35.2	0.4
USA	10	Seattle	2.1	37.3	0.2
USA	11	San Francisco	2.1	39.4	0.3
USA	12	St. Louis	1.9	41.3	0.1
USA	13	Durham	1.7	39.4	0.1
USA	14	Atlanta	1.7	41.1	0.1
China	1	Beijing	18.2	18.2	1.6
China	2	Shanghai	13	31.2	1.8
China	3	Guangzhou	6.2	33.8	1
China	4	Nanjing	5.9	39.8	0.7

❑ **Clustering analysis of the dataset**

In this paper, K-Means method is applied in clustering the dataset. By trying different parameters of k value.

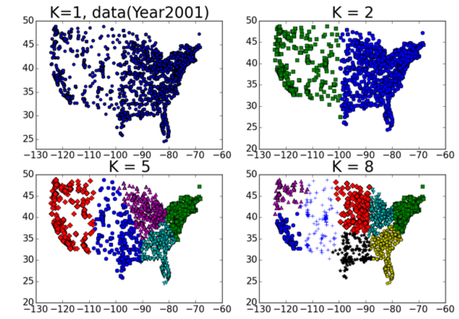


Figure 7. The medical publication distribution in USA by different clusters.

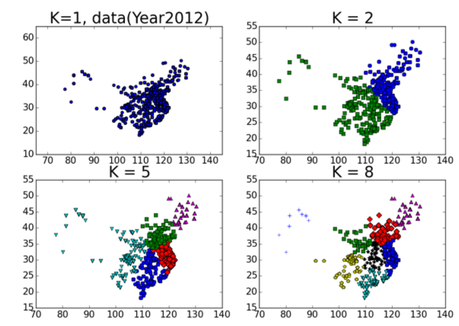


Figure 8. The medical publication distribution in China by different clusters.

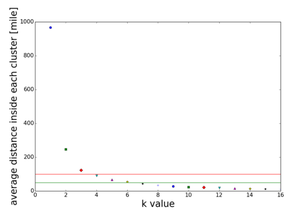


Figure 9. The change of average distance (in miles) versus the change of k values.

As the cluster number increases, the distance (RMSVD) drops. And when the number of clusters reaches 4, the average distance gets 100 miles, according to the USA dataset.

Acknowledgments

Research reported in this publication was supported in part by NIH National Institute on Aging P01AG039347. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

ILLINOIS