

A SYSTEMATIC OVERVIEW AND RESEARCH OUTPUT ON ANDROID TECHNOLOGY: BIBLIOMETRIC STUDY DURING THE PERIOD 2005 TO 2014

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Abstract *The rapid development of research in android technology has led to a tremendous number of publications containing the achieved knowledge of this area of research. Mapping of science has a long tradition in many fields in evaluating and analyzing the growth of technology and we find a lack of comprehensive bibliometric study in the area of android. In this article, we provide extensive insights into basic publication output patterns, research productivity and growth rate, research impact, year-wise distribution of publications, collaborative patterns for author and institutes, highly preferred journals, highly impact factored journals, citation patterns etc. during 2005-2014. Furthermore, we analyzed the keywords evolution for every two year interval during this period. The results of the present study provides a better insight of previous trends, patterns and other pivotal factors which acts as a platform for collaborating research culture and knowledge sharing in the field of android.*

Keywords: *Bibliometric Analysis, Android, Citation Analysis*

INTRODUCTION

Most of the people existing on this planet today grew up without mobile phones and internet. These new technologies have changed our lifestyle in a way few of us could have imagined decades ago. Android Mobile operating system (OS) milestones a picture of the development of mobile phones and smartphones. Mostly all recent mobile phone service providers use a cellular network architecture and therefore mobile phones are often called cell phones, smartphones or cellular telephones. In addition to the general purpose use of telephones, the era of 2000 saw mobile phones supporting a broad spectrum of advanced services ranging from text messaging, multimedia messaging service (MMS), email, Internet (connectivity) access facility, short-range wireless communications (Bluetooth), shopping, business and game applications etc. to digital photography. The Android is a mobile OS which is based on Linux and currently it is being developed by the company Open Handset Alliance which is led by Google. Google has released the Android as an open-source code under the Apache License. With a user interface based on direct operations or manipulation, it is designed primarily to smoothly operate through finger touch screen mobile devices like smart phones and tablet computers

(Wikipedia 2015). The history of Android mobile operating system started on November 5, 2007 with the release of the Android alpha. Android 1.0, the first commercial version, was released in 2008. Since its initial release, android has witnessed variety of updates to its base OS. The design aptly suited for specialized user interface for televisions namely (Android TV), wrist watches (Android Wear), cars (Android Auto) garnered the attention of android in the market. The OS makes use of inputs which are finger touch like tapping, swiping, pinching and reverse pinching to operate on-screen objects and a virtual keyboard. It has additionally been utilized in game consoles, digital cameras, regular PCs and other electronics albeit its general usage for touch screen input. Android has the biggest installed base of all OS as of 2015. Its widespread usage is in mobile industry which includes Galaxy Nexus by Google to go with other phone makers and designers like HTC and Samsung. Large group of researchers around the globe are working to make this technology even more productive. The research in this field in past is noteworthy as the number of articles published in the specific areas of android is 3370 (during the study period 2005-2014). The smartphones that are available in market today comes with a growing set of cheap powerful embedded sensors like digital compass, accelerometer, GPS, gyroscope, microphone and camera that are making it

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possible for personal, group, and community scale sensing applications. This technology is gaining so much attention in the field of disaster management system where a smart phone application using Google’s Android OS was created called MyDisasterDroid which predicts the optimum route along various geographical regions that the rescuers and volunteers ought to undertake so as to serve as many people as possible and provide maximum coverage of the location in the shortest possible time. Patient Monitoring System using Android Technology has also garnered the attention of the scientists over the period of time (Wikipedia 2015; Hanafi and Samsudin 2012). In the field of education, the Android-based learning application has introduced new and novel search that could be capitalized to further strengthen the learning and teaching programs in classrooms.

Such a large scale investigation or in other words use of android in modern world depicts its importance in today’s technological world (Ji, Q. et. al. 2014). Therefore, in this article, we put forward an extensive review of the development of global android studies and give a quantitative analysis of published articles in Android operating systems or smart phones operating systems sectors from 2005 to 2014. The motivation behind this study is to reveal spatiotemporal, national, and categorical patterns in scientific publications on Android and to look for the development and analyze the current status of research from multiple perspectives.

DATA AND METHODS

We built our bibliometric database on 12 September, 2015 using academic publication on Android from the Scopus database. We performed extensive bibliographic search using the following terms:

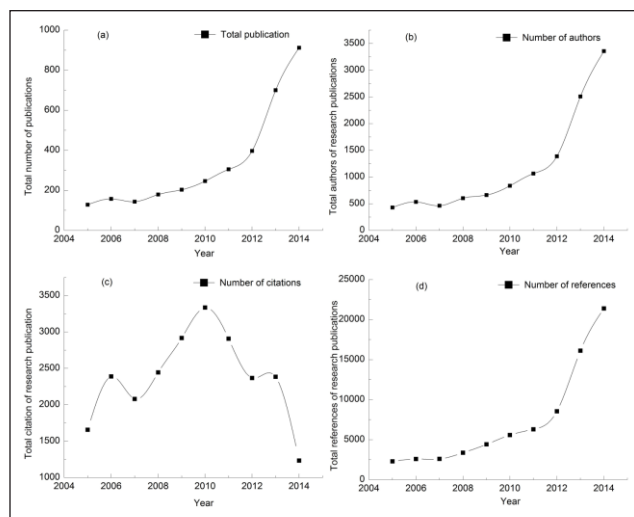


Fig. 1: Basic Publication Output of Android Research Articles

“Android”, “Android Operating Systems”, “Android OS”, “Android Applications”, “Android Devices”, “Mobile Operating Systems”, “Smartphone Operating Systems”, “Smartphone OS”, “Smartphone Applications” and located publication field used ‘Article Title, Abstracts, Keywords and retrieved authors name, affiliations, discipline of Subject, name of journal, title of publications and publication years of all publication. A total of 17163 publications were identified in the Scopus database for the period 2005-2014 based on this search strategy (Ji, Q. et al. 2014; Liu, X. et al. 2012; Wang, L. et al. 2015). The search only considers the existence of the search term and not its true meaning. Therefore, the non-related topics were excluded manually. Thirteen types documents were found and it was found that the most frequently used document type being the peer being the conference papers (12134; 71.28%), peer-reviewed article (3860; 22.49%), Conference Review (524; 3.05%), Review (181; 1.05%), Short Survey (111; 0.64%), Book Chapter(94; 0.54%), Article in Press (72; 0.41%), Note (36; 0.20%), Book (35; 0.20%), Editorial (8; 0.04%), Business Article (3; 0.01), Erratum (3; 0.01%), Letter (2; 0.01%) and five source type document were found that included Conference Proceedings (10,671; 62.17%), Journals (3,834; 22.33%), Book Series (2,013; 11.72%), Trade Publications (515; 3.00%) and Books (130; 0.75). However, in the present study we focused only on journal articles which were published online during the period 2005 to 2014 and the search resulted in 3370 articles which forms the basis for further analysis. Systematic search of articles in our database including journal name, year of publication and author affiliation was fetched to compute the total number of publications (TP) and total number of received citations (TC) for each year, journal, subject category, each country and each affiliated institutes respectively. For citation analysis, the average citations (TC/TA) defined as the average number of citations per article, were also individually computed.

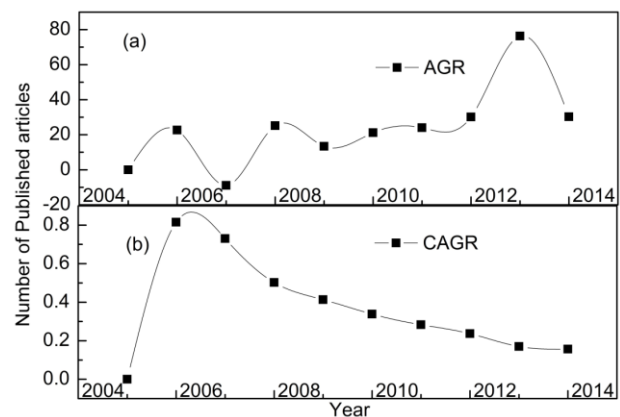


Fig. 2: AGR & CAGR Performance Android Research Published Articles

OBJECTIVES OF THE STUDY

The objectives of the present study are listed below: 1. To ascertain the research productivity of Android Technology in globally during the period 2005 to 2014. 2. To draw and compare a detailed picture of subject-wise distribution, year-wise growth of publications and institution-wise collaboration of research productivity in Android Technology. 3. To identify authorship pattern and collaboration pattern during the study periods. 4. To identify the gaps in the research output in various fields of Android technology during the periods. 5. To find out subject-wise impact factor and highly impact factor research productivity. 6. To examine the communication channel preferred for publication of android technology research output. 7. To identify and tabulated of keywords frequency evaluation used in the study periods.

RESULTS AND DISCUSSION

Basic Scientific Output and Productivity Pattern:

Fig. 1 portrays the annual number of article relating to Android research during 2005 to 2014. The annual number increased from 128 in 2005 to 912 in 2014 with an annual growth ratio of an average article per year being 337. This supports the objective of this literature review which is to show the need for extensive research on android in the past ten years. Figure 1 also summarizes temporal characteristics of scientific research productivity evolution by several indicators. The number of references per articles also grew substantially from 17.92 in 2005 to 23.45 in 2014, clearly indicating an expansion in knowledge based on android. Another indicator was the average number of signatories per article which showed tremendous development. The number of author productivity on android research increased from 3.35 in 2005 to 3.68 in 2014. This is because the research in android has grown many folds which resulted in tremendous increase in both TP and AU. On the other hand, the number of citations has not increased in the same rate, the highest being 3336 in the year 2010 followed by 2009 and 2011 (Ji, Q. et al. 2014; Liu, X. et al. 2012).

Annual Growth Rate (AGR) and Compound Annual Growth Rate (CAGR): Figure 2 shows the AGR of the publications calculated year wise. We observe a steady fluctuation throughout the study period. This fluctuation could be attributed to the fact that there was no steady growth of publications every year.

The AGR and CAGR (Santha and Kaliyaperumal 2015) were calculated using Eq. 1 and 2.

Table 1: General Citation Pattern of the Android Research Output

S.N.	Year	TP	TC	Longevity (in years)	Overall NCII Score	Avg. NCII Score / Pub.
1	2005	128	1647	10	164.7	1.29
2	2006	157	2369	9	263.22	1.68
3	2007	143	2068	8	258.5	1.81
4	2008	179	2433	7	347.57	1.94
5	2009	203	2885	6	480.83	2.39
6	2010	246	3250	5	650	2.64
7	2011	305	2817	4	704.25	2.31
8	2012	397	2273	3	757.67	1.91
9	2013	700	2244	2	1122	1.6
10	2014	912	1089	1	1089	1.94

TP-Total Publication, TC-Total Citation Received, NCII-Normalized citation impact index

$$AGR = \frac{\text{Present value} - \text{Past value}}{\text{Past value}} \times 100 \quad (1)$$

$$CAGR = \frac{\text{Ending value}}{\text{Beginning value}}^{\frac{1}{n}} - 1 \quad (2)$$

The AGR and CAGR were calculated using Eq.1 and 2. The AGR for publications has growing trend from 13.89 in 2009 to 77.17 in 2013. However, the AGR has declined to 30.26 in 2014. However, the CAGR has a declining trend from 2006-2014 with maximum of 0.81 in 2006.

Citation Pattern: We covered general citation pattern of android research during the study period under consideration. We analyzed the distribution and impact of citations. The time factor plays a pivotal role on the number of citation a publication receives, we used normalized citation impact index (NCII) (Heilig and Vob 2014) so as to make the citation numbers of many years comparable. Similar NCII factor has been used by many researchers to compute a comparative study on citations. The NCII depends on the longevity of a publication which is calculated using Eq. 3:

$$NCII \text{ score} = \frac{TC}{n \text{ years}} \quad (3)$$

where n varies from 1 to 10 depending upon period. The data presented in table 1 reveals some interesting patterns. The most intriguing feature lays in the fact that the average NCII per publication is decreasing which suggests the significant impact of early and fundamental publications on other publication. We also observe a significant down growth of citation in the year 2014 when compared with 2012. We observed that in 2010, it received highest citation

in the longevity years (5) and average NCII score comes out to be 2.64 as the highest among all as presented in Table 1. It is interesting to note that the TC/TP showed a tremendous increment in 2006 being 15.22 from 157 articles published during the year, though TC value was highest (3336) in 2010 from 246 articles published. Further, we analyzed the contribution of top 10 authors who contributed 4.52% of the total publications and received 5.88% of total citations as shown in Table 2.

In order to study the subject wise citation pattern, we divided growth productivity of subject year wise and observed the highest publication received in the field of Computer Science (1916) and received 13955 citations which accounted for 58.83%. However, the highest citation was received in the Engineering subjects which accounts to about 62.08% citations as shown in Table 3.

Table 2: Top Ten Prominent Author during Android Research

S.N.	Author	Sin	Coll	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	TP	% TP	TC	% TC
1	Wong, K.L.	-	66	8	4	7	12	13	10	6	3	2	1	66	1.96	697	2.94
2	Ishiguro, H.	3	18	-	5	3	-	-	-	4	-	4	5	21	0.62	309	1.3
3	Lee, Y.S.	-	15	-	-	-	-	-	-	-	1	3	11	15	0.44	12	0.05
4	Nishio, S.	-	8	-	-	-	-	-	-	2	-	2	4	8	0.24	39	0.16
5	Lee, C.T.	-	8	-	1	-	1	1	3	1	1	-	-	8	0.24	143	0.6
6	Li, W.Y.	-	7	-	-	3	1	1	2	-	-	-	-	7	0.21	80	0.33
7	Cha, H.	-	7	-	1	-	-	1	-	-	2	2	1	7	0.21	73	0.3
8	Son, H.S.	-	7	-	-	-	-	-	-	-	-	7	-	7	0.21	1	0
9	Sim, C.Y.D.	1	6	-	-	-	1	2	-	3	1	-	-	7	0.21	36	0.15
10	Lai, Y.C.	-	6	-	-	-	-	-	-	-	-	3	3	6	0.18	13	0.05
Total		4	148	8	11	13	15	18	15	16	8	23	25	152	4.52	1403	5.88

TP-Total Publication, Sin-Single Publication, Coll-Collaborated Publication, %TP-Percentage of Total Publication, TC-Total Citation Received, %TC Percentage of Total Citation

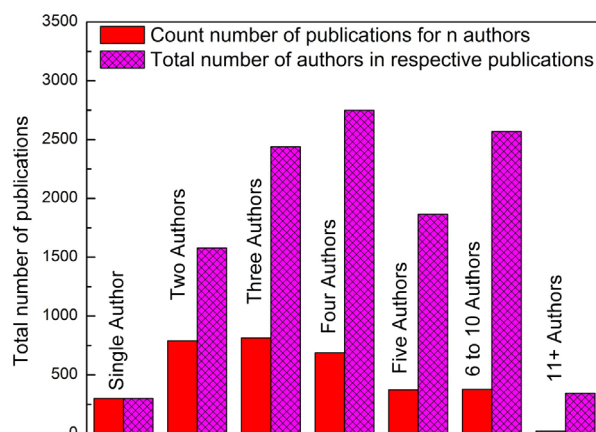


Fig. 3: Authorship Distribution of Published Articles

Authorship Pattern

The analysis on publication records listed 11839 authors. The top 10 most productive authors contributed 152 papers which accounts to 4.52% of total publications. The most productive authors in android research were Wong K L with 66 articles, followed by H. Ishiguro with 18 and Lee Y S with 15 articles as listed in Table 2. Amongst the 66

articles by Wong K L, 13 came in the year 2009. He also has 697 citations and ranks first in the top authors list. He published all articles with collaboration with other authors and it is found that there were no single authored papers. The next to him is Ishiguro who has 15 articles published in collaboration with other authors and has 3 articles published to his name as single author. He received 309 citations with a contribution of 1.3% as evident from Table 2. This study shows that the authors preferred to publish in collaboration

with others. In this context, we analyzed the general trend of no. of authors in an article. It is found that the highest number of published articles had three authors in a single article which contributes to about 24.2% followed by two authors and four authors. The lowest number of publication was found with more than 11 authors' collaboration papers which accounted to merely 0.63% from fig3. This implies that the collaborative pattern in the field of android is mainly characterized by co-authored papers rather than single authored papers. It indicates that the multi authored works contributed more in the overall development of android

related research than that of single authored work. Fig 4 portrays the number of publication vs. time period for papers with single author and multi authors in the field of android during the study period under consideration. The results reveal that there is a slight fluctuation observed for single authored papers and the highest being 57 in 2013. However, the multi authored papers increased rapidly with a maximum in 2014 with 3304 articles. We have also computed average authors per paper (AAPP) and average paper per author (APPA) as shown in fig 5. The results show that there is a growth of 3.68 in 2014 from 3.25 in 2009 in terms of AAPP and a mirror image could be reflected for APPA.

Table 3: Year Wise Distribution of Most Productive Subject Categories

S.N.	Subject Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	TP	TC	Ref	% TP	% TC	% Ref
1	Computer Science	73	75	68	95	96	128	153	238	414	576	1916	13955	42655	56.85	58.83	58.29
2	Engineering	86	116	109	130	131	155	173	212	350	437	1899	14726	32256	56.35	62.08	44.08
3	Physics and Astronomy	20	19	17	22	40	35	36	48	58	80	375	2293	6889	11.12	9.67	9.41
4	Mathematics	5	12	6	19	21	33	21	43	66	80	306	2059	7790	9.08	8.68	10.64
5	Materials Science	2	8	4	9	32	21	34	18	29	50	207	838	3246	6.14	3.53	4.43
6	Social Sciences	1	6	5	-	6	15	16	30	60	67	206	1476	6032	6.11	6.22	8.24
7	Chemistry	7	7	5	11	12	14	26	20	27	57	186	1757	5590	5.52	7.41	7.64
8	Biochemistry, Genetics and Molecular Biology	3	-	3	5	4	7	25	22	25	64	158	1183	4415	4.69	4.99	6.03
9	Medicine	6	3	5	5	7	11	14	22	21	55	149	1404	3343	4.42	5.92	4.57
10	Environmental Science	4	1	4	3	10	6	9	12	19	30	98	545	2259	2.91	2.3	3.09
11	Energy	5	3	2	8	11	7	6	15	14	11	82	478	1531	2.43	2.01	2.09
12	Multidisciplinary	-	3	-	1	3	2	5	6	31	31	82	308	1249	2.43	1.3	1.71
13	Earth and Planetary Sciences	1	3	2	5	5	9	6	9	18	22	80	390	1609	2.37	1.64	2.2
14	Decision Sciences	1	2	-	-	2	5	6	8	21	28	73	464	2217	2.17	1.96	3.03
15	Chemical Engineering	1	1	6	6	5	4	5	8	15	20	71	761	1771	2.11	3.21	2.42

TP-Total Publication, TC-Total Citation Received, Ref-Total References used in TP, %TP-Percentage of Total Publication, %TC-Percentage of Total Citation Received, %Ref-Percentage of Total References used in TP

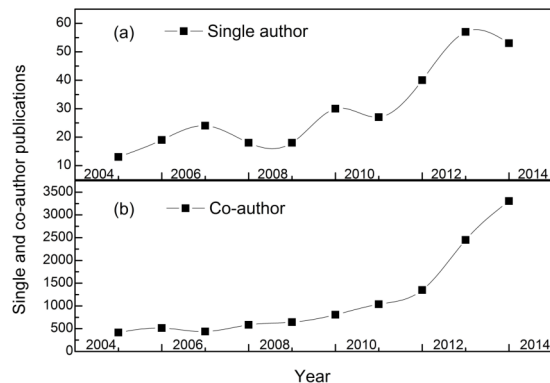


Fig. 4: Annual Growth Rate of Single and Co-Author Published Research Articles

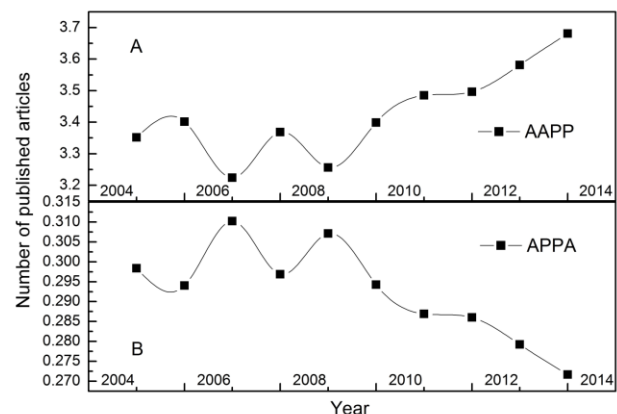


Fig. 5: AAPP and APPA Annual Growth Rate of Published Research Articles

Subject Categories and Major Journals

Android research spanned over 25 major subject categories in Scopus database. In the present article we have presented the 15 most productive subject categories. Table 3 lists the annual growth rates of top subject categories. We observe most highly productive subject category was found to be computer science with a productivity of 1,916 articles (56.85% of TP) followed by Engineering and Technology (1899 articles; 56.35%), Physics and Astronomy (375; 11.12%), Mathematics (306; 9.08%) and Materials science (207; 6.14%). As computer science tops this list in the study period, their applied and implied tradition of research on android technology. Fig 6 describes the growth rates of top subject disciplines annually. These disciplines earmarked a continuous growth and momentum in the last three years as evident from fig 6. Therefore one could say that the research trends in major subject categories like Computer Science are extensive as identified from the present study.

Further, we present top 20 journals that published most android research articles in Table 4, along with the number of papers, the number of citation received, Impact Factor, SCImago Journal Ranking (SJR), Impact per Publication (IPP) and Source Normalized Impact per Paper (SNIP) of each journal. Here our focus is on android related publication in these top journals. These 20 (1.76%) out of the 1136 journals had published 635 (18.84%) of the total 3370 articles and received 6138 (24.77%) of the total 23719 citations. Highest paper published comes out to be 108 on android studies in the journal “Microwave and Optical Technology Letters” followed by the journals IEEE transactions on mobile computing, Sensors with 37 and 35 article respectively as shown in Table 4. The highest citations was received in the journal IEEE communication magazine and found to be 1190 from 31 articles followed by Microwave and Optical Technology Letters with 633 from 108 articles. The journal IEEE communication magazine with maximum citations also is first in terms of SJR, IPP and SNIP rankings and second in Impact factor (4.007) after Journal of chromatography A.

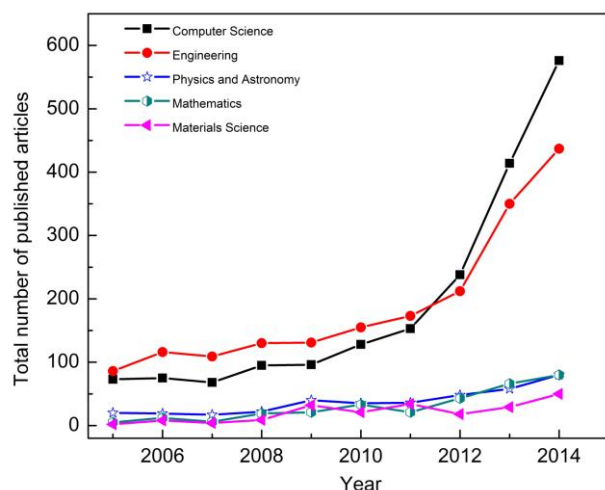


Fig. 6: Year wise Growth Rate of the Top Five Most Productive Subject Categories

Geographic and Institutional Distribution of Research Output

We found that during the study period 2005- 2014, there are 3370 articles being published on android from 89 countries altogether. However, we present publication information on geographic indicators for the most productive

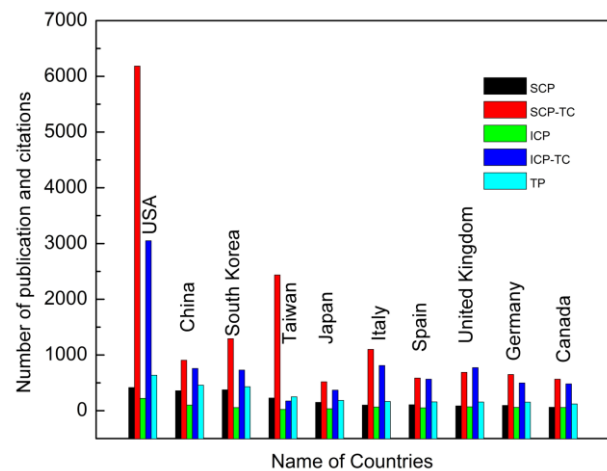


Fig. 7: Country Wise Growth Rate of SCP, ICP and its TC with TP of Published Output

25 countries in Android research as listed in table 5. These top 25 countries/territories in Android research were distributed in different geographic region of which 13 were from Europe, 8 from Asia, 2 from North America, 1 from South America and Australia each and none from Africa and Antarctica. Table 5 gives information on top productive countries with highest number of single country publication (SCP), internationally collaboration publication (ICP) and SCP-TC, ICP-TC denotes total citations received from single country and internationally collaborated publication. USA is found to be the top productive country in terms of SCP (415) and ICP (222) and received highest citation in SCP and ICP (6184 and 3051) respectively along with top average of number of citations. Asian countries like China published second highest number of articles with 459 followed by South Korea 430, Taiwan 249, and Japan 184 as shown in Table 5. Taiwan ranks second in total citations after USA with 2609 from 249 articles. On similar grounds, Fig. 7 describes top 10 countries performance in terms of SCP and ICP including its TCs indicating their growth activity among countries. Fig. 8 describes the annual growth rate of publication in top ten countries during the study period. In this study we observed USA has published highest article during 2005 to 2014. But in the last two years (2013 and 2014) South Korea and China has produced highest number of publications respectively in android study.

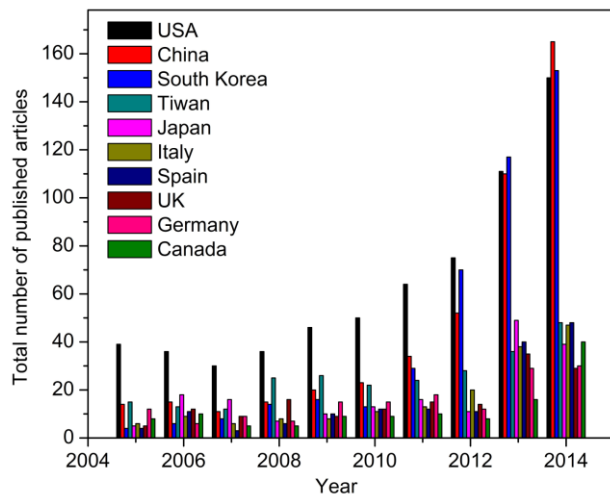


Fig. 8: The Annual Distribution of Top Ten Countries Research Output of Published Article

Further, we present data for the most productive institutes globally in android research during the period under study. Table 6 clearly states the top 23 institutions with the highest publication productivity in the world and presented their total number of publication, Single Institution Publication (SIP) and Institute Collaboration Publication (ICP), with international collaboration articles. The data in Table 6 lists those institutes with $TP \geq 15$. In this evolution we found 9 institutes were from South Korea, 5 from China, 4 from Taiwan, 2 from Japan and 1 each from USA, Italy and Singapore. National Sun Yat-Sen University, Taiwan is listed top ranked institute with 70 articles published among which 58 are SIP and 12 are ICP. It received the highest overall citation of 1529 (1342 SIP and 187 ICA). National Sun Yat-Sen University, Taiwan tops the list in SIP citations whereas Massachusetts institute of technology, USA tops in ICP citations with 817 from 20 publications.

This study clears the picture of top institutes with annual productivity trend since 2005 to 2014. Further, we picked the top five most productive institutes from 23 institutes listed in Table 6 and found that they contributed 184 articles altogether, with an average of 36.8 articles per institutions and received 2319 citations (9.77% of total citations). In the period 2005-2014, Tsinghua University China with 31 articles is after National Sun Yat-Sen University, Taiwan, followed by Yonsei University South Korea, Korea University, South Korea and Osaka University, Japan. The annual growth trend in terms of articles published during the study period is depicted in Fig. 9. We observe that there is a steady growth for National Sun Yat-Sen University, Taiwan up to 2009 and has a rapid decline in TP after 2009 as shown in fig. 9.

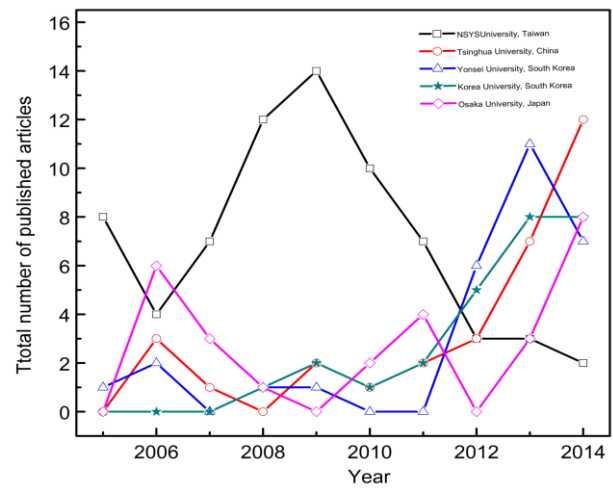


Fig. 9: Annual Distribution of Top Five Institutes Research Output of Published Article

Keywords Evolution

The keywords provide important information about trends and frontiers in research and reveal the areas of research interest. The 3370 articles in our database contained 13621 keywords. We present the top 29 most frequent keywords ≥ 100 times used in total published articles. Every keyword involved was counted and ranked for every two year interval during the study period as shown in Table 7. Other than the keyword “Android”, the most frequently used keywords were “Smartphones”, “Mobile Devices” and “Mobile Telecommunication Systems”. Although smartphones is a universal issue, Android is the most sensitive keyword and many scientist believe that smartphones is the most pervasive theme in Android research.

The keyword “Mobile Telecommunication Systems” ranked first in three group of years namely 2005-06, 2007-08 and 2009-10 which accounts for about 17.09%, 13.22% and 11.43% respectively of the total keywords under study (≥ 100). The keyword “Smartphones” is ranked top for the next two pair of years 2011-12 and 2013-14 with 10% and 15.09% respectively. All keywords with usage ≥ 100 is depicted in table 7. The keyword “Smart Phones” which is ranked first considering the usage in entire study period has been used 505 times. These keywords reflect the nature of research undertaken. This correspondingly reflects many alternatives come out to tackle a more critical and complex field of research interest, considering the choice of researchers from related and entirely different discipline and currents of thought.

CONCLUSION

Android fascinates a galore of interdisciplinary scrutiny and is a fast growing field of research. In the present article,

we conducted a comprehensive bibliometric analysis to investigate the growth of Android related publications based on Scopus data. The analysis of highly influential authors, main contributing affiliations and publications can be a learning roadmap especially to new generations of scholars to have an outer view of all publications, topics, outlets and to figure out main contributors and driving forces in the android sector. Wong K L has the highest number of papers in this field with 66 articles and 697 citations.

In general, this paper presents the strength of a bibliometric analysis in extensively investigating an interest field. Such measures have the potential to catalyze publications activity, improve publication productivity of authors as well as help in improving the quality of research output. This, in comparison, is impossible using structured literature reviews.

Extensive work focusing publication patterns, research productivity, research impact, year-wise distribution of publications, collaborative patterns for author and institutes, highly preferred journals, citation patterns etc. during the period 2005-2014 has been done. The results reveal that there is a tremendous growth of android based research in these years. USA tops the list in highest research papers and has most number of citations with an SCP of 415 and an ICP of 222. We observe most highly productive subject category was found to be computer science with a productivity of 1,916 articles (56.85% of TP). The results of this study may help in understanding trends, patterns and other important parameters as a platform for collaborating research culture in the area of android research.

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Table 4: Top 20 Most Prominent Journals in Android Research

S.N.	Journal	TP	% TP	TC	% TC	TC/TP	IF 2014	SJR	IPP	SNIP
1	Microwave and Optical Technology Letters	108	3.2	633	2.67	5.86	0.568	0.493	0.601	0.593
2	IEEE Transactions on Mobile Computing	37	1.09	404	1.7	10.92	2.543	3.017	3.512	3.758
3	Sensors	35	1.03	107	0.45	3.06	2.245	0.601	2.245	1.688
4	IEICE Transactions on Information and Systems	33	0.98	20	0.08	0.61	0.213	0.252	0.24	0.442
5	IEEE Transactions on Consumer Electronics	31	0.92	92	0.38	2.97	1.045	0.941	1.41	1.915
6	IEEE Transactions on Vehicular Technology	31	0.92	570	2.4	18.39	1.978	1.981	2.807	2.535
7	IEEE Communications Magazine	31	0.92	1190	5.01	38.39	4.007	5.587	5	4.98
8	Wireless Personal Communications	30	0.89	73	0.31	2.43	0.653	0.364	0.805	0.865
9	International Journal of Multimedia and Ubiquitous Engineering	30	0.89	45	0.19	1.5	-	0.229	0.471	1.169
10	IEEE Transactions on Antennas and Propagation	30	0.89	847	3.57	28.23	2.181	2.658	2.582	2.6
11	IEEE Transactions on Wireless Communications	29	0.86	679	2.86	23.41	2.496	3.32	3.005	2.344
12	International Journal of Smart Home	28	0.83	40	0.17	1.43	-	0.277	0.504	1.024
13	IEEE Antennas and Wireless Propagation Letters	27	0.8	376	1.58	13.92	1.579	2.405	2.094	1.922
14	Personal and Ubiquitous Computing	26	0.77	241	0.77	9.27	1.518	1.202	1.667	2.134
15	Journal of Chromatography A	23	0.68	351	0.68	15.26	4.169	1.664	4.211	1.455
16	IEEE Engineering in Medicine and Biology Society Conference Proceedings	22	0.65	61	0.25	2.77	-	0.165	0.275	0.243
17	International Journal of Applied Engineering Research	22	0.65	3	0.01	0.14	-	0.13	0.077	0.166
18	Fujitsu Scientific and Technical Journal	21	0.62	30	0.12	1.43	0.227	0.245	0.228	0.616
19	IEEE Pervasive Computing	21	0.62	348	1.46	16.57	1.545	1.036	2.278	2.824
20	International Journal of Software Engineering and Its Applications	20	0.59	28	0.11	1.4	-	0.205	0.323	0.769

TP-Total Publication, %TP-Percentage of Total Publication, TC-Total Citation Received, %TC-Percentage of Total Citation, IF-Impact Factor, SJR-SCImago Journal Ranking, IPP-Impact per Publication, SNIP-Source Normalized Impact per Paper

Table 5: Top 25 Most Productive Countries in Android Research

S.N.	Country/ Territory	SCP	SCP- TC	ICP	ICP- TC	TP	TC	TC/TP	% TP of SCP	% TC of SCP-TC	% TP of ICP	% TC of ICP-TC	% TP	% TC
1	United States	415	6184	222	3051	637	9235	14.5	12.31	26.07	6.56	12.86	18.9	38.93
2	China	358	906	101	758	459	1664	3.62	10.62	3.81	2.99	3.19	13.62	7.01
3	South Korea	375	1293	55	730	430	2023	4.7	11.13	5.45	1.63	3.08	12.76	8.53
4	Taiwan	227	2435	22	174	249	2609	10.48	6.73	10.26	0.65	0.73	7.39	10.99
5	Japan	150	519	34	368	184	887	4.82	4.45	2.19	1.01	1.55	5.46	3.74
6	Italy	101	1100	65	812	166	1912	11.52	2.99	4.64	1.93	3.42	4.92	8.06
7	Spain	106	585	51	565	157	1150	7.32	3.14	2.45	1.51	2.38	4.66	4.85
8	United Kingdom	86	689	70	772	156	1461	9.36	2.55	2.9	2.08	3.25	4.63	6.16
9	Germany	94	649	59	498	153	1147	7.5	2.79	2.74	1.75	2.09	4.54	4.83
10	Canada	62	565	58	481	120	1046	8.72	1.84	2.38	1.72	2.03	3.56	4.41
11	France	43	311	52	610	95	921	9.69	1.27	1.31	1.54	2.57	2.82	3.88
12	India	76	127	13	124	89	251	2.82	2.25	0.53	0.38	0.52	2.64	1.06
13	Australia	37	188	34	566	71	754	10.62	1.09	0.79	1.01	2.39	2.11	3.18
14	Malaysia	44	130	17	136	61	266	4.36	1.3	0.55	0.5	0.57	1.81	1.12
15	Greece	37	278	18	205	55	483	8.78	1.09	1.17	0.53	0.86	1.63	2.04
16	Finland	27	180	26	265	53	445	8.4	0.8	0.76	0.77	1.12	1.57	1.88
17	Hong Kong	18	394	27	128	45	522	11.6	0.53	1.66	0.8	0.54	1.33	2.2
18	Netherlands	16	132	27	381	43	513	11.93	0.47	0.56	0.8	1.61	1.27	2.16
19	Singapore	15	79	26	135	41	214	5.21	0.44	0.33	0.77	0.57	1.22	0.9
20	Switzerland	16	146	19	100	35	246	7.03	0.47	0.61	0.56	0.42	1.04	1.04
21	Sweden	18	150	15	374	33	524	15.88	0.53	0.63	0.44	0.58	0.98	2.21
22	Poland	26	42	6	64	32	106	3.31	0.77	0.18	0.18	0.27	0.95	0.45
23	Portugal	24	184	7	91	31	275	8.87	0.71	0.77	0.21	0.38	0.92	1.16
24	Brazil	18	80	12	51	30	131	4.37	0.53	0.33	0.36	0.21	0.89	0.55
25	Romania	24	21	6	76	30	97	3.23	0.71	0.09	0.18	0.32	0.89	0.41

Table 6: Top Most Affiliated Institutes in Android Research Publication ≥ 15 of Total Contribution

S.N.	Institute Affiliation	SIP	SIP TC	CIP	CIP TC	TP	TC	% TP of SIP	% TC of SIP-RTC	% TP of CIP	% TC of CIP-RTC	% TP	% TC
1	National Sun Yat-Sen University, Taiwan	58	1342	12	187	70	1529	1.72	5.66	0.36	0.79	2.07	6.45
2	IEEE, New York	0	0	36	825	36	825	0	0	1.06	3.48	1.06	3.48
3	Tsinghua University, China	10	93	21	76	31	169	0.29	0.39	0.62	0.32	0.92	0.71
4	Yonsei University, South Korea	12	101	17	33	29	134	0.36	0.42	0.5	0.14	0.86	0.56
5	Korea University, South Korea	10	45	17	95	27	140	0.29	0.19	0.5	0.4	0.8	0.59
6	Osaka University, Japan	7	92	20	255	27	347	0.21	0.39	0.59	1.07	0.8	1.46
7	Beijing University of Posts and Telecommunications, China	8	19	18	59	26	78	0.24	0.24	0.53	0.25	0.77	0.32
8	Fujitsu Ltd., Japan	15	11	10	68	25	79	0.45	0.45	0.29	0.29	0.74	0.33
9	Massachusetts Institute of Technology, USA	4	89	20	817	24	906	0.12	0.12	0.59	3.44	0.71	3.82
10	National Chiao Tung University Taiwan, Taiwan	4	12	19	119	23	131	0.12	0.12	0.56	0.5	0.68	0.55
11	Seoul National University, South Korea	8	59	15	128	23	187	0.24	0.24	0.44	0.54	0.68	0.79
12	Korea Advanced Institute of Science & Technology, South Korea	10	64	12	36	22	100	0.29	0.29	0.36	0.15	0.65	0.42
13	Electronics and Telecommunications Research Institute, South Korea	4	2	17	64	21	66	0.12	0.12	0.5	0.26	0.62	0.28
14	Seoul National University of Science and Technology (SNUST), South Korea	6	6	15	76	21	82	0.18	0.18	0.44	0.32	0.62	0.34
15	University of Electronic Science and Technology of China, China	12	81	7	26	19	107	0.36	0.36	0.21	0.11	0.56	0.45
16	Hanyang University, South Korea	10	40	9	33	19	73	0.29	0.29	0.27	0.14	0.56	0.31
17	National Taiwan University, Taiwan	8	169	10	95	18	264	0.24	0.24	0.29	0.4	0.53	1.11
18	Xidian University, China	14	49	4	6	18	55	0.41	0.42	0.12	0.2	0.53	0.23
19	Politecnico di Milano, Italy	9	50	8	67	17	117	0.27	0.27	0.24	0.28	0.5	0.49
20	National Taiwan University of Science and Technology, Taiwan	5	4	12	101	17	105	0.15	0.15	0.36	0.42	0.5	0.44
21	Southeast University, China	7	9	9	10	16	19	0.21	0.21	0.27	0.04	0.47	0.08
22	Nanyang Technological University, Singapore	3	9	12	71	15	80	0.09	0.09	0.36	0.29	0.44	0.33
23	Sungkyunkwan University, South Korea	4	50	11	17	15	67	0.12	0.12	0.33	0.07	0.44	0.28
24	Seokyeong University, South Korea	5	6	10	18	15	24	0.15	0.15	0.29	0.07	0.44	0.1

SIP-Single Institute Publications, CIP- Collaborated Institutional Publications, SIP-TC & CIP-TC- total citation received both single and collaborate institutes, TP- Total Publication, TC- Total Citation Received

Table 7: Top Most Prominent Keywords Used >=100 of Total Publication

S.N.	Keyword Cnt	2005-2006		2007-2008		2009-2010		2011-2012		2013-2014		TP	OR	TC	TC/TP					
		R	%	Cnt	R	%	Cnt	R	%	Cnt	R					%				
1	Smartphones	1	17	0.23	4	19	0.77	10	20	1.14	128	1	10	362	1	15.09	505	2381	4.71	
2	Mobile devices	7	12	1.62	23	8	4.41	40	8	4.75	110	2	8.6	268	2	11.17	448	3576	7.98	
3	Mobile telecommunication systems	74	1	17.09	69	1	13.22	100	1	11.43	75	4	5.86	89	9	3.71	407	5452	13.39	
4	Android	1	17	0.23	2	20	0.38	12	18	1.37	63	6	4.92	205	3	8.55	283	1052	3.72	
5	Robots	8	11	1.85	17	13	3.26	24	13	2.74	84	3	6.57	128	5	5.33	261	1757	6.73	
6	Wireless telecommunication systems	53	2	12.24	37	2	7.09	48	7	5.48	48	7	3.75	75	12	3.12	261	2484	9.51	
7	Article	24	6	5.54	29	4	5.55	34	10	3.88	71	5	5.55	90	8	3.75	248	2770	11.16	
8	Signal encoding	1	17	0.23	0	21	0	6	21	0.68	48	7	3.75	163	4	6.79	218	1080	4.95	
9	Mobile phones	4	15	0.92	33	3	6.32	46	7	5.26	47	8	3.67	77	11	3.21	207	2238	10.81	
10	Computer operating systems	31	5	7.16	26	6	4.98	64	2	7.31	36	13	2.81	41	21	1.7	198	1463	7.39	
11	Algorithms	33	4	7.62	22	9	4.21	20	14	2.28	35	14	2.74	79	10	3.29	189	1760	9.31	
12	Mobile computing	17	8	3.93	21	10	4.02	25	12	2.86	24	21	1.88	72	13	3	159	1493	9.39	
13	Telephone sets	6	13	1.38	11	15	2.11	47	6	5.37	46	9	3.6	42	20	1.75	152	1723	11.33	
14	Smartphone	1	17	0.23	0	21	0	4	22	0.46	27	19	2.11	113	6	4.71	145	626	4.32	
15	Mobile antennas	15	9	3.46	24	7	4.6	51	4	5.83	32	16	2.5	19	25	0.79	141	1505	10.67	
16	Mobile applications	1	17	0.23	2	20	0.38	13	17	1.48	33	15	2.58	92	7	3.83	141	829	5.88	
17	Global system for mobile communications	15	9	3.46	23	8	4.41	40	8	4.57	43	10	3.36	14	27	0.58	135	1229	9.1	
18	Wireless networks	5	14	1.15	27	5	5.17	50	5	5.71	27	19	2.11	25	23	1.04	134	1565	11.68	
19	Internet	20	7	4.62	10	16	1.91	17	16	1.94	26	20	2.03	55	16	2.29	128	1243	9.71	
20	Computer simulation	47	3	10.85	23	8	4.41	13	17	1.48	13	24	1.01	31	22	1.29	127	1615	12.72	
21	Mobile phone	7	12	1.62	4	19	0.77	12	18	1.37	37	12	2.89	65	14	2.71	125	1352	10.82	
22	Optimization	12	10	2.77	14	14	2.68	25	12	2.86	19	22	1.48	50	18	2.08	120	894	7.45	
23	Sensors	8	11	1.85	8	17	1.53	11	19	1.26	40	11	3.12	53	17	2.21	120	1577	13.14	
24	Communication systems	4	15	0.92	18	12	3.44	35	9	4	36	13	2.81	23	24	0.96	116	1125	9.7	
25	Human	4	15	0.92	6	18	1.15	11	19	1.26	30	17	2.34	64	15	2.67	115	1245	10.83	
26	Mobile robots	20	7	4.62	27	5	5.17	18	15	2.05	17	23	1.32	31	22	1.29	113	1028	9.08	
27	Telecommunication equipment	2	16	0.46	18	12	3.44	55	3	6.28	24	21	1.88	7	28	0.29	106	968	9.13	
28	Cellular telephone systems	7	12	1.62	20	11	3.83	32	11	3.66	28	18	2.19	18	26	0.75	105	836	7.96	
29	Humans	5	14	1.15	4	19	0.77	12	18	1.37	32	16	2.5	47	19	1.96	100	1347	13.47	
	Total	433			522			875		1279				2398						

Cnt.-Count number of Keywords, R-Year wise Rank, %-Rank percentage of total publication, TP-Total number of publications, OR-Overall Rank, TC-Total number of citation received, TC/TP-average number of per article