



## From the Editor

# Visualizing 20 Years of Applications

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**T**his issue of CG&A marks the Applications department's 20th anniversary. The inaugural article was about one of the first viral events of the then-nascent World Wide Web—the comet Shoemaker-Levy 9's impact into Jupiter earlier that year.<sup>1</sup> The article reported on the resulting Web meltdown caused by the more than 2 million visits to the main Jet Propulsion Laboratory website and a mirror site set up for the week-long event.

Today, Google handles approximately 3.3 billion searches daily, and Facebook receives over 300 billion Web hits daily. (Just loading a typical page causes about 200 individual HTTP requests.) Such is the pace of technological change over these past two decades.

Here, we look back at the 20 years of Applications articles to assess the department's evolution. By aggregating all the articles and applying a little statistical analysis and visual analytics, we've uncovered some interesting characteristics and trends we'd like to share to mark this milestone.

### Metrics

From Nov./Dec. 1994 through Nov./Dec. 2014, CG&A has produced 121 bimonthly issues. To the credit of many hardworking authors and the IEEE editorial staff, an Applications article has appeared in every issue.

Table 1 shows some overall metrics. With an average of six pages per article, the department has published 725 pages of content, the equivalent of a good-size book. More than 385,000 words have been amassed—about 3,200 words per article. This works out to roughly half the size of a typical peer-reviewed CG&A article, in keeping with our desire to make department articles more accessible to readers.

The articles have featured almost 1,300 figures

and tables, averaging over 10 per article and about two per page. The effective number is even larger; many figures combine several images.

Almost 300 references (about 2.5 references per article) have been included. However, that counts only the formal footnoted references; it doesn't include citations in sidebars or directly in the text. In addition, almost double that number of URLs have appeared, reflecting the 20-year presence of the Web in parallel with the department.

The number of authors has averaged just over two per article (although that number has recently increased, as we discuss later). Twenty-two countries have contributed to these pages, demonstrating the wealth of computer graphics applications across the globe.

Several metrics have evolved. For example, Figure 1 shows the average number of words per article over time. When the department was getting started, articles were short and limited in scope, but in five years they grew to something like their present size. In the past five years, the size has slightly decreased, reflecting more stringent editing as more CG&A departments have emerged to share the overall page budget.

Another trend has been an increasing number of authors per article (see Figure 2). The average number of authors per article was essentially one over the department's first eight years but has been more in the two-to-four range since. In the department's first decade,<sup>2</sup> most articles were editor-directed, employing staff or freelancers to research and write articles—hence, the prominence of single-author articles. As the department came into its own, articles became increasingly, and are now exclusively, author-originated. Because many of these articles have reported on collaborative research, the result has been more multi-author articles.

## Geographic Distribution

Table 2 breaks down the 22 countries we mentioned earlier. It excludes articles by staff or freelancers (mostly from the US but also from the UK and the Netherlands) because those were often more matters of convenience for the editor and staff than a true indication of the contributions' origin. Even so, the table seems to reveal a North American bias. However, the disparity isn't quite as large if you compare the US with Europe as a whole (17) and Asia as a whole (12.75).

Viewing the distribution by continent over time reveals an interesting pattern. Figure 3 shows that what started as a preponderance of North Ameri-

Table 1. Building time as a function of data size.

Metric	Total	Per article
No of articles	121	—
No. of pages	725	5.99
No. of words	385,568	3,186.51
No. of figures	1,295	10.70
No. of references	297	2.45
No of URLs	517	4.27
No of authors	264	2.18
No. of countries	22	—

can articles has been overtaken by much more worldwide participation. Indeed, over the past five years, less than 30 percent of articles (8.5 of 30)

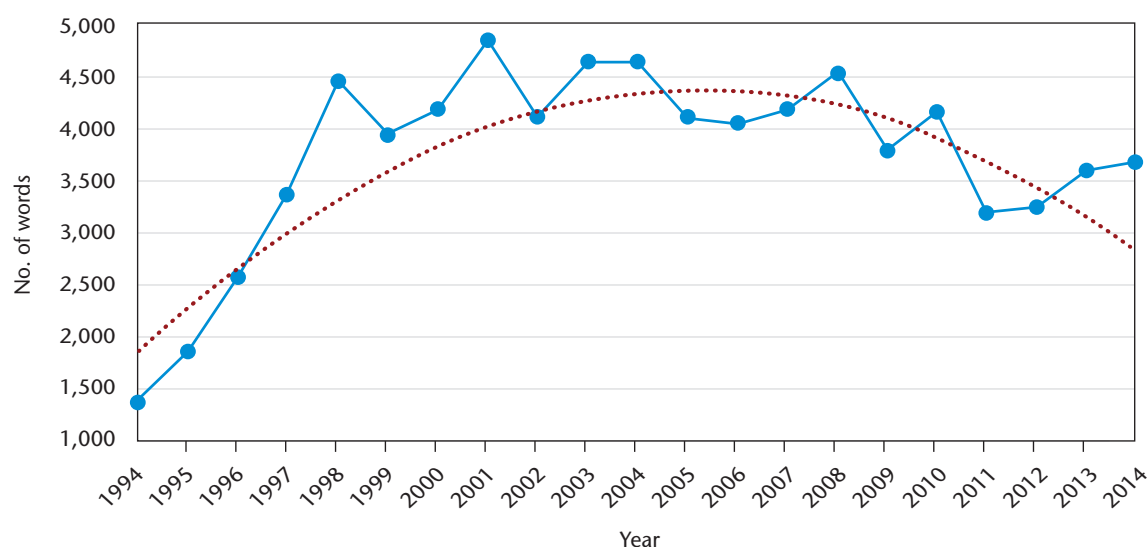


Figure 1. The average number of words per Applications department article. In the past five years, the article size has slightly decreased, reflecting more stringent editing as more CG&A departments have emerged to share the overall page budget.

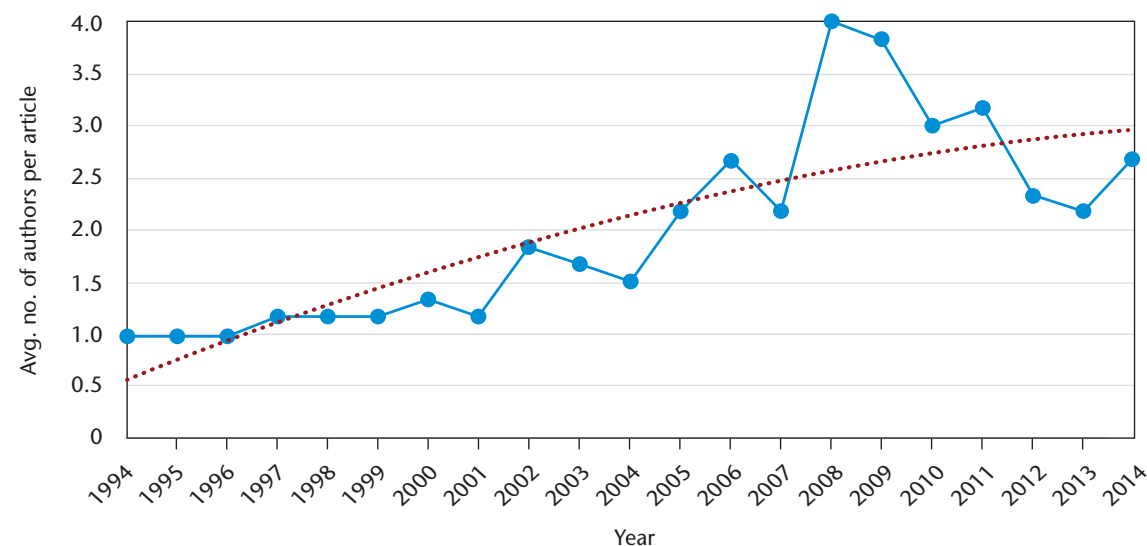


Figure 2. The average number of authors per article. Initially, the articles were written by staff or freelancers. Over time that changed so that now most articles are written by groups of researchers.

**Table 2. The articles' originating countries (excluding articles by staff or freelancers).\***

Country	No of articles
US	27.00
Canada	5.50
Japan	5.25
UK	5.25
Korea	3.00
Portugal	3.00
Brazil	2.00
China	2.00
France	1.50
Spain	1.50
Taiwan	1.50
Chile	1.25
Australia, Columbia, Denmark, Germany, Italy, Malaysia, Netherlands, Norway, Poland, Slovenia	≤ 1.00

\*Fractional amounts are due to articles from two or more countries.

have come from the US and Canada, reflecting the strong international scope of the computer graphics community.

We compared the list of countries with the Bloomberg Global Innovation Index ([www.bloomberg.com/slideshow/2014-01-22/30-most-innovative-countries.html](http://www.bloomberg.com/slideshow/2014-01-22/30-most-innovative-countries.html)), a yearly assessment of the top 50 countries in innovation. Each country published in the Applications department is on Bloomberg's list except Columbia and Chile, both of which reflect the emerging technology presence of South America. Of the top 15 countries on Bloomberg's list, only four are missing from the department: Sweden and Finland (although Scandinavia is represented by Norway and Denmark), Singapore (although Malaysia is represented), Russia, and

Switzerland. Also, Africa is missing, despite South Africa and Tunisia appearing on Bloomberg's list. We would be pleased to see contributions from all these places and more.

### Author Affiliation

Figure 4 breaks down the author affiliations into academia, industry, government, and military (with staff and freelancers as a separate category). A notable trend is the increasing number of articles from academic institutions, which we hope reflects increased emphasis on and interest in interdisciplinary work by the educational research community.

### Application Areas

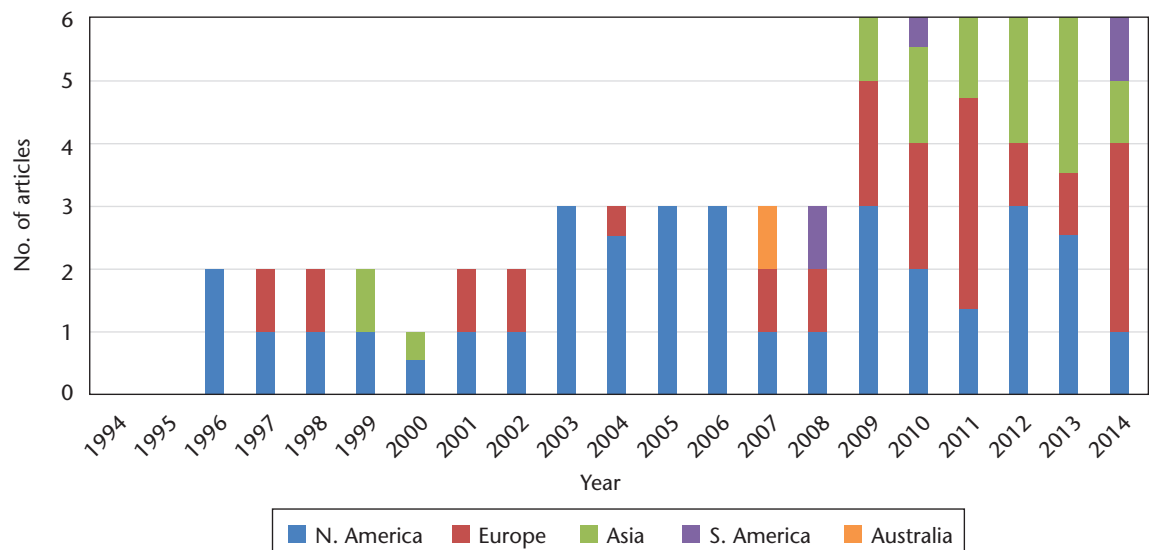
We were curious about the general distribution of article topics in broad application categories. Figure 5 shows that engineering accounted for half the articles, which makes sense because computer graphics is ubiquitous in the design, building, and use of real-world things. The rest were divided more or less equally between the natural sciences and medicine on one hand and entertainment, the social sciences, and the arts on the other. So, there has been a good balance.

### A Word Cloud

We examined the frequency of words across all the articles, displaying them in a word cloud generated by Jonathan Feinberg's popular Wordle generator ([www.wordle.net](http://www.wordle.net)). Figure 6 shows the results.

It isn't surprising to see words such as "data," "information," "figure," and "image" dominating in articles about the applications of computer graphics, along with words such as "system," "software," and "computer." But it is interesting

**Figure 3.** The articles' originating continents over time (excluding articles by staff or freelancers). What started as a preponderance of North American articles has been overtaken by much more worldwide participation.



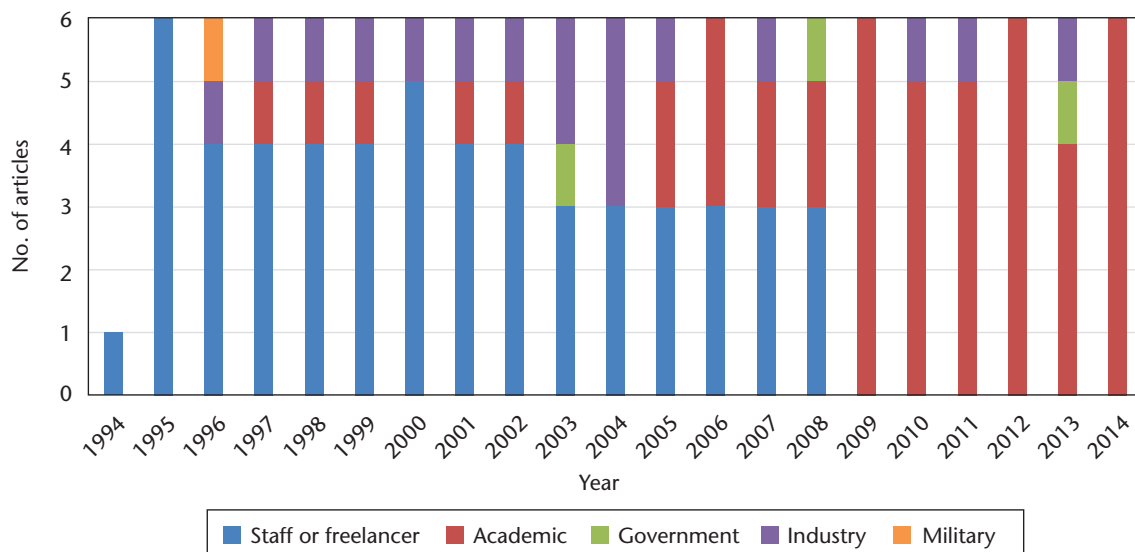


Figure 4. The distribution of author affiliations across institutions over time. A notable trend is the increasing number of articles from academic institutions.

to see the importance of words such as “model,” “use” (and other forms of the word), “design,” “time,” and “see,” along with many other terms of the trade.

### An IN-SPIRE Document Visualization

Statistics can only reveal so much; it’s often necessary to further interrogate the data. So, we turned to visual-analytics software. IN-SPIRE, developed by the Pacific Northwest National Laboratory (<http://in-spire.pnnl.gov>), can uncover relationships, trends, and themes hidden in large collections of documents. The IN-SPIRE Galaxy and ThemeView visualizations display groups of documents with similar or related information by clustering documents with similar keywords. A faceted browser lets users drill down to specific information, much like the approach used by e-commerce sites such as Amazon. A Correlation tool displays relationships among user- or computer-generated groupings of documents.

Figure 7 shows a screenshot of our analysis. The Galaxy view (the upper middle panel) visualizes document clustering using a scatterplot. The ThemeView (the lower middle panel) depicts a bird’s-eye view of the information space through an interactive 3D terrain map. The Correlation tool (the panel on the right with the bar graphs) shows the overlap of document categories over time.

Figure 8 shows the Galaxy visualization panel in greater detail, revealing clusters of documents sharing similar themes. The white labels show major themes. Related clusters are closer to each other. For example, the upper-right cluster is mainly about scientific-visualization topics such as flow fields and volume rendering. On the other hand, the lower-left clusters contain documents about mobile communication devices and game applications.

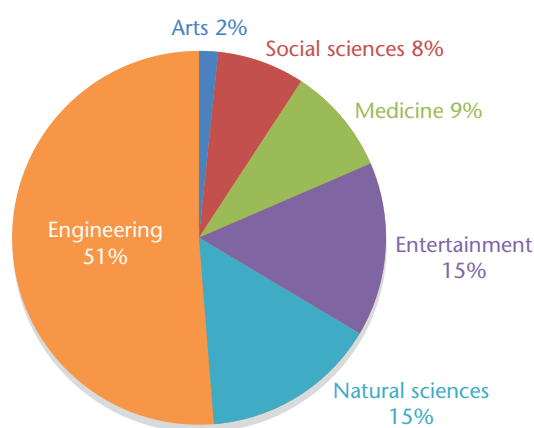


Figure 5. The distribution of articles across application categories. Engineering accounted for half the articles. The rest were divided more or less equally between the natural sciences and medicine on one hand and entertainment, the social sciences, and the arts on the other.

IN-SPIRE also revealed trends in selected topics over time. Figure 9 presents a matrix of documents grouped by year and topic. Certain topics, such as Flow (flow visualization) and Visual Analytics, showed increasing presence. Others, such as Map and Medical, had more coverage early on. Some, such as Human Body, held steady. The topic trends largely resembled trends in the computer graphics community during the same period.

Twenty years provides an interesting perspective on a body of work such as the Applications department. This department represents the CG&A editors’ ongoing commitment to the “and Applications” part of the magazine’s title. We welcome contributors from all application fields to this forum and hope they’ll continue to share







Figure 8. The IN-SPIRE Galaxy visualization uses the metaphor of the stars in the night sky to show documents with related content. Related clusters are closer to each other. The white labels show major themes.

their work with our readership for many more years to come.



Selected CS articles and columns are also available for free at <http://ComputingNow.computer.org>.

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## Reference

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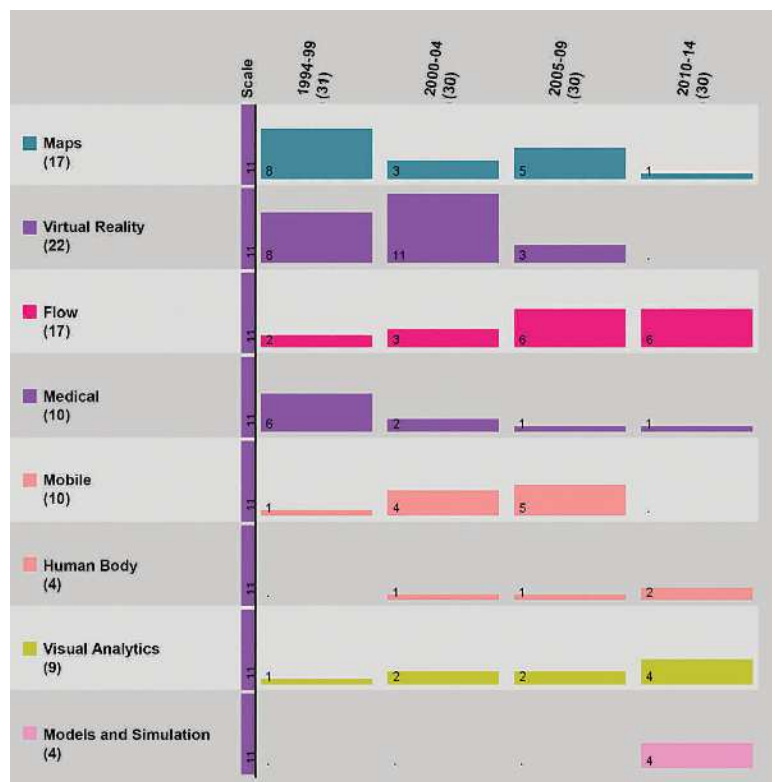


Figure 9. Trends in article topics. The trends largely resembled trends in the computer graphics community during the same period.