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Computer science research: the top 100 institutions in India and in the world

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Abstract:

The focus of this research is to examine the top 100 Indian and worldwide institutions producing computer science researchers. The analytical characterization is based on data from the last quarter-century of Scopus-indexed research output (1989-2013). Our In the context of computational analysis, the usual scientometric methods are used in a two-dimensional framework. Include reading closely at literature. We want to compare the quality of CS research in India to that of other nations using scientometric indicators. Emphasize the similarities and differences among the world's top from a global viewpoint. We conducted a complete probe along traditional scientometric indicators of achievement like as output, citation impact, and number of co-authored works fluctuations, levels of international collaboration, etc. The written description is meant to help pick out the most crucial research. Similarities and developments throughout time in the two categories of institutions. This study breaks new territory, and it's possible this is the first comprehensive look at how different areas of computer science share and diverge in their approaches to a problem. Examining Indian Organizations Next to International Models Insightful analytical results and practical recommendations from the research inferences.

Introduction

These days, IT plays a crucial part in every country's development. A lot of the research and development that goes into ICT (Information and Communication Technologies) is done so that we may have reliable and secure methods of exchanging information. Technological progress in the field of computing (CS). Knowledge-based economies have been more prominent this century and governments everywhere are spending more money to advance scientific research and technological innovation, especially in the realm of information and communication technologies. India may have been a bit of a late bloomer in the field of computer science (CS) research, but the country has made up for lost time in the previous two decades by becoming a major player in the IT development industry. Contrarily, Indian In the field of computer science, institutions has not yet advanced to the point where they are producing cutting-edge research. In this measuring and assessing the research ability of India's top universities is crucial. In comparison to the most effective organizations worldwide. Our studies in this more general area are presented in this publication. Inspiration and it details the results and conclusions reached by using both conventional scientometric methods and an innovative text- using a technique of analysis that is based on. Among the institutions we analyzed were the 100 most productive in both in India and elsewhere. Analysis is performed on the past 25 years of published research in the CS area.

Scopus1-indexed (1989–2013).

To further identify the similarities and differences between the We have attempted to undertake a comprehensive computational study to academic work from some of India's and the world's most successful universities. Our aim has been to provide a comparative analysis of computer science (CS) output at India's top universities highest-performing organizations in the world. To be more specific, our study aims to address the following questions:

To what extent does the most fruitful CS domain research share and diverge from one another?

How do Indian institutions compare to the world's most successful ones?

How much does India contribute to international CS research as a whole, and how significant is that contribution?

Asking questions such, "What are the main areas of study that the best Indian universities are focusing on, and how does this

Correspond to the topics studied by the world's leading academic centers?

Can we draw any conclusions about the role of Indian academic institutions in CS field research based on this description?

As far as we're concerned, the paper's findings and discussion contribute to addressing the specified study questions. Above, and a few more that are linked

For the duration of the paper, the structure will be as follows: Part 2 provides a quick summary of relevant research. In section 3, we provide a high-level summary of studies conducted in India's CS field. Data gathering is discussed in Section 4, and the approach used is laid out in Section 5. Indicators of scientific progress are presented in Section 6. Calculations for Indian and international organizations. CS analysis for India and the rest of the globe is provided in Section 7. Schools that analyze trajectories using Energy. In Chapter 8, we learn how to spot:

Tendencies and patterns in the data that may be explored. Part 9 provides a brief overview of the project and the key conclusions drawn from it.

Related Work

We highlight some earlier research work focusing on scientometric profiling for a country/region and/or a

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specific topic, but no previous study has done the type of analytical characterization we intended to undertake. In spite of this, the majority of the cited studies are only applicable to "gold standard" science-based measurement and evaluation. Nonetheless, we acknowledge the contributions of the following researchers whose questions for study, and a plan for conducting a comparative analysis. Somewhat recently, the topic was investigated in a publication (Fu, 2013).

Independent study in China, and compared their findings to the published works of seven nations with a developed industrial sector. In addition, Kao (2012) analyzed the progress made in the field of management research in for a narrow field, Taiwan is an excellent choice. As mentioned before, Gupta (2011) accessed many factors, including total study results, development, position, and worldwide publication share, citation impact, and international works published as a group by Indian computer scientists during the years 1999 and 2008. Recent research from South African institutions has attempted to establish norms for two metrics of productivity: the number of articles published by each author and the total author share in those papers. A different study (De Souza, 2012) set out to display the researchers' information, the nature of their scientific partnership, and the findings they've uncovered. Group in Brazil devoted to the field of information science. For example, in a paper that we just had printed (Uddin, in 2014a, we made an effort to create a map of the multidisciplinary academic research scene in South Asian nations. A comparable study of CS domain research in SAARC countries was conducted in a more recent publication (Uddin, 2014b). Region. Researchers have devoted whole studies to the question of how the two disciplines work together, while others have focused on only one aspect of the partnership. Scientific fields learning how to work together, and what it means for research. A prime example of this Nanotechnology and China's Fast Development (Tang, 2011) works (Tang, 2011) discusses China's rapid development of nanotechnology and the country's ascension to global leadership in the area. Joint efforts between China and the United States in this developing field. The same may be said for a few other recent publications.

According to several studies (Ozel, 2012; Onyancha, 2011; Costa, 2013; Prathap, 2013; Teodorescu, 2011; Abramo, 2013; Viana, 2013; Ortega, 2013; and Liu, 2013) showed divergent findings on partnership, expansion, and quantitative/ estimations based on qualitative criteria. The research presentation and analysis methods used in the majority of these books Production varies throughout researcher requirements, and so do the datasets that are included. While we did take some cues from the works that before ours, we set out to create something entirely new. Descriptive dissection using both conventional scientometric methods and cutting-edge computer methods based on a characterization of the textual content.

Overview of CS Research in India

The formal establishment of computer science (CS) as a field of study may be traced back to the 1950s. In 1953, the University of Cambridge Computer Laboratory launched the first computer science degree program in the world with the Cambridge Diploma in Computer Science. A pioneering American undergraduate computer science degree

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program began in 19622 with an initiative from Purdue. Popularity of the Computer Science program at once-obscure in 1965, Stanford University opened its doors to its first students. After thereafter, several institutions of higher education in industrialized nations established computer science programs somewhere in the 1960s. Computer science (CS) was first taught formally at India's academic institutions in began in 1963 at Indian Institute of Technology (IIT) Kanpur with the introduction of "Computer-related" classes and the first computer science classroom, however the first formal computer science degree program did not begin until 19714. In the Computer Science (CS) Department of the Indian Institute of Technology the department's origins may be traced back to 19735, however it was first known as the Computer center. Similar to the official establishment of the CS department, they continued their efforts in education at IIT Kharagpur in 1980–6 and IIT Bombay in 1982–7. Programs in Computer Science. The Indian Institute of Science's (IISc) Computer Science and Automation (CSA) 8 department The Indian Institute of Science (IISc) in Bangalore was founded in 1969. The original name for this establishment was "School of Automation," and it has been around since the 1960s. To keep using this moniker until around the middle of the 1980s. As part of the academic system, Jabalpur University initiated It was the first of its type in 1968 when I earned a master's degree in computer science. Out of the original department of computer science Department of ECTE split into three separate branches in 19889. Calcutta, India's (Indian Statistical Institute) ISI has kicked up a two its 10-year Master of Technology (M. Tech.) in Computer Science program, which began accepting students in 1981, is widely regarded as the first of its type. As at the close of In the 1980s, numerous prestigious universities launched new computer science departments or established existing ones. In contrast, back in the early at this time education, training, and the growth of skilled laborers were prioritized. Computing Science (CS) research growth really got going in the 1990s. Research in the field of computer science (CS) has gained steam during the last two decades, with widespread adoption of computer science curricula and programs, as well as the development of specialized educational and research establishments devoted to Information Technology (IT). New types of specialized information technology Institutions have emerged as major players in the field of computer science research in a very little amount of time. During the last several decades, India has been home to the research labs of many major IT corporations, including IBM Research (1988) and Microsoft Research (2005). In addition to theoretical studies, there is now additional conducted in a wide range of government research facilities, including CSIR11, DRDO12, ISRO13, etc.

We've compiled this data to get a clearer idea of where computer science (CS) studies are in India right now. Numbers for the 25-year time span between 1989 and 2013 pertaining to the total research output of all Indian universities in the CS area using the Scopus information archive. This time frame coincides with the era of genuine development in India's CS research. We chart India's relative share in international CS domain research in terms of funding, as a percentage of the country's total, over the course of a decade. In Figure 1, we can see that

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India is contributing a growing fraction of the world's computer science (CS) research output. Except in a very little timeframe. Rising from 1.88 percent in 1989 to 4.95 percent in 2013, this figure represents a significant growth over the preceding two decades. The acceleration of growth becomes more apparent after the year 2000. Calculating the Development Rates of Computer Science According to studies conducted in India and throughout the globe as a whole, India has a faster growth rate than the global average.

Data Collection

Scopus, an established bibliometric database, has provided us with information on the production of CS research during a quarter century (1989-2013). As of March 1, 2015, a total of 2,876,512 publishing records have been located for the whole globe covering the years 1989–2013, with India accounting for 84,385 (or around 2.93%) of them. 2014. Institution-by-institution data was gathered for India's top 100 research universities (hence referred to as we (the I-100) and the rest of the (referred to as W100). Despite its limitations, our archive serves as a decent representation of its kind. Of information collected as a result of study. There are 846,527 records out of a total of 846.526 that make up the gathered sample. 59,682 59,619 records (70.73% 71%) represent the whole of India's CS research output, which accounts for 29.6% of the global total. results of studies. There are 61,502 entries for Indian CS-related research output in Scopus, however only 1,314 of these are from the top 100 institutions. There are about 506 duplicate entries and a missing year value, bringing the total number of distinct records to 59,682. Out Scopus eliminated duplicates from 60,119 items related to Indian CS research output (I100). In which case there are still 59,619 separate files. Equally, 846,527 researchers at the top 100 institutions in the world for computer science (W100) As opposed to the total of 924,575 records, only 846,526 are really unique. Other beyond the realm of computer science Besides compiling data on the research output of I100 and W100, we also gathered other global and Indian statistics on topics like as The total amount spent on R&D, the number of scientists employed per 1,000,000 citizens, etc. In order to provide a larger context for our analytical characterization, we have included these data in table 1.

Methodology

As a rule, we use a two-dimensional approach to analytical characterization, which consists of the more common scientometric analysis as well as computational text analysis. To begin, we do a scientometric characterization along the six primary indicators: total publications (TP), total citations (TC), year of publication (YP), and field of study (FoS) (TC), Standardized Citation Counts (SCC), Highly Cited Papers (HiCP), and Internationally Collaborative Papers (ICP) plus the indicated proportion. Only TP is a major signal here; the others are all just supplementary ones. Automated computation based on existing data. We have calculated these metrics for every establishment in all of them, together. Part two of our study involves defining the major concerns of the studies we've looked at and promoted by the included institutions. The full dataset has been processed to label each product of study in one of the 11 main subject areas of computer science research (shown in the Appendix). The Scopus database's subcategory labels aren't as instructive as this thematic mapping. Continued from a recent publication (Uddin & Singh, 2015). In order to determine which academic discipline a given article should be filed under, document's 'author keyword,' 'paper title,' and 'abstract' fields, as well as the overall topic area. Whenever a student submits a research a topical category when a lot of the terms appear in other preset topical categories. After By ascribing topics to each publication, we were able to assess each organization's strength in a given field of study. Institutions that excel in a certain field of study were recognized (Thematic trend, we have done for I100 & W100). Generally speaking, but not in the context of specific institutions. Both the I100 and W100 sets are complete. Although, the the analytical and comparative characterization of research competitiveness is facilitated by scientometric analysis. To determine the most influential studies in the I100 and W100 datasets, we use a computer analysis of text. Parallels and differences between the topics explored by institutions in the two groups.

Research Output

At first, we attempted to compare the institutions in the I100 and the W100 using a variety of indicators. Before we give the statistics, it's worth noting that none of India's academic institutions are among the world's 100 most productive. Organizational output in India may be ranked compared to that of other countries. that the entire computer science research output of the 100th institution (University College) during a 25-year period While the W100 rating of the University of London (U.K., London) stands at 5,747, the output of the two best Indian universities (I.I.T., Indian There are 3,514 students at Indian Institute of Technology Bangalore and 3,506 at the Institute of Technology in Kharagpur. respectively. Even India's most prolific institution produces at a rate lower than the 150th ranked institution in the W100. It's also worth noting that just two Indians appear in a recently released rating by ARWU14. Two Indian institutes among the top 200: the Indian Statistical Institute and the Indian Institute of Science. File this under the Computer Science heading. Here, we provide comprehensive data on a variety of scientometric indicators used to compare the evaluation in Tables 2 and 3. Table 2 provides contrasting data for the I100 and W100 sets. Whole. When we compare ACPP (I100) with other indicators, we see a big difference. Having a mean of 2.66 and a median of 9.37 for W100, respectively), HiCP (average value of 60 for I100 and 855 for W100), ICP Both the raw numbers (110 for I100 vs. 2419 for W100) and percentages (39.33% for I100 vs. 58.91% for W100) are lower than they should be. Data for the 20 most productive universities in the I100 are shown in table 3 below. And W100 to provide a more in-depth evaluation.

6.2 Co-authorship Patterns

The second major topic we covered was the nature of the partnerships between leading academic institutions in India and elsewhere across the globe in the field of computer science. It is well-known that the distribution of authors on a research publication may affect the study's overall significance. When there are two or more authors on a paper, it is called the work of two or more writers working together; it incorporates ideas from other sources. More complex multi- the number of papers an author has published is a good measure of the amount of interdisciplinary work being done or the degree to which different fields of study work together among academics on a regional, national, or global scale. Large-scale research programs are another higher-quality multi-author works. We looked over the data and saw how often writers from India worked together. Approximately 32% of the CS research papers published by the I100 have three authors, and 34% have two. Authors. Around 95% of all CS production is collaborative in nature, with just around 5% coming from a single author. Entails working together in a meaningful way. However, the W100 co-authorship structure reveals a distinct situation where there is less of a tail than there is in Indian computer science distribution (1.51). (1.51). Trends in co-authorship over time for the are shown in Figures 2(a) and 2(b) by year. Data that has been gathered. One indicator that shows a definite upward trend in academics' willingness to work together is the number of There are increasingly more people contributing to academic articles. As much as half of all CS was produced last year, and W100 studies often include three or more authors, but only around 30% of I100 studies have that many authors.

6.3 International Collaboration Patterns

Having seen an increase in articles with many authors, we set out to quantify the extent to which these efforts included researchers from different countries. Higher levels of international cooperation reflect the maturity and global character of a field, as well as the importance of multi-national collaboration. Evidence from Research

As far as we know, (Smith 1958) was the first study on collaboration, and its proposal that collaborative works may be seen as a surrogate for actual researcher interaction. Meanwhile, Glanzel (2001) demonstrated in another study on average, articles written by a group of writers from different countries get more citations than those written only by one author. Newspaper articles published inside a country. From our computational research, we learn that 95.5% of the I100 are written in collaboration (with another author). When comparing the W100 to the Scrimmage, the average number of authors per paper is 2.92, whereas 93.5% of the W100 are co-authored. A 3.41 authorship rating). W100 papers tend to have more authors, a trend that is indicative of a better quality of research. Collaboration. Cooperation patterns in I100 and W100 outputs are shown in Figure 3. As far as we can tell, International cooperation accounts for 25% of I100 articles, whereas it accounts for 30% of papers in the W100. We also ranked the top nations with whom Indian writers collaborated. Table 2 displays a list of top 20 nations with the most I100 production cooperation over a quarter century. The People's Republic of the United States is the leading country in international cooperation among the I100 (with 4316 research articles contributed), followed by China. Authored by Singapore (849 research articles) and Canada (801 research papers). According to the W100 statistics, there are multi-country research partnership results, as well as international research articles Analysis of Trajectories for Effectiveness A recent work (Nishy, 2012) used a thermodynamic analogy to suggest a ranking system for energy. An exergonic a scientist's or researcher's indicator (denoted by the letter X) is the multiplicative product of the quality and quantity of their work. Effectiveness of the group as a whole. Primarily and secondary metrics like as impact, citations, and print run means a lot of papers. The suggested framework operates on the assumption that defining a single meaningful signals that

Both the quantity (the number of articles published, P) and the quality (as evaluated by impact, I=C/P, where C represents citation quantify) features. Energy, denoted by the symbol X, is a quality proxy calculated as follows: X = (C/P)*C. How I and P or I and C are valued shown as two-dimensional functions of time (i.e., iPX and iCX trajectories). (Methodologies, etc.). The icy (the iC=X contour lines) and the iPX (the iP=X i2P contour lines)

For data visualization in two dimensions. The pixy method is simpler to understand since it displays the direct connection between the two variables of interest (P and I in the icy framework the output P is not transparent and does not accurately depict the amount (P). Specifically, we have used the energy metric to ranking certain institutions in the I100 and the W100 based on a quantity-quality composite metric we have ranked the top five Indian colleges in I100 based on their research output and displayed the results with ranking the top five universities in the W100 by TP value. For the most part, this is done so that we may contrast the related a comparison of Indian institutions' performance to that of the top 100 universities and colleges in the globe. No Indians, alas, institution is included in the World's Top 100. The chosen institutions' energy values are shown in figure 8(a). A year's worth of time is represented by the X-axis, and the energy score for a given day is shown on the Y-axis.

Two groups of schools were chosen, one using ACPP and the other using Hip values. Selecting By comparing the performance of various institutions based on the values of various indicators, we may better understand the range of possible outcomes. Number one on a variety of measures. See how well institutions fared in terms of energy in Figures 8(b) and 8(c). Selectable on the basis of ACPP and Hip. All the plans are created for eight different time periods of five years each. Shifting the time frame from 2001-2005 to 2008-2012 to evaluate the results in the sixth year after that (2006-2013). Everybody can see that As a consequence, the performance of chosen Indian colleges is worse than that of all selected W100 institutions.

That should be given some serious consideration. Most of the top Indian universities in the I100 are IITs. Exergonics in their entirety Indian institutions are statistically much less effective than their international the average of the W100's top universities. The point here is that we ignored the scholarly community. Infrastructure, including the presence of faculty, researchers, etc. The numbers and computations Table 5 in the Appendices display these values (a-c). The tables in the appendices accompany the paper written by and the top schools throughout a five-year period of time, and the number of citations (C) they received the following year for every available window for publishing. The effect (I=C/P) and the energy (X=C2/P) are calculated using these parameters.

Identifying Research Themes in Output

We also did a textual analysis of the data to find the most common study themes and how they changed over time, complementing the scientometric analysis. Burst detection method (Kleinberg, 2003) was employed for this purpose. The "indexed keyword" column of our database was the target of our algorithmic application. Whole data set covering those 25 years. A function of the keyword weights is used in the burst detection process. Of how often the keyword appears and for how long. Use of Sci2: The Science behind Science Examination of Time Periods (Burst Detection). Strong emphasis on a term suggests that the subject was investigation into this topic on a regular basis for a long time. Numbers 6(a) and 6(b) illustrate the prevalence of certain keywords. For both I100 and W100 data, weighted scatter plots are generated. In order to picture VOSviewer was used to show the relative importance of each term. Indeed, the "Computer" slogan is plain to observe. In both diagrams, the terms "Simulation" and "Mathematical Models" appear prominently. Similarly both stories include the theme of "Problem Solving." The W100 figure, however, highlights the relevance of issues like as Computational complexity, network protocols, approximation theory, and algorithmic study all fall under this umbrella. The importance of "Computer Networks," "Information Technology," and other similar subjects may be seen in the I100 graphic. To be more specific, "Communication" and "Computational Methods" during the course of the full 25-year window. In The main topics of the study are shown as a tag cloud (Figures 6(c)–6(g)). To the far left, the I-Top 10, and to the far right, the W-100. The time span 1989-1993 is represented by a tag cloud, which reveals that In I100, students primarily focused on concepts like "algorithm," "mathematical models," and "computer simulation," while Words like "algorithm," "computer simulation," "optimization," and "image" appeared often in W100. Processing". Algorithms, Communication, Optimization, and Information Theory were all hot topics from 1994 and 1998. The most popular courses in I100 were those dealing with "Technology" and "Artificial Intelligence," whereas the most popular courses in CM100 were those dealing with "Mathematical Models" and "Computational Theory W100 was dominated by "Computer Simulation." Between the years of 1999 and 2003, "Mathematical Models" was once again the most-cited academic journal in its field.

Mathematical models and optimization topped the charts, followed by "Algorithms for the I100." W100. Between the years of 2004 and 2008, "Mathematical Models" eclipsed "Algorithm" in terms of prominence. Both in I100 and W100, the concepts of "Problem Solving" and "Optimization" played a significant role. The period from 2009–2013 reveals a marginal Computer simulation and algorithms emerged as important topics, marking a shift from the preceding block's fashions.

Studies for I100, whereas W100 has a wider range of topics to explore, such as "Optimization," "Artificial Intelligence," Signal Processing, and Artificial Intelligence. Words like "algorithm," "computer simulation," and "mathematical" are thrown about a lot these days. The statistics from both the I- and the W-lists show that "models" is a popular topic of study. In addition, the W100 data demonstrates "optimization" as a common topic of study.

Summary and Conclusion

In this paper, we present the findings of a scientometric, network-theoretic, and text-based analysis of computer science (CS) research conducted over the course of the last 25 years at leading institutions in India (using the I100 as a representative sample) and around the world (using the W100 as a representative sample) (1989-2013). As a consequence of the measurements and analysis, we are able to provide the Comparison of I100 and W100; revealing major and secondary indices of CS examine factors including absolute and relative expansion, patterns of cooperation, and the influence of citations by year. Evaluation, etc. We have also made an effort to demonstrate the impact that Indian academic institutions have had on global CS production. The influence of Indian CS production, etc. Energy-quality performance metrics were presented, and analyzed for the I100 and W100's best universities. Finally, we discuss the general pattern that emerged from our study. Mapping by use of a statistical analysis of the textual material. A temporal trend analysis by year range of thematic analysis and spike detection in computer science research output data are both carried out and shown visually. Results show that India has a lot of room to improve the quality of its research operations. India, against all odds kept on with the same lines of inquiry in CS, but progress has slowed due to a paucity of high-quality studies. Statistical Analysis and Discussion the study covers a long time frame (25 years) and has several applications: to investigate Computer Science studies in India in comparison to the world's best universities; to develop strategies for encouraging scientific inquiry and maximizing the country's academic potential produce high-quality work; aid a student in choosing an appropriate research institution; and serve a variety of other scholarly and scientific purposes.

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