Half a century of computer methods and programs in biomedicine: A bibliometric analysis from 1970 to 2017

Half a century of Computer Methods and Programs in Biomedicine: A bibliometric analysis from 1970 - 2017

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Abstract

Background and Objective:

Computer Methods and Programs in Biomedicine (CMPB) is a leading international journal that presents developments about computing methods and their application in biomedical research. The journal published its first issue in 1970. In 2020, the journal celebrates the 50th anniversary. Motivated by this event, this article presents a bibliometric analysis of the publications of the journal during this period (1970 – 2017).

Methods:

The objective is to identify the leading trends occurring in the journal by analysing the most cited papers, keywords, authors, institutions and countries. For doing so, the study uses the Web of Science Core Collection database. Additionally, the work presents a graphical mapping of the bibliographic information by using the visualization of similarities (VOS) viewer software. This is done to analyze bibliographic coupling, co-citation and co-occurrence of keywords.

Results:

CMPB is identified as a leading and core journal for biomedical researchers. The journal is strongly connected to *IEEE Transactions on Biomedical Engineering* and *IEEE Transactions on Medical Imaging*. Paper from Wang, Jacques, Zheng (published in 1995) is its most cited document. The top author in this journal is James Geoffrey Chase and the top contributing institution is Uppsala U (Sweden). Most of the papers in CMPB are from the USA followed by the UK and Italy. China and Taiwan are the only Asian countries to appear in the top 10 publishing in CMPB. A keyword co-occurrences analysis revealed strong co-occurrences for classification, picture archiving and communication system (PACS), heart rate variability, survival analysis and simulation. Keywords analysis for the last decade revealed that machine learning for a variety of healthcare problems (including image processing and analysis) dominated other research fields in CMPB.

Conclusions:

It can be concluded that CMPB is a world-renowned publication outlet for biomedical researchers which has been growing in a number of publications since 1970. The analysis also conclude that the journal is very

international with publications from all over the world although today European countries are the most productive ones.
Keywords: Bibliometrics; Web of Science; Co-citation; VOS viewer.

1. Introduction

Computer Methods and Programs in Biomedicine (CMPB) is one of the main journals in the field of biomedical research which focuses on the development of formal computing methods and their application in biomedical research and practice. The journal started publishing papers from 1970 under the name Computer Programs in Biomedicine. In 1985, it was renamed to Computer Methods and Programs in Biomedicine. Prof Werner Schneider from Uppsala University was its first managing editor in 1970. Since then, the journal has been publishing theoretical and application oriented papers addressing biomedical research challenges and problems. In 2013, Editor-in-Chief of the journal was changed to Prof Yu-Chuan Li. The journal initially started publishing less than 4 issues a year, later increasing to 6 issues and after 2015, it has grown to publish more than 12 issues per year suggesting a growing interest of the research community in the journal. CMPB is considered to be an A* journal in the field of Biomedical Engineering in Australia (according to 2010 Excellence in Research Australia John Lamp journal ranking). Currently, its CiteScore is 3.49 and the impact factor is 2.674. It is in top 20% of journals in Computer Science Applications, Software and Health Informatics discipline.

To celebrate CMPB's 50th anniversary, this paper develops a bibliometric analysis of the leading trends observed in the biomedical research field through this journal from 1970 to 2017. It is important to keep track of topic changes and other bibliometric trends to maximise the benefits of the use of computing methods in medical and biomedical research fields so that novel and innovative applications of computational methods can be embraced. As the topics of research change over time, it is difficult to track and analyse them appropriately. The bibliographic research employed in this study aims to provide an overview of topic trends and challenges dealt with in the literature. Bibliometric analysis is applied to the literature published in CMPB since its inception. We also analyse the dynamic trend of topics covered in CMPB over time. In the analysis, leading topics, authors, institutions and countries along with citation structure and analysis are identified and discussed. In this work, we have

employed the Web of Science (WoS) Core Collection database to collect and analyse the bibliographic material. We used the visualization of similarities (VOS) viewer software developed in Van Eck & Waltman [1] to systematically visualise the bibliographic data. The visualisation work presented in this paper used range of analysis including bibliographic coupling [2], co-citation [3], citation, co-authorship and co-occurrence of keywords.

When keywords of the papers published in CMPB were analysed, it was revealed that research related to classification, PACS (picture archiving and communication system), heart rate variability, survival analysis and simulation were popular in the journal since its inception. The analysis also revealed the popular themes of research in the CMPB publications. The most popular themes were: (i) machine learning methods for medical data analysis, (ii) signal processing in case of heart rate variability, (iii) simulation models for diabetes, (iv) use of PACS data for its use in health technology assessments and image processing, (v) decision support systems development based on healthcare records and (vi) survivability analysis for health conditions. It is common in the literature to develop some sort of activities such as editorials, reviews and special issues for the journal to mark a significant anniversary. Many journals recently have presented a bibliometric analysis of their publications by celebrating anniversaries. This type of approach has been used for journals including the Journal of Business Research, Knowledge-Based Systems , the Journal of Business & Industrial Marketing , International Journal of Intelligent Systems , and the Computers in Biology and Medicine.

The rest of the paper is organised as follows. Section 2 briefly describes the bibliometric methods used in this paper for analysis. Section 3 presents the results obtained from the bibliometric analysis including the publication and citation structure, the leading authors, institutions and countries, the most cited papers and the most citing papers. Section 4 visualises the results from co-citation, bibliographic coupling of institutions, countries, and keywords. Finally, Section 5 summarizes the main findings of the presented bibliometric analysis.

2. Methods

Bibliometrics is a research area of library and information sciences that studies the bibliographic material by using quantitative approaches [12-13]. Due to the development of

computers and internet, today it is quite easy to develop a bibliometric analysis since most of the information is available online [14]. Therefore, many authors have developed bibliometric studies of a wide range of areas including management [15], economics [16], innovation [17], entrepreneurship [18], fuzzy research [19] and linguistic decision making [20].

Bibliometrics is developed for a wide range of purposes including the analysis of a topic [21], journal [22], country [17] or university [23]. The analysis of a journal is of particular interest when the journal celebrates a special event like a significant anniversary. At this time, it becomes of great interest to develop a bibliometric overview of the journal in order to identify and commemorate the leading trends of the journal [24]. Many journals have already published a bibliometric analysis of their publications including the Accounting Review [25], Journal of Financial Economics [26], Strategic Management Journal [27], Technovation [28] and the Journal of Product Innovation Management [29]. Recently, many other journals are also publishing this approach including Computers & Human Behavior [30], European Journal of Operational Research [31], Computers & Industrial Engineering [32], Information Sciences [33], European Journal of Marketing [34], IEEE Transactions on Fuzzy Systems [35] and the Journal of Knowledge Management [36].

When analysing the bibliographic data in order to generate bibliometric results, it is important to define the bibliometric indicators to be used in the analysis in order to obtain the most representative information [37-39]. This work considers the number of papers as a measure of productivity and the number of citations as a measure of popularity and influence. Additionally, it also considers the citations per paper ratio, citations thresholds and the *h*-index [40]. The *h*-index is a measure that connects publications with citations by analysing the X number of papers that have received X citation or more [41-42]. The *h*-index has been extended and generalised under a wide range of frameworks [43]. In some specific cases, the study also considers some other indicators in order to get a more general picture of the results. For universities, the paper considers the general university rankings (Academic Ranking of World Universities (ARWU) and Quacquarelli & Symonds (QS) University Ranking) in order to analyse the general standing of the institutions that publish in the journal.

Considering the factor "countries", the work normalizes the results per million inhabitants in order to compare countries with different size in population.

In order to provide a deeper analysis of the bibliometric information, the paper develops a graphical mapping of the bibliographic data with the aim of identifying how the leading actors of the journal connect with each other. This work uses the VOS viewer [1] software. However, note that in the literature there are other software available to build graphical networks of the data [44, 47]. VOS viewer collects the bibliographic information from a database (e.g. Web of Science or Scopus) and builds graphical maps by using bibliographic coupling, co-citation and co-occurrence of keywords [45-46]. The bibliographic coupling analyses those documents that cite the same third material [2]. Co-citation focuses on those publications that receive citations from the same third documents [3]. Co-occurrence of keywords measures those keywords that appear more frequently in the same publications.

The search of the bibliographic information was carried out in October 2018. The search used in the Web of Science Core Collection database uses the two names the journal has had between 1970 and 2018: “Computer Methods and Programs in Biomedicine” and “Computer Programs in Biomedicine”. Up to December 2017, the research has found 4225 documents published in CMPB considering only articles, reviews, letters and notes. In October 2018, these documents had received 59,094 citations. The *h*-index is 82. That is, 82 documents have received 82 citations or more.

3. Results

3.1. Publication and citation structure of CMPB

In 1970, CMPB started publishing just over 20 papers a year and an upward trend continued exceeding 50 papers annually in the nineties, until 2004, when over 100 papers a year were being published. After 2012, more than 200 papers per year have been published in the journal. Figure 1 illustrates the number of papers published in CMPB since its inception in 1970. It can be seen that the number of papers published in CMPB has increased tenfold in the last 50 years showing growing interest of the researchers towards this journal as well as a rapid evolution of the biomedical research field in the last two decades due to growth in

medical data/information storage, retrieval and analysis technologies and advancement of computing methods.

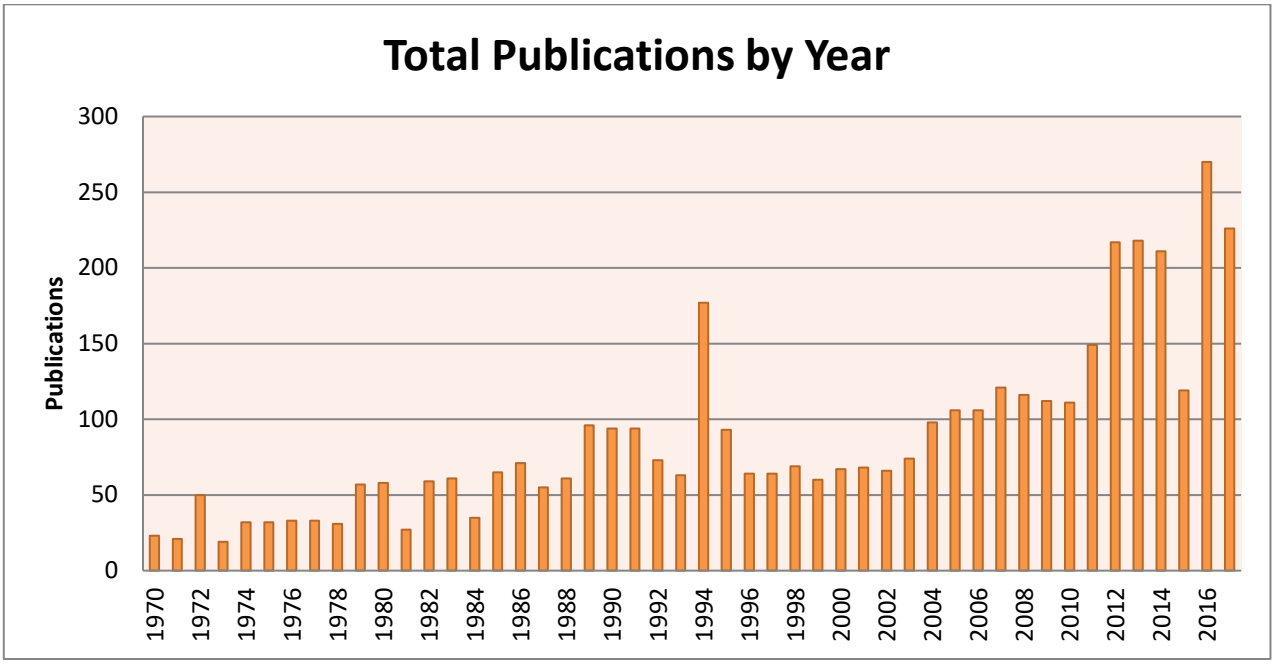

Figure 1. Annual number of papers published in CMPB

Table 1 shows the annual citation structure of the papers published in CMPB. Several citation thresholds (such as ≥200, ≥100, ≥50, ≥20, ≥10, ≥5, and ≥1) have been used to study the citations arising from the papers. Table 1 indicates that CMPB has been able to attract citations by publishing papers which are highly cited. Papers published in the last few years still need some time to catch up in terms of attracting citations. CMPB has been getting high citations consistently with 31 papers (0.73%) receiving more than 200 citations. Nearly, 14.75% of papers received more than 20 citations which is quite significant for an area not particularly amenable to high citations. It can also be seen that most of the highly cited papers are published after 1995 through to 2012 indicating improved quality of research over time.

Table 1. Annual citation structure of CMPB

Year	TP	TC	≥200	≥100	≥50	≥20	≥10	≥5	≥1
1970	23	122	0	0	0	2	2	7	14
1971	21	150	0	0	0	2	6	8	14
1972	50	1096	1	1	2	5	9	16	24

1973	19	185	0	0	1	4	5	6	14
1974	32	198	0	0	0	2	6	14	22
1975	32	198	0	0	0	2	6	14	22
1976	33	392	0	1	1	6	8	17	25
1977	33	210	0	0	0	2	8	13	19
1978	31	186	0	0	0	1	6	12	24
1979	57	1587	2	3	5	7	12	22	45
1980	58	503	0	2	2	3	4	13	34
1981	27	376	0	1	1	3	8	11	19
1982	59	481	0	0	1	6	12	21	41
1983	61	1889	2	2	3	6	12	17	42
1984	35	209	0	0	0	1	5	12	24
1985	65	944	1	1	4	11	19	32	51
1986	71	1255	2	2	2	8	18	29	50
1987	55	247	0	0	0	1	7	17	37
1988	61	473	0	0	2	6	11	18	37
1989	96	1189	1	3	3	8	22	35	69
1990	94	857	0	0	1	11	28	43	71
1991	94	696	0	0	2	7	21	35	76
1992	73	553	0	0	2	7	14	23	46
1993	63	544	0	0	2	7	14	27	45
1994	177	1134	0	0	4	11	28	52	116
1995	93	2989	2	2	4	13	17	26	63
1996	64	1208	1	2	4	12	20	38	55
1997	64	1550	2	4	8	18	28	42	53
1998	69	743	0	0	1	9	21	37	59
1999	60	1982	3	4	5	18	28	42	56
2000	67	1130	0	2	5	13	27	44	62
2001	68	1311	1	3	5	18	31	38	60
2002	66	1432	1	2	8	18	32	46	57
2003	74	1149	0	0	4	16	32	48	64
2004	98	2271	3	3	7	23	45	63	91
2005	106	2659	2	7	8	23	51	70	100
2006	106	2466	1	2	8	28	57	79	98
2007	121	2087	0	2	7	34	53	80	110
2008	116	2370	2	2	6	35	62	86	108
2009	112	1985	0	1	9	28	54	79	106
2010	111	2639	2	4	5	35	53	74	104
2011	149	2157	0	2	8	29	53	90	133
2012	217	3106	1	1	8	39	90	144	199
2013	218	2234	0	0	2	27	77	131	198
2014	211	2922	1	1	9	35	74	127	189
2015	119	893	0	0	0	10	24	53	108
2016	270	1551	0	0	0	13	38	95	200
2017	226	586	0	0	0	0	7	31	115
Total	4225	59094	31	60	159	623	1265	2077	3369
%	100%		0.73%	1.42%	3.76%	14.75%	29.94%	49.16%	79.74%

Abbreviations: TP and TC = Total papers and citations; ≥100, ≥50, ≥25, ≥10, ≥5, ≥1 = Number of papers with equal or more than 100, 50, 25, 10, 5 and 1 citations.

3.2.Influential papers in CMPB

In terms of most cited papers published in CMPB, Table 2 presents the top 50 highly cited papers of all time. The most cited paper is from *Lihong Wang, Steven L. Jacques, Liqiong Zheng* published in 1995 on Monte Carlo model of steady-state light transport in multi-layered tissues receiving more than 2000 citations. The next highly cited paper is from *Grant A. McPherson* on computer-based approach to the analysis of radioligand binding experiments published in 1983. It should be noted that most of the highly cited papers developed some type of computer programs to aid medical problems/decision making. These papers made the source codes for their programs openly available for other researchers/practitioners to use. The top most contributing authors to the highly cited papers are *Natarajan Kannathal, Niclas E. Jonsson and U Rajendra Acharya* each with 3 papers.

Another interesting analysis is presented in Table 3 where a list of the top 40 papers cited in CMPB papers is highlighted. The top most cited paper by *Goldberger* presented an open-source data archive, analysis tools and knowledge sharing forum for analysis of well-characterised digital recordings of physiological signals for its use by the biomedical research community. The second most cited document was the seminal paper by *Cox* in 1972 which proposed hazard functions and age-specific failure rates. Vast applicability of hazard functions in survival models and health risk assessments has led to the paper's popularity in CMPB. It is evident from the remaining papers in this list that machine learning based papers developing new algorithms or methods (for image analysis and numeric data analysis) were popular among the authors publishing in CMPB.

3.3.Leading authors, institutions and countries

In this section, a set of analyses was conducted to identify top contributing authors for CMPB. Table 4 lists all-time top authors in CMPB and their affiliations. Top authors include *Yu-Chuan Li, James Geoffrey Chase* and *Geoffrey M. Shaw*. The top contributing authors are from a range of institutions from Asia, US and Europe. Interesting to see that 3 authors out of top 5 leading authors are from New Zealand. These authors are also very well cited in literature as shown in Table 4. Table 5 shows the temporal evolution of top contributing authors in CMPB.

Table 2. The 50 most cited documents in CMPB

R	TC	Title	Author/s	Year	Citations per year

1	2083	MCML - monte-carlo modeling of light transport in multilayered tissues	WANG, LH; JACQUES, SL; ZHENG, LQ	1995	86.79
2	1000	A practical computer-based approach to the analysis of radioligand binding experiments	MCPHERSON, GA	1983	27.78
3	682	DtiStudio: Resource program for diffusion tensor computation and fiber bundle tracking	Jiang, HY; van Zijl, PCM; Kim, J; Pearlson, GD; Mori, S	2006	52.46
4	654	Xpose - an S-PLUS based population pharmacokinetic/pharmacodynamic model building aid for NONMEM	Jonsson, NE; Karlsson, MO	1999	32.7
5	549	MINMOD - a computer-program to calculate insulin sensitivity and pancreatic responsivity from the frequently sampled intravenous glucose-tolerance test	PACINI, G; BERGMAN, RN	1986	16.64
6	533	Program package for simulation and parameter-estimation in pharmacokinetic systems	DARGENIO, DZ; SCHUMITZKY, A	1979	13.33
7	488	PsN-Toolkit - A collection of computer intensive statistical methods for non-linear mixed effect modeling using NONMEM	Lindbom, L; Pihlgren, P; Jonsson, NE	2005	34.86
8	485	Lagran program for area and moments in pharmacokinetic analysis	ROCCI, ML; JUSKO, WJ	1983	13.47
9	484	PKSolver: An add-in program for pharmacokinetic and pharmacodynamic data analysis in Microsoft Excel	Zhang, Yong; Huo, Meirong; Zhou, Jianping; Xie, Shaofei	2010	53.78
10	476	MLAB - mathematical-modeling tool	KNOTT, GD	1979	11.9
11	404	Kubios HRV - Heart rate variability analysis software	Tarvainen, Mika P.; Niskanen, Juha-Pekka; Lipponen, Jukka A.; Ranta-aho, Perttu O.; Karjalainen, Pasi A.	2014	80.8
12	398	Software for advanced HRV analysis	Niskanen, JP; Tarvainen, MP; Ranta-Aho, PO; Karjalainen, PA	2004	26.53
13	351	A review of smart homes - Present state and future challenges	Chan, Marie; Esteve, Daniel; Escriba, Christophe; Campo, Eric	2008	31.91
14	351	A monte-carlo program for the simulation of scintillation camera characteristics	LJUNGBERG, M; STRAND, SE	1989	11.7
15	350	Fast free-form deformation using graphics processing units	Modat, Marc; Ridgway, Gerard R.; Taylor, Zeike A.; Lehmann, Manja; Barnes, Josephine; Hawkes, David J.; Fox, Nick C.; Ourselin, Sebastien	2010	38.89
16	314	Entropies for detection of epilepsy in EEG	Kannathal, N; Choo, ML; Acharya, UR; Sadasivan, PK	2005	22.43
17	310	A computer-program package for relative survival analysis	HAKULINEN, T; ABEYWICKRAMA, KH	1985	9.12
18	308	Perls-speaks-NONMEM (PsN) - a Perl module for NONMEM related programming	Lindbom, L; Ribbing, J; Jonsson, NE	2004	20.53
19	297	Blood vessel segmentation methodologies in retinal images - A survey	Fraz, M. M.; Remagnino, P.; Hoppe, A.; Uyyanonvara, B.; Rudnicka, A. R.; Owen, C. G.; Barman, S. A.	2012	42.43
20	294	MedCalc: A new computer program for medical statistics	Schoonjans, F; Zalata, A; Depuydt, CE; Comhaire, FH	1995	12.25
21	289	MIXOR: A computer program for mixed-effects ordinal regression analysis	Hedeker, D; Gibbons, RD	1996	12.57
22	266	Adjusted survival curves with inverse probability weights	Cole, SR; Hernan, MA	2004	17.73
23	255	A procedure for generating bootstrap samples for the validation of nonlinear mixed-effects population models	Parke, J; Holford, NHG; Charles, BG	1999	12.75
24	230	CONV - convolution for responses to a finite diameter photon beam incident on multi-layered tissues	Wang, LH; Jacques, SL; Zheng, LQ	1997	10.45
25	229	A step-by-step guide to non-linear regression analysis of experimental data using a Microsoft Excel spreadsheet	Brown, AM	2001	12.72
26	229	Kruskal-wallis test - basic computer-program to perform nonparametric one-way analysis of variance and multiple comparisons on ranks of several independent samples	THEODORSSONNORHEIM, E	1986	6.94
27	221	Interactive algorithms for the segmentation and quantitation of 3-D MRI brain scans	Freeborough, PA; Fox, NC; Kitney, RI	1997	10.05
28	214	Recent development on computer aided tissue engineering - a review	Sun, W; Lal, P	2002	12.59
29	214	Structure of the standardized computerized 24-h diet recall interview used as reference method in the 22 centers participating in the EPIC project	Slimani, N; Deharveng, G; Charrondiere, RU; van Kappel, AL; Ocke, MC; Lagiou, A; van Liere, M; Agudo, A; Pala, V; Brandstetter, B; Andren, C; Stripp, C; van Staveren, WA; Riboli, E	1999	10.7
30	212	Computing normalised prediction distribution errors to evaluate nonlinear mixed-effect models: The npde add-on package for R	Comets, Emmanuelle; Brendel, Karl; Mentre, France	2008	19.27
31	196	MIXREG: A computer program for mixed-effects regression analysis with autocorrelated errors	Hedeker, D; Gibbons, RD	1996	8.52
32	188	Conversational SAAM - an interactive program for kinetic-analysis of biological-systems	BOSTON, RC; GREIF, PC; BERMAN, M	1981	4.95
33	180	MaZda-A software package for image texture analysis	Szczypinski, Piotr M.; Strzelecki, Michal; Materka, Andrzej; Klepaczko, Artur	2009	18
34	180	Classification of EEG signals using neural network and logistic regression	Subasi, A; Ercelebi, E	2005	12.86
35	165	Gaining more flexibility in Cox proportional hazards regression models with cubic spline functions	Heinzl, H; Kaider, A	1997	7.5

36	157	Computerized collection and analysis of dietary-intake information	FESKANICH, D; SIELAFF, BH; CHONG, K; BUZZARD, IM	1989	5.23
37	149	Non-linear analysis of EEG signals at various sleep stages	Acharya, R; Faust, O; Kannathal, N; Chua, T; Laxminarayan, S	2005	10.64
38	142	Skin photoplethysmography - a review	KAMAL, AAR; HARNESS, JB; IRVING, G; MEARNS, AJ	1989	4.73
39	142	Computer-programs for the radioactive microsphere technique - determination of regional blood flows and other hemodynamic variables in different experimental circumstances	SAXENA, PR; SCHAMHARDT, HC; FORSYTH, RP; HOEVE, J	1980	3.64
40	142	A program for non-linear regression-analysis to be used on desk-top computers	KOEPPE, P; HAMANN, C	1980	3.64
41	139	Real-time deformable models for surgery simulation: a survey	Meier, U; Lopez, O; Monserrat, C; Juan, MC; Alcaniz, M	2005	9.93
42	138	DAISY: A new software tool to test global identifiability of biological and physiological systems	Bellu, Giuseppina; Saccomani, Maria Pia; Audoly, Stefania; D'Angio, Leontina	2007	11.5
43	137	A SAS macro for estimation of direct adjusted survival curves based on a stratified Cox regression model	Zhang, Xu; Loberiza, Fausto R.; Klein, John P.; Zhang, Mei-Jie	2007	11.42
44	133	Pirana and PCluster: A modeling environment and cluster infrastructure for NONMEM	Keizer, Ron J.; van Benten, Michel; Beijnen, Jos H.; Schellens, Jan H. M.; Huitema, Alwin D. R.	2011	16.63
45	132	MASTER: a Windows program for recording multiple auditory steady-state responses	John, MS; Picton, TW	2000	6.95
46	131	A review of atlas-based segmentation for magnetic resonance brain images	Cabezas, Mariano; Oliver, Arnau; Llado, Xavier; Freixenet, Jordi; Cuadra, Meritxell Bach	2011	16.38
47	123	MIC-II - program for determination of cardiac-output, arteriovenous shunt and regional blood-flow using radioactive microsphere method	SCHOSSER, R; ARFORS, KE; MESSMER, K	1979	3.08
48	119	ECG beat classification by a novel hybrid neural network	Dokur, Z; Olmez, T	2001	6.61
49	116	A state of the art review on intima-media thickness (IMT) measurement and wall segmentation techniques for carotid ultrasound	Molinari, Filippo; Zeng, Guang; Suri, Jasjit S.	2010	12.89
50	115	Characterization of EEG - A comparative study	Kannathal, N; Acharya, UR; Lim, CM; Sadasivan, P	2005	8.21

Table 3. Top 40 most cited documents in CMPB publications

Rank	Year	First author	Reference	Vol	Page	Type	TC	Co-citations
1	2000	Goldberger AL	Circulation	v101	pe215	A	50	32
2	1972	Cox DR	J R Stat Soc B	v34	p187	A	48	19
3	1973	Haralick RM	IEEE T Syst Man Cyb	v3	p610	A	45	34
4	1979	Otsu N	IEEE T Syst Man Cyb	v9	p62	A	45	29
5	2001	Breiman L	Mach Learn	v45	p5	A	33	30
6	1995	Cortes C	Mach Learn	v20	p273	A	31	26
7	1974	Akaike H	IEEE T Automat Contr	v19	p716	A	30	17
8	1985	Pan J	IEEE T Bio-Med Eng	v32	p230	A	30	21
9	1963	Marquardt DW	J Soc Ind Appl Math	v11	p431	A	27	16
10	1991	Pincus SM	P Natl Acad Sci Usa	v88	p2297	A	26	20
11	2001	Chan TF	IEEE T Image Process	v10	p266	A	25	20
12	2001	Duda RO	Pattern Classificati			B	25	17
13	1987	Lorensen WE	Comput Graph	v21	p163	A	25	10
14	2005	Witten IH	Data Mining Practica			B	24	14
15	2011	Chang CC	ACM T Intel Syst Tec	v2		A	23	19
16	1977	Dempster AP	J Roy Stat Soc B Met	v39	p1	A	23	14
17	1989	Mallat SG	IEEE T Pattern Anal	v11	p674	A	23	13
18	1998	Burges CJC	Data Min Knowl Disc	v2	p121	A	22	19
19	1983	Carson ER	Math Modeling Metabo			B	22	13
20	2004	Hovorka R	Physiol Meas	v25	p905	A	21	14
21	1996	Breiman L	Mach Learn	v24	p123	A	20	20
22	1973	Duda RO	Pattern Classificati			B	20	11
23	2008	Gonzalez RC	Digital Image Proces			B	20	14
24	1987	Kass M	Int J Comput Vision	v1	p321	A	20	17
25	1965	Nelder JA	Comput J	v7	p308	A	20	8
26	1996	Camm AJ	Circulation	v93	p1043	A	19	16
27	2005	Hann CE	Comput Meth Prog Bio	v77	p259	A	19	16
28	1998	Huang NE	P Roy Soc A-Math Phy	v454	p903	A	19	14
29	2000	Richman JS	Am J Physiol-Heart C	v278	ph2039	A	19	19
30	2004	Staal J	IEEE T Med Imaging	v23	p501	A	19	15
31	1998	Vapnik V	Stat Learning Theory			B	19	14
32	1986	Bland JM	Lancet	v1	p307	A	18	7
33	1984	Breiman L	Classification Regre			B	18	14
34	1982	Hanley JA	Radiology	v143	p29	A	18	10
35	1986	Liang KY	Biometrika	v73	p13	A	18	6
36	1998	Maintz JB	Med Image Anal	v2	p1	A	18	15
37	1992	Press WH	Numerical Recipes C			B	18	7
38	1999	Rueckert D	IEEE T Med Imaging	v18	p712	A	18	15
39	1986	Canny J	IEEE T Pattern Anal	v8	p679	A	17	14
40	1989	Chaudhuri S	IEEE T Med Imaging	v8	p263	A	17	16

Table 4. Top 50 leading authors in CMPB

R	Author Name	University	Country	TP	TC	H	C/P	≥200	≥100	≥50
1	James Geoffrey Chase	U Canterbury	New Zealand	40	650	15	16.25	1	3	18
2	Geoffrey M. Shaw	Christchurch Hospital, Christchurch	New Zealand	32	545	14	17.03	1	2	15
3	Yu-Chuan Li	Taipei Medical U	Taiwan	28	222	9	7.93	0	0	6
4	Christopher E. Hann	U Canterbury	New Zealand	24	536	14	22.33	1	3	14
5	Arie Hasman	Reactor Institute Delft	Netherlands	23	193	8	8.39	0	0	5
6	Steen Andreassen	Aalborg U	Denmark	21	303	10	14.43	0	1	10
7	Marco Viceconti	Insigneo: Inst for in silico medicine	UK	20	308	10	15.40	0	0	10
8	Torgny L. Groth	Uppsala U	Sweden	19	192	8	10.11	0	0	6
9	Jian Wang	BioFortis, Inc.	USA	18	169	9	9.39	0	0	6
10	Usman Iqbal	Taipei Medical U	Taiwan	16	102	6	6.38	0	0	4
11	Jasjit S. Suri	Global Biomedical Technologies	USA	15	404	10	26.93	1	2	10
12	Roman Hovorka	U Cambridge	UK	15	305	8	20.33	0	2	7
13	Debora Testi	CINECA	Italy	15	226	9	15.07	0	0	7
14	Hans Peter Meinzer	German Cancer Research Center	Germany	13	129	6	9.92	0	1	3
15	James F. Reed III	Christiana Care Health System	USA	13	82	5	6.31	0	0	2
16	Derek Arthur Linkens	U Sheffield	UK	13	76	5	5.85	0	0	1
17	Michael J. Chappell	U Warwick	UK	13	72	4	5.54	0	0	2
18	Jessica Lin	U Otago	New Zealand	12	324	7	27.00	1	2	6
19	Ewart R. Carson	City U London	UK	12	258	10	21.50	0	1	10
20	Phung Anh (Alex) Nguyen	Taipei Medical U	Taiwan	12	75	5	6.25	0	0	3
21	Mohammad A.A. Moussa	Kuwait U	Kuwait	12	32	3	2.67	0	0	0
22	U Rajendra Acharya	Ngee Ann Polytechnic	Singapore	11	656	10	59.64	2	3	10
23	Claudio Cobelli	U Padua	Italy	11	293	9	26.64	0	2	9
24	Thomas Desaive	U Liège	Belgium	11	120	5	10.91	0	0	4
25	Ove B. Wigertz	Linköping U	Sweden	11	89	7	8.09	0	0	2
26	Kiyonari Inamura	Osaka U	Japan	11	49	4	4.45	0	0	1
27	Martti Juhola	U Tampere	Finland	10	99	7	9.90	0	0	3
28	Cinzia Zannoni	CINECA	Italy	9	185	7	20.56	0	0	6
29	Tibor Deutsch	Applied Logic Laboratory	Hungary	9	179	7	19.89	0	0	7
30	Ewert Bengtsson	Uppsala U	Sweden	9	102	5	11.33	0	1	1
31	Uwe Engelmann	CHILI GmbH	Germany	9	74	5	8.22	0	0	2
32	Syed-Abdul Shabbir	Taipei Medical U	Taiwan	9	56	4	6.22	0	0	1
33	Kouhei Akazawa	National U Niigata	Japan	9	35	4	3.89	0	0	1
34	Angus M. Brown	U Nottingham	UK	8	316	6	39.50	1	1	5
35	Maurizio Rocchetti	Independent Consultant	Italy	8	209	6	26.13	0	2	3
36	Riccardo Bellazzi	U Pavia	Italy	8	195	7	24.38	0	2	4
37	Roberto Hornero	U Valladolid	Spain	8	191	5	23.88	0	1	4
38	Atam Prakash Dhawan	New Jersey Institute of Technology	USA	8	188	8	23.50	0	0	8
39	Mario Stefanelli	U Pavia	Italy	8	188	7	23.50	0	2	3
40	Ole Kristian Hejlesen	Aalborg U	Denmark	8	165	7	20.63	0	1	4
41	Peter Sonksen	U Southampton	UK	8	157	8	19.63	0	0	7
42	Yongtian Wang	Beijing Institute of Technology	PR China	8	102	5	12.75	0	0	2
43	Georgios C. Nikiforidis	U Patras	Greece	8	89	4	11.13	0	0	3
44	Ming Huei Hsu	Taipei Medical U	Taiwan	8	82	5	10.25	0	0	2
45	Herman P. Wijnand	Herman P. Wijnand	Israel	8	80	6	10.00	0	0	3
46	Jeongjin Lee	Soongsil U	South Korea	8	70	2	8.75	0	1	1
47	Nobutaka Ikeda	Toho U	Japan	8	64	5	8.00	0	0	2
48	Sanghoon Lee	Yonsei U	South Korea	8	61	3	7.63	0	0	2
49	Patrice Degoulet	Hop Europe Georges-Pompidou	France	8	41	4	5.13	0	0	1
50	Neil Evans	U Warwick	UK	8	36	4	4.50	0	0	0

Table 5. Temporal evolution of the most productive authors

R	Author	TP	TC
	1970-1977		
1	Elisa T Lee	25	877
2	John R. Cunningham	7	105
3	Jan Van De Geijn	6	99
4	Andrew S. French	6	77
5	Jan E. Ekstedt	4	59
6	Horowitz JM	4	7
	1978-1987		
1	Moussa MAA	10	26
2	Groves WE	7	12
3	Begole EA	6	26
4	Rocchetti M	5	184
5	Okada M	5	7
6	Recchia M	4	108
7	Gath I	4	60
8	Miller PL	4	55
9	Larsen SO	4	28
10	Tyson H	4	14
11	Horowitz JM	4	10
12	Duisterhout JS	4	8
	1988-1997		
1	Hasman A	17	133
2	Groth T	12	103
3	Hovorka R	10	259
4	Wigertz O	10	79
5	Reed JF	10	56
6	Carson ER	8	208
7	Engelmann U	8	52
8	Degoulet P	8	41
9	Inamura K	8	27
10	Sonksen PH	7	144
11	Andreassen S	7	142
12	Meinzer HP	7	44
13	Jean FC	7	42
14	Brender J	6	66
15	Schroter A	6	43
16	Grimson W	6	31
17	Theodoropoulos G	6	25
18	Kormano M	6	17

R	Author	TP	TC
	1998-2007		
1	Viceconti M	16	293
2	Chase JG	11	290
3	Testi D	11	213
4	Shaw GM	10	237
5	Zannoni C	9	185
6	Hann CE	8	247
7	Cappello A	7	147
8	Akazawa K	7	26
9	Brown AM	6	305
10	Gomez EJ	6	228
11	Andreassen S	6	94
12	Xu YH	6	75
13	Kannathal N	5	616
14	Bellazzi R	5	173
15	Fischer G	5	110
16	Tilg B	5	110
17	Baruffaldi F	5	68
18	Pitot HC	5	51
19	Hasman A	5	38
20	Inoue M	5	26
	2008-2017		
1	Chase JG	29	360
2	Li YC	27	189
3	Shaw GM	22	308
4	Hann CE	16	289
5	Iqbal U	16	102
6	Suri JS	15	411
7	Jian WS	15	96
8	Nguyen PA	12	75
9	Chappell MJ	12	58
10	Lin J	10	195
11	Desaive T	10	96
12	Syed-Abdul S	9	56
13	Acharya UR	8	221
14	Andreassen S	8	67
15	Evans ND	8	36
16	Hornero R	7	163
17	Saba L	7	108

Abbreviations are available in the previous tables.

Another set of analyses (shown in Table 6) provides information about the most productive and influential institutions (in terms of cites/paper and university rankings) in CMPB. The top 3 institutions in the list are *Uppsala U (Sweden), Taipei Medical U (Taiwan)* and *INSERM (France).* The highest number of institutions in the list is from the USA with top ranked institutes like *Harvard University, Stanford University, UCLA* and *Yale University*. North American and European institutions dominate in this list and only a few institutions are from

Asia (South Korea, Taiwan and China). If we look at the temporal evolution of institutions since the early days of the journal, US and European institutions dominated the list (1978-1987) with an exception of *Kuwait University*. In the last 10 years, there is a number of institutions from Asia (*Taipei Medical U, National Yang Ming U, Shanghai Jiao Tong U, Seoul National U, National Taiwan U, Chinese Academy of Sci, National Taiwan U Sci Tech, National U Singapore, Amirkabir U Technology, National U Sci Tech Pakistan, Nanyang Technological U, China Medical U Taiwan*), South America (*U Est Rio de Janeiro*) and Oceania (*U Canterbury*) have started to come up in the list as well which is overall still very much dominated by European and US institutions.

To get an overall summary of the contributions to CMPB, we have analysed the publications at the country level (see Table 8). In terms of the most number of papers, the USA, the UK and Italy occupy the top 3 positions with only PR China and Taiwan appearing in the top 10 list from outside North America and Europe. However, if we analyse these results on a per capita basis, Sweden, Finland, Slovenia, Denmark and New Zealand are the top most productive countries. Further, if we look at the citations per capita, Sweden and Finland top the list with Singapore, New Zealand and Slovenia occupying the next three positions. Overall, it is evident that CMPB publications are diverse and are coming from all over the world. This shows the reach and overall standing of this journal in different parts of the world. If we look at the trend of papers coming from each of these countries annually (see Table 9), we find that papers from countries like China, Taiwan, Spain, Italy, UK are rapidly increasing while contributions from USA have been stable over the last few decades. If we just look at the papers from the last decade (2017-2008), we observe that the number of papers from PR China is increasing and it has overtaken the US in recent years (2017 and 2016).

Table 6. The most productive and influential institutions in CMPB

R	Institution	Country	TP	TC	H	C/P	≥250	≥100	≥50	QS	ARWU
1	Uppsala U	Sweden	77	2232	15	28.99	3	6	28	112	63
2	Taipei Medical U	Taiwan	61	411	12	6.74	0	0	13	362	-
3	INSERM	France	58	1082	17	18.66	2	3	27	-	-
4	CNR	Italy	56	953	11	17.02	1	1	12	-	-
5	Harvard U	USA	47	820	15	17.45	1	2	18	38	1
6	U California Davis	USA	45	255	8	5.67	0	1	6	3	96
7	CNRS	France	42	1083	18	25.79	1	3	25	100	-
8	Assistance Publ Hop Paris	France	42	856	14	20.38	2	3	17	-	-
9	U Canterbury	New Zealand	42	662	15	15.76	1	3	19	231	401-500
10	National Inst Health	USA	39	1155	12	29.62	2	4	14	-	-
11	National Yang Ming U	Taiwan	39	253	9	6.49	0	0	8	292	501-600
12	Helmholtz Association	Germany	37	389	10	10.51	0	1	10	-	-
13	U Politec Valencia	Spain	35	544	13	15.54	1	2	16	561-570	401-500
14	Erasmus U Rotterdam	Netherlands	34	440	9	12.94	1	3	9	147	73
15	U Washington Seattle	USA	33	598	12	18.12	1	2	15	66	14
16	Maastricht U	Netherlands	32	244	9	7.63	0	0	7	211	201-300
17	U Padua	Italy	30	607	12	20.23	1	4	13	296	151 - 200
18	Linkoping U	Sweden	30	315	10	10.5	0	1	9	302	301-400
19	City U London	UK	29	526	14	18.14	0	2	15	343	-
20	Aalborg U	Denmark	29	434	13	14.97	0	2	13	343	201-300
21	U Toronto	Canada	29	420	8	14.48	1	2	5	31	23
22	Christchurch Hospital	New Zealand	28	470	11	16.79	1	2	12	-	-
23	German Cancer Res Center	Germany	27	273	8	10.11	0	1	7	-	-
24	U Pittsburgh	USA	27	202	8	7.48	0	0	7	136	68
25	Karolinska Instit	Sweden	26	476	10	18.31	1	2	8	-	-
26	Taipei Municipal Wanfang Hosp	Taiwan	26	140	7	5.38	0	0	2	-	-
27	Irccs Istituto Ortopedico Rizzoli	Italy	25	364	11	14.56	0	0	11	-	-
28	Seoul National U	South Korea	25	261	9	10.44	0	1	8	36	101-150
29	National Taiwan U	Taiwan	25	195	8	7.8	0	0	7	72	151-200
30	U Bologna	Italy	24	305	10	12.71	0	0	10	188	201 - 300
31	Stanford U	USA	24	211	7	8.79	0	1	5	2	2
32	U Patras	Greece	24	191	7	7.96	0	0	7	701-750	901-1000
33	U Turku	Finland	24	180	7	7.5	0	0	6	285	301-400
34	Johns Hopkins U	USA	23	1157	10	50.3	2	2	10	21	18
35	U Sheffield	UK	23	182	7	7.91	0	1	3	75	101-150
36	U Munich	Germany	22	274	7	12.45	1	1	6	61	53
37	VTT Technical Research Center	Finland	22	196	7	8.91	0	1	4	156	201-300
38	U California Los Angeles	USA	22	85	5	3.86	0	0	1	32	11
39	Yale U	USA	21	951	9	45.29	2	2	7	15	12
40	U Pavia	Italy	21	278	9	13.24	0	2	7	581-590	301-400
41	U Michigan	USA	21	274	7	13.05	1	1	7	20	24
42	Ruprecht Karls U Heidelberg	Germany	21	272	9	12.95	0	1	6	64	47
43	U Tampere	Finland	21	246	10	11.71	0	0	10	366	601-700
44	Polytechnic U Milan	Italy	21	146	7	6.95	0	0	5	170	201-300
45	U Warwick	UK	21	142	7	6.76	0	0	3	57	101-150
46	National U Singapore	Singapore	20	591	9	29.55	2	2	9	15	91
47	U Ljubljana	Slovenia	20	263	8	13.15	0	1	7	651-700	401-500
48	Sapienza U Rome	Italy	20	152	8	7.6	0	0	6	215	151 - 200
49	Shanghai Jiao Tong U	China	19	359	9	18.89	0	2	8	59	101-150
50	Polytechnic U Madrid	Spain	19	353	10	18.58	0	2	10	470	501-600

Abbreviations: ARWU = Academic Ranking of World Universities; QS = Quacquarelli & Symonds University Ranking.

Table 7. Temporal evolution of the most productive institutions

R	Institution	TP	TC
	1978-1987		
1	U California Davis	22	122
2	Erasmus U Rotterdam	19	258
3	Vrije U Amsterdam	15	27
4	INSERM	12	80
5	Kuwait U	12	30
6	U Michigan	11	101
7	German Cancer Res Center	10	71
8	Helmholtz Association	10	71
9	Medical U South Carolina	10	25
	1988-1997		
1	Uppsala U	31	365
2	CNR Italy	27	193
3	Maastricht U	22	180
4	Linkoping U	19	192
5	Istit Naz di Fisica Nucleare	19	103
6	Hasselt U	17	144
7	U Turku	17	115
8	Vtt Tech Res Center Finland	16	151
9	City U London	14	366
10	INSERM	14	160
11	Karolinska Instit	11	121
12	German Cancer Res Center	11	105
13	Osaka U	11	37
14	Guy S St Thomas NHS Found Trust	10	222
15	Aalborg U	10	159
16	Erasmus U Rotterdam	10	148
	1998-2007		
1	Istit Naz di Fisica Nucleare	21	458
2	Irccs Istit Ortopedico Rizzoli	19	317
3	U Washington Seattle	15	438
4	Uppsala U	13	1552
5	Harvard U	12	509
6	U Ljubljana	11	810
7	U Padua	11	427
8	U Canterbury	11	290
9	U Bologna	11	225
10	City U London	11	145
11	U Munich	10	82

R	Institution	TP	TC
	2008-2017		
1	Taipei Medical U	58	340
2	National Yang Ming U	35	186
3	CNRS	29	931
4	U Canterbury	29	360
5	U Politec Valencia	28	280
6	National Taiwan U	23	172
7	INSERM	22	531
8	Istit Naz di Fisica Nucleare	21	138
9	U Warwick	20	128
10	CNR Italy	18	86
11	Seoul National U	17	111
12	Harvard U	16	133
13	U Porto	15	173
14	U Girona	14	203
15	Shanghai Jiao Tong U	14	177
16	U Patras	14	117
17	U Padua	14	113
18	Idaho State U	13	377
19	U Valladolid	13	285
20	Uppsala U	13	236
21	U Otago	12	236
22	U Athens	12	116
23	U da Coruna	12	112
24	Aalborg U	12	95
25	Chinese Academy of Sci	12	81
26	National Taiwan U Sci Tech	12	37
27	U Est Rio de Janeiro	11	120
28	Ghent U	11	110
29	National U Singapore	11	106
30	Polytechnic U Madrid	11	89
31	Ciber Centro de Inv Biomed	11	70
32	Amirkabir U Technology	10	230
33	National U Sci Tech Pakistan	10	124
34	Nanyang Technological U	10	119
35	U Pittsburgh	10	104
36	U Liege	10	96
37	Sapienza U Rome	10	85
38	U Vigo	10	85
39	U Sao Paulo	10	68
40	China Medical U Taiwan	10	58

Abbreviations are available in the previous tables.

Table 8. The most productive and influential countries in CMPB

R	Country	TP	TC	H	C/P	Population	P/Po	C/Po
1	USA	1098	17578	45	16.01	324118787	3.39	54.23
2	United Kingdom	333	5081	33	15.26	65640000	5.07	77.41
3	Italy	305	3891	28	12.76	59801004	5.1	65.07
4	Germany	296	3405	29	11.5	80682351	3.67	42.2
5	Spain	226	2773	27	12.27	46064604	4.91	60.2
6	France	225	3882	30	17.25	64668129	3.48	60.03
7	Peoples R China	217	2624	24	12.09	1382323332	0.16	1.9
8	Sweden	182	3899	23	21.42	9851852	18.47	395.76
9	Taiwan	181	1724	19	9.52	23395600	7.74	73.69
10	Canada	143	1419	17	9.92	36286378	3.94	39.11
11	Japan	141	927	15	6.57	126323715	1.12	7.34
12	Netherlands	131	1652	18	12.61	16979729	7.72	97.29
13	Australia	106	2573	24	24.27	24309330	4.36	105.84
14	India	105	1245	19	11.86	1326801576	0.08	0.94
15	Greece	101	1213	19	12.01	10919459	9.25	111.09
16	Finland	91	2034	17	22.35	5523904	16.47	368.22
17	Turkey	90	1216	18	13.51	79622062	1.13	15.27
18	Belgium	86	1085	16	12.62	11371928	7.56	95.41
19	Brazil	79	1055	18	13.35	209567920	0.38	5.03
20	Denmark	74	949	17	12.82	5690750	13	166.76
21	South Korea	74	696	16	9.41	50503933	1.47	13.78
22	Iran	64	817	15	12.77	80280000	0.8	10.18
23	Portugal	61	625	14	10.25	10304434	5.92	60.65
24	Switzerland	56	765	15	13.66	8379477	6.68	91.29
25	Austria	49	818	16	16.69	8747000	5.6	93.52
26	New Zealand	48	941	16	19.6	4565185	10.51	206.13
27	Singapore	44	1281	17	29.11	5696506	7.72	224.87
28	Poland	41	649	13	15.83	38593161	1.06	16.82
29	Czech Republic	38	238	9	6.26	10560000	3.6	22.54
30	Israel	34	316	9	9.29	8192463	4.15	38.57
31	Pakistan	32	473	11	14.78	193200000	0.17	2.45
32	Slovenia	32	351	11	10.97	2065000	15.5	169.98
33	Mexico	29	208	8	7.17	128632004	0.23	1.62
34	Norway	28	213	6	7.61	5271958	5.31	40.4
35	Malaysia	27	429	13	15.89	30751602	0.88	13.95
36	Hungary	27	392	12	14.52	9818000	2.75	39.93
37	Saudi Arabia	26	308	9	11.85	32157974	0.81	9.58
38	Ireland	21	191	7	9.1	4713993	4.45	40.52
39	Lithuania	21	115	4	5.48	2872000	7.31	40.04
40	Serbia	19	154	8	8.11	7057000	2.69	21.82
41	Kuwait	17	47	4	2.76	4053000	4.19	11.6
42	Egypt	15	253	10	16.87	93383574	0.16	2.71
43	Colombia	13	125	5	9.62	48650000	0.27	2.57
44	Algeria	11	240	9	21.82	40650000	0.27	5.9
45	Slovakia	11	55	4	5	5429000	2.03	10.13
46	Cyprus	10	175	7	17.5	1170000	8.55	149.57
47	Thailand	9	449	4	49.89	68860000	0.13	6.52
48	Russia	9	63	4	7	143439832	0.06	0.44
49	Romania	9	53	5	5.89	19710000	0.46	2.69
50	Argentina	8	72	5	9	43847277	0.18	1.64

Table 9. Annual number of papers classified by countries

R	Country	D1	D2	D3	D4	D5	Total	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008
1	USA	121	254	249	187	287	1098	34	33	19	26	46	35	23	27	27	17
2	United Kingdom	14	25	100	63	131	333	19	14	7	18	20	23	13	8	4	5
3	Italy	4	20	80	73	128	305	13	12	11	19	23	18	8	9	7	8
4	Germany	15	33	91	72	85	296	5	11	5	7	12	17	7	8	9	4
5	Spain	1	1	13	33	178	226	26	25	17	24	30	27	8	10	6	5
6	France	6	25	54	52	88	225	7	10	5	9	14	12	6	12	2	11
7	Peoples R China	0	3	7	35	172	217	38	36	16	19	12	15	7	7	12	10
8	Sweden	19	25	73	35	30	182	4	2	1	4	3	4	4	3	3	2
9	Taiwan	0	1	3	40	137	181	17	22	18	24	15	9	8	9	2	13
10	Canada	24	28	22	14	55	143	9	6	3	4	9	8	8	2	1	5
11	Japan	3	15	48	46	29	141	2	7	3	5	1	1	3	3	3	1
12	Netherlands	3	33	54	20	21	131	1	3	2	0	3	2	3	1	3	3
13	Australia	0	5	14	20	67	106	9	14	7	10	8	7	4	2	3	3
14	India	1	8	8	8	80	105	22	28	7	6	5	3	2	2	2	3
15	Greece	0	0	13	26	62	101	8	0	5	5	7	18	3	6	5	5
16	Finland	0	3	38	35	15	91	1	0	0	1	1	2	3	1	2	4
17	Turkey	0	0	1	19	70	90	10	14	4	10	10	6	5	3	4	4
18	Belgium	4	9	20	15	38	86	3	3	1	3	6	4	8	5	1	4
19	Brazil	0	0	4	14	61	79	11	15	4	5	9	4	3	4	1	5
20	South Korea	0	0	0	16	58	74	13	11	4	7	1	10	2	2	4	4
21	Denmark	2	9	24	17	22	74	0	2	0	0	3	1	6	3	2	5
22	Iran	0	0	0	1	63	64	22	11	6	8	5	2	2	4	2	1
23	Portugal	0	0	8	3	50	61	6	13	4	9	3	5	4	3	2	1
24	Switzerland	6	6	12	14	18	56	2	2	1	2	1	1	3	1	2	3
25	Austria	0	2	10	18	19	49	0	2	1	3	4	3	0	1	3	2
26	New Zealand	0	2	3	14	29	48	0	1	0	5	4	1	10	2	1	5
27	Singapore	0	0	1	13	30	44	2	4	1	4	8	7	1	1	1	1
28	Poland	0	2	6	8	25	41	1	4	2	3	3	4	3	1	1	3
29	Czech Republic	3	0	14	4	17	38	2	4	0	1	4	2	2	0	1	1
30	Israel	5	9	11	6	3	34	0	1	0	0	0	0	1	0	1	0
31	Pakistan	0	0	1	0	31	32	7	15	2	4	0	3	0	0	0	0
32	Slovenia	0	0	1	17	14	32	1	0	3	2	2	0	1	1	3	1
33	Mexico	0	0	3	4	22	29	3	8	0	2	4	1	1	1	2	0
34	Norway	3	1	8	5	11	28	2	0	0	2	1	3	0	1	1	1
35	Malaysia	0	0	0	2	25	27	3	5	2	4	4	4	2	0	1	0
36	Hungary	0	4	5	7	11	27	1	2	0	1	2	1	3	0	1	0
37	Saudi Arabia	3	1	4	7	11	26	2	6	0	2	0	1	0	0	0	0
38	Ireland	0	1	10	1	9	21	0	1	0	0	1	3	3	0	1	0
39	Serbia	0	0	2	1	16	19	2	1	2	5	0	2	2	1	1	0
40	Kuwait	0	12	4	1	0	17	0	0	0	0	0	0	0	0	0	0

Abbreviations: D1 (1970-1977), D2 (1978-1987), D3 (1988-1997) D4 (1998-2007), D5 (2008-2017).

Table 10 classifies publications based on the regions they originate from. In terms of the overall number of papers, North America ranks first followed by Europe, Asia and Oceania. Although, the number of papers from Oceania is lower compared to other regions, the per capita numbers for papers and citations are higher. The per capita citations received for publications from Oceania is 121.7, which is by far the highest among all of the regions indicating high publication quality/relevance.

Table 10. Publication structure classified by supranational regions

R	Region	TP	TC	H	C/P	Population	P/Pop	C/Pop
1	North America	1241	18997	62	15.31	360405165	3.44	52.71
2	Europe	2533	35414	393	13.98	599570795	4.22	59.07
	Western and North Europe	2132	29582	292	13.88	411599209	5.18	71.87
	Eastern Europe	401	5832	101	14.54	187971586	2.13	31.03
3	Asia	1033	12163	205	11.77	3651581397	0.28	3.33
	Eastern Asia	622	6034	78	9.7	1725986412	0.36	3.5
	Western Asia	92	966	32	10.5	55029437	1.67	17.55
	South Asia	319	5163	95	16.18	1870565548	0.17	2.76
4	Oceania	154	3514	40	22.82	28874515	5.33	121.7
5	Latin and South America	135	1512	40	11.2	448829051	0.3	3.37
6	Africa	26	493	19	18.96	134033574	0.19	3.68

Abbreviations available in previous tables except: P/Po and C/Po = Papers and cites per million inhabitants.

Table 11 presents an interesting analysis of the publications citing CMPB papers in terms of citing authors, universities, countries and journals. The top most citing authors are *Mats O. Karlsson* followed by *Nick C. Fox, James Geoffrey Chase* and *U. Rajendra*. It can be seen that the top citing authors also appear in the top 50 list of contributors to the CMPB (see Table 4). The top 3 most citing universities include *INSERM France, Harvard University* and *Uppsala University*. The highest number of citations for CMPB originated from the USA followed by the UK and PR China. In terms of journals, CMPB tops the list. It is not un-common for a journal to have self-cited papers as most of the papers are from the same discipline/research areas of biomedical research. Other source journals for citations include *Plos One, Computers in Biology and Medicine, IEEE Transactions on Biomedical Engineering*, and *Physics in Medicine and Biology*. All of these journals are top journals in the field of biomedical sciences indicating that CMPB is well regarded and has an impact in the research community.

Table 11. Citing articles of CMPB: Authors, universities, countries and journals

R	Author	TP	University	TP	Country	TP	Journal	TP
1	Karlsson MO	168	INSERM France	733	USA	12016	Computer Methods Progr Biomed	1317
2	Fox NC	126	Harvard U	634	UK	3522	Plos One	506
3	Chase JG	117	Uppsala U	586	PR China	2888	Computers in Biology and Medicine	382
4	Acharya UR	116	CNRS France	534	Germany	2859	IEEE Trans Biomedical Engineering	314
5	Saxena PR	96	U College London	507	France	2323	Physics in Medicine and Biology	294
6	Suri JS	89	Johns Hopkins U	479	Italy	2311	Antimicrobial Agents and Chemotherapy	264
7	Slimani N	86	U Toronto	475	Canada	1985	J Biomedical Optics	246
8	Ourselin S	83	Erasmus U Rotterdam	467	Netherlands	1862	Medical Physics	237
9	Shaw GM	83	Assistance Publ Hop Paris	436	Sweden	1713	Expert Systems with Applications	217
10	Bergman RN	81	Helmholtz Association	430	Spain	1644	Methods of information in Medicine	206
11	Boeing H	80	Imperial College London	404	Australia	1422	British J Clinical Pharmacology	199
12	Egorin MJ	77	Karolinska Institutet	404	India	1104	Biomedical Signal Processing and Control	188
13	Jusko WJ	77	Utrecht U	347	Japan	999	J Medical Systems	185
14	Riboli E	76	U Washington Seattle	338	Belgium	903	Medical Biological Engineering Computing	182
15	Haffner SM	73	U Pennsylvania	314	Switzerland	854	J American Medical Informatics Assoc	173
16	Overvad K	71	Lund U	308	South Korea	789	Neuroimage	172
17	Ljungberg M	70	U Oxford	307	Brazil	756	Statistics in Medicine	172
18	Pacini G	69	U Copenhagen	300	Taiwan	723	Int J Medical informatics	159
19	Tjonneland A	68	CNR Italy	293	Denmark	685	J Clinical Pharmacology	153
20	Danhof M	64	U California Los Angeles	293	Finland	583	J Pharmacology and Experimental Therapeut	150
21	Trichopoulou A	59	U Minnesota Twin Cities	292	Iran	539	IEEE Transactions on Medical Imaging	148
22	Rossor MN	58	U Pittsburgh	289	Turkey	513	Artificial Intelligence in Medicine	145
23	Forrest A	56	U Southern California	283	Austria	512	Physiological Measurement	138
24	Viceconti M	56	Mcgill U	280	Greece	477	Cancer Chemotherapy and Pharmacology	130
25	Grafman J	55	U Cambridge	268	Poland	468	J Pharmacokinetics and Pharmacodynamics	130
26	Mori S	54	U North Carolina Chapel Hill	267	Singapore	417	Clinical Pharmacology Therapeutics	129
27	Urien S	54	German Cancer Res Center	266	New Zealand	375	Sensors	129
28	Beijnen JH	53	Duke U	263	Norway	371	J Biological Chemistry	128
29	Tumino R	52	Stanford U	262	Malaysia	342	Clinical Pharmacokinetics	127
30	Bueno-De-Mesquita HB	51	Leiden U	249	Portugal	335	Scientific Reports	127

4. Mapping CMPB with VOS viewer software

In the previous sections, we have provided a general overview with respect to the most relevant variables of the journal's performance. In addition to that, we will now provide an in-depth analysis of the journals citation structure and the development of the bibliographic connections over time. For the visualisation of these results, we use the VOS viewer software [1]. This allows us to create graphical maps to shed light on bibliographic coupling, citation and co-citation analysis, co-authorship, and co- occurrence of author keywords [17].

Firstly, Figure 2 provides an overview of the co-citations landscape for articles published in CMBP. Co-citation of journals occurs when two documents from two different journals receive a citation from the same document from a third journal. The graph visualizes the two journals that have received the citation. This will count as one co-citation link. Results are presented with a threshold of 50 co-citations. Connections are displayed with a threshold of 100 co-citations. The colours of the circles indicate the thematic clusters, to which the journals belong.

While self-citations from CMBP unsurprisingly play the biggest role, strong connections can also be identified to *IEEE Transactions on Biomedical Engineering* and the *IEEE Transactions on Medical Imaging*. Also noteworthy are the strong connections with journals such as *Biometrics, Journal of Applied Physiology* and *Circulation*. This confirms CMBP's broad, interdisciplinary profile, citing also journals from outside the field.

To provide more insights into the development of co-citations over time and to understand the evolutions of each journal's influence, Figures 3-5 show snapshot of the co-citations landscape for the last three decades (slightly varying the connection thresholds). In the eighties and nineties, the number of journals as well as the overall number of papers published was smaller than today. Therefore, the graphical map is less dense than the ones representing the more recent decades (despite having set lower connection thresholds). Between 1988-1997, journals such as *Am J Physiol, Comput Biomed Res, IEEE T Bio-Med Eng, Biometrics,* and *Diabetes Care* were co-cited with CMPB. From the later nineties (Figure 4), strong connections to the fields of *IEEE T Bio-Med Eng, IEEE T Med Imaging, IEEE T Pattern Anal, Biometrics,* and *J Biomech* emerge, which are still seen today.

In the last decade, a similar co-citation structure was found (see Figure 5) with new journal additions such as *Lect Notes Comput Sc, Comput Biol Med, Neuroimage* and *Expert Syst Appl.* Top journals such as *Lancet* and *Science* are also featured in the top 50 co-citation analysis of CMPB indicating the quality of work that is being published and its impact on academia. A more detailed breakdown of co-citations and trends is provided in Table 12.

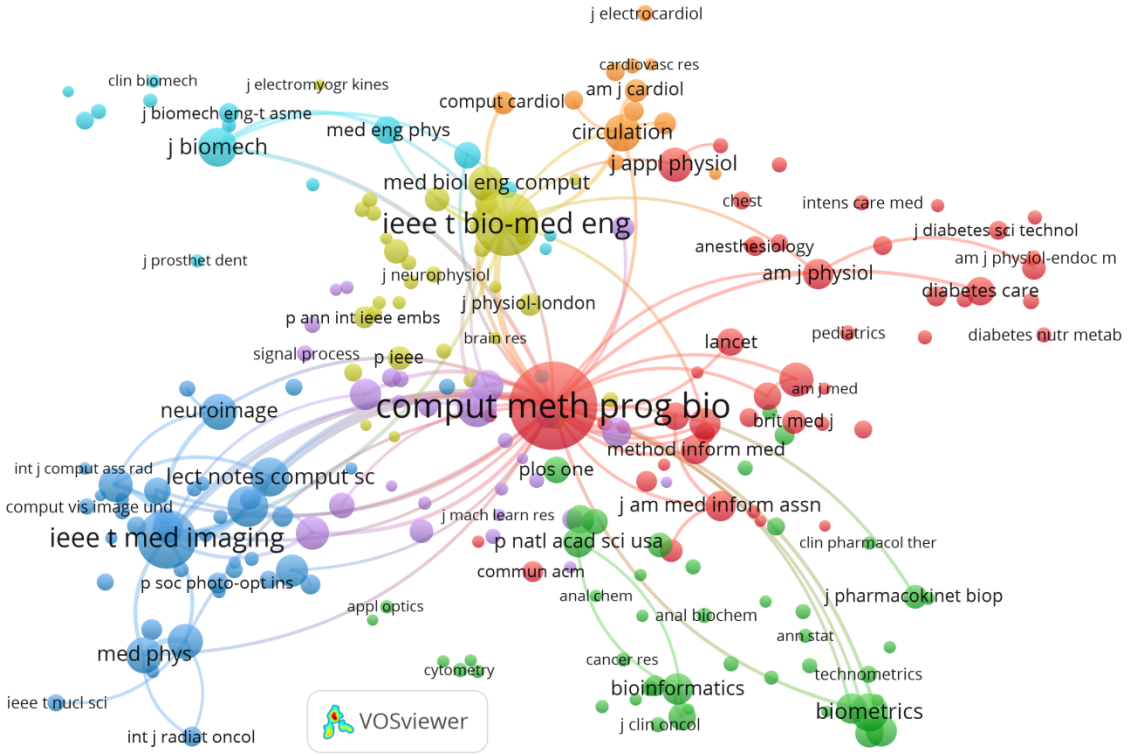

Figure 2. Co-citation of journals in CMPB: minimum citation threshold of 50 and 100 links

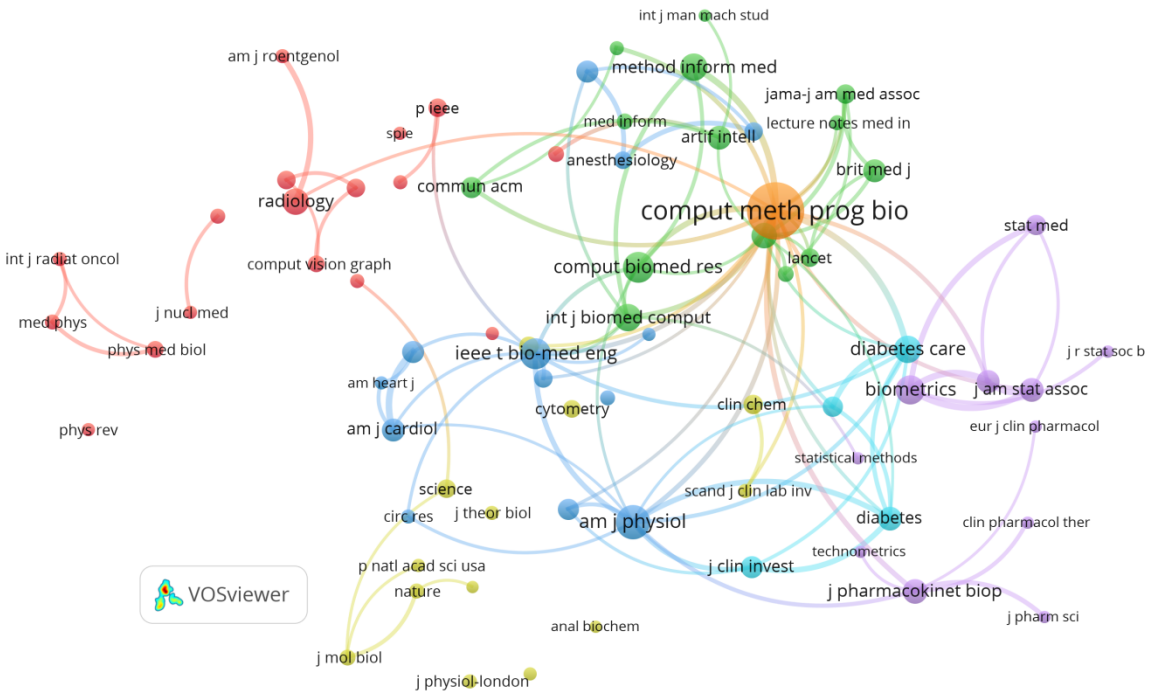

Figure 3. Co-citation of journals in CMPB: 1988-1997 (minimum citation threshold of 20 and 100 links)

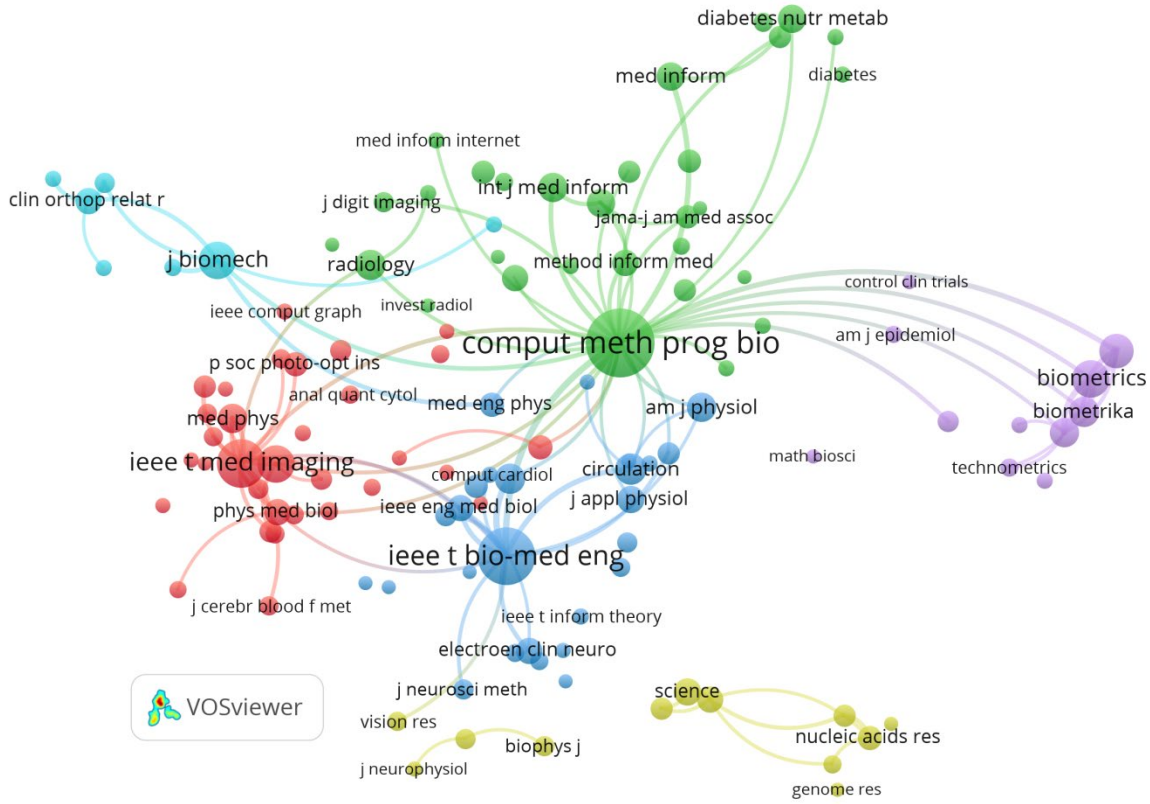

Figure 4. Co-citation of journals in CMPB: 1998-2007 (minimum citation threshold of 20 and 100 links)

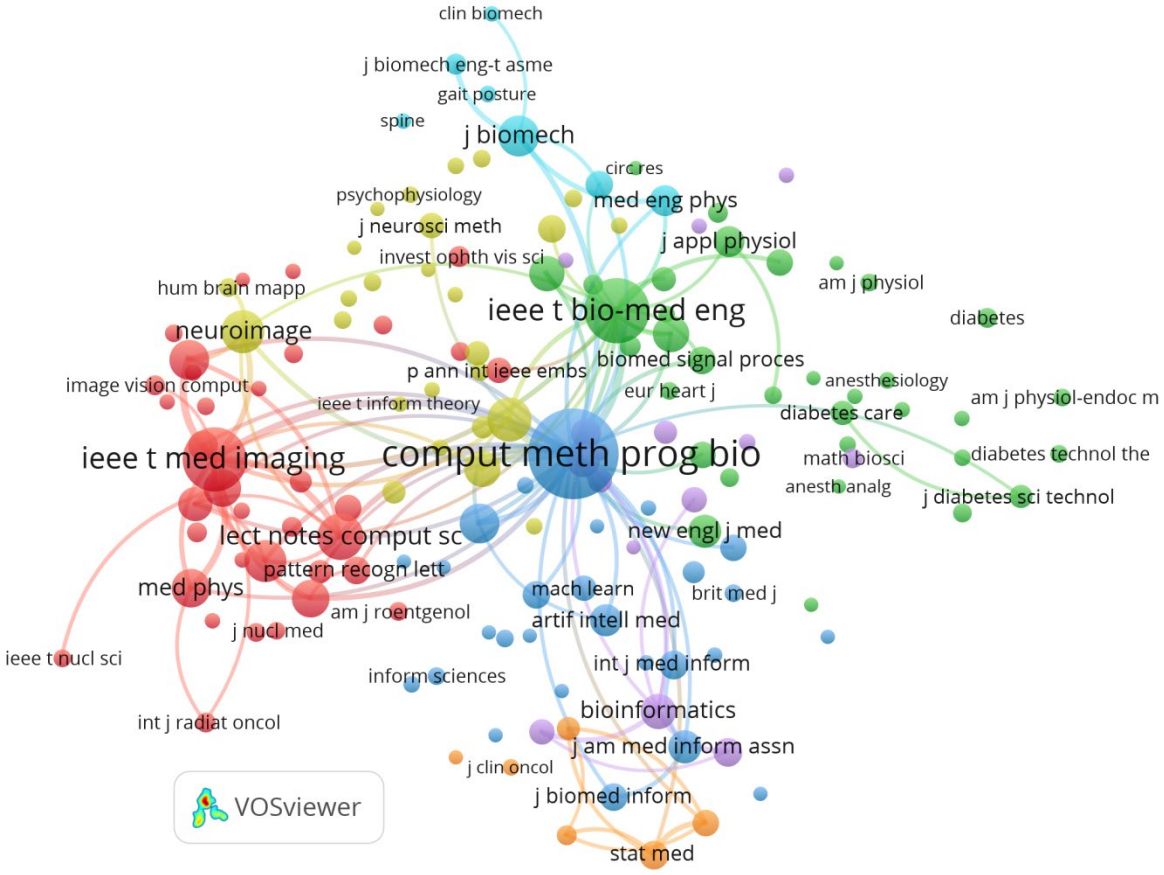

Figure 5. Co-citation of journals in CMPB: 2008-2017 (minimum citation threshold of 50 and 100 links)

Table 12. Co-citation of journals in CMPB: Global and temporal analysis

	Global			2008-2017			1998-2007			1988-1997		
R	Journal	Cit	CLS	Journal	Cit	CLS	Journal	Cit	CLS	Journal	Cit	CLS
1	Comput Meth Prog Bio	2835	2203.57	Comput Meth Prog Bio	1951	1536.66	Comput Meth Prog Bio	467	363.37	Comput Meth Prog Bio	398	224.03
2	IEEE T Bio-Med Eng	1537	1251.74	IEEE T Bio-Med Eng	1019	835.4	IEEE T Bio-Med Eng	330	235.27	Am J Physiol	144	106.6
3	IEEE T Med Imaging	1277	1036.91	IEEE T Med Imaging	995	805.04	IEEE T Med Imaging	237	175.79	Comput Biomed Res	118	102.22
4	IEEE T Pattern Anal	619	561.94	Lect Notes Comput Sc	514	468.19	IEEE T Pattern Anal	144	126.99	IEEE T Bio-Med Eng	117	96.57
5	Comput Biol Med	598	557.86	Comput Biol Med	468	439.91	Biometrics	139	101.43	Biometrics	103	74.3
6	J Biomech	564	404.55	Neuroimage	447	334.03	J Biomech	138	91.04	Diabetes Care	96	69.8
7	Lect Notes Comput Sc	561	515.05	IEEE T Pattern Anal	421	385.75	Stat Med	119	85.1	Method Inform Med	94	62.16
8	Biometrics	525	394.03	J Biomech	401	272.09	Circulation	97	78.77	Int J Biomed Comput	91	74.01
9	Circulation	521	453.48	Expert Syst Appl	388	338.9	Med Biol Eng Comput	96	85.15	Radiology	90	51.01
10	Neuroimage	483	368.51	Med Image Anal	379	349.94	Radiology	94	70.27	New Engl J Med	84	68.79
11	Med Phys	480	391.97	Med Phys	357	295.93	Biometrika	91	73.63	J Pharmacokinet Biop	76	53.81
12	Phys Med Biol	470	376.76	Phys Med Biol	343	268.87	Int J Med Inform	89	72.29	Artif Intell	72	47.35
13	Med Biol Eng Comput	458	428.69	Pattern Recogn	335	311.69	Med Phys	88	63.24	Diabetes	70	54.71
14	Med Image Anal	430	397.59	IEEE T Inf Technol B	329	305.49	Am J Physiol	86	72.98	J Am Stat Assoc	69	55.17
15	New Engl J Med	428	395.61	Circulation	324	287.7	J Am Stat Assoc	86	69.75	Am J Cardiol	67	43.66
16	J Appl Physiol	425	290.72	Bioinformatics	312	255.05	Med Inform	81	64.51	Biometrika	66	52.07
17	Pattern Recogn	408	377.36	Med Biol Eng Comput	296	279.51	J Am Med Inform Assn	80	62.49	Brit Med J	66	51.55
18	Expert Syst Appl	398	350.63	IEEE T Image Process	292	267.79	Diabetes Nutr Metab	79	35.43	J Clin Invest	62	48.14
19	Radiology	383	306.89	PLOS One	275	254.07	Science	77	68.75	Circulation	60	46.59
20	Stat Med	378	286.67	J Am Med Inform Assn	262	212.04	J Appl Physiol	74	43.27	Electroen Clin Neuro	59	32.33
21	Bioinformatics	365	302.62	New Engl J Med	261	245.05	Clin Orthop Relat R	73	52.96	J Appl Physiol	57	35.25
22	IEEE T Inf Technol B	364	340.39	Artif Intell Med	248	221.98	Method Inform Med	73	55.99	Commun ACM	55	40.39
23	Comput Biomed Res	357	303.11	J Appl Physiol	237	162.77	Phys Med Biol	72	62.19	Stat Med	52	38.55
24	Am J Physiol	354	297.54	Med Eng Phys	232	212.86	P Natl Acad Sci Usa	71	60.82	Diabetologia	50	43.18
25	J Am Med Inform Assn	350	286.07	P Natl Acad Sci Usa	223	201.62	IEEE Eng Med Biol	70	60.09	Comput Biol Med	47	37.05
26	J Am Stat Assoc	349	299.17	Comput Med Imag Grap	217	196.69	Electroen Clin Neuro	69	51.3	Clin Chem	46	23.94
27	IEEE T Image Process	341	315.08	Stat Med	204	143.92	Artif Intell Med	68	54.54	JAMA-J Am Med Assoc	46	38.66
28	P Natl Acad Sci Usa	341	305.97	Int J Med Inform	199	168	Comput Biol Med	61	54.63	Science	45	38.08
29	Artif Intell Med	331	294.46	Nucleic Acids Res	195	142.59	Med Eng Phys	60	54.57	IEEE T Med Imaging	44	32.56
30	Method Inform Med	324	252.67	J Biomed Inform	191	174.16	P Soc Photo-Opt Ins	60	51.63	Lancet	44	39.88
31	Science	314	291.59	Pattern Recogn Lett	191	184.55	Nucleic Acids Res	59	41.81	Med Biol Eng Comput	44	39.38
32	Biometrika	302	254.72	Ann Biomed Eng	190	176.87	J Telemed Telecare	57	28.2	P IEEE	44	37.23
33	Diabetes Care	298	247.64	Biomed Signal Proces	189	181.93	New Engl J Med	57	53.86	Brit J Anaesth	43	23.96
34	Med Eng Phys	294	272.72	Clin Neurophysiol	186	157.06	Ann Biomed Eng	56	51.03	IEEE T Pattern Anal	43	31.01
35	JAMA-J Am Med Assoc	292	263.09	J Med Syst	184	158.61	JAMA-J Am Med Assoc	56	49.13	Anesthesiology	39	32.8
36	Nucleic Acids Res	292	212.28	Lancet	175	162.05	Bioinformatics	53	39.87	Cytometry	38	15.98
37	Int J Med Inform	288	243.03	Biometrics	172	135.14	Brit Med J	51	46.21	Phys Med Biol	37	26.21
38	Lancet	277	257.57	Radiology	171	155.65	Comput Biomed Res	51	47.55	Comput Vision Graph	34	27.92
39	PLOS One	275	256.14	JAMA-J Am Med Assoc	170	156.54	Lancet	51	46.03	Ann Intern Med	33	28.59
40	Ann Biomed Eng	272	253.62	Physiol Meas	168	152.53	Med Image Anal	51	43.59	J Mol Biol	33	19.52

Abbreviations: Cit = Citations; CLS = Citation link strength.

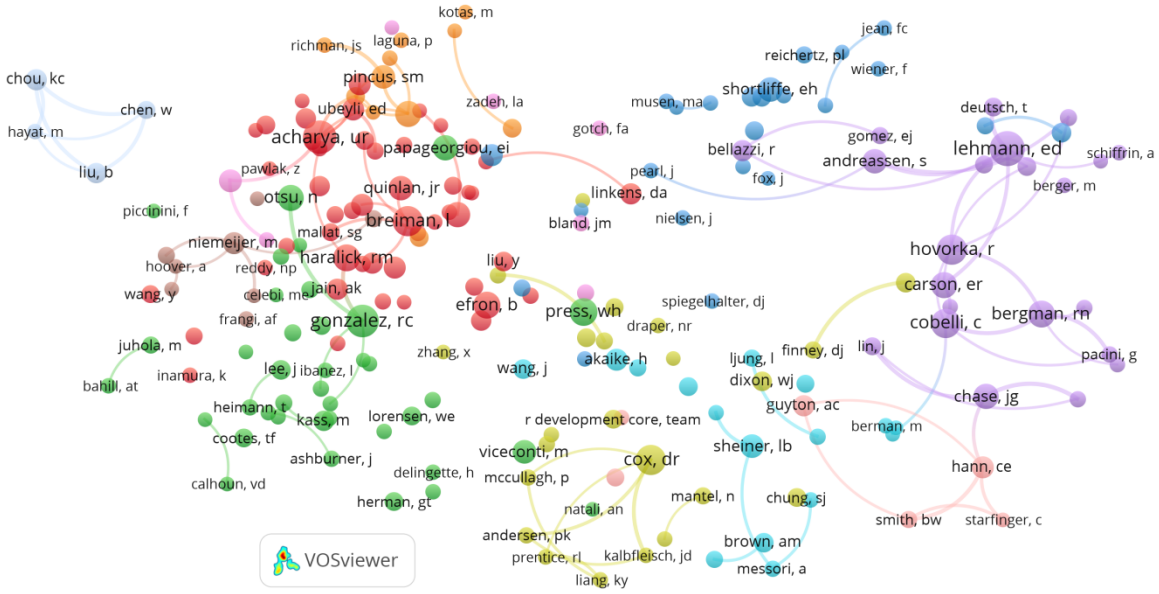

Figure 6. Co-citation of authors in CMPB: minimum citation threshold of 20 and 100 links

We will now take a look at the co-citation of authors who have published in CMBP. Similar to the co-citation of journals, a co-citation of authors occurs, when the authors of two documents cite the same third document [2]. CMBP's most productive authors are shown in Figure 6 using a citation threshold of 20 and bibliographic coupling links between authors of more than 100. Looking at the network of authors in Figure 6 and an analysis of the authors discipline areas, we could establish that authors having similar research domains cite similar bibliographic material. For example the cluster of authors including *Acharya* and *Breiman* work in signal processing analysis for heart disorders; similarly the cluster with *Lehmann, Cobelli, Hovorka* and *Bergman* work on decision support systems for Diabetes; and the cluster with *Gonzales* and *Otsu* work towards image processing and analysis.

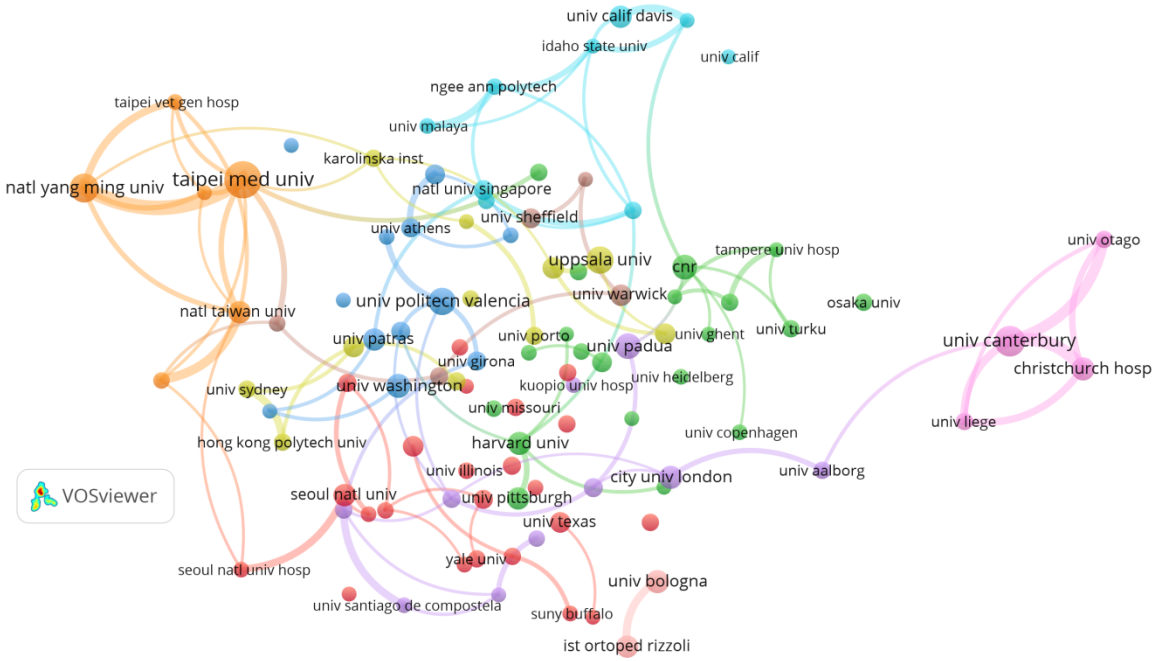

Figure 7. Bibliographic coupling of institutions publishing in CMPB: minimum publication threshold of 10 documents and 100 links

Moving on from this, we will look at the bibliographic coupling of institution publishing in CMBP in Figure 7. In line with previous analyses, thresholds are set for documents (10) and links (100). Results are in line with those diplayed in Table 6. An interesting result here is that the universities from the same country (or to a lesser extent the same continent) tend to have a similar profile between them, often clustered together and with strong connections. Figure 8 presents the bibliometric coupling between different countries. It shows that there are strong links between the USA and China, Spain, Germany, Taiwan and England.

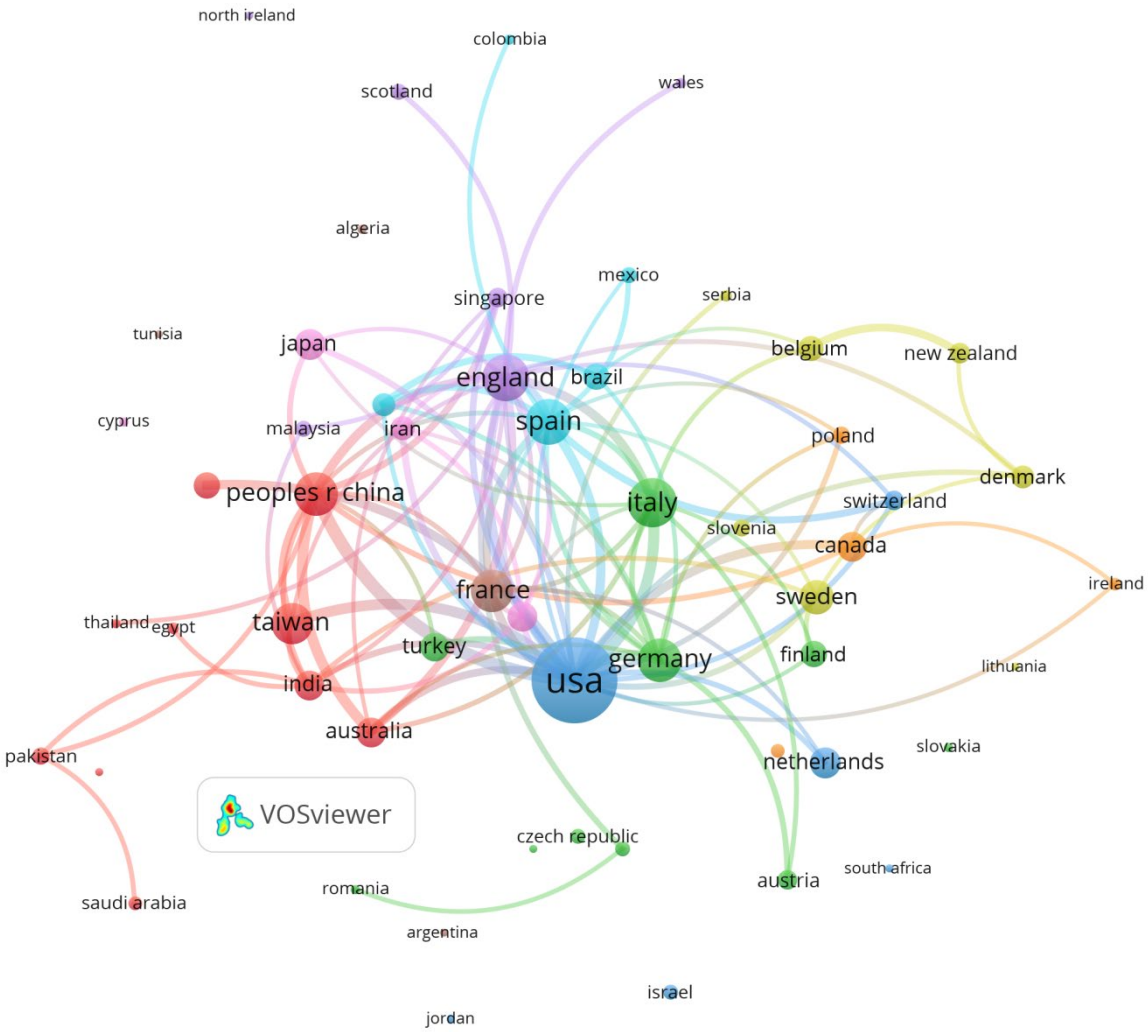

Figure 8. Bibliographic coupling of countries publishing in CMPB: minimum publication threshold of 5 documents and 50 links

Following on towards the keywords analysis from the articles published in CMPB, Figure 9 shows the network mapping between various keywords used by authors. As CMPB aims at publishing computer methods and programs applied to the biomedical research field, the keyword analyses reveal interesting co-relations between the biomedical area of research and the computer methods that were used. Strong clusters are identified around the keywords classification (including deep learning), PACS (picture archiving and communication system), heart rate variability, survival analysis and simulation. The cluster around classification includes areas where some sort of machine learning methods were developed/applied towards image processing. Other topics of research can be identified such as (i) signal processing in case of heart rate variability, (ii) simulation models for diabetes,

(iii) use of PACS data for its use in health technology assessments and image processing, (iv) decision support systems development based on healthcare records and (v) survivability analysis for health conditions. All of these topics are popular among CMPB authors. When analysing the trends in keywords co-occurrences from 1988-2017, we see an interesting trend. In 1988-1997, keywords such as computer simulations, PACS, image processing, mathematical modelling, expert systems, knowledge-based systems, and decision support systems were common. In the period 1998-2007, machine learning related keywords such as segmentation, classification, neural networks were beginning to pick up. Simulation models and software development for a variety of health data analyses were prominent in this period as well. However, in the last decade (2008-2017), keywords related to the machine learning field such as classification, segmentation, feature selection/ extraction, image processing became the central theme in CMPB. This may be due to the advancements in the storage, retrieval and analysis of large health datasets in form of images, videos, text and numeric records during the last decade. On closer analysis of recent publications (in the last 2 years) in CMPB, we found that deep learning was an important research area. In particular, its application in healthcare areas where physiological signals are available. The application areas of deep learning included Electroencephalogram (EEG), Electrocardiogram (ECG) and Electrooculogram (EOG). It is highlighted through the publications that the deep learning approach performs better for large and varied datasets for machine-based classification problems. In the future, it is anticipated that there would be growing research on the application of deep learning in biomedical research fields. Table 13 provides a detailed account of keywords co-occurrences in CMPB articles.

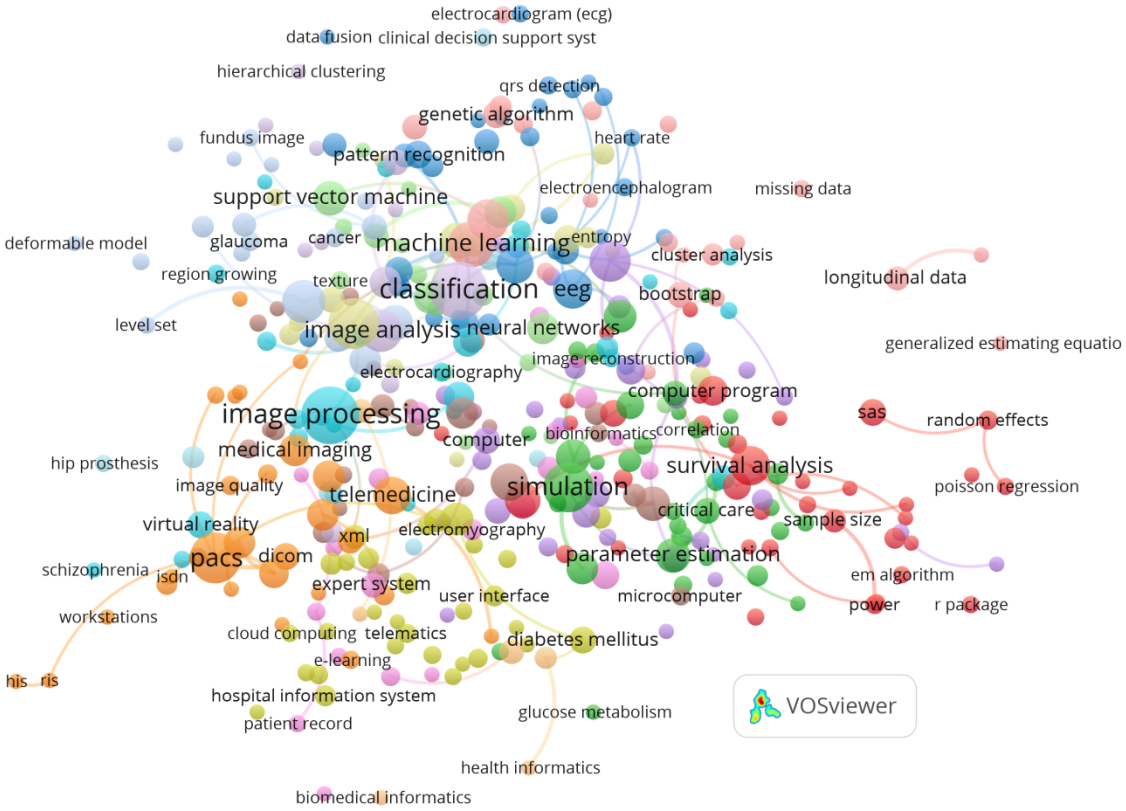

Figure 9. Co-occurrence of author keywords in CMPB: minimum occurrence threshold of 5 and 100 links

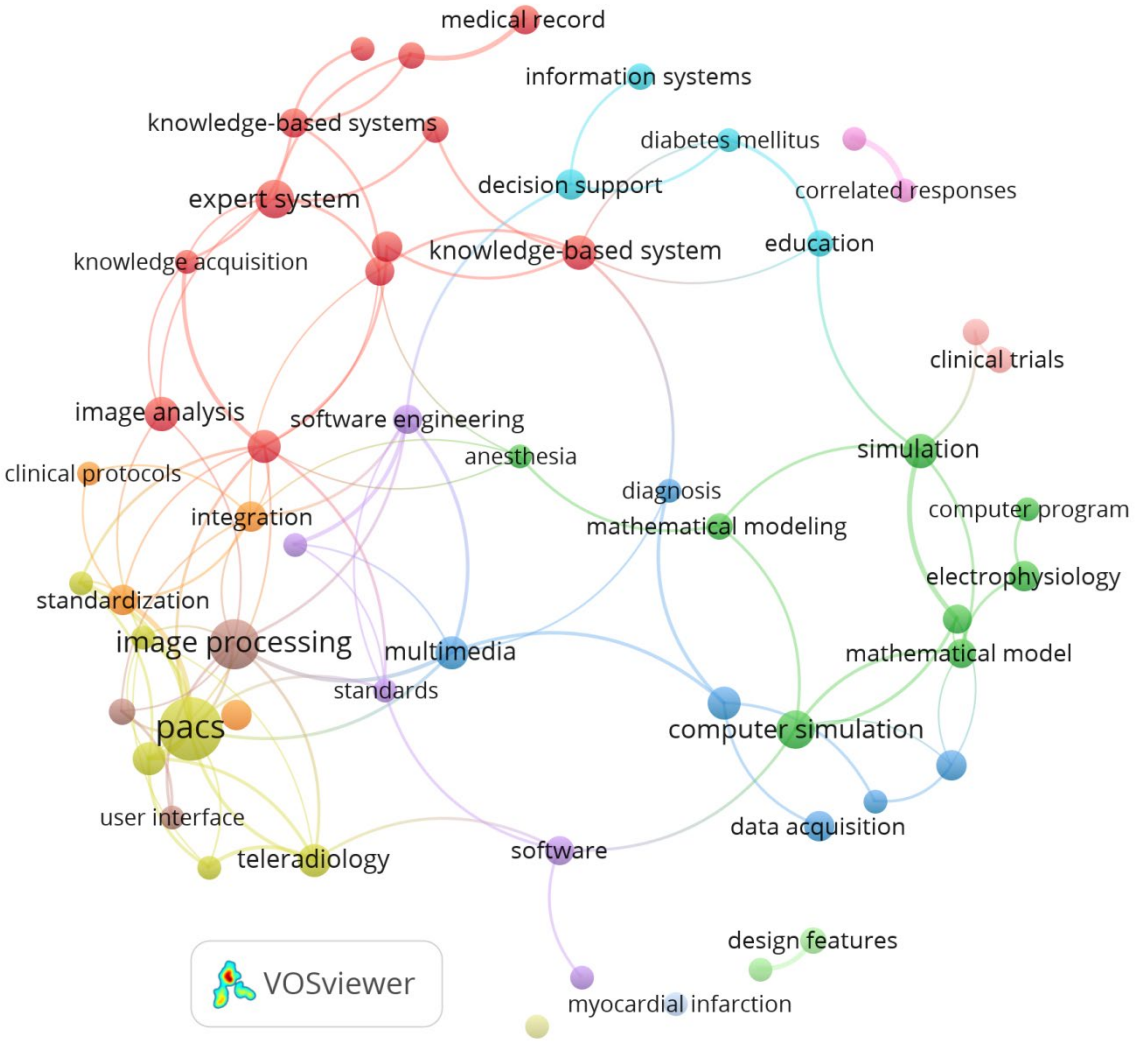

Figure 10. Co-occurrence of author keywords in CMPB: 1988-1997 (minimum occurrence threshold of 3 and 100 links)

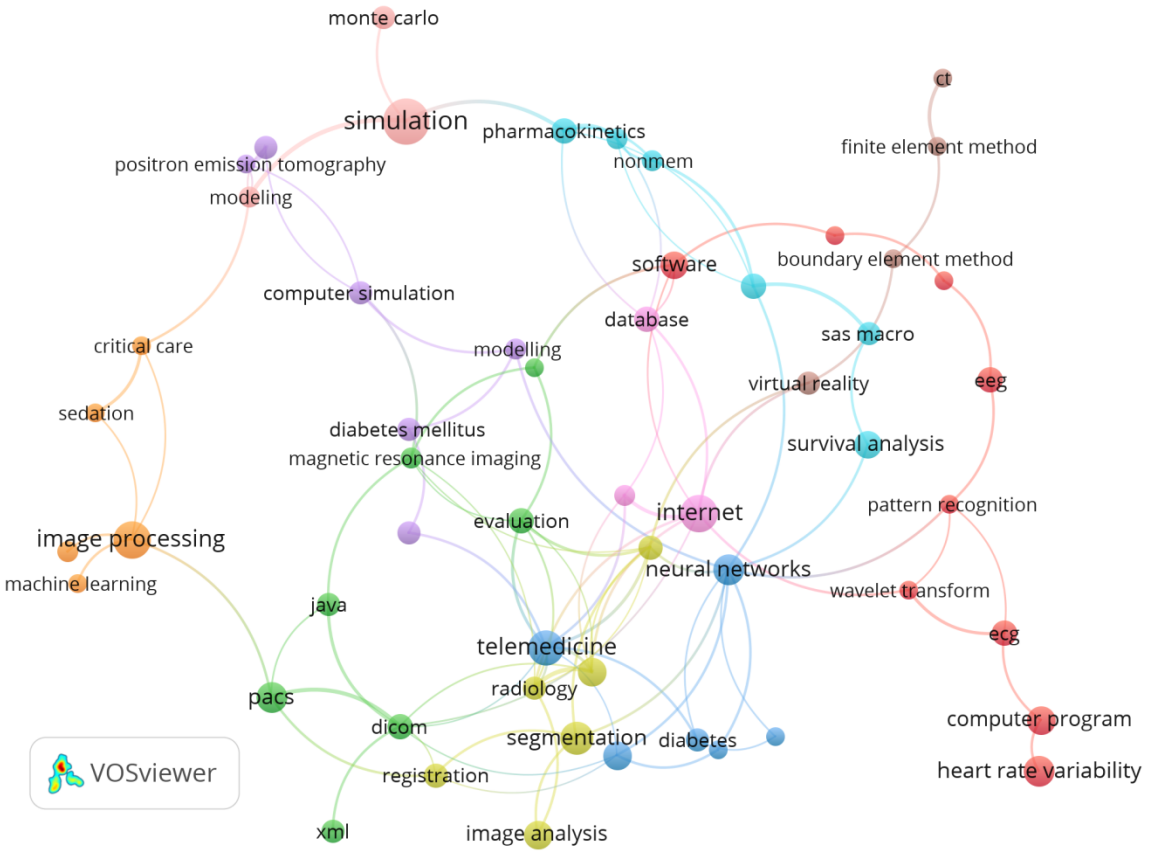

Figure 11. Co-occurrence of author keywords in CMPB: 1998-2007 (minimum occurrence threshold of 5 and 50 links)

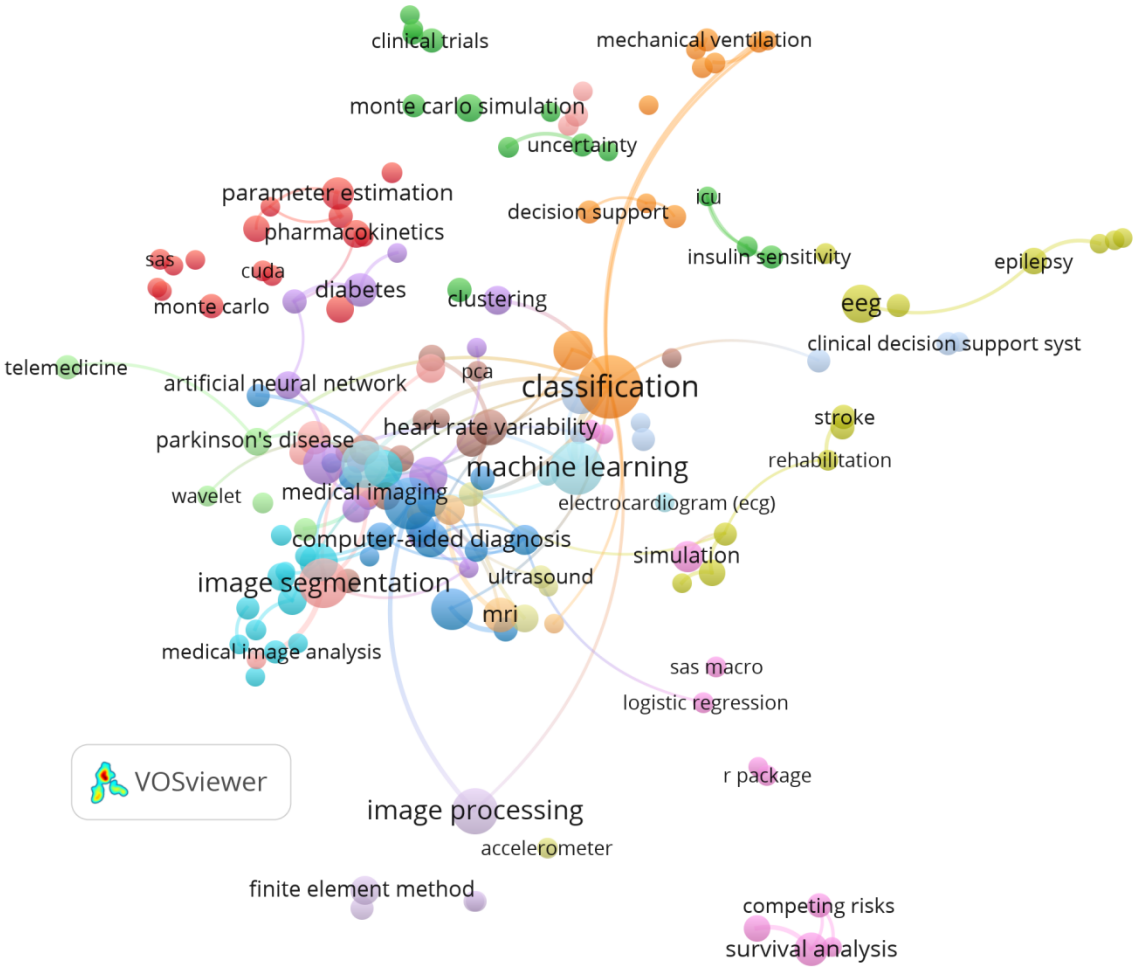

Figure 12. Co-occurrence of author keywords in CMPB: 2008-2017 (minimum occurrence threshold of 5 and 100 links)

Table 13. Co-occurrence of author keywords in CMPB: Global and temporal analysis

	Global			2008-2017			1998-2007			1988-1997		
R	Keyword	Occ	Co-oc	Keyword	Occ	Co-oc	Keyword	Occ	Co-oc	Keyword	Occ	Co-oc
1	Image Processing	68	43	Classification	52	39	Simulation	28	7	PACS	33	17
2	Classification	67	49	EEG	39	18	Image Processing	19	4	Image Processing	21	8
3	EEG	61	43	Machine Learning	37	27	Internet	19	8	Knowledge-Based System	17	9
4	Segmentation	53	35	Segmentation	35	23	EEG	18	5	Decision Support	16	5
5	PACS	52	35	Image Segmentation	32	20	Telemedicine	17	9	Computer Simulation	12	5
6	Simulation	51	36	Feature Selection	29	17	Segmentation	15	4	Expert System	12	4
7	Machine Learning	44	37	Image Processing	28	16	Heart Rate Variability	13	1	Modeling	11	9
8	Decision Support	38	22	Feature Extraction	23	17	Neural Networks	13	9	Image Analysis	10	2
9	Image Segmentation	38	27	Support Vector Machine	23	11	PACS	13	5	Simulation	10	7
10	Image Analysis	36	28	Artificial Neural Networks	22	11	Modeling	12	9	Computer	9	5
11	Feature Selection	34	23	Breast Cancer	19	14	Classification	11	3	Evaluation	9	8
12	Heart Rate Variability	34	24	Computed Tomography	19	15	Computer Program	11	2	Multimedia	9	8
13	Modeling	34	28	Data Mining	19	9	Image Analysis	11	2	Radiology	9	9
14	Survival Analysis	31	21	Magnetic Resonance Imaging	19	13	Teleradiology	11	7	Teleradiology	9	7
15	Telemedicine	29	21	Computer-Aided Diagnosis	17	13	Decision Support	10	4	Data Acquisition	8	1
16	Artificial Neural Networks	29	19	Heart Rate Variability	17	10	Software	10	4	Electrophysiology	8	2
17	Computer Simulation	28	13	MRI	16	11	Survival Analysis	10	2	Integration	8	5
18	Feature Extraction	27	25	Diabetes	15	10	Bootstrap	9	5	Microcomputer	8	2
19	Magnetic Resonance Imaging	26	21	Image Analysis	15	8	Database	9	3	Standardization	8	6
20	Software	26	16	Survival Analysis	15	6	Dicom	9	7	Telematics	8	1
21	Parameter Estimation	25	21	Parameter Estimation	14	9	Evaluation	9	5	Intensive Care	7	4
22	Diabetes	24	16	Simulation	13	7	Pharmacokinetics	9	8	Mathematical Model	7	4
23	Pharmacokinetics	24	18	Atrial Fibrillation	12	8	Medical Imaging	8	7	Medical Record	7	3
24	Support Vector Machine	24	14	Decision Support	12	7	Registration	8	3	Software	7	4
25	Data Mining	22	12	Genetic Algorithm	12	8	Computer Simulation	7	3	Software Engineering	7	7
26	Computed Tomography	21	18	Mutual Information	12	8	Diabetes	7	2	Artificial Intelligence	6	2
27	Internet	21	12	SVM	12	5	Diabetes Mellitus	7	2	Clinical Trials	6	1
28	Medical Imaging	21	18	Clustering	11	8	Java	7	3	Design Features	6	3
29	Neural Networks	21	17	Diabetic Retinopathy	11	9	Monte Carlo	7	1	Education	6	3
30	Breast Cancer	20	15	Finite Element Method	11	3	Parameter Estimation	7	4	Hospital Information System	6	3
31	Computer-Aided Diagnosis	20	17	Image Registration	11	7	Radiology	7	7	Information Systems	6	1
32	Database	20	12	Modelling	11	9	SAS Macro	7	3	Mathematical Modeling	6	3
33	Evaluation	20	15	Principal Component Analysis	11	9	Virtual Reality	7	3	Patient Record	6	5
34	MRI	20	14	GPU	10	7	Xml	7	1	Survival Analysis	6	2
35	Teleradiology	20	17	Mammography	10	8	Hip Prosthesis	6	1	Anesthesia	5	2
36	Knowledge-Based System	19	13	Mathematical Morphology	10	7	Magnetic Resonance Imaging	6	4	Clinical Protocols	5	1
37	Monte Carlo	19	12	Matlab	10	7	Nonmem	6	4	Computer Program	5	1
38	Computer Program	18	7	Medical Imaging	10	8	Pharmacodynamics	6	6	Correlated Responses	5	5
39	Radiology	18	18	Monte Carlo Simulation	10	5	World Wide Web	6	4	Diabetes Mellitus	5	3
40	Finite Element Method	17	6	Parkinson's Disease	10	8	3D Reconstruction	5	0	Diagnosis	5	3

Abbreviations: Occ = Occurrences; Co-oc = Co-occurrence link strength.

5. Discussion

CMPB is identified as a leading and core journal for biomedical researchers in the world. The journal is strongly connected to many other journals including *IEEE Transactions on Biomedical Engineering* and *IEEE Transactions on Medical Imaging*. The most cited CMPB paper is from the authors - Lihong Wang, Steven L. Jacques, Liqiong Zheng (published in 1995) receiving more than 2000 citations. Top CMPB authors include Yu-Chuan Li, James Geoffrey Chase and Geoffrey M. Chase and the top 3 institutions publishing in CMPB are Uppsala U (Sweden), Taipei Medical U (Taiwan) and INSERM (France). The journal is very diverse in terms of institutions and countries and is strongly influenced by North America and Europe. The highest number of CMPB papers were from the USA followed by the UK and Italy. In Asia, only China and Taiwan appear in the top 10 countries publishing in CMPB. Keyword co-occurrences analysis reveals an interesting co-relation between the biomedical area of research and methods that were used. Strong co-occurrences were identified for keywords such as classification, PACS, heart rate variability, survival analysis and simulation. In the last decade, keywords analysis found that topics relating to machine learning systems for variety of healthcare problems (including image processing and analysis) dominated other research fields in CMPB.

This bibliometric approach provides a practical review of the current leading trends of CMPB. However, it is worth noting that the result presented in this work consider publications until 31 December 2017. Therefore, note that in the future the results may evolve in different directions with new trends emerging in the journal. Additionally, the work follows the methodology and results available in the WoS core collection. Thus, any limitation that applies to this database, also applies to this study. Finally, each research field may have different results that may also condition the bibliometric results producing more publications or citations. In any case, the objective of this study is to identify the publication and citation trends of the journal in order to get a general overview of the current state of the art.

Following on from the bibliometric analysis, we now present some of the insights for the journal. There was a drop in number of papers published in 2015 in CMPB compared to the previous years for some reasons. Since then, the journal has consistently increased the

number of publications. CMPB should try to attract quality papers consistently and a good and prompt review feedback will go a long way in achieving these objectives. There is an increasing number of papers published in last 10 years in CMPB which implies higher number of submissions and therefore higher manuscript handling workload for the Editor-in-Chief, editorial board members and reviewers. As such, effective and efficient review mechanism should be adopted to reduce this workload. Some of the strategies may include expanding the editorial board of the journal as well as rigorous initial screening of the manuscripts submitted to the journal for their suitability. CMPB should also encourage submissions involving (i) software tools along with its methodology application to a biomedical field (ii) state-of-the-art review to increase the citation appeal. It was found that the papers providing software tools and reviews are getting high citations compared to a regular paper proposing a methodology. The journal can expand its editorial board members to include authors of highly cited CMPB publications. It can attract quality submissions from their network and area of influence. CMPB should pay particular attention to submissions involving classification, segmentation, feature selection/ extraction, image processing as it has become central theme in the publications in last decade. In particular, submissions with deep learning methods should be encouraged further as it is emerging out to be a theme of considerable interest to the biomedical research community. In past, publications involving some type of computer simulation were popular but in recent decade publications with machine learning methods are more prominent. Some special issues by leading experts in the area could be regularly planned on the emerging topics of the journal such as deep learning applications in biomedical areas to reinvigorate quality and focussed submissions.

6. Conclusions

To celebrate the 50th anniversary of CMPB, this paper presents a bibliometric analysis and overview of the major trends that have occurred in the journal in its publication history. The study uses the WoS core collection and the analysis was presented on all the papers published from the journal between 1970 and 2017. The trends suggest that CMPB is a world renowned publication outlet for biomedical researchers which has been growing in number of publications produced every year since 1970.

The study presented a range of analyses on the papers published and their citations to identify leading institutions, countries, authors, and key research areas. To better understand the bibliometric results, this study also presents the graphical and mapping analysis of the papers through the use of VOS viewer software. The study considered co-citation, bibliographic coupling, citation, co-authorship and co-occurrence of author keywords. These analyses can provide readers with better understanding and growing importance of CMPB journal.

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