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40 years of Computer Standards & Interfaces: A bibliometric retrospective

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ABSTRACT

Computer Standards & Interfaces (CSI) is a leading international journal in the field of computer applications, standards, data management, interfaces, and software developments. This bibliometric study analyzes a four-decade journey of the CSI from 1982 to 2023. We captured data related to the CSI publications from two trustworthy databases: Web of Science (WoS) Core Collection and Scopus. We analyze the journal's performance in relationships with publications, citations, topics, periods, authors, institutions, countries, and regions. Visualization of similarities (VOS) viewer software is used to construct network visualizations of co-citations, co-occurrences, and bibliographic couplings of related issues. The present work finds that 2001 published articles in CSI have received 24,139 citations. David C. Yen from Texas Southern University (USA) and Ahmed Patel from Ceará State University (Brazil) are the most productive authors. The USA, Europe and East Asia are the most productive regions. Security, Standardization, Standards, Interoperability, Authentication, Privacy, and Cryptography are highly discussed research topics by the authors in CSI. This retrospective study explores the reach and credibility of CSI capturing active and significant involvements of the authors from different parts of the world.

1. Introduction

Computer Standards & Interfaces (CSI) is an international journal focused on the advances and applications of standards for computers, data management, software development, interfaces, and measurement. The journal promotes topics covering various development issues of interfaces (hardware and software), digitalization, complex computing, communication, multimedia, and measuring systems. CSI publishes high-level research papers on standards, software development, and features, distributed systems, information management, open systems, data procurement, and digital instruments standardization. CSI also covers general issues like the standardization process for seamless communication, data exchange, and hardware integration; and their effect on the business, law-making, and associations among national and international standards bodies.

CSI was established in 1982. It is listed in well-known indexes like Scopus and Science Citation Index Expanded (SCIE). The journal is presently operating under the supervision of the Editor-in-Chief Professor Ricardo Colomo-Palacios (Polytechnic University of Madrid). CSI received an *Impact Factor* of 4.1 in 2023 from the Journal Citation Reports (JCR) of the Web of Science (WoS) and a *Cite Score* of 11.9 from Scopus. It is currently ranked 10th among 59 journals in the category of "Computer Science, Harware & Architecture" and 20th of 131 journals in "Computer Science, Software Engineering" of JCR [1]. In Scopus, it is ranked in five different categories: Computer Science Applications, General Computer Science, Hardware and Architecture, Law, and Software. In all these categories, the journal ranks well above the 90th percentile. For example, in General Computer Science, it is ranked 12th of 232 journals [2].

At its inception, CSI published four issues per year. Later, from 1992 to 2014, it published six issues in one volume per year. Since 2015, it has been publishing six volumes per year. CSI maintains the standard of a double-blind peer-review process to ensure high-quality and unbiased research publications. The journal has grown continuously during its four decades journey contributing to society and science. During its lifetime, there have been huge modernization, discoveries, and progress happening in the field of computer science and computer applications. Keeping up with all those discoveries and innovations through its scientific publications, CSI's presence is quite significant and remarkable [3–5]. The present work uses a general bibliometric approach to review

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Table 1
Examples of bibliometric studies to analyze performance of academic journals.

Journal	Published Work	Interval	Celebration
Journal of Knowledge Management	Gaviria-Marin [11]	1997–2016	20 years
Information Systems Frontiers	Beydoun et al. [12]	1999–2018	20 years
Electronic Commerce Research	Kumar et al. [13]	2001–2020	20 years
Knowledge-Based Systems	Cobo et al. [14]	1991–2014	25 years
IEEE Transactions on Fuzzy Systems	Yu. et al. [15]	1994–2015	25 years
Applied Intelligence	López-Robles et al. [16]	1991–2020	30 years
Computers in Human Behavior	Vošner et al. [17]	1985–2015	30 years
Engineering Applications of Artificial Intelligence	Shukla et al. [18]	1988–2018	30 years
Computers & Chemical Engineering	Modak et al. [8]	1977–2016	40 years
Journal of Business Research	Merigó et al. [19]	1973–2014	40 years
European Journal of Operational Research	Laengle et al. [7]	1977–2016	40 years
Computers & Industrial Engineering	Cancino et al. [20]	1976–2015	40 years
Computer Methods and Programs in Biomedicine	Shukla et al. [21]	1970–2017	50 years
International Journal of Systems Science	Wang et al. [22]	1970–2019	50 years
Transportation Research	Modak et al. [23]	1967–2016	50 years

the journey of the journal since its commencement by analyzing and quantifying the publication and citation patterns. The objective is to map the intellectual structure and detect emerging trends and topics in the field of computer science and computer applications. The article identifies leading topics, papers, authors, institutions and countries. Additionally, it also analyzes the connection of CSI with other journals in this research area and the citing articles. To do so, the analysis uses the WoS Core Collection database and the visualization of similarities (VOS) viewer [6].

Undertaking bibliometric studies is a common practice to review the performance of a journal to celebrate its journey for a significant period [7,8]. Table 1 presents instances of bibliometric studies to analyze the journey of some well-established journals at their significant anniversaries. These types of publications have been amplified in recent years due to easy data accessibility from scientific databases like Web of Science and Scopus [9,10].

The present study aims to re-examine the performance of the CSI based on its published articles from the year 1982 to 2023. It aims to explore publication patterns, citation patterns, and the impact of the journal over the years. In particular, it responds to the following research questions on the four decades journey of the CSI:

I. Which authors, institutions, and countries/regions are leading in CSI? (Sections 3.3, 4.1, and 4.2).
II. How is CSI positioned in the scientific community? (Sections 3.1, 4.1, and 4.2).
III. Which are the most cited documents and how is the publication and citation structure? (Sections 3.1 and 3.2)
IV. Which are the keywords and topics most frequently published in CSI? (Section 4.2).

The purpose of this bibliometric study is to depict comprehensive information on CSI since its creation and analyze those to assess the overall performance and impact of the journal. The next section discusses the methodological background of the study. Section 3 presents the bibliometric results of CSI and Section 4 develops a graphical mapping of the bibliographic information. Section 5 ends the paper with the main conclusions.

2. Methods

Bibliometrics is a research field of information and library sciences that analyzes the bibliographical material with quantitative measures [24,25]. Since the initial contributions of leading pioneers [26,27], bibliometrics has been growing a lot during the last decades thanks to the development of computers and internet [28,29]. Today, it is a very practical approach to measure academic research in a wide range of contexts, including topics [30–32], journals [33,34], authors [35], institutions, and countries [36–38]. Bibliometrics is widely used in systematic literature reviews as a key tool to provide a better understanding of a research topic [39–41].

The present article collects data from two trustworthy databases: Web of Science (WoS) Core Collection and Scopus. We first collect data from the WoS Core Collection under the "PubTitle – Computer Standards Interfaces OR Interfaces in Computing". The WoS search engine reveals 2237 documents up to 2nd June 2024. Excluding the papers published in the running year 2024, we get a total of 2162 documents including 1945 articles and reviews. Note that this study analyzes articles and reviews to strictly focus on research contributions. The rest of documents published in the journal are editorial material (173 documents), reprints (17 documents), notes (10 documents), corrections (8 documents), software review (5 documents), letters (2 documents), database review (1 document), and item about an individual (1 document).

Through the cited reference search of WoS (that shows documents not indexed in WoS with at least one citation) and the webpage of the journal, we identified papers not indexed in WoS from 1982 to 1985. In this case, we obtained 56 additional documents and the total number of publications from the year 1982 to 2023 is 2001 documents.

To conduct this bibliometric study, we use qualitative and quantitative measures to organize data and present it effectively [42]. Total papers (TP), total citations (TC), *h*-index, average citations per paper (C/P), and different citation thresholds (>200, 100, 50, 20, 10, 5, and 1 citations) are used as indicators to recognize and classify collected data. TP and TC are the first two basic indicators of a bibliometric study. We use TP to recognize the publication patterns, and productivity of an entity (like a journal, author, institution, and country). TP has limitations as it cannot measure the value of research work in the development of future research studies. The indicator, TC can help to realize the tribute of a publication in further research developments. Based on TC, the present work also captures information and classified data based on the citation thresholds like >200, 100, 50, 20, 10, 5, and 1 citation. Individual use of the indicators TP and TC have some boundaries to measure the overall performance of a journal. However, an indicator developed from a combination of TP and TC, namely, the *h*-index is a broadly accepted indicator for a bibliometric study [43,44]. If K is the value of the *h*-index of an entity, then it has K papers having at least K citations each.

Network images of co-citation of journals, and authors [45]; bibliographic coupling of institutions, and countries [46]; and co-occurrence of keywords [47], are generated with the help of visualization of similarities (VOS) viewer software [6] and *bibliometrix* [48]. Network images are created using the value number of links, and link strength. Circle size is related to link number and network connections are designed following their link strength. Research collaborations among the institutions or countries are depicted through bibliographic coupling images. Comparable articles and topics are explored from network

Fig. 1. Procedure of the study based on the SPAR-4-SLR protocol.

Table 2
Annual citation structure of CSI.

Year	TP	TC	C/P	≥200	≥100	≥50	≥20	≥10	≥5	≥1	T50
1982	18	21	1.17	0	0	0	0	0	0	10	0
1983	24	9	0.38	0	0	0	0	0	0	8	0
1984	31	30	0.97	0	0	0	0	0	2	13	0
1985	33	17	0.52	0	0	0	0	0	0	10	0
1986	29	8	0.28	0	0	0	0	0	0	4	0
1987	39	31	0.79	0	0	0	0	1	2	13	0
1988	51	24	0.47	0	0	0	0	0	0	12	0
1989	16	9	0.56	0	0	0	0	0	0	7	0
1990	26	47	1.81	0	0	0	1	1	2	14	0
1991	56	58	1.04	0	0	0	0	1	2	24	0
1992	21	20	0.95	0	0	0	0	0	0	14	0
1993	19	16	0.84	0	0	0	0	0	1	9	0
1994	44	425	9.66	1	1	1	3	5	9	19	1
1995	48	202	4.21	0	0	1	3	5	0	28	0
1996	29	46	1.59	0	0	0	0	1	2	13	0
1997	22	110	5.00	0	0	0	2	3	7	12	0
1998	46	227	4.93	0	0	1	3	6	11	33	1
1999	23	88	3.83	0	0	0	0	3	6	17	0
2000	27	127	4.70	0	0	0	1	3	9	25	0
2001	31	228	7.35	0	0	0	3	6	15	26	0
2002	34	371	10.91	0	0	2	4	11	19	26	1
2003	42	401	9.55	0	0	0	6	15	25	38	0
2004	58	1080	18.62	0	2	0	12	27	42	55	3
2005	70	1090	15.57	0	1	6	13	27	41	67	5
2006	38	557	14.66	0	1	3	8	13	25	37	2
2007	70	1584	22.63	2	4	8	18	34	45	66	6
2008	48	691	14.40	0	0	2	12	11	33	46	0
2009	141	3486	24.72	3	6	18	47	80	102	135	9
2010	34	808	23.76	0	2	5	7	16	24	33	5
2011	59	1127	19.10	0	2	6	17	31	44	58	3
2012	54	940	17.41	1	1	2	11	26	37	53	1
2013	78	1083	13.88	0	1	5	17	32	52	73	2
2014	64	1061	16.58	1	1	1	9	29	41	63	1
2015	64	858	13.41	0	0	1	17	32	49	63	0
2016	78	1005	12.88	0	0	3	16	32	57	75	1
2017	92	1998	21.72	0	3	9	33	58	77	92	5
2018	70	1130	16.14	0	0	4	21	37	55	69	2
2019	80	1150	14.38	0	0	4	16	42	63	80	1
2020	31	509	16.42	0	0	1	9	17	22	31	0
2021	44	532	12.09	0	0	3	7	16	30	41	1
2022	57	706	12.39	0	0	1	15	26	36	53	0
2023	62	229	3.69	0	0	0	0	8	20	53	0
Total	2001	24,139	12.06	8	25	87	331	655	1007	1618	50
%	100 %	–	–	0.40 %	1.25 %	4.35 %	16.54 %	32.73 %	50.32 %	80.86 %	2.50 %

Abbreviations: TP and TC = Total papers and citations; C/P = Cites per paper; ≥200, ≥100, ≥50, ≥20, ≥10, ≥5, ≥1 = Number of papers with equal or >200, 100, 50, 20, 10, 5 and 1 citations; T50 = Number of papers in the Top 50 of Table 7.

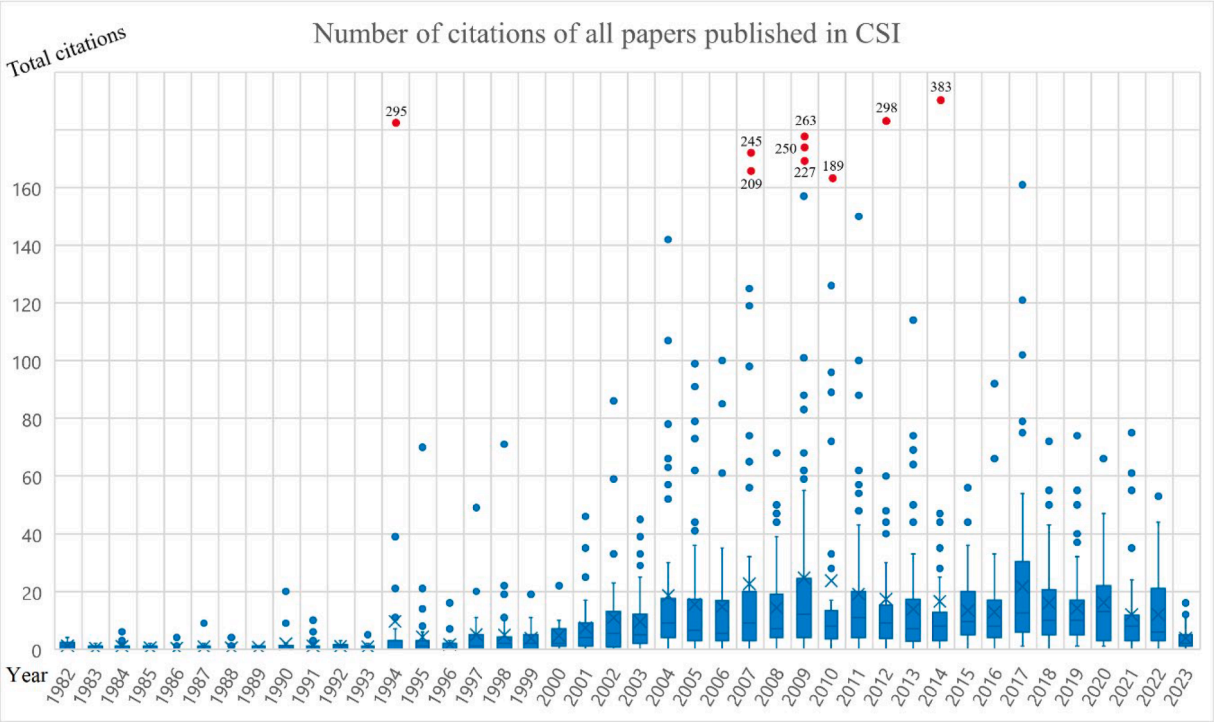

Fig. 2. Annual box-plot structure of the citations of all papers published in CSI.

Table 3
Analysis of CSI in the JCR of the WoS and Scopus.

Year	TC*	IF	5YIF	ImIn	AIS	PHA	RHA	Q	PSE	RSE	Q*	CS	BP	QS
2004	101	0.31	–	0.06	–	28.41	32/44	Q3	19.08	62/76	Q4	–	–	–
2005	134	0.62	–	0.04	–	39.77	27/44	Q3	39.87	48/79	Q3	–	–	–
2006	137	0.41	–	0.13	–	30.68	31/44	Q3	17.68	68/82	Q4	–	–	–
2007	221	0.50	0.64	0.11	0.16	32.22	31/45	Q3	22.02	66/84	Q4	–	–	–
2008	386	1.07	1.02	0.22	0.23	47.78	24/45	Q3	51.74	42/86	Q2	–	–	–
2009	489	1.37	1.24	0.21	0.23	64.29	18/49	Q2	60.75	37/93	Q2	–	–	–
2010	481	0.86	0.94	0.20	0.24	42.71	28/48	Q3	44.95	55/99	Q3	–	–	–
2011	566	1.25	1.11	0.22	0.37	73	14/50	Q2	73.56	28/104	Q2	4.2	98-L	Q1
2012	768	0.97	1.42	0.25	0.41	49	26/50	Q3	48.1	55/105	Q3	6.0	99-L	Q1
2013	781	1.17	1.41	0.21	0.38	61	20/50	Q2	64.29	38/105	Q2	3.3	93-L	Q1
2014	790	0.87	1.31	0.23	0.33	53	24/50	Q2	41.83	61/104	Q3	3.4	94-L	Q1
2015	986	1.26	1.45	0.31	0.33	65.69	18/51	Q2	67.45	35/106	Q2	3.6	94-L	Q1
2016	1175	1.63	1.52	0.56	0.27	54.81	24/52	Q2	62.74	40/106	Q2	3.7	94-L	Q1
2017	1259	1.46	1.47	0.81	0.29	45.19	29/52	Q3	55.29	47/104	Q2	3.9	94-L	Q1
2018	1499	2.44	1.95	0.94	0.29	68.87	17/53	Q2	73.36	29/107	Q2	4.9	97-L	Q1
2019	1509	2.80	2.22	0.8	0.33	70.75	16/53	Q2	77.31	25/108	Q1	6.7	98-L	Q1
2020	1748	2.48	2.35	0.96	0.43	53.77	25/53	Q2	62.5	41/108	Q2	9.4	99-L	Q1
2021	1933	3.72	2.9	1.47	0.44	67.59	18/54	Q2	78.64	24/110	Q1	8.8	99-L	Q1
2022	2204	5	3.7	0.9	0.53	84.3	9/54	Q1	84.7	17/108	Q1	10.5	98-L	Q1
2023	1858	4.1	3.2	0.8	0.61	83.9	10/59	Q1	85.1	20/131	Q1	11.9	98-L	Q1

Abbreviations: TC = Total citations; IF = Impact factor; 5YIF = 5-year impact factor; ImIn = Immediacy index; AIS = Article Influence Score; PHA = Journal impact factor percentile in Computer Science – Hardware & Architecture; RHA = Ranking in the WoS category of Computer Science – Hardware & Architecture; Q = Quartile in HA; PSE = Journal impact factor percentile in Computer Science – Software Engineering; RSE = Ranking in the WoS category of Computer Science – Software Engineering; Q* = Quartile in SE; CS = CiteScore (Scopus); BP = Best percentile in Scopus among the subject areas where CSI is currently indexed (CS = Computer Science Applications, GC = General Computer Science, HA = Hardware and Architecture, L = Law, S = Software); QS = Best quartile in Scopus.

visualization of co-occurrence analysis [49].

To summarize the bibliometric methodology of this study, Fig. 1 presents the approach followed in this paper based on the scientific procedures for systematic literature reviews (SPAR-4-SLR) [50,51].

3. Results

CSI published its first issue in 1982, and it is indexed since 1986 in WoS. The first issue of the fifth volume is published as an SCI-indexed journal under the supervision of the editor-in-chief professor John L. Berg. This section presents the collected data categorized from different perspectives. This helps to explore CSI in research developments and patterns over the years. The section also discusses citation and publication info on CSI, the performance of CSI in the JCR of the WoS, leading journals in CS connected to CSI, and leading authors, institutions, and countries of CSI.

3.1. Publication and citation structure of CSI

Using the WoS database we analyze year-wise published CSI articles

Table 4
Publication record of leading journals in computer science connected to CSI (Rank by TC).

Journal name	P10	C10	C/P10	H10	TP	TC	C/P	H	≥500	≥100	≥10	IF	JIFP	CS	Y	YW
CSI	642	9213	14.35	40	2001	24,139	12.06	63	0	25	664	5	85.1	10.5	1982	1984
Expert Syst Appl	10,519	273,300	25.98	170	18,787	622,418	33.13	236	40	1231	12,212	8.5	88.1	12.6	1990	1991
Inform Sciences*	9341	250,780	26.85	162	14,902	487,576	32.72	218	51	877	8985	8.1	92.1	13.4	1968	1968
Commun ACM	914	72,617	79.45	82	7010	463,403	66.11	261	129	765	3886	22.7	99.2	9.8	1958	1958
IEEE Commun Mag	2298	144,585	62.92	172	6550	346,761	52.94	250	97	790	3856	11.2	94.5	21.1	1973	1983
MIS Quart	596	31,879	53.49	92	1594	313,879	196.91	249	102	583	1311	7.3	92.2	18.7	1977	1979
IEEE T Instrum Meas	8844	120,350	13.61	106	17,735	291,291	16.42	144	10	313	7816	5.6	88.8	7.4	1963	1964
IEEE T Ind Inform	5378	212,228	39.46	167	5987	259,023	43.26	180	21	559	4501	12.3	98.5	22.4	2005	2005
IEEE T Comput	2110	33,681	15.96	77	7642	226,439	29.63	170	38	406	4136	3.7	72	6.1	1952	1964
IEEE Internet Things J	7647	213,401	27.91	165	7647	213,401	27.91	165	20	397	4108	10.6	96.6	17.4	2014	2014
IEEE T Software Eng	1132	24,959	22.05	75	3930	182,287	46.38	193	33	424	2503	7.4	93.5	9.5	1975	1977
Future Gener Comp Sy	4397	122,031	27.75	125	6185	174,258	28.17	142	23	268	3367	7.5	90.6	21.1	1984	1994
Comput Netw	3506	58,628	16.72	92	5990	142,443	23.78	126	18	174	2596	5.6	85.6	10.7	1976	1999
Computer J	1535	9028	5.88	32	5193	99,330	19.13	95	21	91	1262	1.4	50.7	3.4	1958	1958
Comput Commun	2741	41,616	15.18	78	7033	96,938	13.78	108	6	122	2367	6	79.7	11	1978	1978
J Syst Software	1918	32,408	16.9	69	5060	95,873	18.95	108	2	130	2378	3.5	82.9	9	1979	1981
J Netw Comput Appl	2015	61,927	30.73	110	3008	87,942	27.79	123	8	178	1717	8.7	95.8	19	1978	1996
Inform Software Tech	1369	26,739	19.53	65	3507	74,257	21.17	103	4	108	1640	3.9	80.5	9.2	1959	1987
Comput Secur	2227	40,521	18.2	80	3375	68,673	20.35	101	2	107	1534	5.6	81.7	11.6	1982	1994
J Supercomputing	4297	42,891	9.98	68	5697	58,522	10.27	77	1	54	1622	2.5	67.5	6.3	1987	1990
IEEE Software	669	9722	14.53	46	2564	56,845	22.17	102	5	105	1110	3.3	73.7	4.9	1983	1984
IEEE T Depend Secure	1300	24,488	18.84	71	1638	40,723	24.86	88	2	68	813	7.3	95	10.4	2004	2004
IEICE T Inform Syst	3219	10,740	3.34	29	8635	35,569	4.12	49	2	15	762	0.6	7.3	1.4	1991	1992
Int J Adv Comp Sci Appl	9140	29,456	3.22	48	10,232	34,329	3.35	50	0	18	754	0.7	27.6	2.3	2010	2010
Int J Distrib Sensor Netw	2898	24,198	8.35	51	4027	33,539	8.33	60	1	24	961	1.9	37.6	6.5	2005	2005
Security Commun Netw	4049	28,824	7.12	55	4543	32,998	7.26	57	0	17	940	–	–	–	2008	2008
Int J Commun Syst	2862	21,313	7.45	46	4040	31,192	7.72	55	0	10	952	1.7	35.6	5.9	1988	1994
Wiley Int Rev – DMKD	316	15,523	49.12	59	425	23,152	54.48	67	8	49	274	6.4	92	22.7	2011	2011
IEEE T Cloud Comput	1038	21,466	20.68	64	1053	22,704	21.56	67	0	34	542	5.3	88.5	9.4	2013	2013
Cognitive Computation	885	17,495	19.77	59	1078	21,606	20.04	64	2	26	544	4.3	72.8	9.3	2009	2009
J Inform Security Appl	1204	18,300	15.2	53	1222	18,468	15.11	53	0	12	505	3.8	72.1	10.9	1996	2013
J Universal Comp Sci	743	4337	5.84	26	2267	18,357	8.1	47	0	11	539	0.7	27.6	2.7	1994	2001
Peer-to-Peer Netw Appl	1318	15,473	11.74	50	1463	16,569	11.33	50	1	14	451	3.3	64.1	8	2008	2008
IEEE T Big Data	510	10,025	19.66	42	510	10,025	19.66	42	1	11	235	7.5	93.4	11.8	2015	2017
Int J Inform Security	504	5385	10.68	33	686	9038	13.17	43	0	8	244	2.4	65.4	6.3	2002	2007
J Internet Tech	1597	6745	4.22	25	2149	8406	3.91	26	0	7	117	0.9	18.7	3.2	2000	2008
Int J Found Comput Sci	583	1959	3.36	16	1373	7872	5.73	31	0	0	248	0.6	18.5	1.6	1990	2004
IET Inform Security	526	4167	7.92	26	719	7460	10.38	37	0	6	225	1.3	44.4	3.8	2007	2007
IET Software	421	2980	7.08	23	676	6009	8.89	32	0	2	199	1.5	37.8	4.2	2007	2007
IET Comput Digital Tech	316	1632	5.16	17	651	4418	6.79	29	0	1	131	1.1	39.5	3.5	2007	2007

Abbreviations: P10, C10, C/P10 and H10 = Publications, citations, cites per paper and *h*-index between 2014 and 2023; TP, TC, C/P and *H* = Total publications, citations, cites per paper and *h*-index available in Scopus; ≥500, ≥100 and ≥10 = Number of articles with equal or >500, 100 and 10 citations; IF = 2023 Impact Factor (Web of Science); JIFP = Journal Impact Factor Percentile; CS = CiteScore (Scopus); Y = Year of origin; YW = Year available in WoS. The numbers provided in the table only consider "Articles" and "Reviews" up to 31 December 2023. *Note that the impact factor of *Information Sciences* is from 2022.

from 1982 to 2023. Table 2 presents the publication and citation data of the journal in a year-wise pattern, and seven citation thresholds including more than or equal to two hundred, one hundred, fifty, twenty, ten, five, and one citation. The final column shows the number of documents that are listed among the 50 most cited in Table 7.

Although the number of publications per year oscillates during its journey of four decades, the overall trend is upwards during the last two decades. The year 2009 has the most publications with 141 followed by the year 2017, which has 92 publications. On the other hand, the year 1989 has the least number of publications. According to the WoS core collection database, 2001 documents of the CSI have received a total of 24,139 citations up to 31st December 2023.

During the last ten years (2014 to 2023) it published 642 articles at an average of 64.2 articles per year. It published the most, 650 numbers of articles during the third decade (2004–2013) of its journey. Articles published in the third decade have received the highest 12,446 citations among the four decades of its journey. Articles published during the first twenty years have a low citation rate compared to the other periods. Articles published in the year 2009 have received the most citations. Note that, nine articles of 2009 are placed in the list of the top 50 most cited articles of CSI.

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Table 5
Citing articles of CSI: Authors, universities and countries/regions.

R	Author	TP	University	TP	Country/ Region	TP
1	Chang CC	79	Chinese Academy of Sciences	172	PR China	3014
2	Khan MK	64	King Saud U	161	India	1655
3	Kumari S	56	Beijing U Posts Telecommunications	111	USA	1172
4	Das AK	55	Wuhan U	111	Taiwan	1143
5	Zaidan AA	49	CNRS France	110	Spain	1025
6	Albahri OS	47	Xidian U	103	South Korea	686
7	He DB	47	Chaoyang U Technology	102	England	676
8	Zaidan BB	45	Feng Chia U	100	Italy	562
9	Albahri AS	44	Asia U Taiwan	98	Saudi Arabia	532
10	Islam SKH	44	U Electronic Science Tech China	98	Iran	521
11	Kumar R	39	Vellore Institute of Technology	98	Australia	498
12	Piattini M	37	U Technology Malaysia	94	Malaysia	481
13	Chen CL	35	U Murcia	94	Pakistan	436
14	Kumar S	35	U Castilla La Mancha	92	Germany	415
15	Lee CC	35	Beihang U	82	France	384
16	Alamoodi AH	32	Comsats U Islamabad	78	Turkey	381
17	Mishra D	32	National Chung Hsing U	78	Canada	364
18	Chen JH	31	Shanghai Jiao Tong U	75	Brazil	337
19	Kumar N	31	U Carlos III Madrid	74	Japan	227
20	Yoo KY	31	National Taiwan U Science Technology	73	Portugal	214
21	Chaudhry SA	30	CNR Italy	70	Greece	204
22	Rahmani AM	30	U Malaya	70	Netherlands	200
23	Biswas GP	29	National Yang Ming Chiao Tung U	69	Poland	159
24	Fernández-Medina E	28	Zhejiang U	67	Iraq	143
25	Choo KKR	27	Melbourne Genomics Health Alliance	66	Sweden	139
26	Li CT	27	U Putra Malaysia	65	Finland	130
27	Susilo W	27	Kyungpook National U	63	U Arab Emirates	128
28	Chen TH	26	U Polytech Madrid	61	Mexico	123
29	Hwang MS	26	Central South U	60	Singapore	120
30	Wang XN	26	King Abdulaziz U	59	Egypt	118

Abbreviations: R = Rank; TP = Total papers.

Note that, nine articles of 2009 are placed in the list of the top 50 most cited articles of CSI.

To provide a general picture of the annual citation structure of CSI, Fig. 2 presents a box-whisker plot [52] structure of the citations of all papers published in CSI. Note that the figure uses box-whisker plots for the set of documents of each year providing the 25 % (quartile 1), 50 % (the median – quartile 2), and 75 % (quartile 3) most cited article, the interquartile range (quartile 1 – quartile 3), the maximum, the minimum, and the outliers. Note that the figure is adjusted to 160 citations, so the extreme outliers appear in red with the number of citations they have currently achieved (May 2024).

From Fig. 2, one may note that highly cited papers (>100 citations) were gathered during the period from 2004 to 2017. Articles from the last five years still need more time to consolidate a significant citation record. Documents from the eighties and nineties are usually less focused on the current mainstreams, so they do not receive many citations during the last years except for foundational papers.

Table 3 presents information on CSI in the JCR of the WoS [1] and Scopus [2]. Note that the table considers the number of citations that the journal is receiving each year (TC*), the impact factor, the 5-year impact factor, the immediacy index, the article influence score, and the ranking, percentile and quartile in a specific research category of WoS [53,1]. With Scopus the table considers the CiteScore, the best percentile and the best quartile among the categories that currently index CSI.

From Table 3, one may note that both the impact factor and 5-year impact factor of the CSI increased consistently during the last six years. CSI's impact factors improved significantly during the last five years. The AIS of the CSI is quite consistent from the year 2008. CSI has the highest AIS in the recent year 2022. Also, notice that it has the best three AIS achieved in the last three years. That means the quality and impact of its articles better in recent years compared to its previous performances. CSI's presence in the quartiles over the years in Hardware & Architecture (HA) and Software Engineering (SE) are also presented in Table 3. It gets a Q2 position in HA for the first time in the year 2009. It qualifies in Q1 in HA for the first time in the year 2022. In the subject area SE, it got Q2 position for the first time in the year 2008 and in 2019, it entered in Q1 rank for the first time. The best ranking of CSI in HA and SE category journals are 9/54 and 17/108 respectively, which it achieved in the year 2022.

Next, let us present a list of 40 top journals in computer science strongly to connected to CSI. Table 4 presents the publication record of these journals. The table considers a wide range of indicators including the total publications and citations, the cites per paper, the *h*-index, citation thresholds, the impact factor, the cite score, the years of origin, first year available in WoS and current number of highly cited papers according to the Essential Science Indicators (ESI) of the WoS. Note that the numbers provided in the table only consider "Articles" and "Reviews" up to 31 December 2023. To compare the performances of the leading journals in CS carefully for the recent years, Table 4 also provides information on publications and citations for the last ten years (2014 to 2023).

The journal *Expert Systems with Applications* has the greatest number of publications as well as citations. *Information Sciences* is in the second position according to the P10 and C10 indexes. The journal *Communications of the ACM* has performed the best in the C/P10 category. *IEEE Communications Magazine* has the best performance in the H10 category. *IEEE Communications Magazine* has published 172 papers between 2014 and 2023, which have at least 172 citations.

Another interesting issue is to analyze the citing articles of CSI to see who are citing more frequently the journal. Table 5 presents the leading authors, universities, and countries/regions based on citing articles to CSI.

Professor Chin-Chen Chang cited articles from CSI in 79 of his research publications and as a result he is leading the list of authors of citing articles from CSI. 11 authors have accredited articles of CSI in >40 publications. Chinese Academy of Sciences and King Saud University are the leading two institutions that have acknowledged articles of CSI in more than one hundred sixty publications. China's mainland leads the list of countries followed by India, the USA, Taiwan region, and Spain. All these five countries have cited articles of CSI in more than one thousand publications.

Table 6 presents the list of the leading journals according to citing articles to CSI. Note that this table shows the total results and the evolution through time with six five-year periods between 1994 and 2023, and one old decade (1984–1993).

IEEE Access is the leading journal in Table 6 as it cited articles of CSI in 552 research publications. CSI is in the second position as 533 publications of CSI have cited at least one article of its own (self-citations). Two journals, *Sensors* and *Multimedia Tools and Applications*, have cited articles of CSI in >250 research publications. Temporal data presented in Table 6, clearly shows that all the leading journals have shown more interest in cited articles of CSI in recent years. The next sub-section discusses the most cited papers published in the journal.

3.2. Influential papers in CSI

This sub-section highlights 50 research papers of the CSI which have

Table 6
Citing articles of CSI: journals.

R	Journal	TP	Q1	Q2	Q3	Q4	Q5	Q6	D1
1	IEEE Access	552	462	90	0	0	0	0	0
2	Computer Standards Interfaces	533	145	141	117	72	24	22	12
3	Sensors	285	205	64	15	1	0	0	0
4	Multimedia Tools and Applications	254	123	126	4	1	0	0	0
5	Wireless Personal Communications	192	81	88	21	2	0	0	0
6	Security and Communication Networks	180	59	91	28	2	0	0	0
7	Sustainability	142	135	7	0	0	0	0	0
8	Applied Sciences Basel	133	123	10	0	0	0	0	0
9	Expert Systems with Applications	127	31	33	58	5	0	0	0
10	International Journal of Communication Systems	117	46	52	17	2	0	0	0
11	IEEE Transactions on Instrumentation and Measurement	112	11	24	42	22	11	2	0
12	Journal of Systems and Software	106	35	23	37	8	3	0	0
13	Journal of Network and Computer Applications	105	39	34	29	3	0	0	0
14	Electronics	101	93	8	0	0	0	0	0
15	Future Generation Computer Systems	95	54	34	6	1	0	0	0
16	Computer Networks	89	49	26	9	3	2	0	0
17	Journal of Supercomputing	88	51	23	13	0	1	0	0
18	Information Sciences	86	29	20	26	11	0	0	0
19	Computers Security	85	39	20	17	9	0	0	0
20	Computer Communications	80	34	11	18	6	4	7	0
21	International Journal of Advanced Computer Science and Applications	79	45	28	6	0	0	0	0
22	Information and Software Technology	77	29	17	11	5	9	5	1
23	Computers Electrical Engineering	74	23	29	19	2	1	0	0
24	Journal of Information Security and Applications	74	53	20	1	0	0	0	0
25	International Journal of Distributed Sensor Networks	71	14	36	21	0	0	0	0
26	International Journal of Innovative Computing Information and Control	71	2	4	63	2	0	0	0
27	Journal of Medical Systems	70	11	28	30	1	0	0	0
28	Measurement	69	15	12	26	9	7	0	0
29	Journal of Internet Technology	63	27	20	16	0	0	0	0
30	Peer-to-Peer Networking and Applications	62	44	16	2	0	0	0	0

Abbreviations: Q1 = 2019–2023; Q2 = 2014–2018: Q3 = 2009–2013; Q4 = 2004–2008; Q5 = 1999–2003; Q6 = 1994–1998; D1 = 1984–1993.

received the highest number of citations according to WoS Core Collection. Table 7 presents details of the 50 most cited articles published in the CSI.

The review work, by Abbasi et al. [3], received the most citations among all papers published in the journal CSI so it leads the Table 7. This most cited article reviewed the necessity of wireless sensors in diverse aspects of agriculture. It has already received 383 citations with the best average of 38.30 citations per year. Chinosi and Trombetta [4] are in the second position in the list with 298 citations. It presents the Business Process Model and Notation (BPMN) standard, its application context, history, motivations, and main constructs based on a survey on BPMN practice and understanding. Around 30 years ago, Riedmiller [5] published a study based on adaptive learning strategies and procedures, very well recognized with 295 citations and achieved the third position in Table 7. Note that, it is the oldest document on the list. Tan et al. [54] is the most recent research paper that got a position on the list. Note that, it has the second-best average of 25 citations per year to get the 41st position in Table 7. Eight articles in Table 7 have >15 citations received per year and the top four among them have received >20 citations per year. The top eight articles in Table 7 have already been cited in >200 articles. There are nine papers in the list which are published in the year 2009. The year 2007 also performed well with six quality publications in the list. Review papers including systematic reviews and survey-based reviews performed well in the leading articles.

Table 8 presents the 50 documents most highly cited in CSI publications. Note that this table includes articles, books and book chapters.

The article entitled “New Directions in Cryptography” written by Diffie and Hellman [55] is cited in 33 publications in CSI, and it is the topper in Table 8. The oldest paper in the list was published in 1970, and it is placed in the 19th position, as it was cited in 10 publications in CSI. Three recent articles published in 2022 also got a position in Table 8 ranking 22nd, 28th, and 29th. There are five books, four book chapters, and forty-one articles in the top 50 cited documents in the CSI publications. Note that, Table 8 has 15 documents from IEEE journals. It has five articles from the *Communications of the ACM*. This result proves the close connection of the CSI with *Communications of the ACM* and IEEE journals.

3.3. Leading authors, institutions and countries

This subsection tries to find out those authors, institutions, and countries/regions, that have highly contributed and affiliated in publications of CSI. Table 9 presents the list of forty leading authors in CSI. It also presents information on the university and country associated with each author.

The ranking of the authors in Table 9 is prepared based on publication numbers in CSI. It also presents info on the leading authors' TC, *h*-index, C/P, and citation thresholds including more than or equal to 50, and 10 citations in CSI. David C. Yen from Texas Southern University (USA) leads the table of most contributing authors with 33 publications. Dr. Ahmed Patel from Ceará State University (Brazil) has the second-highest number of published articles in the CSI. Mario Piattini from the University of Castilla-La Mancha (Spain) has secured the third position in the list of top 40 most productive authors in CSI. Note that, at the 30th rank, six articles of Professor Maria J. Escalona at the University of Seville have a total of 332 citations, and this is why Prof. Escalona leads in the C/P category with a score of 55.33. Eleven authors have an average of >20 citations per paper. Institutions from several countries and regions (e.g., Taiwan, USA, Spain, and Italy) from different parts of the world are showing their important presence in Table 9. Note that four authors on the list work at the Scientific Research Council of Italy (CNR), and two authors at Chaoyang University of Technology, Tunghai University and University of Castilla La Mancha. 12 authors are in the region of Taiwan, seven in Italy, four in China's mainland and Spain, and three in the USA and South Korea.

Table 10 shows how the leading authors perform over the decades and who the best-performing authors are over time. The results also show the number of citations that the articles have received.

Table 10 shows that Kim from South Korea is the leading author in the first decade of CSI with 3 publications and 5 citations. Four more

Table 7
The 50 most cited documents of CSI.

R	TC	Title	Author/s	Year	C/Y
1	383	A review of wireless sensors and networks' applications in agriculture	Aqeel-ur-Rehman; Abbasi, AZ; Islam, N; Shaikh, ZA	2014	38.30
2	298	BPMN: An introduction to the standard	Chinosi, M; Trombetta, A	2012	24.83
3	295	Advanced supervised learning in multilayer perceptrons - from backpropagation to adaptive learning algorithms	Riedmiller, M	1994	9.83
4	263	A secure dynamic ID based remote user authentication scheme for multi-server environment	Liao, YP; Wang, SS	2009	17.53
5	250	An improved smart card based password authentication scheme with provable security	Xu, J; Zhu, WT; Feng, DG	2009	16.67
6	245	Mutual authentication protocol for RFID conforming to EPC Class 1 Generation 2 standards	Chien, HY; Chen, CH	2007	14.41
7	227	Improvement of the secure dynamic ID based remote user authentication scheme for multi-server environment	Hsiang, HC; Shih, WK	2009	15.13
8	209	Using a multi-criteria decision making approach to evaluate mobile phone alternatives	Isiklar, G; Büyüközkan, G	2007	12.29
9	189	Advanced smart card based password authentication protocol	Song, RG	2010	13.50
10	161	Agile Requirements Engineering: A systematic literature review	Schön, EM; Thomaschewski, J; Escalona, MJ	2017	23.00
11	158	A new robust reference watermarking scheme based on DWT-SVD	Bhatnagar, G; Raman, B	2009	10.53
12	157	Data hiding method using image interpolation	Jung, KH; Yoo, KY	2009	10.47
13	149	An effective image retrieval scheme using color, texture and shape features	Wang, XY; Yu, YJ; Yang, HY	2011	11.46
14	142	A flexible biometrics remote user authentication scheme	Lin, CH; Lai, YY	2004	7.10
15	126	Improving the robustness of DCT-based image watermarking against JPEG compression	Lin, SD; Shie, SC; Guo, JY	2010	9.00
16	125	A common criteria based security requirements engineering process for the development of secure information systems	Mellado, D; Fernández-Medina, E; Piattini, M	2007	7.35
17	120	Technology pillars in the architecture of future 5G mobile networks: NFV, MEC and SDN	Blanco, B; Fajardo, JO; Giannoulakis, I; Kafetzakis, E; Peng, SP; Pérez-Romero, J; Trajkovska, I; Nodashenas, PS; Goratti, L; Paolino, M; Sfakianakis, E; Liberal, F; Xilouris, G	2017	17.14
18	119	Improving the security of 'a flexible biometrics remote user authentication scheme'	Khan, MK; Zhang, JS	2007	7.00
19	113	Named Entity Recognition: Fallacies, challenges and opportunities	Marrero, M; Urbano, J; Sánchez-Cuadrado, S; Morato, J; Gómez-Berbís, JM	2013	10.27
20	107	Security of Chien et al.'s remote user authentication scheme using smart cards	Hsu, CL	2004	5.35
21	102	How to develop usability heuristics: A systematic literature review	Quiñones, D; Rusu, C	2017	14.57
22	101	Smart phone for mobile commerce	Chang, YF; Chen, CS; Zhou, H	2009	6.73
23	100	The antecedent factors on trust and commitment in supply chain relationships	Chen, JV; Yen, DC; Rajkumar, TM; Tomochko, NA	2011	7.69
24	100	A semi-blind digital watermarking scheme based on singular value decomposition	Shieh, JM; Lou, DC; Chang, MC	2006	5.56
25	99	Sharing visual multi-secrets using circle shares	Wu, HC; Chang, CC	2005	5.21
26	98	Cryptanalysis and improvement on two efficient remote user authentication scheme using smart cards	Wang, XM; Zhang, WF; Zhang, JS; Khan, MK	2007	5.76
27	96	A systematic review of security requirements engineering	Mellado, D; Blanco, C; Sánchez, LE; Fernández-Medina, E	2010	6.86
28	93	Consumer-based m-commerce: exploring consumer perception of mobile applications	Mahatanankoon, P; Wen, HJ; Lim, B	2005	4.89
29	91	Building automation systems: Concepts and technology review	Domingues, P; Carreira, P; Vieira, R; Kastner, W	2016	11.38
30	91	An AHP-based methodology to rank critical success factors of executive information systems	Salmeron, JL; Herrero, I	2005	4.79
31	89	Towards pre-standardization of trust and reputation models for distributed and heterogeneous systems	Mármol, FG; Pérez, GM	2010	6.36
32	88	Vehicle model recognition from frontal view image measurements	Psyllos, A; Anagnostopoulos, CN; Kayafas, E	2011	6.77
33	88	Efficient and provably-secure certificateless short signature scheme from bilinear pairings	Du, HZ; Wen, QY	2009	5.87
34	86	Performance evaluation of switched Ethernet for real-time industrial communications	Lee, KC; Lee, S	2002	3.91
35	85	A hybrid particle Swann optimization algorithm for optimal task assignment in distributed systems	Yin, PY; Yu, SS; Wang, PP; Wang, YT	2006	4.72
36	83	Denial-of-Service attacks and countermeasures in IEEE 802.11 wireless networks	Bicakci, K; Tavli, B	2009	5.53
37	83	A new provably secure authentication and key agreement protocol for SIP using ECC	Wu, LF; Zhang, YQ; Wang, FJ	2009	5.53
38	79	Applying standards to systematize learning analytics in serious games	Serrano-Laguna, A; Martínez-Ortiz, I; Haag, J; Regan, D; Johnson, A; Fernández-Manjón, B	2017	11.29
39	79	Improved remote authentication scheme with smart card	Lee, NY; Chiu, YC	2005	4.16
40	78	Four-parameter fitting of sine wave testing result: iteration and convergence	Bilau, TZ; Megyeri, T; Sárhegyi, A; Márkus, J; Kollár, I	2004	3.90

(*continued on next page*)

Table 7 (*continued*)

R	TC	Title	Author/s	Year	C/Y
41	75	A blockchain-empowered crowdsourcing system for 5G-enabled smart cities	Tan, L; Xiao, H; Yu, KP; Aloqaily, M; Jararweh, Y	2021	25.00
42	75	Research on Big Data - A systematic mapping study	Akoka, J; Comyn-Wattiau, I; Laoufi, N	2017	10.71
43	74	The impact of enterprise risk management on competitive advantage by moderating role of information technology	Saeidi, P; Saeidi, SP; Sofian, S; Saeidi, SP; Nilashi, M; Mardani, A	2019	14.80
44	74	A review on application of technology systems, standards and interfaces for agriculture and food sector	Suprem, A; Mahalik, N; Kim, K	2013	6.73
45	74	A practical verifiable multi-secret sharing scheme	Zhao, JJ; Zhang, JZ; Zhao, R	2007	4.35
46	73	A methodology to develop usability/user experience heuristics	Quiñones, D; Rusu, C; Rusu, V	2018	12.17
47	73	User acceptance of WAP services: test of competing theories	Hung, SY; Chang, CM	2005	3.84
48	72	Formal verification approaches and standards in the cloud computing: A comprehensive and systematic review	Souri, A; Navimipour, NJ; Rahmani, AM	2018	12.00
49	72	A hybrid public key infrastructure solution (HPKI) for HIPAA privacy/security regulations	Hu, JK; Chen, HH; Hou, TW	2010	5.14
50	71	The UML as a formal modeling notation	France, R; Evans, A; Lano, K; Rumpe, B	1998	2.73

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year.

authors also have three publications in CSI from 1984 to 1993. Professor Ahmed Patel from Ceará State University (Brazil) is leading the second quarter of CSI with 13 publications. Professor David C. Yen from the Texas Southern University (USA) has 7 publications and 154 citations. Professor Yen has a far better citation rate than the other leading authors in this period (1994–2003). Professor David C. Yen is the best performer in the third quarter of CSI with 18 publications and 373 citations. Four authors have 10 or >10 publications in CSI during this period (2004–2013). Distinguished Professor and IEEE Fellow in Computer Society, Dr. Willy Susilo from the University of Wollongong (Australia), has 15 publications in the last quarter of CSI and is leading this period. Professor Yen along with the other three authors has eight publications in this period (2014–2013). Temporal analysis confirms that the top two authors in Table 9 appear significantly in each of the last three decades' journey of CSI and highlights their presence in Table 10.

To deepen the analysis on an institutional basis, Table 11 presents the 50 most productive institutions among the CSI publications. Note that this table uses similar bibliometric indicators than Table 9. Additionally, it also shows the general university ranking according to Quacquarelli & Symonds (QS) and to the Academic Ranking of World Universities (ARWU). The objective is to see the general university ranking of the most productive universities in CSI.

National Yang-Ming Chiao Tung University, in the region of Taiwan, is the most productive institution with 32 publications. Another university from the region of Taiwan, National Chung Cheng University, has 29 publications in CSI, and it secures second position in Table 11. Note that, there is no single author in Table 9 from these two universities. This means, that different authors from these top two universities contributed to research publications in CSI. The Spanish institution University of Castilla-La Mancha is the most influential institution as its 26 articles in CSI are cited 655 times. An American institution, Miami University has the best score in the *h*-index category in Table 11. Nine publications of the Chinese Academy of Sciences have a total of 433 citations, and it leads the C/P category among the top 50 productive institutions in CSI. The top 50 productive institutions have contributed only twelve T50 papers. Several well-ranked universities of the world (as per ARWU and QS ranking) significantly contributed to the CSI publications and highlighted their presence in Table 11.

Table 12 presents the top contributing institutions in CSI over its journey for four decades: 1984–1993, 1994–2003, 2004–2013, and 2014–2023.

Table 12 shows that the National Institute of Standards and Technology (USA) is the leading institution in the first decade of CSI. The European research organization, the Fraunhofer-Gesellschaft is leading the second quarter of CSI with 19 publications. Miami University is the best performer during the third quarter of CSI with 20 publications. University of Wollongong (Australia) has 17 publications in the last quarter of CSI and is leading this period. Temporal analysis depicts that Asian institutions appear significantly in the third decade (2004–2013) of CSI. Also, note that different institutions from different parts of the world lead this journal over time. Moreover, note that 11 Spanish universities, nine from the Taiwan region, and eight from China's mainland, get positions in Table 12. Universities from different regions and various parts of the world contributed to the CSI publications. These prove the acceptance and presence of CSI all over the world.

To get a better insight into these results, we consider the geographical-wise publication output in CSI. A country/region here represents the institution where an author is affiliated at the time of publication. Table 13 presents the list of the most productive countries/regions in the journal.

The USA leads Table 13 as it is the most productive country/region for CSI. The USA has 277 publications in this journal. Spain, the region of Taiwan, and China's mainland, follow the USA and have 237, 227, and 207 publications, respectively. The region of Taiwan gets the greatest number of citations, and it leads in the TC, *h*-index, and ≥50, categories. Taiwan also leads in the C/P category if we consider only those regions that have at least 20 publications in CSI. Both China's mainland and Taiwan region have eight publications which are positioned into the top 50 research papers in the history of CSI. If we normalize the population of these regions Slovenia leads the publications per million population (P/Po) category. Expectedly, the region of Taiwan heavily leads in the citations per million population (C/Po) category.

Next, let us analyze the co-authorship network between the most productive countries. Recall that each country considers the publications of each author affiliated with an institution from this country. However, note that many authors working in a country may have a different nationality and may change country through time. Fig. 3 presents the results.

The results are equivalent to those presented in Table 13. The advantage of Fig. 3 is that it visualizes the connectivity between the most frequent country co-authors. The most representative co-authoring networks occur between China and the USA with 36 co-authored documents, followed by China and Australia with 17, and Spain and the United Kingdom with 15.

Table 14 depicts the annual number of papers classified by countries-regions in CSI. Results from Table 14 show how the participation of the top 40 countries-regions increases or decreases over time. The number of publications in the USA and the UK are declining over time. Spain, PR China, India, and Australia are increasing their presence in CSI over time. In Table 13, the top 12 countries have >50 publications in CSI. Year-wise data shows that PR China has performed far better than other regions in the last three years (2021, 2022, and 2023). There are six European countries-regions, four Asian countries-regions, Australia and

Table 8
Top 50 most cited documents in CSI publications.

Rank	Year	First author	Reference	Vol	Page	Type	TC
1	1976	Diffie W	IEEE T Inform Theory	v22	p644	A	33
2	1978	Rivest RL	Commun ACM	v21	p120	A	32
3	1985	Elgamal T	IEEE T Inform Theory	v31	p469	A	19
4	1980	Hill ID	Programming Language			B	19
5	1989	Davis FD	MIS Quart	v13	p319	A	16
6	2012	Pardo C	Comput Stand Inter	v34	p48	A	14
7	1984	Shamir A	Proc Workshop Theory		p47	BC	14
8	1987	Koblitz N	Math Comput	v48	p203	A	13
9	1981	Lamport L	Commun ACM	v24	p770	A	13
10	2021	Li YN	IEEE T Depend Secure	v18	p679	A	13
11	1987	Bolognesi T	Comput Networks Isdn	v14	p25	A	12
12	2000	Hwang MS	IEEE T Consum Electr	v46	p28	A	12
13	1979	Shamir A	Commun ACM	v22	p612	A	12
14	2007	Ateniese G	14th ACM Conf Comp Comm Security		p598	BC	11
15	2003	Boneh D	SIAM J Comput	v32	p586	A	11
16	2020	Chen RN	IEEE Internet Things	v7	p4143	A	11
17	2012	Wohlin C	Expt Software Eng			B	11
18	2015	Schneier B	Appl Cryptography			B	11
19	1970	Codd EF	Commun ACM	v13	p377	A	10
20	1983	Dolev D	IEEE T Inform Theory	v29	p198	A	10
21	1982	Lamport L	ACM T Progr Lang Sys	v4	p382	A	10
22	2022	Liu DZ	Comput Stand Inter	v79		A	10
23	2021	Ma X	Comput Stand Inter	v78		A	10
24	2001	Rivest RL	Adv Cryptology Asiac		p552	A	10
25	2009	Runeson P	Empir Softw Eng	v14	p131	A	10
26	2010	Atzori L	Comput Netw	v54	p2787	A	9
27	2007	Bethencourt J	P IEEE S Secur Priv		p321	BC	9
28	2022	Ge CP	IEEE T Depend Secure	v19	p2864	A	9
29	2022	Li YN	IEEE T Depend Secure	v19	p119	A	9
30	1976	Pin-Shan Chen P	ACM Trans Database Systems	v1	p9	A	9
31	2005	Sahai A	Lect Notes Comput Sc	v3494	p457	A	9
32	2000	Sun HM	IEEE T Consum Electr	v46	p958	A	9
33	2022	Tian GH	IEEE T Depend Secure	v19	p3941	A	9
34	2002	Akyildiz IF	Comput Netw	v38	p393	A	8
35	2002	Akyildiz IF	IEEE Commun Mag	v40	p102	A	8
36	1992	Bellovin SM	Proc IEEE Comp Soc Res Sec Privacy		p72	BC	8
37	1997	Bordegoni M	Comp Stand Inter	v18	p477	A	8
38	2014	Chen XF	IEEE T Parall Distr	v25	p3285	A	8
39	1997	Cox IJ	IEEE T Image Process	v6	p1673	A	8
40	1984	Doernberg J	IEEE J Solid-St Circ	v19	p820	A	8
41	1995	Gamma E	Design Patt Elem Reus Obj Orient Softw			B	8
42	2013	Garzás J	Comput Stand Inter	v35	p616	A	8
43	1993	Gruber TR	Knowl Acquis	v5	p199	A	8
44	2004	Hevner AR	MIS Quart	v28	p75	A	8
45	2000	Koblitz N	Design Code Cryptogr	v19	p173	A	8
46	1997	Menezes AJ	HDB Appl Cryptograph			B	8
47	2000	Steen MWA	Comput Stand Inter	v22	p165	A	8
48	2003	Al-Riyami SS	Lect Notes Comput Sc	v2894	p452	A	7
49	2010	Armbrust M	Commun ACM	v53	p50	A	7
50	2001	Berners-Lee T	Sci Am	v284	p34	A	7

Abbreviations: TC = Total citations; A = Article; B = Book; BC = Book chapter.

the US, in the top 12. The results show that there is significant participation of countries from different four continents of the world in CSI.

Next, we present Table 15 to generalize this result and see more specifically the contribution of the supranational regions in CSI. This table uses similar indicators as Table 13 including TP, TC, cites per paper, *h*-index, citation threshold, and paper and citations per million inhabitants.

As expected from the analysis of previous tables, the supranational region Europe has the highest number of publications in CSI followed by Asia and North America. Temporal analysis of the countries clearly shows that the presence of the Asian regions is increasing rapidly and if this trend persists then Asia will have more publications in CSI shortly. According to Table 15, Asia leads in the other major categories (TC, *h*-index, C/P, ≥100). Oceania leads in both population-based publications and citation categories (P/Pop and C/Pop).

4. Mapping CSI with the VOS viewer software

In this section, we construct graphical network visualizations with the help of the VOS viewer software [6]. For more information about this software, see the webpage https://www.vosviewer.com/ and the reference manual [56]. Network Graphs are generated using the value of weight and link strength. Node dimension is determined by its weight while connective edges with other nodes are traces based on link strength.

4.1. Co-citation analysis

Co-citation of journals occurs when two documents of two different journals receive a citation from the same third document [45]. Fig. 4 depicts the co-citation of journals in CSI. Please note that to construct this figure we have set the minimum citation threshold of 20 and 200 links. Note that all the figures in this section use the LinLog/modularity method for normalization [57–59]. Additionally, to generate the layout,

Table 9
Top 50 leading authors in CSI.

R	Author Name	University	Country/Region	TP	TC	H	C/P	≥50	≥10	T50
1	Yen DC	Texas Southern U	USA	33	675	15	20.45	3	21	1
2	Patel A	U Estadual Ceara	Brazil	30	180	7	6	0	7	0
3	Piattini M	U Castilla La Mancha	Spain	18	454	11	25.22	3	14	0
4	Valenzano A	CNR IEIIT	Italy	18	197	7	10.94	0	5	0
5	Susilo W	U Wollongong	Australia	16	164	8	10.25	0	8	0
6	Chang CC	Feng Chia U	Taiwan	13	316	8	24.31	2	7	0
7	Wang SC	Chaoyang U Technol	Taiwan	12	100	6	8.33	3	3	0
8	Yuan SM	Natl Chiao Tung U,	Taiwan	12	73	5	6.08	0	4	0
9	Chou DC	Eastern Michigan U	USA	10	294	8	29.4	2	8	0
10	Cena G	CNR Natl Res Council	Italy	10	125	5	12.5	0	3	0
11	Fernández-Medina E	U Castilla La Mancha	Spain	9	366	9	40.67	2	9	1
12	Cavalieri S	U Catania	Italy	9	137	5	15.22	0	4	0
13	Thuraisingham B	U Texas Dallas	USA	9	137	6	15.22	0	6	0
14	Chen TS	Tunghai U	Taiwan	9	131	6	14.56	0	6	0
15	Lee S	POSCON R&D Ctr	S. Korea	9	130	5	14.44	1	3	1
16	Yan KQ	Chaoyang U Technol	Taiwan	9	85	6	9.44	0	2	0
17	Bertolotti IC	CNR Natl Res Council	Italy	9	55	6	6.11	0	1	0
18	Vitturi S	U Padua	Italy	8	248	7	31	1	7	0
19	Chung YF	Tunghai U	Taiwan	8	126	6	15.75	0	6	0
20	Gungor VC	Abdullah Gul U	Turkey	8	119	7	14.88	0	4	0
21	Kim K	Gwangju Inst Sci & Technol	S. Korea	8	84	2	10.5	1	1	0
22	Wang XN	Changshu Inst Technol	PR China	8	62	6	7.75	0	3	0
23	Wang SJ	Cent Police U	Taiwan	8	60	4	7.5	0	2	0
24	Kapus-Kolar M	Jozef Stefan Inst	Slovenia	8	15	3	1.88	0	0	0
25	Hwang MS	Natl Cent U	Taiwan	7	155	6	22.14	0	6	0
26	Larrucea X	U Basque Country	Spain	7	114	7	16.29	0	5	0
27	Kim DS	Kumoh Natl Inst Technol	S. Korea	7	65	5	9.29	0	3	0
28	Chen KF	Hangzhou Normal U	PR China	7	49	5	7	0	2	0
29	Chang YS	Natl Taipei U	Taiwan	7	23	3	3.29	0	1	0
30	Escalona MJ	U Seville	Spain	6	332	6	55.33	3	6	0
31	Lou DC	Natl Def U Tahsi	Taiwan	6	324	6	54	4	5	0
32	Rusu C	Pontif U Cat Valparaiso	Chile	6	299	5	49.83	3	5	2
33	Huang KH	Natl Taiwan U	Taiwan	6	126	5	21	0	4	0
34	Daponte P	U Sannio	Italy	6	120	4	20	1	4	0
35	Yu Y	Shaanxi Normal U	PR China	6	115	5	19.17	1	4	0
36	O'Connor RV	Dublin City U	Ireland	6	114	6	19	0	4	0
37	Gritzalis S	U Aegean	Greece	6	82	5	13.67	0	4	0
38	Li CL	Beihang U	PR China	6	78	5	13	0	3	0
39	Durante L	CNR IEIIT	Italy	6	60	5	10	0	2	0
40	Liang WY	Natl Changhua U Educ	Taiwan	6	54	5	9	0	3	0

Abbreviations are available in the previous tables.

the algorithm of all the figures uses an attraction parameter of 4 and a repulsion of 1.

The most cited source is the *Lecture Notes in Computer Science* that has a score of 1836 citations, which confirms its strong influence in CSI. The second position is the self-citations of CSI. *Communications of the ACM* is the third most cited journal in CSI with 389 citations from CSI. *Information and Software Technology* and *Journal of Systems and Software* are the other two highly cited journals close to CSI, and their presence is highlighted in Fig. 4.

The blue cluster forms the core of the network, and it is led by the *Lecture Notes in Computer Science* and CSI. The green cluster has a focus on software and includes journals such as the *Information and Software Technology, Journal of Systems and Software*, and the *IEEE Transactions on Software Engineering*. The yellow cluster has a focus on information systems and includes *MIS Quarterly, Expert Systems with Applications, Information and Management*, and *Decision Support Systems*. The red cluster focuses on networks and communications and includes *IEEE Access, Computer Networks, IEEE Communications Magazine*, and *Future Generation Computer Systems*.

Table 16 presents the 40 most cited journals in CSI globally, and for the intervals of 1994–2003, 2004–2013, and 2014–2023, respectively. The main advantage of this table is that we can see exactly the number of citations of the most cited journals in CSI.

The journal *IEEE Transactions on Instrumentation and Measurement* has the highest citation count in CSI from 1994 to 2003. However, CSI and the *Communications of the ACM*, are also highly cited. The *Lecture Notes in Computer Science* is mostly prominent in the citations index during 2004–2013 and 2014–2023, followed by the self-citations of CSI. In 2004–2013, *Communications of the ACM* continues to be the third most cited journal while the *IEEE Transactions on Instrumentation and Measurement* decreases its influence going down to the fourth place. In 2014–2023, the *Lecture Notes in Computer Science* and CSI continue to be the most cited sources. However, in this period many other journals increase their influence including *Information and Software Technology, IEEE Access* and the *Journal of Systems & Software*.

Figs. 5 and 6 respectively present a co-citation of documents and authors in CSI. First, let us look to the co-citation of documents of Fig. 5 that considers a minimum citation threshold of five citations, the 200 strongest co-citation links, an attraction of 4 and a repulsion of 1.

The results of this figure follow the data of Table 8 where we have seen the 50 most cited documents among the publications of CSI. The figure visualizes how the most cited papers of CSI connect between each other in terms of co-citations. The two most cited documents of Table 8 are strongly co-cited in CSI [55,60]. Additionally, the documents of the figure are classified in 11 representative clusters.

Next, let us look to co-citation of authors. Fig. 6 presents the results considering a minimum citation threshold of 15, visualizing the 200 most frequent links, an attraction of 4 and a repulsion of 1.

Note that the most cited authors are connected to the cited documents. Dan Boneh (Standford University), Chin-Chen Chang (Feng Chia University) and Barbara Ann Kitchenham (Keele University), are the most cited authors among CSI publications. Note also that it is frequent in CSI to cite some general institution like the *International Organization for Standardization* (ISO), the IEEE or the *International Electrotechnical*

Table 10
Temporal evolution of the most productive authors.

R	Author	TP	TC	R	Author	TP	TC
1984–1993				1994–2003			
1	Kim K	3	5	1	Patel A	13	18
2	Berg JL	3	4	2	Yen DC	7	154
3	Halang WA	3	2	3	Valenzano A	6	44
4	Lang FH	3	1	4	Saxena PC	5	40
5	Radack SM	3	0	5	Schumny H	5	27
6	Burrows JH	2	2	6	Chang YS	5	22
7	Booth AW	2	1	7	Yuan SM	5	22
8	Barnard DT	2	0	8	Cena G	4	35
9	Ciminiera L	2	0	9	Bowman H	4	33
10	Dallaire GP	2	0	10	Cavalieri S	4	25
2004–2013				2014–2023			
1	Yen DC	18	373	1	Susilo W	15	153
2	Chang CC	11	284	2	Yen DC	8	148
3	Piattini M	10	363	3	Gungor VC	8	119
4	Wang SC	10	85	4	Patel A	8	97
5	Chen TS	9	131	5	Piattini M	8	91
6	Chung YF	8	126	6	Larrucea X	7	114
7	Patel A	8	64	7	Rusu C	6	299
8	Fernández-Medina E	7	338	8	O'Connor RV	6	113
9	Yan KQ	7	70	9	Zhang MW	6	48
10	Wang SJ	7	35	10	Espada JP	5	48
11	Lou DC	6	324	11	Kim DS	5	35
12	Vitturi S	6	183	12	Bertolotti IC	5	27
13	Huang KH	6	126	13	Boubeta-Puig J	4	89
14	Thuraisingham B	6	101	14	Choo KKR	4	81
15	Valenzano A	6	97	15	Criado J	4	57
16	Lee S	6	43	16	Baldassarre MT	4	55
17	Kapus-Kolar M	6	11	17	Crespo RG	4	40
18	Chou DC	5	114	18	Chen XF	4	38
19	Gritzalis S	5	46	19	Barros-Justo JL	4	31
20	Chen KF	5	40	20	Chen YH	4	12

Abbreviations are available in the previous tables.

Commission (IEC). The network of the figure is classified in five representative clusters (green, blue, red, yellow, and purple) and five smaller clusters (light blue, brown, pink, orange, and light pink).

4.2. Bibliographic coupling

Fig. 7 presents a network visualization of the bibliographic coupling of the most cited documents published in CSI. Recall that bibliographic coupling occurs when two documents cite the same third document [46]. All the figures in this section use the LinLog/modularity method for normalization [57–59].

There are six major clusters in Fig. 7, which are differentiated using different colors. Some documents from the years 2009 and 2007 show a bright presence in Fig. 7. Presence of the top three most cited documents: Abbasi et al. [3], Chinosi and Trombetta [4], and Riedmiller [5] are significant in the center of Fig. 7. Most of the Top 50 documents presented in Table 7 highlight their presence in the figure.

Fig. 8 depicts network visualization of the bibliographic coupling of authors published in CSI. Leading productive authors from Table 9 also show their significant presence in Fig. 8: Yen, Patel, Piattini, and Susilo. Note that in this figure (also Figs. 9 and 10), the colours indicate the average year of the publications of an author to see if the productivity of the author is concentrated during the last years or it is an older author. These results are in accordance with Tables 9 and 10.

Fig. 9 presents network visualization of the bibliographic coupling of institutions in CSI. Fig. 9 clearly shows that the top three contributing institutions: National Yang Ming Chiao Tung University, National Chung Cheng University, and Miami University, in CSI are closely connected with each other. Other productive institutions as per Table 11 are also glowing in Fig. 9.

When looking at the average year of publication of the institutions, we see that institutions with an older average year of publications are usually from North America or Europe. On the other side, most of the Asian institutions that appear in the figure have an average year of publications within the last two decades.

Fig. 10 shows the bibliographic coupling of countries-regions in CSI with a minimum publication threshold of five documents and visualizing the 100 strongest links. The top seven productive regions of Table 13 form the main core of the figure: the USA, Spain, Taiwan, PR China, England, Italy, and Germany. Note that the USA and England have their average year of publication much older than the rest of countries/regions. On the other side, Spain and China are currently emerging with a significant productivity during the last years.

4.3. Keyword and topical analysis

This subsection discusses the co-occurrence of author keywords [47] in CSI on an overall and temporal basis. Like Section 4.1., all the figures use the LinLog/modularity method for normalization [57–59] and an attraction of four and a repulsion of one in the generation of the layout. Fig. 11 highlights the co-occurrence of author keywords in CSI for its overall journey of 40 years considering a minimum occurrence threshold of five and visualizing the 200 strongest co-occurrence links. The figure also shows when a keyword appeared more frequently.

The keyword Security is mostly used by the authors if we consider all the publications in CSI. According to Table 17, the keyword Security is used in 66 different CSI publications. Other highly used keywords like Standardization, Standards, Interoperability, Authentication, Privacy, and Cryptography also show their bright presence in Fig. 11 coherent with Table 17. Table 17 also shows mostly used keywords by the authors during the time periods: 1994–2003, 2004–2013, and 2014–2023. Obviously, the data is in accordance with Fig. 11 where we can see, for example, that Standardization was frequently published in the nineties and Security in the last two decades.

Three keywords that are mostly used by the authors in CSI during the years 1994 to 2003 are Standardization, Programming languages, and Fieldbus. Security, Authentication, and Cryptography are the keywords mostly used by the authors in the time period 2004 to 2013. During the last decade (2014–2023), research works by the authors in CSI have mostly evolved on topics like Cloud computing, Security, and Blockchain [61,62]. Outcomes clearly give an outline about how quickly the focuses of the research ideas on computer applications change over time.

Figs. 12, 13, and 14 respectively depicted the co-occurrence of author keywords in CSI for supranational regions: North America, Europe, and East Asia. Fig. 12 presents the results for North America. Note that the threshold of occurrences for North America is two, while for Europe and East Asia is three because the productivity of these two regions is higher.

Authors from the North American region frequently use keywords like Standards, Object-oriented, Standardization, Interoperability, Cloud computing, Internet, Security, and Semantics.

According to Fig. 13, European authors focus on topics like Security, Standardization, Standards, Privacy, and Interoperability. Note that the colours of the figure that visualize the average year of publication of the keyword consider a range between 2000 and 2020, while in North America the range was between 1990 and 2010. The reason for this is that North America has been very productive in CSI during all its journey while most of the publications of Europe started later. Like the general picture (Fig. 11), Standardization was more popular 20–30 years ago while Security has become popular during the last two decades.

Fig. 14 presents the results for the publications of East Asia. Asian authors commonly focus on research topics like Security, Authentication, Cryptography, Cloud Computing, Blockchain, Privacy, Digital Signature, Smart Card, and Wireless Sensor Networks. Note that in this case, the year range for the average year of publication is between 2005 and 2020, indicating that most of the publications of East Asia in CSI are

Table 11
The most productive and influential institutions in CSI.

R	Institution	Country/Region	TP	TC	H	C/P	≥50	≥10	T50	QS	ARWU
1	National Yang Ming Chiao Tung U	Taiwan	32	288	11	9	0	15	0	217	401–500
2	National Chung Cheng U	Taiwan	29	607	13	20.93	3	17	0	901–950	–
3	Miami U	USA	28	650	14	23.21	4	17	2	1201–1400	–
4	CNR	Italy	27	406	10	15.04	1	11	0	–	–
5	U Castilla La Mancha	Spain	26	655	13	25.19	4	18	1	951–1000	601–700
6	Polytechnic U Turin	Italy	24	190	8	7.92	0	5	0	252	601–700
7	Chaoyang U Technology	Taiwan	23	524	11	22.78	1	11	0	1201–1400	–
8	Xidian U	China	22	333	10	15.14	2	10	1	–	401–500
9	U Wollongong	Australia	22	230	11	10.45	0	11	0	162	201–300
10	Tunghai U	Taiwan	21	375	10	17.86	1	10	1	1201–1400	–
11	U Malaga	Spain	21	203	9	9.67	0	9	0	–	801–900
12	U Sevilla	Spain	20	472	12	23.6	3	12	0	494	601–700
13	U Carlos III Madrid	Spain	20	412	11	20.6	2	13	1	319	901–1000
14	Jozef Stefan Institute	Slovenia	18	108	5	6	0	4	0	–	–
15	Slovenian Acad Sciences Arts	Slovenia	18	108	5	6	0	4	0	–	–
16	National Chung Hsing U	Taiwan	17	295	9	17.35	1	9	0	661–670	701–800
17	Inst Elect Eng Inform (IEIIT) CNR	Italy	17	279	8	16.41	1	7	0	–	–
18	U Politec Madrid	Spain	15	189	8	12.6	0	7	0	349	_601–700_
19	U College Dublin	Ireland	15	189	8	12.6	0	7	0	171	301–400
20	Physik Tech Bundes (PTB)	Germany	15	49	3	3.27	0	1	0	–	–
21	U Murcia	Spain	14	31	3	2.07	0	1	0	901–950	701–800
22	Shanghai Jiao Tong U	China	13	226	9	17.38	1	8	0	51	46
23	U Aegean	Greece	12	193	6	16.08	1	5	1	–	–
24	U Oviedo	Spain	12	142	7	11.83	0	5	0	1001–1200	601–700
25	U Catania	Italy	12	142	5	11.83	0	4	0	851–900	501–600
26	Polytech U Catalunya	Spain	11	266	8	24.18	1	6	0	354	701–800
27	King Saud U	Saudi Arabia	11	243	7	22.09	2	6	0	203	101–150
28	U Lisbon	Portugal	11	209	7	19	1	5	0	266	201–300
29	U Alacant	Spain	11	148	8	13.45	0	7	0	801–850	501–600
30	CNRS	France	11	113	7	10.27	0	5	0	–	–
31	Guilin U Electronic Tech	China	11	110	6	10	0	5	0	–	401–500
32	U Maribor	Slovenia	11	109	6	9.91	0	5	0	851–900	–
33	U Texas Dallas	USA	11	104	6	9.45	0	4	0	520	_501–600_
34	Rutherford Appleton Laborat	UK	11	56	2	5.09	0	1	0	–	–
35	National Cheng Kung U	Taiwan	10	392	8	39.2	5	8	0	228	301–400
36	National Defense U Taiwan	Taiwan	10	369	7	36.9	4	7	0	_-_	_-_
37	Korea U	South Korea	10	189	7	8.9	0	7	0	79	201–300
38	National Taiwan U	Taiwan	10	138	6	13.8	0	5	0	69	201–300
39	Kocaeli U	Turkey	10	120	6	12	0	4	0	_-_	_-_
40	U Alcala	Spain	10	93	6	9.3	0	4	0	538	901–1000
41	Xi An U Posts Telecom	China	10	84	6	8.4	0	5	0	–	–
42	Delft U Technology	Netherlands	10	59	5	5.9	0	2	0	47	151–200
43	U Wolverhampton	UK	10	16	2	1.6	0	0	0	1001–1200	–
44	Chinese Academy of Sciences	China	9	433	5	48.11	3	4	2	–	–
45	Eastern Michigan U	USA	9	293	8	32.56	2	8	0	–	–
46	Beijing U Posts Telecomm	China	9	289	5	32.11	2	3	2	851–900	601–700
47	U Electronic Science Tech China	China	9	275	9	30.56	1	9	0	486	101–150
48	Shaanxi Normal U	China	9	194	6	21.56	1	5	1	–	501–600
49	Feng Chia U	Taiwan	9	168	6	18.67	1	5	0	1201–1400	–
50	U Cadiz	Spain	9	153	6	17	0	6	0	–	901–1000

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

from the last 20 years. Due to this, Standardization does not appear as a significant keyword among the publications of East Asia.

Another interesting issue is to analyze the annual evolution of the most popular topics of CSI through time. For doing so, the study uses the *bibliometrix* software through the *biblioshiny* online platform [48]. Fig. 15 presents the trend topics of CSI considering the most frequent topic each year through the author keywords.

Security is the most remarkable topic with 66 occurrences that are scattered mainly between 2007 and 2015 with a median age of occurrence of 2015. Some other popular topics are Standard/s and Standardization with 53 and 40 occurrences, respectively. Standardization was more popular in the nineties while Standard/s has been used widely during the last 40 years. Interoperability, Authentication and Wireless Sensor Network/s are also very frequent keywords with 35, 34 and 33 occurrences, respectively.

Next, let us build a thematic map of CSI based on the author keywords. For doing so, we also use the *bibliometrix* software [48]. Fig. 16 presents a thematic map with the 250 most frequent author keywords and a minimum cluster frequency of five keywords to appear in the map. Each cluster shows a maximum of four author keywords that have occurred at least five times in CSI.

The figure shows 12 clusters: 3 big clusters (pink, green and light brown), four medium clusters (grey, light green, light blue and blue), and five small clusters (very light blue, light grey, light pink, purple, light orange). The pink cluster is the biggest one with 313 occurrences and focuses on Security, Authentication, Privacy and Cryptography. It is in a central position but with a positive degree of relevance and development. The green cluster has a frequency of 152 and focuses on Standard/s, Interoperability, Object-Oriented and Conformance Testing. It has a high degree of relevance indicating that it is a basic theme in CSI. The light brown cluster includes keywords connected to Ontology, Reference Model of Open Distributed Processing (RM-ODP), Distributed Systems and Common Object Request Broker Architecture (CORBA). The frequency count of this cluster is 124. The grey and light green clusters are less relevant but have a keyword frequency of 79 and 73, respectively.

Table 12
Temporal evolution of the most productive institutions.

R 1984–1993	Institution	TP	TC	R 1994–2003	Institution	TP	TC
1	Nat Inst Stand Tech USA	12	3	1	Fraunhofer Gesellschaft	19	39
2	U Wolverhampton	8	7	2	Fra Inst Cent Schloss Birlinghoven	17	21
3	Texas Instruments	6	2	3	National Yang Ming Chiao Tung U	13	94
4	U London	5	5	4	U College Dublin	12	18
5	CNR Italy	5	2	5	Physik Tech Bundesanstalt	8	25
6	Boeing	4	5	6	Miami U	7	154
7	Honeywell	4	2	7	National Chung Cheng U	6	59
8	Polytechnic U Turin	4	0	8	Sci Tech Facilit Council STFC UK	6	54
9	Sci Techy Facilit Council STFC UK	4	0	9	Jozef Stefan Institute	6	46
10	Rutherford Appleton Laboratory	4	0	10	Polytechnic U Turin	6	44
2004–2013				2014–2023			
1	Miami U	20	494	1	U Wollongong	17	170
2	National Chung Cheng U	19	483	2	Xidian U	16	134
3	Chaoyang U Technology	17	424	3	U Castilla La Mancha	13	146
4	Tunghai U	17	367	4	Guilin U Electronic Technology	11	110
5	National Chung Hsing U	16	293	5	U Politecnica De Madrid	11	109
6	National Yang Ming Chiao Tung U	14	167	6	U Sevilla	10	386
7	U Castilla La Mancha	13	509	7	U Carlos III Madrid	10	108
8	CNR Italy	12	216	8	Xi An U Posts Telecomm	10	83
9	Shanghai Jiao Tong U	11	215	9	U Malaga	9	153
10	IEIIT CNR Italy	11	213	10	U Cadiz	9	126
11	U Carlos III Madrid	10	304	11	U Oviedo	9	126
12	Jozef Stefan Institute	10	61	12	Abdullah Gul U	9	91
13	Slovenian Acad Sci Arts	10	61	13	Peng Cheng Laboratory	9	56
14	U Malaga	10	56	14	U Alcala	8	76
15	National Cheng Kung U	9	371	15	Pontificia U Catolica Valparaiso	7	309
16	National Defense U Taiwan	9	347	16	King Saud U	7	232
17	U Aegean	9	143	17	Islamic Azad U	7	162
18	Korea U	8	176	18	Shaanxi Normal U	7	102
19	Feng Chia U	8	162	19	Kumoh National U Technology	7	66
20	National Taiwan U	8	137	20	Polytechnic U Turin	7	41

Abbreviations are available in the previous tables.

Another interesting approach to visualize the keyword and topical structure of CSI is by using the word cloud representation [63,64]. Fig. 17 presents the word cloud of CSI by using the *bibliometrix* software [48]. Note that the figure shows the 50 most frequent author keywords of CSI.

The results are in accordance with the previous figures (Figs. 11–16) where Security, Standard/s and Standardization are the most frequent author keywords of CSI. As mentioned before, some other significant topics in CSI are Interoperability, Wireless Sensor Network/s, Authentication, Cryptography, Privacy, Cloud Computing and Programming Languages.

To deepen the analysis of keywords, let us develop a topical analysis that groups the keywords into general topics. These data are collected through the SciVal platform from Scopus [65]. Note that currently, SciVal only provides information for a maximum period of 10 years. In any case, it is a good approach to get an overview of the leading topics of the journal. Table 18 presents the leading topics in CSI between 2013 and 2022 considering the TP, the field-weighted citation impact (FWCI) [66] and the prominence percentile [67]. The ranking is according to TP and in the case of a tie, according to the prominence percentile.

According to Table 18, CSI has 10 publications on the topic 'Human Computer Interaction; Usability Evaluation; Information System' between 2013 and 2022. These 10 publications have a score of 3.75 in FWCI and are placed in the top 6 % of worldwide prominent publications in its field. The topic 'Software Process; Process Engineering; Ontology' has nine publications and is in the second position in Table 18. Five publications on the topic 'Irrigation System; Wireless Sensor Network; Internet of Things' have the highest score 7.94 on the FWCI index. Note that this topic is placed in the 99.66 percentile which indicates that it is not only popular in the journal but also from a general point of view considering all the journals indexed in Scopus [68]. Note that this proves the growing popularity of the internet of things in the scientific community [69–71].

Four CSI publications on the topics 'Data Privacy; Health Care; and Blockchain' have performed excellently to secure their position in 99.938 percentiles. Four CSI publications on the topic 'Big Data; Decision-Making; Data Analytics' also get high citations to place in the 99th percentiles. Note also that most of the topics has a FWCI above one which indicates that the articles of CSI on these topics are usually cited above the average of citations that these topics achieve in other journals indexed in Scopus.

Next, let us investigate the topic clusters that group several topics into a general topic cluster. Table 19 presents the results considering the same indicators and ranking criteria than in Table 18.

As per Table 19, the topic cluster 'Software Engineering; Open Source Software; Information System' has the most 61 research papers in CSI from 2013 to 2022. The journal publishes 35 research papers on the topic cluster 'Authentication; Network Security; Cloud Computing' and 31 research papers on 'Cloud Computing; Data Center; Network Security'. Seven publications on the topic cluster 'Authentication; Network Security; Cloud Computing' has received the best FWCI score.

On the other hand, the high acknowledgment rate of the six publications on the topic cluster 'Image Segmentation; Deep Neural Network; Object Detection' is put it in 99.97 percentile showing the growing popularity of deep learning methods [72]. Significantly higher citation receiving rate of the publication on the topic clusters 'Sentiment Analysis; Natural Language Processing; Machine Learning' and 'Blockchain; Smart Contract; Authentication' have positioned them in the 99th percentile. From a general point of view and like Table 18, the FWCI of most of the topic clusters in CSI is above one. This implies that the papers published in CSI are getting more citations than the average of citations of these topic clusters in other journals indexed in Scopus. This is a clear indication that documents published in CSI are achieving a very significant impact in the academic community.

Table 13
The most productive and influential countries-regions in CSI.

R	Country/Region	TP	TC	H	C/P	≥50	≥10	T50	Population	P/Po	C/Po
1	USA	277	2575	27	9.3	10	80	5	331,000,000	0.84	7.78
2	Spain	237	3902	30	16.46	15	122	7	47,350,000	5.01	82.41
3	Taiwan	227	4640	33	20.44	23	116	8	23,580,000	9.63	196.78
4	PR China	207	3343	29	16.15	14	91	8	1441,000,000	0.14	2.32
5	UK	164	1030	18	6.28	4	26	2	67,220,000	2.44	15.32
6	Italy	126	1962	22	15.57	7	51	1	60,360,000	2.09	32.50
7	Germany	108	1217	18	11.27	6	22	3	83,130,000	1.30	14.64
8	South Korea	91	1276	19	14.02	5	35	3	51,780,000	1.76	24.64
9	Turkey	68	72	19	15.19	3	33	2	85,000,000	0.80	0.85
10	France	63	731	13	11.6	3	18	1	65,270,000	0.97	11.20
11	India	61	915	16	15	4	26	1	1393,409,038	0.04	0.66
12	Australia	61	866	15	14.2	5	31	1	25,690,000	2.37	33.71
13	Canada	48	496	9	10.33	1	9	1	38,010,000	1.26	13.05
14	Greece	38	649	13	17.08	3	20	2	10,420,000	3.65	62.28
15	Brazil	36	399	12	11.08	1	14	0	212,600,000	0.17	1.88
16	Japan	35	351	10	10.03	2	10	1	125,800,000	0.28	2.79
17	Slovenia	33	247	10	7.48	0	10	0	2078,000	15.88	118.86
18	Ireland	32	226	10	7.06	0	11	0	4977,000	6.43	45.41
19	Netherlands	31	157	7	5.06	0	6	0	17,480,000	1.77	8.98
20	Switzerland	27	263	8	9.74	1	7	0	8655,000	3.12	30.39
21	Malaysia	26	423	9	16.27	4	9	1	32,366,000	0.80	13.07
22	Portugal	25	385	10	15.4	1	11	1	10,310,000	2.42	37.34
23	Saudi Arabia	20	325	8	16.25	3	8	0	34,810,000	0.57	9.34
24	Poland	19	159	8	8.37	0	5	0	38,260,000	0.50	4.16
25	Pakistan	17	641	10	37.71	2	11	1	220,892,340	0.08	2.90
26	Czech Republic	17	54	5	3.18	0	1	0	10,710,000	1.31	5.04
27	Iran	16	283	9	17.69	1	8	1	83,990,000	0.19	3.37
28	Tunisia	16	209	7	13.06	1	5	0	11,820,000	1.35	17.68
29	Austria	16	155	4	9.69	1	3	1	8901,000	1.80	17.41
30	Chile	14	353	8	25.21	3	6	2	19,240,000	0.73	18.35
31	Sweden	14	81	5	5.79	0	4	0	10,450,000	1.34	7.75
32	Singapore	14	76	5	5.43	0	3	0	5703,600	2.45	13.32
33	Norway	13	135	6	10.38	0	4	0	5391,000	2.41	25.04
34	Mexico	13	107	8	8.23	0	4	0	126,200,000	0.10	0.85
35	Belgium	13	52	4	4	0	2	0	11,590,000	1.12	4.49
36	U Arab Emirates	11	188	7	17.09	1	5	1	9890,402	1.11	19.01
37	Denmark	10	47	4	4.7	0	2	0	5677,000	1.76	8.28
38	Colombia	9	234	7	26	2	6	0	55,400,000	0.16	4.22
39	Jordan	9	114	5	12.67	1	2	1	10,203,000	0.88	11.17
40	Algeria	9	109	4	12.11	1	2	0	43,851,000	0.21	2.49
41	Romania	9	67	5	7.44	0	2	0	19,129,000	0.47	3.50
42	Finland	9	47	3	5.22	0	1	0	5531,000	1.63	8.50
43	Hungary	8	96	3	12	1	1	1	9708,000	0.82	9.89
44	Argentina	7	55	5	7.86	0	2	0	45,195,774	0.15	1.22
45	Iraq	5	198	5	39.6	2	5	1	40,220,000	0.12	4.92
46	Israel	5	103	4	20.6	0	4	0	9350,000	0.53	11.02
47	Luxembourg	5	59	3	11.8	0	2	0	645,397	7.75	91.42
48	Russia	5	43	3	8.6	0	2	0	146,000,000	0.03	0.29
49	Vietnam	5	43	3	8.6	0	1	0	97,338,579	0.05	0.44
50	Kuwait	5	11	2	2.2	0	0	0	4271,000	1.17	2.58

Abbreviations are available in the previous tables.

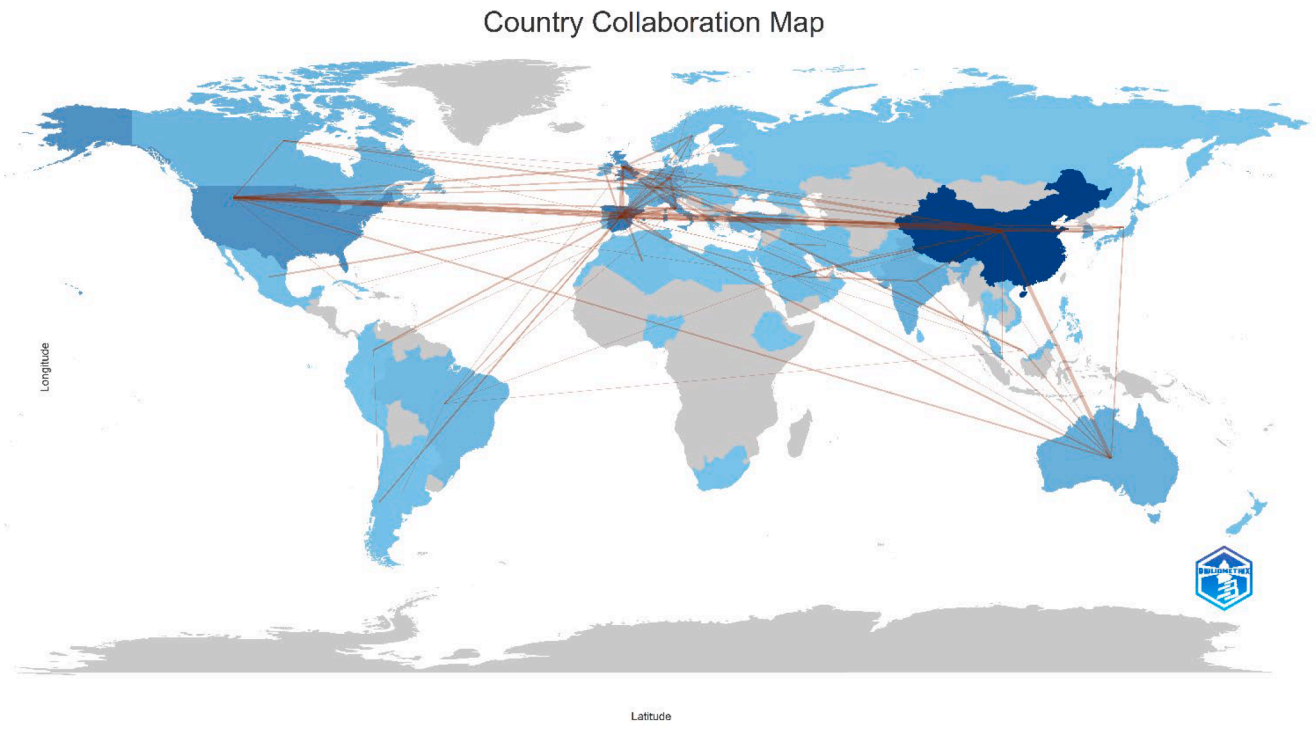

Fig. 3. Country co-authorship map with *bibliometrix* software [48].

5. Conclusions

This section summarizes the main conclusions of the article. First, it provides a general overview of the main results and findings. Second, it analyzes the main limitations of this bibliometric approach. Third, it briefly provides some practical implications and open questions for future research.

5.1. General discussion

This retrospective bibliometric study looks back at the forty years' colorful journey of the CSI journal since its inception in1982. During this journey, CSI has published many exceptional research works to cement its reputation in subject areas like computer applications, standards, data management, software development, and information systems. In 2023, this SCI-indexed journal got an impact factor of 4.1 from the SCIE and a CiteScore of 11.9 from the Scopus. This study has assessed data of the CSI publications from the WoS and Scopus databases and analyzed this information using quantitative and qualitative measures. This revealed interesting features of the CSI and its nature of publications. Some noteworthy conclusions are worth highlighting in what follows.

There are several periods of ups and downs in the yearly publication pattern of the CSI. But overall, the decade-wise count of publications has increased significantly, particularly in the last two decades. The journal shows the highest and the lowest publishing levels in 2009 and 1989 respectively. It published 2001 articles up to 31st December 2023, receiving a total of 24,139 citations at an average of 12.06 citations per paper. Twenty-four CSI publications have crossed the threshold of 100 citations and eight among those have crossed the 200 citations threshold. The research work published in the year 2014 entitled "A review of wireless sensors and networks' applications in agriculture" is the most cited CSI article.

Professor David C. Yen from the Texas Southern University is the most productive author. National Yang Ming Chiao Tung University is the most productive institution in the CSI. Publications from the University of Castilla La Mancha have received the greatest number of citations while Miami University performs the best score in the *h*-index category. The USA leads in the TP while the region of Taiwan leads in all other major categories like TC, *h*-index, and $\geq$50. Although Europe has the highest number of publications, Asia leads in the other major categories (TC, *h*-index, C/P, $\geq$100). The research profile of the CSI confirms the global participation of researchers from different parts of the world. This worldwide reach of the journal illustrates its strong reputation as a leading publication outlet in this field. An interesting result seen in this work is how the journal has evolved from having publications mostly from English-speaking countries to a more diversified journal with articles from all over the World. Particularly, in the last years, Spain and China are becoming the most productive countries/regions of CSI.

To provide a deeper analysis of the bibliographic information, this work has developed a graphical mapping of the data by using the VOS

Table 14
Annual number of papers classified by countries-regions.

R	Country/Region	Total	D1	D2	D3	D4	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	USA	277	100	60	73	44	3	14	1	11	2	8	1	13	8	12	7	10	4	10	7	3	1	1	0	1
2	Spain	237	0	7	77	153	0	5	2	4	7	14	7	7	9	22	21	12	21	26	19	21	12	6	8	7
3	Taiwan	227	1	26	145	55	28	19	7	13	10	38	5	8	6	11	11	9	10	5	5	7	1	2	2	3
4	PR China	207	8	5	71	123	4	5	5	13	4	21	0	5	7	7	8	4	8	14	6	2	0	21	28	32
5	UK	167	56	53	27	31	0	4	3	3	3	3	0	2	2	0	5	5	5	6	3	2	0	2	2	1
6	Italy	126	15	34	46	31	4	2	3	4	3	5	4	8	6	7	1	3	8	5	2	5	3	1	3	0
7	South Korea	91	0	9	47	33	5	5	2	9	5	13	2	3	2	1	4	6	5	11	2	3	1	1	0	0
8	Germany	90	24	48	15	21	0	2	5	1	2	0	0	1	1	0	3	1	2	5	0	4	3	1	1	1
9	Turkey	72	2	0	21	49	1	0	1	2	3	6	0	2	3	3	2	5	3	7	5	12	3	3	5	4
10	France	63	17	8	14	24	1	3	0	2	1	3	1	2	1	0	1	1	7	4	2	1	2	0	4	2
11	India	61	2	5	14	40	1	1	1	1	0	7	1	0	0	2	1	1	3	6	3	6	1	7	7	5
12	Australia	61	3	7	13	38	0	1	0	0	2	4	1	0	1	4	2	6	3	0	3	1	0	5	8	5
13	Canada	48	19	11	7	11	0	0	1	1	0	0	2	1	0	2	0	1	2	2	0	2	0	2	2	0
14	Greece	38	3	10	18	7	2	4	0	2	2	2	3	3	0	0	1	1	0	3	1	1	0	0	0	0
15	Brazil	36	1	1	10	24	0	0	0	0	0	3	0	1	2	4	1	2	6	2	3	4	3	0	2	1
16	Japan	35	8	6	11	10	0	2	0	1	0	4	2	2	0	0	0	0	3	1	1	1	0	2	1	1
17	Slovenia	33	0	7	21	5	2	2	1	3	1	8	0	1	1	2	0	0	2	1	0	2	0	0	0	0
18	Ireland	32	1	13	6	12	1	0	0	0	0	0	0	1	0	2	0	1	2	3	3	3	0	0	0	0
19	Netherlands	31	11	9	6	5	0	1	0	1	1	2	0	0	1	0	0	1	0	2	1	0	1	0	0	0
20	Switzerland	27	12	5	5	5	0	1	0	0	1	0	1	0	1	1	1	1	0	2	0	0	0	0	1	0
21	Malaysia	26	0	0	11	15	0	0	0	3	3	1	0	2	2	0	2	2	0	1	0	5	2	1	2	0
22	Portugal	25	0	5	9	11	1	0	2	0	1	0	2	2	1	0	1	1	2	3	1	1	0	1	1	0
23	Saudi Arabia	20	3	2	2	13	0	0	0	0	0	1	0	0	1	0	0	0	1	2	0	0	3	4	3	0
24	Poland	19	0	7	7	5	0	1	0	0	0	1	0	2	2	1	0	0	0	1	2	0	0	0	0	2
25	Pakistan	17	0	0	3	14	0	0	1	0	0	0	0	0	0	2	1	2	1	1	1	3	0	4	1	0
26	Czech Republic	17	1	2	9	5	2	3	0	0	0	0	1	1	1	1	1	0	0	1	2	1	0	0	0	0
27	Iran	16	0	0	3	13	0	2	0	0	1	0	1	0	1	0	0	3	0	1	3	2	1	0	2	1
28	Tunisia	16	0	1	7	8	1	2	1	1	0	0	0	0	2	0	1	0	1	1	2	1	1	0	1	0
29	Austria	16	1	5	5	5	0	0	1	1	1	0	0	0	1	1	1	0	1	5	1	0	0	1	0	1
30	Chile	14	0	0	1	13	0	0	0	0	0	0	0	1	0	0	0	0	2	3	2	5	0	0	0	1
31	Sweden	14	2	2	4	6	0	0	1	0	1	1	1	0	0	0	0	0	0	3	0	0	0	2	0	1
32	Singapore	14	4	4	4	2	1	0	1	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	1
33	Norway	13	1	1	3	8	0	1	0	0	0	0	0	0	2	0	0	0	1	1	1	0	3	0	0	2
34	Mexico	13	0	0	4	9	0	0	0	1	0	1	0	1	0	1	0	1	1	1	2	2	2	1	0	0
35	Belgium	13	3	3	0	7	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	1	0	1	1	0
36	U Arab Emirates	11	0	1	4	6	1	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1	2	0	1
37	Denmark	10	4	2	3	1	0	0	0	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
38	Colombia	9	0	0	2	7	0	0	0	0	0	0	0	0	1	1	0	0	1	1	2	1	1	0	1	0
39	Jordan	9	0	2	4	3	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	2	0	1	0	0
40	Algeria	9	0	0	2	7	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	1	2	2

Abbreviations: D1 = 1982–1993; D2 = 1994–2003; D3 = 2004–2013; D4 = 2014–2023; 04–23 = Annual number of papers published between 2004 and 2023.

Table 15
Publication structure classified by supranational regions.

R	Region	TP	TC	H	C/P	≥100	Population	P/Pop	C/Pop
1	Europe	894	9346	42	10.45	6	750,000,000	1.19	12.46
2	Asia	766	12,618	52	16.47	16	4700,000,000	0.16	2.68
3	North America	321	3031	30	9.44	3	380,626,560	0.84	7.97
4	Latin America	80	1115	17	13.94	1	660,000,000	0.12	1.69
5	Oceania	65	898	15	13.82	0	31,000,000	2.10	28.96
6	Africa	36	466	11	12.94	0	1400,000,000	0.03	0.33

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

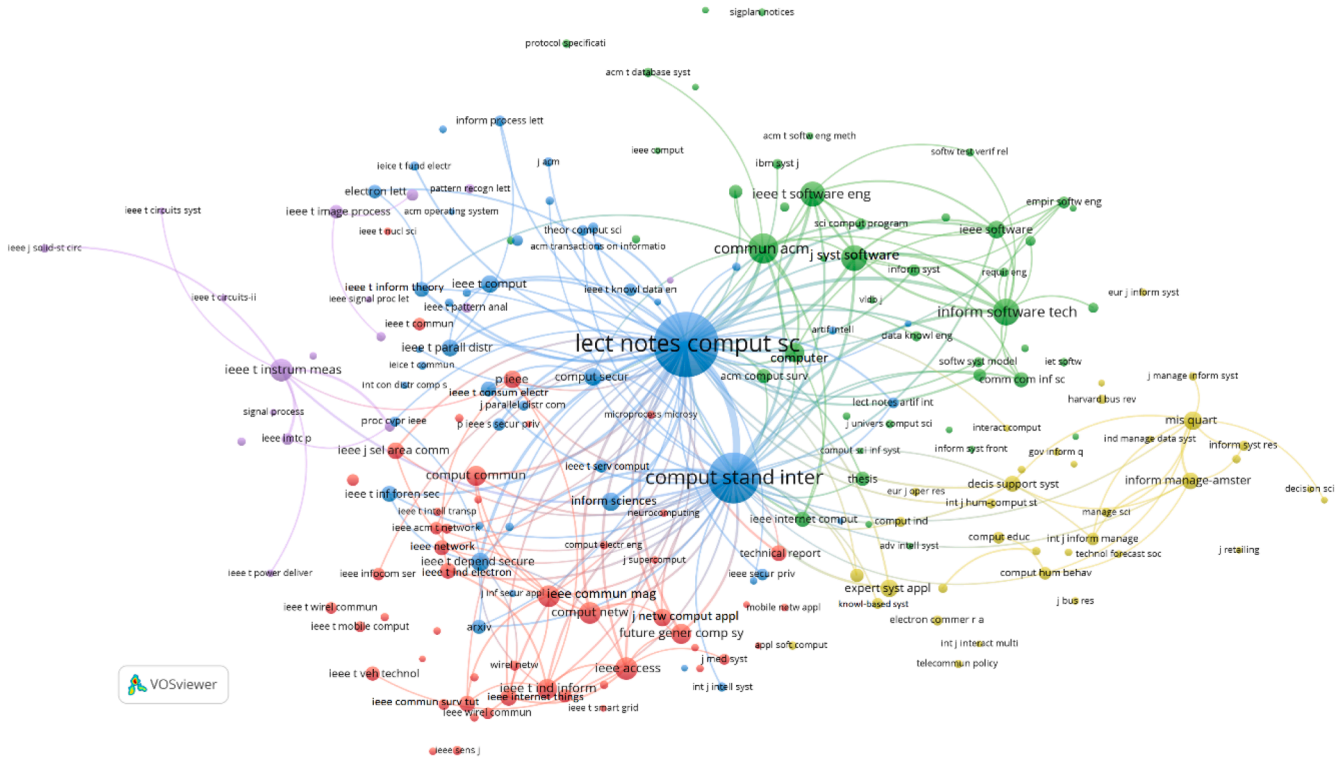

Fig. 4. Co-citation of journals in CSI: minimum citation threshold of 20 and 200 links.

Table 16
Most cited journals in CSI: Global and temporal analysis.

	Global		2014–2023		2004–2013		1994–2003	
R	Journal	Cit	Journal	Cit	Journal	Cit	Journal	Cit
1	Lect Notes Comput Sc	1836	Lect Notes Comput Sc	1220	Lect Notes Comput Sc	578	IEEE T Instrum Meas	75
2	Comput Stand Inter	1121	Comput Stand Inter	785	Comput Stand Inter	322	Comp Stand Inter	54
3	Commun ACM	389	Inform Software Tech	283	Commun ACM	163	Commun ACM	49
4	Inform Software Tech	318	IEEE Access	224	IEEE T Instrum Meas	142	Programming Language	35
5	J Syst Software	297	J Syst Software	220	Comput Commun	81	Comput Networks Isdn	31
6	IEEE T Software Eng	269	Future Gener Comp Sy	170	Comput Netw	75	IEEE T Software Eng	30
7	IEEE T Instrum Meas	226	IEEE T Ind Inform	166	IEEE T Consum Electr	75	IEEE J Solid-St Circ	28
8	IEEE Access	224	IEEE T Software Eng	150	Electron Lett	68	Lect Notes Comput Sc	28
9	Comput Netw	207	IEEE T Depend Secure	139	Comput Secur	67	Computer	27
10	IEEE Commun Mag	202	Inform Sciences	131	IEEE T Inform Theory	65	IEEE T Comput	23
11	Future Gener Comp Sy	185	Comput Netw	125	J Syst Software	65	IEEE T Parall Distr	23
12	IEEE T Ind Inform	183	IEEE Commun Mag	123	IEEE Commun Mag	64	Computers Standards	22
13	Comput Commun	180	J Netw Comput Appl	122	MIS Quart	64	ACM T Comput Syst	21
14	Computer	170	IEEE Internet Things	120	IEEE T Software Eng	63	IEEE J Sel Area Comm	21
15	MIS Quart	156	Commun ACM	118	IEEE T Image Process	58	Information Technolo	18
16	Inform Sciences	154	Expert Syst Appl	106	Computer	56	Inform Process Lett	16
17	IEEE T Depend Secure	147	IEEE Commun Surv Tut	104	P IEEE	55	Comput Commun	15
18	J Netw Comput Appl	140	IEEE T Inf Foren Sec	101	Inform Manage-Amster	51	Electron Lett	15
19	Comput Secur	138	Comm Com Inf Sc	92	IEEE J Sel Area Comm	50	IEEE Imtc P	15
20	IEEE Software	138	MIS Quart	91	IEEE T Comput	46	IEEE T Circuits Syst	14
21	P IEEE	136	IEEE Software	90	IEEE T Ind Electron	46	Formal Description T	13
22	IEEE T Comput	135	Comput Commun	83	Pattern Recogn	43	IEEE Internet Comput	13
23	Expert Syst Appl	132	IEEE T Parall Distr	81	Decis Support Syst	41	IEEE Commun Mag	12
24	IEEE T Parall Distr	131	IEEE T Veh Technol	81	IEEE Imtc P	41	J Parallel Distr Com	12
25	IEEE J Sel Area Comm	130	Decis Support Syst	78	IEEE Internet Comput	39	P IEEE	12
26	Inform Manage-Amster	122	Procedia Comput Sci	77	IEEE ACM T Network	34	IEEE T Ind Electron	11
27	IEEE Internet Things	120	Computer	75	IEICE T Fund Electr	34	Sigplan Notices	11
28	Decis Support Syst	119	Sensors-Basel	74	Measurement	33	IEEE T Inform Theory	10
29	IEEE T Ind Electron	113	IEEE T Serv Comput	73	Inform Software Tech	32	Protocol Specificati	10
30	IEEE T Inf Foren Sec	111	Inform Manage-Amster	71	IEEE Software	31	Software Pract Exper	10
31	IEEE Commun Surv Tut	108	IEEE Network	70	Inform Process Lett	30	Computer World	9
32	IEEE T Inform Theory	105	Comput Secur	68	IEEE T Knowl Data En	29	IEEE Software	9
33	Comput Networks ISDN	102	Lect Notes Bus Inf P	68	Appl Math Comput	27	J Syst Software	9
34	IEEE Internet Comput	102	ACM Comput Surv	67	IEEE T Parall Distr	27	IEEE Network	8
35	Comm Com Inf Sc	99	Comput Hum Behav	63	Comput Networks Isdn	26	IEEE T Commun	8
36	IEEE Network	99	Empir Softw Eng	62	IEEE Commun Lett	26	Theor Comput Sci	8
37	IEEE T Consum Electr	98	P IEEE S Secur Priv	57	IEEE T Pattern Anal	26	Artif Intell	7
38	ACM Comput Surv	96	IEEE J Sel Area Comm	56	IEICE T Commun	26	Comput Netw	7
39	IEEE T Veh Technol	91	IEEE T Ind Electron	56	Expert Syst Appl	25	IBM Syst J	7
40	Electron Lett	85	P IEEE	56	Pattern Recogn Lett	25	IEEE T Knowl Data En	7

Abbreviations: R = Rank; Cit = Citations.

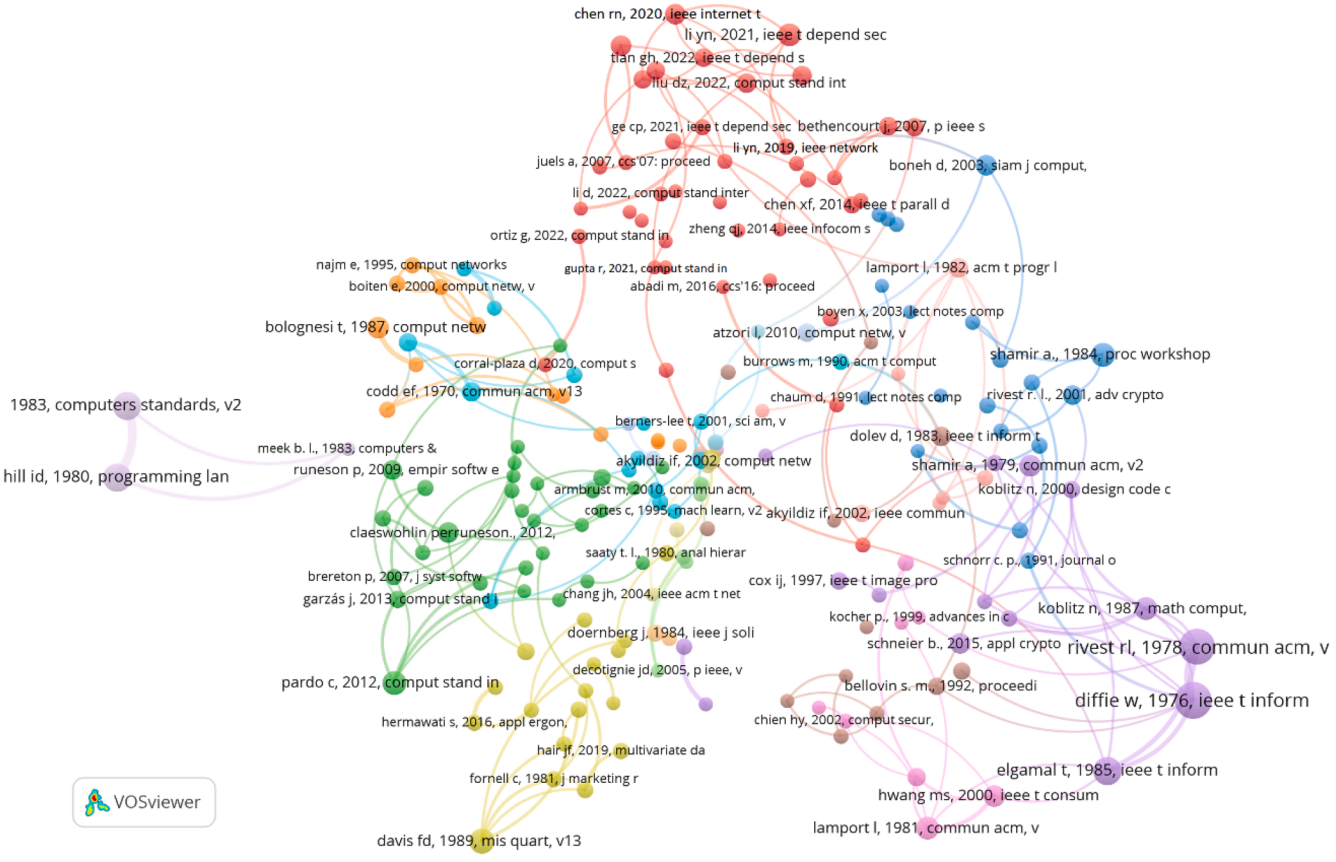

Fig. 5. Co-citation of documents in CSI: minimum citation threshold of 5 and 200 links.

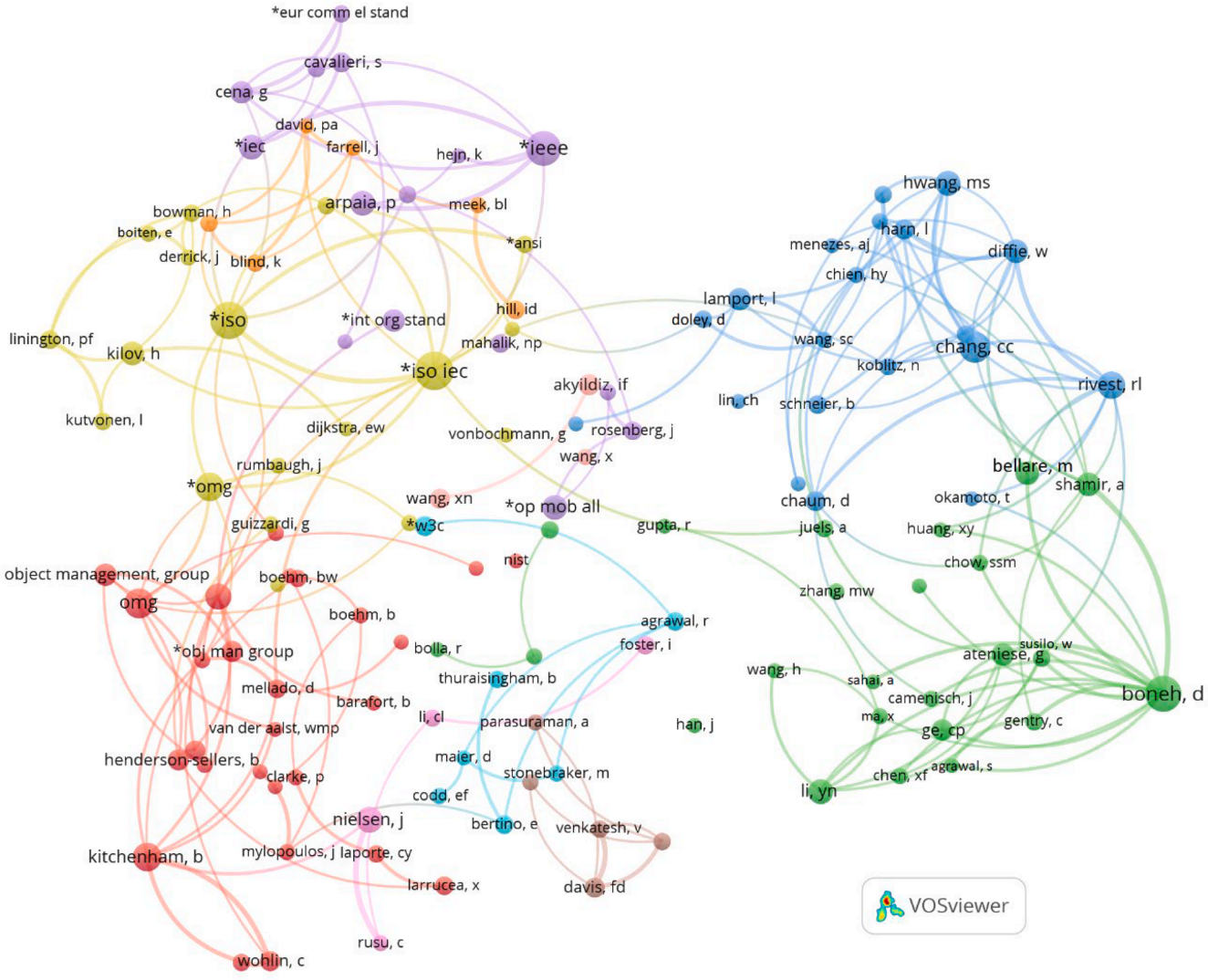

Fig. 6. Co-citation of authors in CSI: minimum citation threshold of 15 and 200 links.

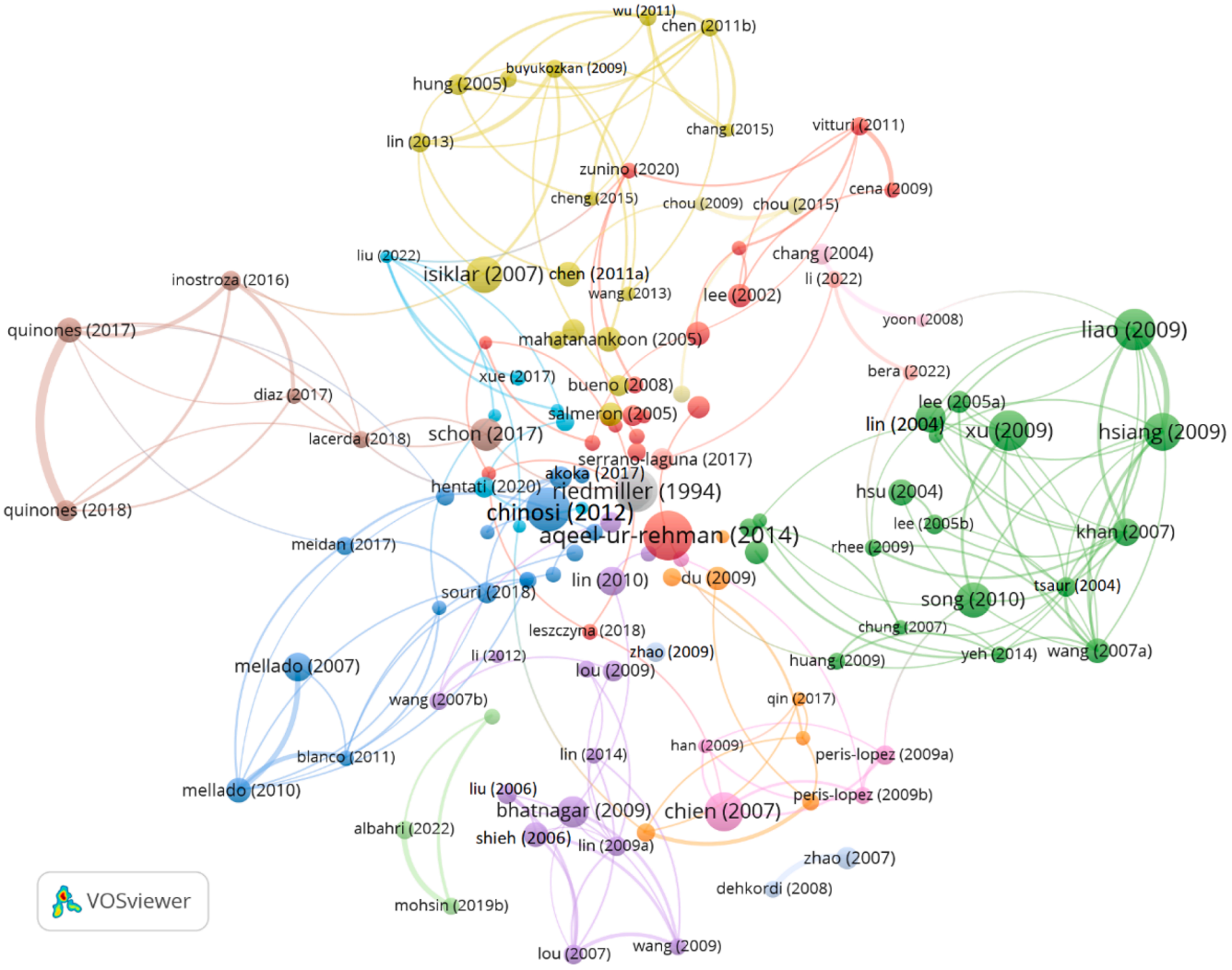

Fig. 7. Bibliographic coupling of documents published in CSI: minimum threshold of 30 citations, 200 bibliographic coupling links, 4 units of attraction and 1 unit of repulsion.

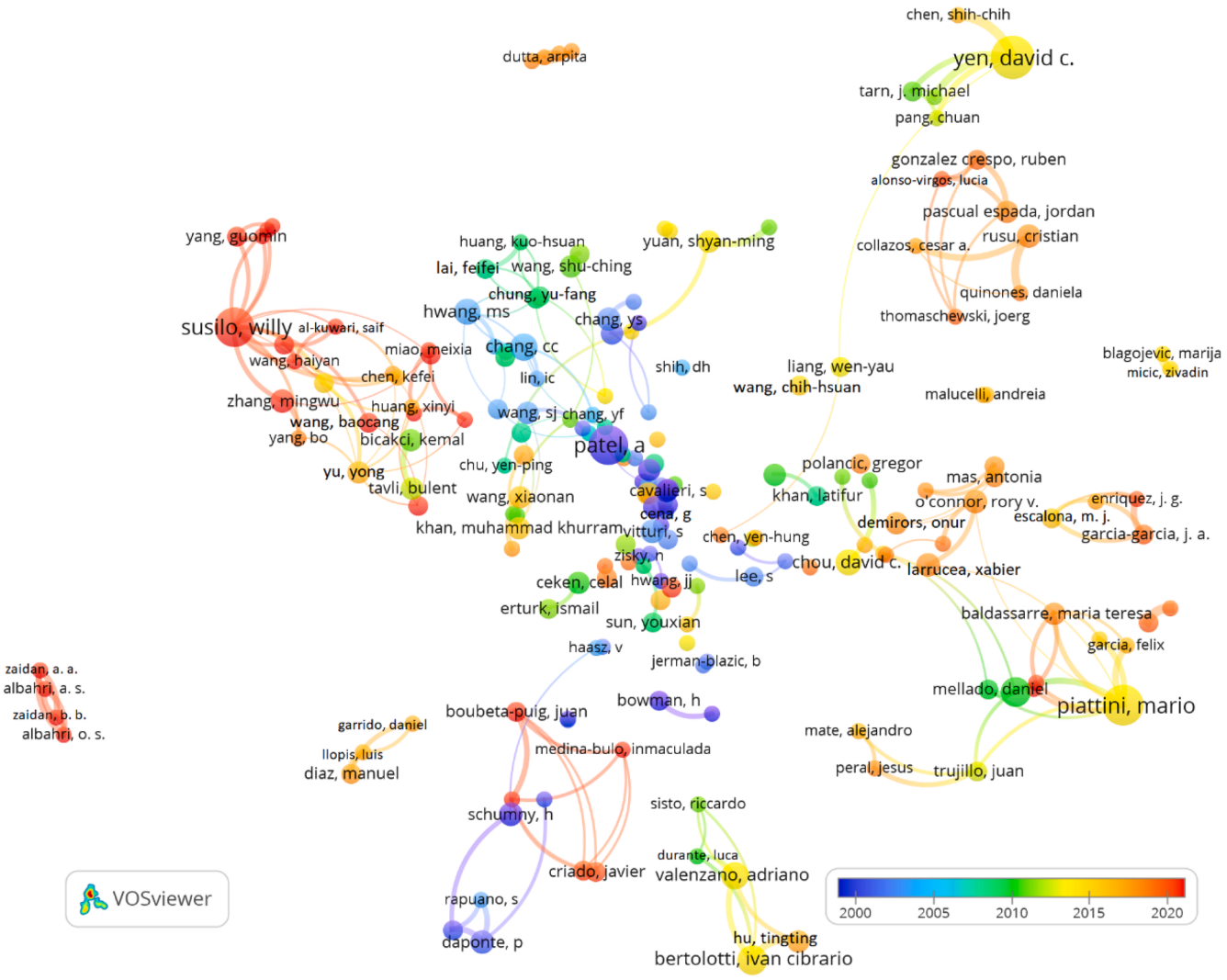

Fig. 8. Bibliographic coupling of authors publishing in CSI: minimum threshold of 3 documents, 200 links, 4 units of attraction and 1 unit of repulsion.

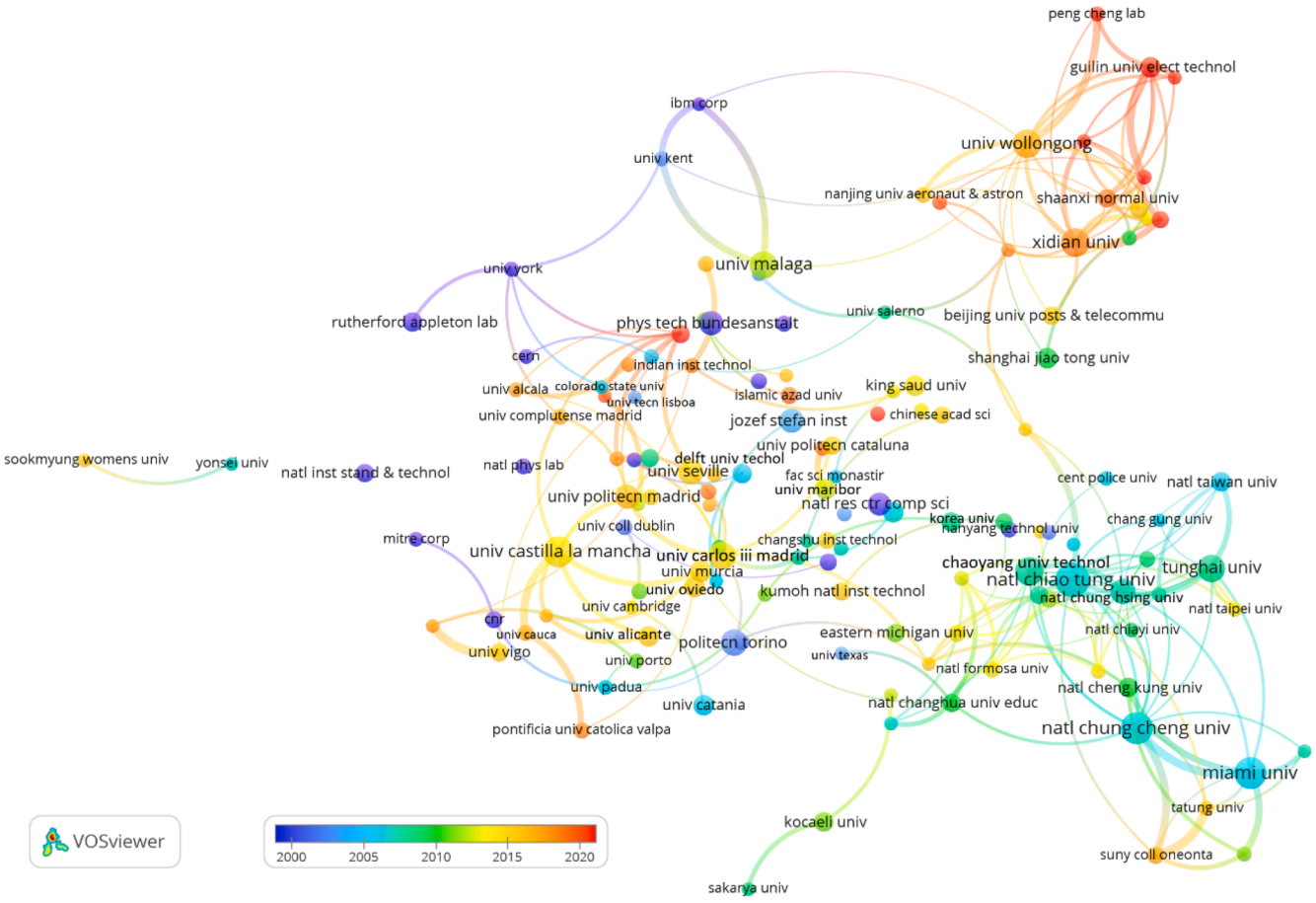

Fig. 9. Bibliographic coupling of institutions publishing in CSI: minimum publication threshold of 5 documents, 200 links, 4 units of attraction and 1 unit of repulsion.

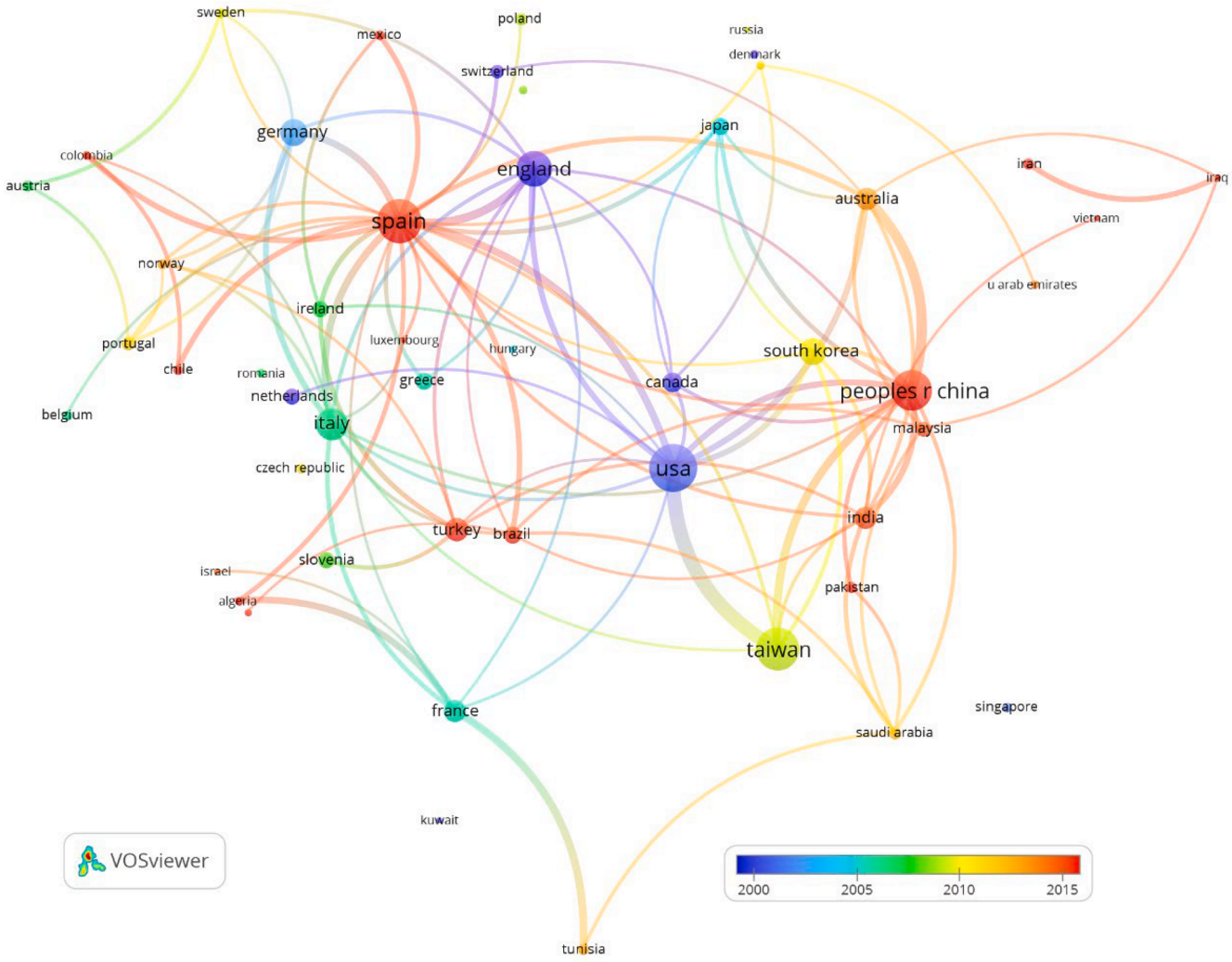

Fig. 10. Bibliographic coupling of countries-regions publishing in CSI: minimum publication threshold of 5 documents, 100 links, 4 units of attraction and 1 unit of repulsion.

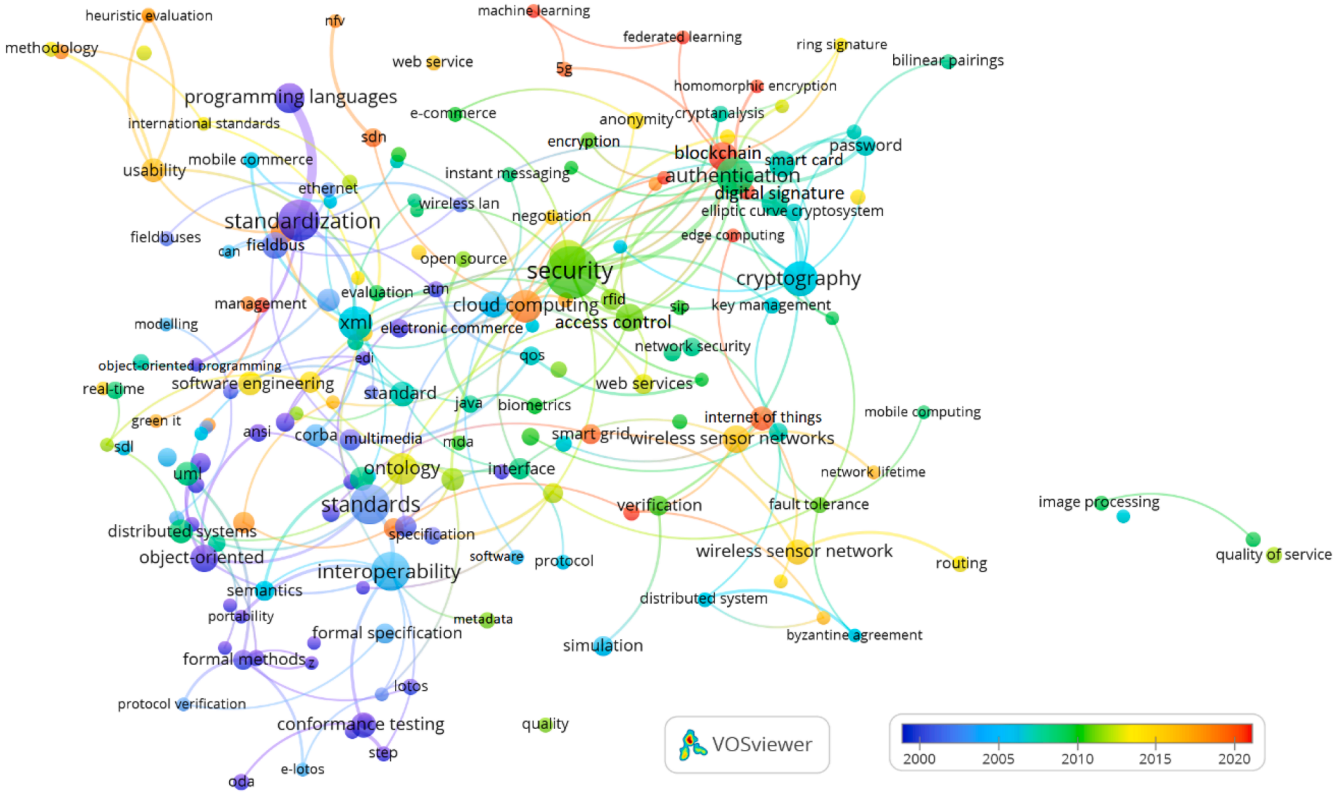

Fig. 11. Co-occurrence of author keywords in CSI: minimum occurrence threshold of 5, 200 links, 4 units of attraction and 1 unit of repulsion.

Table 17
Most frequent author keywords in CSI: Global and temporal analysis.

	Global		2014–2023		2004–2013		1994–2003	
R	Keyword	Occ	Keyword	Occ	Keyword	Occ	Keyword	Occ
1	Security	66	Cloud computing	26	Security	39	Standardization	29
2	Standards	53	Security	22	Authentication	24	Programming languages	20
3	Standardization	40	Wireless sensor networks	21	Cryptography	21	Standards	14
4	Interoperability	35	Blockchain	20	XML	19	Fieldbus	12
5	Authentication	34	Standards	15	Privacy	15	Corba	9
6	Wireless sensor networks	33	Internet of things	14	Smart card	15	Electronic commerce	9
7	Privacy	31	Privacy	13	Ontology	14	Interoperability	9
8	Cryptography	30	Systematic literature review	13	Wireless sensor network	12	Testing	8
9	XML	28	Usability	12	RM-ODP	11	Formal methods	7
10	Cloud computing	26	Big data	10	Standards	11	Internet	7
11	Ontology	24	Ontology	10	Access control	10	SGML	7
12	Programming languages	21	Smart grid	10	Digital signature	10	Cryptography	6
13	Blockchain	20	SDN	9	Interoperability	10	Formal specification	6
14	Access control	19	Software process improvement	9	Password	9	Lotos	6
15	Object-oriented	18	Interoperability	8	Semantic web	9	Analog-digital conversion	5
16	Internet	17	Middleware	8	Digital watermarking	8	ATM	5
17	Digital signature	16	Software engineering	8	Elliptic curve cryptosystem	8	Express	5
18	Fieldbus	16	Access control	7	Internet	8	Multimedia	5
19	Smart card	16	Authentication	7	RFID	8	Network management	5
20	Conformance testing	15	IoT	7	UML	8	Performance evaluation	5
21	Internet of things	14	5G	6	Verification	8	Software architecture	5
22	RM-ODP	14	Cloud storage	6	Cryptanalysis	7	Step	5
23	Usability	14	Data mining	6	Mobile agent	7	XML	5
24	Distributed systems	13	Management	6	QoS	7	ADC	4
25	Software engineering	13	Performance	6	Web services	7	Distributed systems	4
26	Systematic literature review	13	Privacy protection	6	ADC testing	6	Fieldbuses	4
27	UML	13	Process assessment	6	Bilinear pairings	6	Intelligent multimedia presentation systems	4
28	Corba	12	Attribute-based encryption	5	Biometrics	6	Open distributed processing	4
29	Performance evaluation	12	Distributed systems	5	Copyright protection	6	Specification	4
30	Semantic web	12	Edge computing	5	Data hiding	6	Standard reference model	4
31	Interface	11	Federated learning	5	Distributed computing	6	Artificial neural networks	3
32	Middleware	11	Formal verification	5	Java	6	Authentication	3
33	Multimedia	11	Handover	5	Metadata	6	Conformance testing	3
34	RFID	11	Heuristic evaluation	5	Mobile commerce	6	Digital signatures	3
35	Software process improvement	11	Homomorphic encryption	5	Performance evaluation	6	Diskette	3
36	Testing	11	Information technology	5	Proxy signature	6	Error analysis	3
37	Big data	10	Machine learning	5	Anonymity	5	Estelle	3
38	Data Mining	10	NFV	5	Evaluation	5	Ethernet	3
39	Formal Methods	10	Systematic Mapping Study	5	Grid Computing	5	Formal Semantics	3
40	Formal Specification	10	Usability Heuristics	5	Key Management	5	GPIB	3

Abbreviations: Occ = Occurrences.

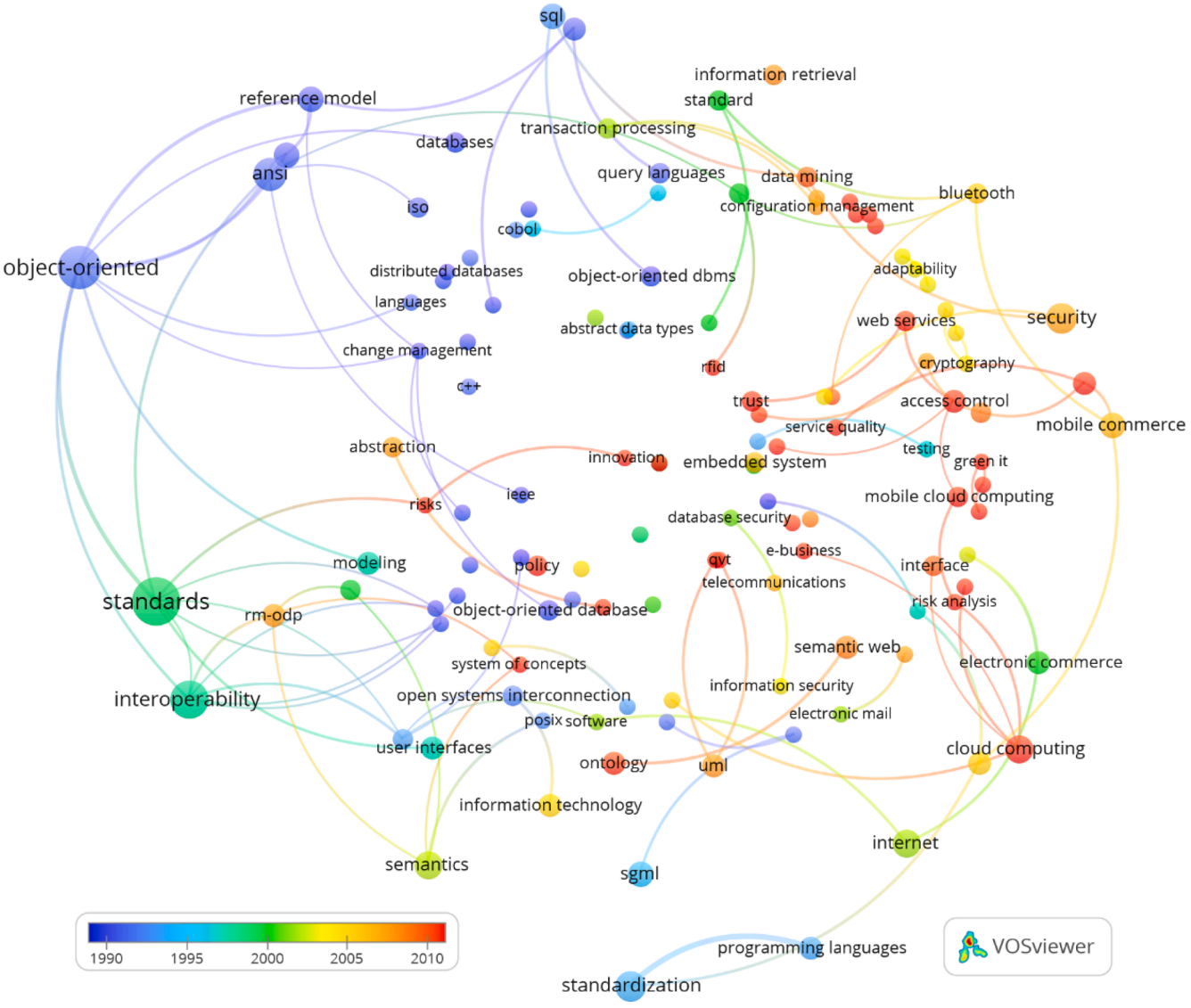

Fig. 12. Co-occurrence of author keywords in CSI (North America): minimum occurrence threshold of 2, 100 links, 4 units of attraction and 1 unit of repulsion.

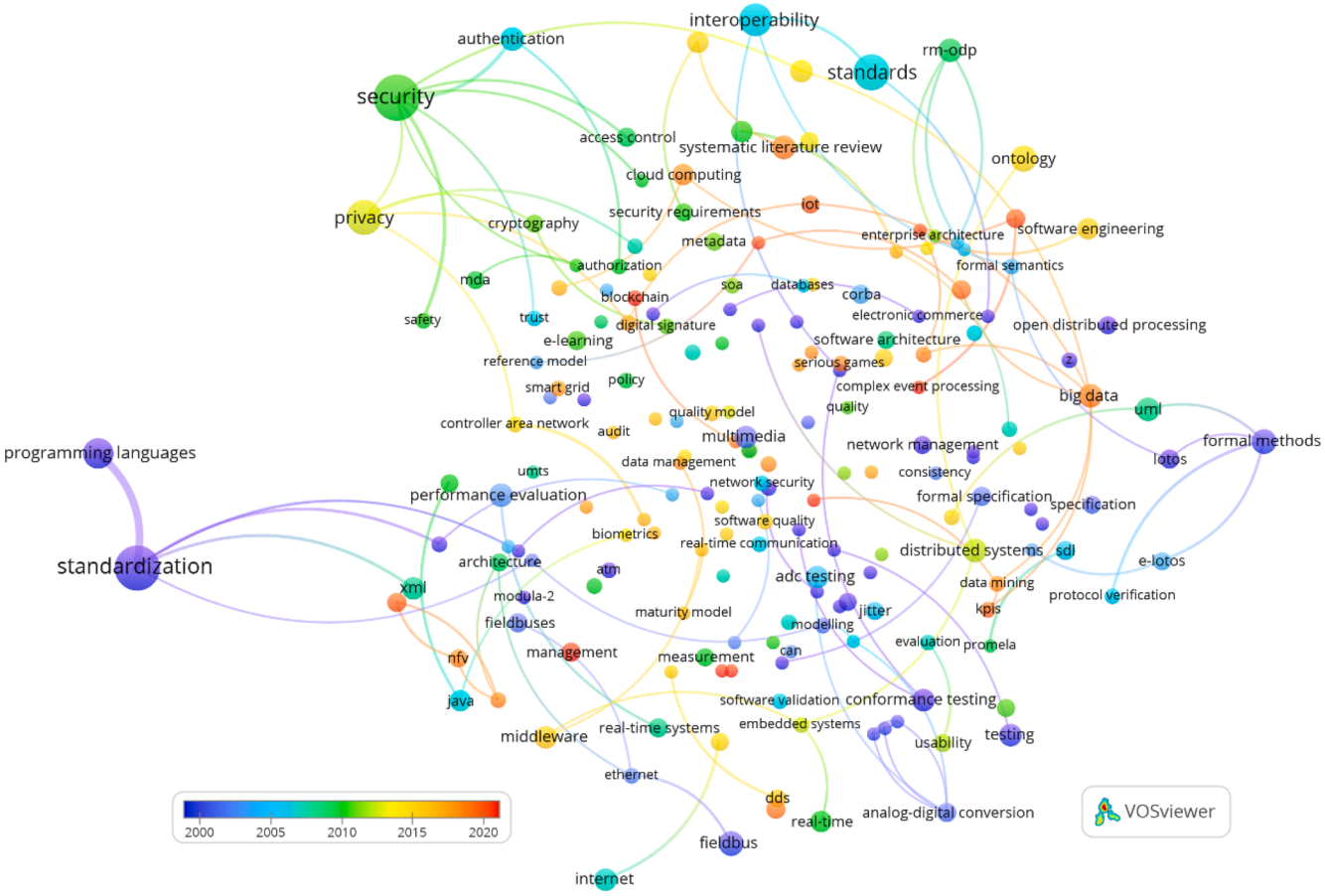

Fig. 13. Co-occurrence of author keywords in CSI (Europe): minimum occurrence threshold of 3, 100 links, 4 units of attraction and 1 unit of repulsion.

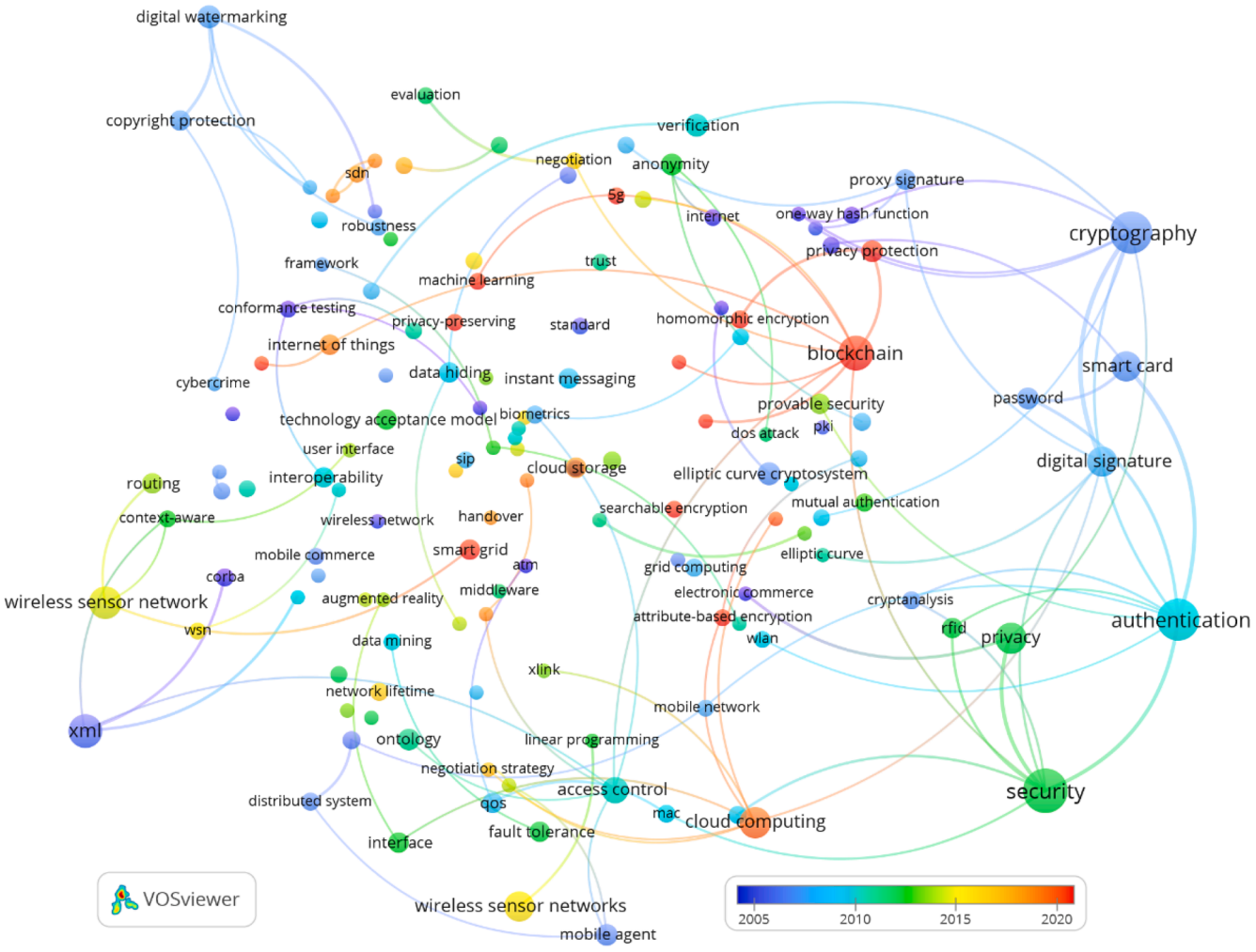

Fig. 14. Co-occurrence of author keywords in CSI (East Asia): minimum occurrence threshold of 3, 100 links, 4 units of attraction and 1 unit of repulsion.

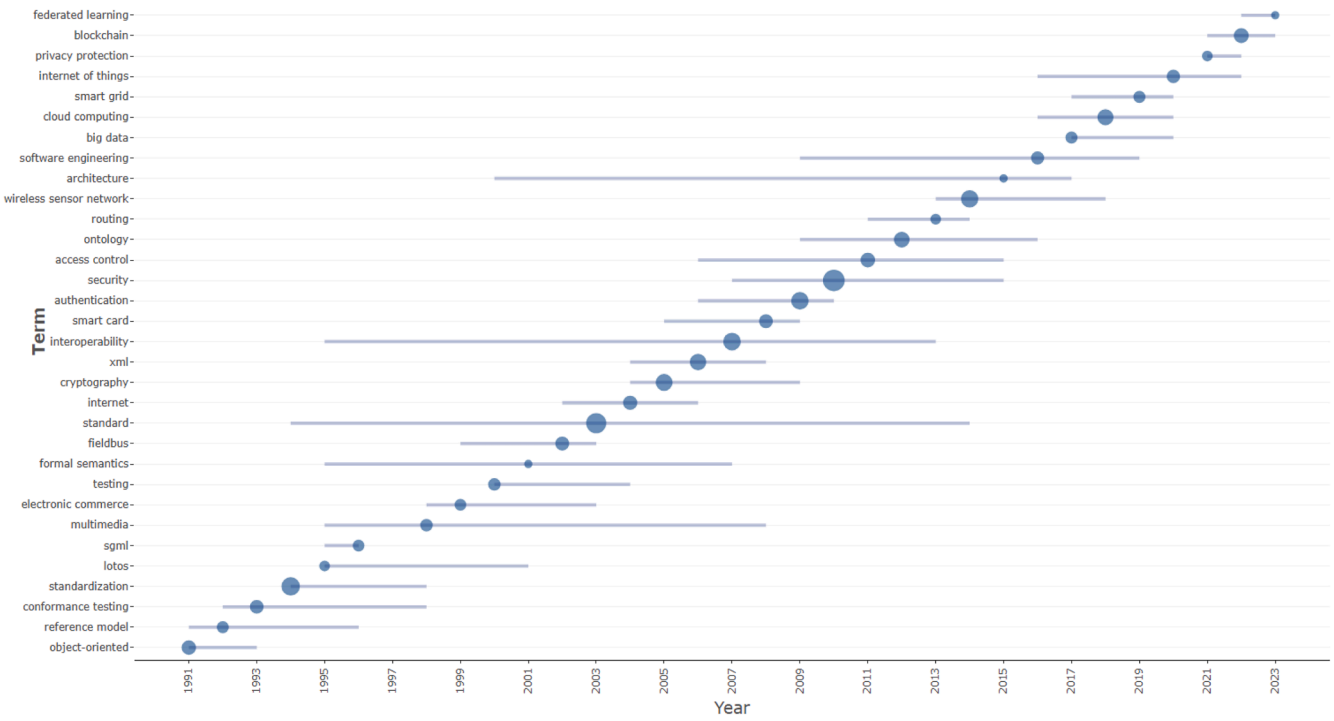

Fig. 15. Trend Topics in CSI.

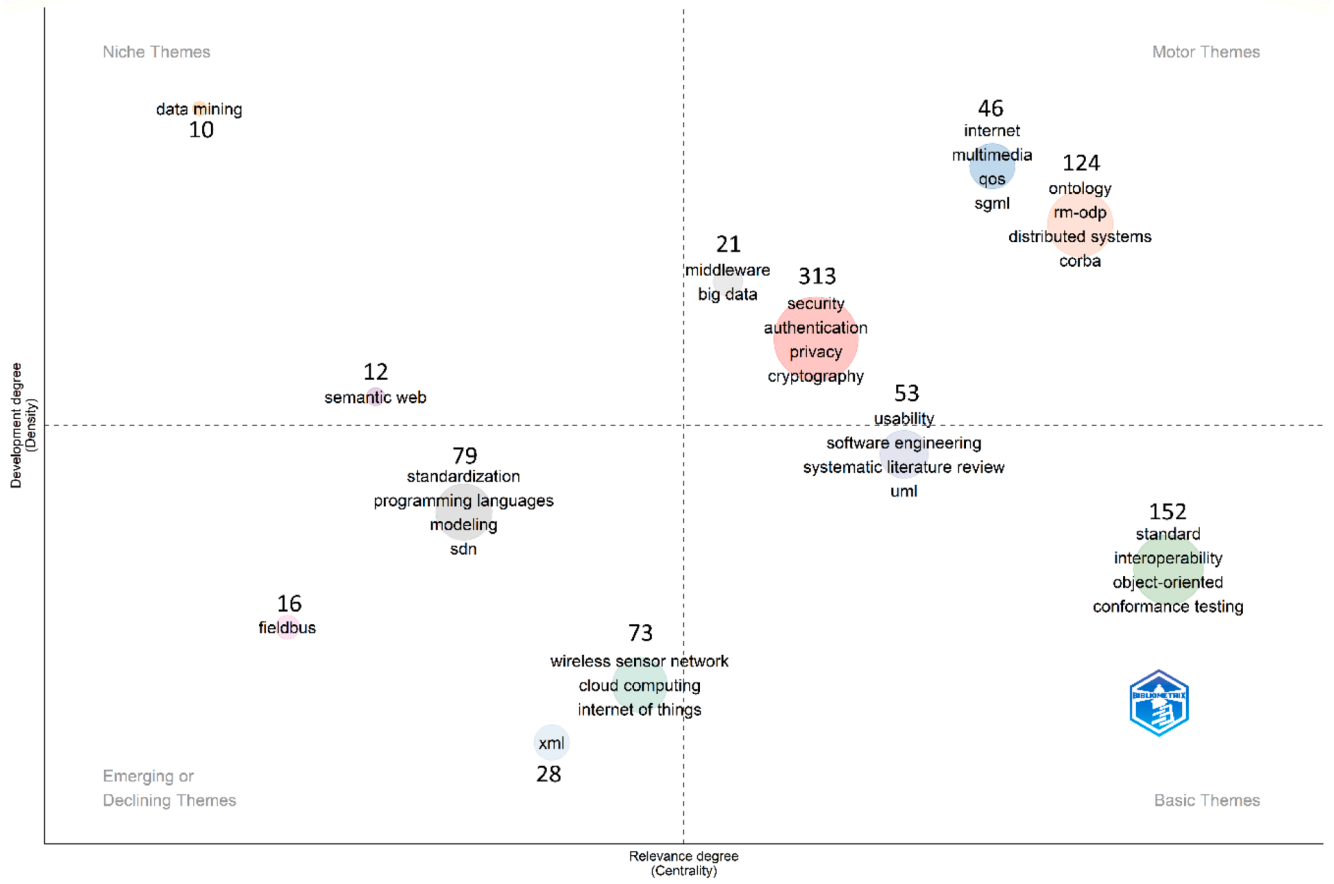

Fig. 16. Thematic map with the 250 most frequent author keywords and minimum cluster frequency of 5 (clustering algorithm: leading eigenvalues).

Fig. 17. Word cloud of the most frequent author keywords of CSI.

viewer and the *bibliometrix* software. The main advantage of this approach is that it can visualize the leading actors and show how they connect between each other. In doing so, the study considers three significant bibliometric techniques: co-citation, bibliographic coupling and co-occurrence of author keywords. The co-citation analysis of the journals shows that the *Lecture Notes in Computer Science, Communications of the ACM, Information and Software Technology*, and *Journal of Systems and Software*, have a close citation connection with CSI. Co-occurrence of authors' keywords and topical analysis disclosures that *Security, Standardization, Standards, Interoperability, Authentication, Privacy*, and *Cryptography*, are the most common keywords used by the authors of CSI.

5.2. Limitations

As mentioned in Fig. 1, although this study provides a general overview of the publication and citation trends of CSI, it is worth mentioning some limitations. First, the article uses the WoS database and therefore, the limitations of this database also applies to this work. A key issue is that WoS does not index CSI since the origin. Thus, for articles published in the first volumes of the journal, the study retrieves them by using the "Cited Reference Search" and the webpage of the journal. Additionally, WoS uses a full counting approach which benefits documents written by multiple authors against single-written articles. Note that the main alternative is fractional counting that this paper uses in Section 4 with the VOS viewer to partially solve this limitation. However, fractional counting also has limitations because usually the contribution of each co-author is not equal, so using an arithmetic fraction for each co-author requires further improvements.

Another important limitation is that each subfield within CSI has different publication and citation characteristics. Therefore, it is not easy to correctly measure the bibliographic information. This article provides a general picture showing different bibliometric indicators so each reader can focus on the variables that considers to be more interesting. However, still there are many difficulties to provide a correct picture. The main assumption is that this analysis identifies some leading trends occurring in the journal. But obviously, there are many exceptional cases that need a deeper examination. A simple example could be the case of very significant contributions that are not highly cited because the current community in this field is very small.

5.3. Practical implications and future research

This bibliometric study will be of practical assistance for researchers/academicians that want to know about the research profile of CSI. It can also benefit the editors of the journal to decide the future strategies of CSI. Moreover, politicians and decision makers will benefit from this study in order to obtain a better understanding of the journal and its current position and strategies. This will be very practical to reach more accurate decisions concerning funding opportunities, special issues and new research directions.

In the future, further analyses and rankings can be done using an enhanced and deeper methodology during this dynamically changing behavior of bibliometric analyses to provide additional information to the current approach. Due to the fact that the data changes through time, future updates of this bibliographic information will be needed, for example, for the 50th or 60th anniversary of CSI. Moreover, it would be also interesting to analyze individually some key topics of CSI that currently deserve more attention.

CRediT authorship contribution statement

Nikunja Mohan Modak: Investigation, Validation, Data curation, Writing – original draft, Methodology, Formal analysis. **Ghassan Beydoun:** Validation, Project administration, Writing – review & editing, Conceptualization, Supervision, Investigation, Formal analysis. **José M. Merigó:** Writing – review & editing, Methodology, Formal analysis, Conceptualization, Investigation, Data curation, Writing – original draft, Validation, Software, Visualization, Supervision, Project administration. **Iman Rahimi:** Investigation, Methodology, Data curation. **Willy Susilo:**

Table 18
Leading topics in CSI between 2013 and 2022 (SciVal – Scopus).

R	Topic	TP	FWCI	PP
1	Human Computer Interaction; Usability Evaluation; Information System	10	3.75	94.616
2	Software Process; Process Engineering; Ontology	9	1.29	54.42
3	Keyword Search; Data Privacy; Cloud Computing	6	3.66	98.134
4	Software Process; Process Engineering; Information System	6	1.74	69.617
5	Cloud Storage; Data Possession; Network Security	6	4.45	96.05
6	Wireless Sensor Network; Energy Efficiency; Routing Protocol	5	2.91	98.889
7	Software Product Line; Computer Software Reusability; Software Design	5	0.63	94.063
8	Data Security; Cloud Storage; Authentication	5	6.64	94.278
9	Irrigation System; Wireless Sensor Network; Internet of Things	5	7.94	99.66
10	Network Function Virtualization; Transfer Function; Quality of Service	5	2.72	98.241
11	Security Requirements; Software Development; Information System	5	2.88	82.816
12	Data Privacy; Health Care; Blockchain	4	7.9	99.938
13	Agile Software Development; Agile Methods; Software Engineering	4	5.43	98.656
14	Big Data; Decision-Making; Data Analytics	4	3.18	99.682
15	Ciphertext; Data Privacy; Attribute-Based Encryption	4	3.32	98.089
16	Signature Scheme; Electronic Document; Authentication	4	1.72	88.782
17	Multi Agent Systems; Decision-Making; Intelligent Agent	4	2.17	78.95
18	Smart Grid; Power Transmission Network; Internet of Things	4	2.89	93.408
19	Web Accessibility; Human Computer Interaction; User Experience	4	1.12	92.845
20	Sustainable Development; Information Systems; Adoption	4	1.38	91.225
21	Model Checking; Test Generation; Symbolic Execution	4	1.23	78.68
22	Assurance Case; Security Systems; Software Engineering	4	1.11	73.943
23	Service Management; Information Technology Infrastructure Library; Information System	4	1.34	84.242
24	Process Control; Embedded Systems; Industry 4.0	4	3.15	89.513
25	Mobility Network; Telecommunication System; Internet Protocol	4	0.92	52.945
26	Engineering Education; Project Management Software; Serious Game	4	2.57	52.564
27	Assessment Process; Process Improvement; Risk Management	4	1.21	38.13
28	Recommender Systems; Collaborative Filtering; E-Commerce	3	4.55	98.177
29	Image Quality Assessment; Reference Image; Quality of Service	3	0.86	98.028
30	Software Defined Networking; OpenFlow; Quality of Service	3	2.52	97.866

Abbreviations: R = Rank; TP = Total papers; FWCI = Field-weighted citation impact (data from Scopus); PP = Worldwide prominent percentile (according to Scopus and FWCI).

Table 19
Leading topic clusters in CSI between 2013 and 2022 (SciVal – Scopus).

R	Topic Cluster	TP	FWCI	PP
1	Software Engineering; Open Source Software; Information System	61	1.67	86.593
2	Authentication; Network Security; Cloud Computing	35	2.71	76.586
3	Cloud Computing; Data Center; Network Security	31	3.56	81.426
4	Internet of Things; Routing Protocol; Energy Engineering	29	2.21	78.81
5	Web Service; Quality of Service; Data Mining	24	1.68	45.193
6	Routing Protocol; Quality of Service; Vehicle-to-Vehicle Communication	20	2.38	91.89
7	User Experience; User-Centered Design; Human-Computer Interaction	20	2.67	48.398
8	Quality of Service; Internet Protocol; Network Architecture	18	0.88	30.216
9	Network Security; Quality of Service; Time-Sensitive Networking	18	2	28.058
10	Ontology; Semantic Web; Linked Data	17	1.06	51.537
11	Network Security; Cybersecurity; Machine Learning	17	1.74	85.808
12	Quality of Service; Network Architecture; Data Center	17	3.22	70.634
13	Quality of Service; Network Security; Video Streaming	15	0.76	9.68
14	Blockchain; Smart Contract; Authentication	14	4.37	99.084
15	Image Processing; Public-Key Cryptography; Quantum Computing	12	1.2	78.483
16	Energy Engineering; Battery Charging; Electric Power	10	3.73	96.599
17	Access Control; Network Security; Cloud Computing	10	0.75	28.777
18	Supply Chain Management; Industry; Airline	9	1.6	98.038
19	Social Media; Adoption; e-Commerce	9	1.51	98.365
20	Data Mining; Artificial Intelligence; e-Commerce	9	2.79	80.903
21	Quality of Service; Internet of Things; Access Control	8	1.45	17.593
22	Software Engineering; Information System; Artificial Intelligence	8	1.94	11.118
23	Sentiment Analysis; Natural Language Processing; Machine Learning	7	1.9	99.346
24	Data Mining; Artificial Intelligence; Information System	7	2.8	78.679
25	Internet of Things; Network Security; Cloud Computing	7	6.54	87.704
26	Industry 4.0; Digital Twin; Internet of Things	7	4.09	97.515
27	Information System; Query Processing; Artificial Intelligence	7	0.51	5.952
28	Commerce; Pricing; Industry	7	0.64	40.288
29	Image Segmentation; Deep Neural Network; Object Detection	6	3.99	99.935
30	Edge Computing; Internet of Things; Computation Offloading	6	4.62	86.854

Abbreviations are available in Table 18.

Writing – review & editing, Supervision, Conceptualization, Validation, Project administration.

Declaration of competing interest

The authors declare that they do not have any conflict of interests, and the paper follows the ethical responsibilities of the journal.

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Data availability

Data will be made available on request.

References

[1] Clarivate (2024). *Journal Citation Reports*, Clarivate.
[2] Scopus. (2024). *Scopus*. CiteScore: https://www.elsevier.com/products/scopus/metrics/citescore.
[3] A.Z. Abbasi, N. Islam, Z.A. Shaikh, A review of wireless sensors and networks' applications in agriculture, Comput. Stand. Interfaces 36 (2) (2014) 263–270.
[4] M. Chinosi, A. Trombetta, BPMN: an introduction to the standard, Comput. Stand. Interfaces 34 (1) (2012) 124–134.
[5] M. Riedmiller, Advanced supervised learning in multi-layer perceptrons—from backpropagation to adaptive learning algorithms, Comput. Stand. Interfaces 16 (3) (1994) 265–278.
[6] N.J. Van Eck, L. Waltman, Software survey: VOSviewer, a computer program for bibliometric mapping, Scientometrics 84 (2) (2010) 523–538.
[7] S. Laengle, J.M. Merigó, J. Miranda, R. Słowiński, I. Bomze, E. Borgonovo, R. G. Dyson, J.F. Oliveira, R. Teunter, Forty years of the European journal of operational research: a bibliometric overview, Eur. J. Oper. Res. 262 (3) (2017) 803–816.
[8] N.M. Modak, V. Lobos, J.M. Merigó, B. Gabrys, J.H. Lee, Forty years of computers & chemical engineering: a bibliometric analysis, Comput. Chem. Eng. 141 (2020) 106978.
[9] L. Guan, G. Laporte, J.M. Merigó, S. Nickel, I. Rahimi, F. Saldanha-da-Gama, 50 years of computers & operations research: a bibliometric analysis, Comput. Oper. Res. 175 (2025) 106910.
[10] N. Kazemi, N.M. Modak, K. Govindan, A review of reverse logistics and closed loop supply chain management studies published in IJPR: a bibliometric and content analysis, Int. J. Prod. Res. 57 (15–16) (2019) 4937–4960.
[11] M. Gaviria-Marin, J.M. Merigó, S. Popa, Twenty years of the journal of knowledge management: a bibliometric analysis, J. Knowl. Manag. 22 (8) (2018) 1655–1687.
[12] G. Beydoun, B. Abedin, J.M. Merigó, M. Vera, Twenty years of information systems frontiers, Inf. Syst. Front. 21 (2) (2019) 485–494.
[13] S. Kumar, W.M. Lim, N. Pandey, J.C. Westland, 20 years of electronic commerce research, Electron. Commer. Res. 21 (1) (2021) 1–40.
[14] M.J. Cobo, M.A. Martínez, M. Gutiérrez-Salcedo, H. Fujita, E. Herrera-Viedma, 25 years at knowledge-based systems: a bibliometric analysis, Knowl. Based Syst. 80 (2015) 3–13.
[15] D. Yu, Z.S. Xu, Y. Kao, C.T. Lin, The structure and citation landscape of IEEE transactions on fuzzy systems (1994–2015), IEEE Trans. Fuzzy Syst. 26 (2018) 430–442.
[16] J.R. López-Robles, M.J. Cobo, M. Gutiérrez-Salcedo, M.A. Martínez-Sánchez, N. K. Gamboa-Rosales, E. Herrera-Viedma, 30th anniversary of applied intelligence: a combination of bibliometrics and thematic analysis using SciMAT, Appl. Intell. 51 (2021) 6547–6568.
[17] H.B. Vošner, P. Kokol, S. Bobek, D. Železnik, J. Završnik, A bibliometric retrospective of the journal computers in human behavior (1991–2015), Comput. Hum. Behav. 65 (2016) 46–58.
[18] A.K. Shukla, M. Janmaijaya, A. Abraham, P.K. Muhuri, Engineering applications of artificial intelligence: a bibliometric analysis of 30 years (1988–2018), Eng. Appl. Artif. Intell. 85 (2019) 517–532.
[19] J.M. Merigó, A. Mas-Tur, N. Roig-Tierno, D. Ribeiro-Soriano, A bibliometric overview of the journal of business research between 1973 and 2014, J. Bus. Res. 68 (12) (2015) 2645–2653.
[20] C. Cancino, J.M. Merigó, F. Coronado, Y. Dessouky, M. Dessouky, Forty years of computers & industrial engineering: a bibliometric analysis, Comput. Ind. Eng. 113 (2017) 614–629.
[21] N. Shukla, J.M. Merigó, T. Lammers, L. Miranda, Half a century of computer methods and programs in biomedicine: a bibliometric analysis from 1970 to 2017, Comput. Methods Progr. Biomed. 183 (2020) 105075.
[22] X.X. Wang, Y. Chang, Z.S. Xu, Z. Wang, V. Kadirkamanathan, 50 years of international journal of systems science: a review of the past and trends for the future, Int. J. Syst. Sci. 52 (8) (2021) 1515–1538.
[23] N.M. Modak, J.M. Merigó, R. Weber, F. Manzor, J.D. Ortuzar, Fifty years of transportation research journals: a bibliometric overview, Transp. Res. A 120 (2019) 188–223.
[24] R.N. Broadus, Toward a definition of "bibliometrics, Scientometrics 12 (5–6) (1987) 373–379.
[25] A. Pritchard, Statistical bibliography or bibliometrics, J. Doc. 25 (4) (1969) 348–349.
[26] S.J. Bensman, Garfield and the impact factor, Annu. Rev. Inf. Sci. Technol. 41 (1) (2007) 93–155.
[27] E. Garfield, Citation indexes for science: new dimension in documentation through association of ideas, Science 122 (1955) 108–111.
[28] Ding, Y., Rousseau, R., & Wolfram, D. (2014). *Measuring Scholarly impact: Methods and Practice*. Springer, Switzerland.
[29] Glanzel, W., Moed, H.F., Schmoch, U., & Thelwall, M. (2019). *Springer Handbook of Science and Technology Indicators*. Springer.
[30] J. Akoka, I. Comyn-Wattiau, N. Laoufi, Research on big data – a systematic mapping study, Comput. Stand. Interfaces 54 (2) (2017) 105–115.
[31] R. Heradio, H. Perez-Morago, D. Fernandez-Amoros, F.J. Cabrerizo, E. Herrera-Viedma, A bibliometric analysis of 20 years of research on software product lines, Inf. Softw. Technol. 72 (2016) 1–15.
[32] A. Rejeb, K. Rejeb, A. Appolloni, H. Treiblmaier, Foundations and knowledge clusters in TikTok (Douyin) research: evidence from bibliometric and topic modelling analyses, Multimed. Tools Appl. 83 (2024) 32213–32243.
[33] H. Liao, X. Jin, Y. Shi, G. Kou, A bibliometric overview and visualization of the international journal of information technology and decision making between 2012 and 2022, Int. J. Inf. Technol. Decis. Mak. 23 (1) (2024) 171–195.
[34] G. Zurita, A.K. Shukla, J.A. Pino, J.M. Merigó, V. Lobos-Ossandón, P.K. Muhuri, A bibliometric overview of the journal of network and computer applications between 1997 and 2019, J. Netw. Comput. Appl. 165 (2020) 102695.
[35] W.E. Wong, N. Mittas, E.M. Arvanitou, Y. Li, A bibliometric assessment of software engineering themes, scholars and institutions (2013–2020), J. Syst. Softw. 180 (2021) 111029.
[36] X. Bai, E. Cheng-Xi Aw, G. Wei-Han Tan, K.B. Ooi, Livestreaming as the next frontier of e-commerce: a bibliometric analysis and future research agenda, Electron. Commer. Res. Appl. 65 (2024) 101390.
[37] A. Rejeb, K. Rejeb, A. Abdollahi, H. Treiblmaier, The big picture on Instagram research: insights from a bibliometric analysis, Telemat. Inform. 73 (2022) 101876.
[38] A. Sadeghi-Niaraki, Internet of Things (IoT) review of review: bibliometric overview since its foundation, Future Gener. Comput. Syst. 143 (2023) 361–377.
[39] Z. Amiri, A. Heidari, N. Jafari, M. Hosseinzadeh, Deep study on autonomous learning techniques for complex pattern recognition in interconnected information systems, Comput. Sci. Rev. 54 (2024) 100666.
[40] Z. Amiri, A. Heidari, N.J. Navimipour, Comprehensive survey of artificial intelligence techniques and strategies for climate change mitigation, Energy 308 (2024) 132827.
[41] S. Toumaj, A. Heidari, R. Shahhosseini, N. Jafari Navimipour, Applications of deep learning in Alzheimer's disease: a systematic literature review of current trends, methodologies, challenges, innovations, and future directions, Artif. Intell. Rev. 58 (2) (2024) 44.
[42] D. Hicks, P. Wouters, L. Waltman, S. de Rijcke, I. Rafols, Bibliometrics: the Leiden Manifesto for research metrics, Nature 520 (2015) 429–431.
[43] S. Alonso, F.J. Cabrerizo, E. Herrera-Viedma, F. Herrera, *h*-index: a review focused on its variants, computation and standardization for different scientific fields, J. Inf. 3 (4) (2009) 273–289.
[44] J.E. Hirsch, An index to quantify an individual's scientific research output, Proc. Natl. Acad. Sci. 102 (46) (2005) 16569–16572.
[45] H. Small, Co-citation in scientific literature - new measure of relationship between 2 documents, J. Am. Soc. Inf. Sci. 24 (4) (1973) 265–269.
[46] M. Kessler, Bibliographic coupling between scientific papers, Am. Doc. 14 (1963) 10–25.
[47] M. Callon, J.P. Courtial, W.A. Turner, S. Bauin, From translations to problematic networks: an introduction to co-word analysis, Soc. Sci. Inf. 22 (2) (1983) 191–235.
[48] M. Aria, C. Cuccurullo, bibliometrix: an R-tool for comprehensive science mapping analysis, J. Inf. 11 (4) (2017) 959–975.
[49] M.J. Cobo, A.G. Lopez-Herrera, E. Herrera-Viedma, F. Herrera, Science mapping software tools: review, analysis and cooperative study among tools, J. Am. Soc. Inf. Sci. Technol. 62 (7) (2011) 1382–1402.
[50] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, W.M. Lim, How to conduct a bibliometric analysis: an overview and guidelines, J. Bus. Res. 133 (2021) 285–296.
[51] J. Paul, W.M. Lim, A. O'Cass, A.W. Hao, S. Bresciani, Scientific procedures and rationales for systematic literature reviews (SPAR-4-SLR), Int. J. Consum. Stud. 45 (4) (2021) O1–O16.
[52] Tukey, J. (1977). *Exploratory data analysis*. Addison-Wesley.
[53] Clarivate (2018). InCites indicators handbook. Clarivate Analytics.
[54] L. Tan, H. Xiao, K. Yu, M. Aloqaily, Y. Jararweh, A blockchain-empowered crowdsourcing system for 5G-enabled smart cities, Comput. Stand. Interfaces 76 (2021) 103517.
[55] W. Diffie, M. Hellman, New directions in cryptography, IEEE Trans. Inf. Theory 22 (6) (1976) 644–654.
[56] Van Eck, N.J., & Waltman, L. (2023). *VOSviewer Manual: Manual for VOSviewer Version 1.6.20*. Leiden University. https://www.vosviewer.com/getting-started#vosviewer-manual.

[57] M.E.J. Newman, Fast algorithm for detecting community structure in networks, Phys. Rev. E 69 (2004) 066133.
[58] A. Noack, Energy models for graph clustering, J. Graph Algorith. Appl. 11 (2) (2007) 453–480.
[59] A. Noack, Modularity clustering is force-directed layout, Phys. Rev. E 79 (2009) 026102.
[60] R.L. Rivest, A. Shamir, L. Adleman, A method for obtaining digital signatures and public-key cryptosystems, Commun. ACM 21 (1978) 120–126.
[61] A. Heidari, N.J. Navimipour, M. Unal, A secure intrusion detection platform using blockchain and radial basis function neural networks for internet of drones, IEEE Internet Things J. 10 (10) (2023) 8445–8454.
[62] A. Heidari, N.J. Navimipour, H. Dag, S. Talebi, M. Unal, A novel blockchain-based deepfake detection method using federated and deep learning models, Cogn. Comput. 16 (2024) 1073–1091.
[63] W. Cui, Y. Wu, S. Liu, F. Wei, M. Zhou, H. Qu, Context-preserving, dynamic word cloud visualization, IEEE Comput. Graph. Appl. 30 (6) (2010) 42–53.
[64] C. McNaught, P. Lam, Using Wordle as a supplementary research tool, Qual. Rep. 15 (3) (2010) 630–643.
[65] SciVal. (2024). *Quick reference guide.* Elsevier, London, UK.
[66] A. Purkayastha, E. Palmaro, H. Flak-Krzesinski, J. Baas, Comparison of two article-level, field-independent citation metrics: field-weighted citation impact (FWCI) and relative citation ratio (RCS), J. Inf. 13 (20) (2019) 635–642.
[67] R. Klavans, K.W. Boyack, Research portfolio analysis and topic prominence, J. Inf. 11 (4) (2017) 1158–1174.
[68] S. Norozpour, M. Darbandi, Proposing new method for clustering and optimizing energy consumption in WSN, Talent Dev. Excell. 12 (3) (2020) 2631–2643.
[69] A. Heidari, N.J. Navimipour, H. Dag, M. Unal, Deepfake detection using deep learning methods: a systematic and comprehensive review, Wiley Interdiscipl. Rev.: Data Min. Knowl. Discov. 14 (2) (2024) e1520.
[70] A. Vakili, H.M.R. Al-Khafaji, M. Darbandi, A. Heidari, N.J. Navimipour, M. Unal, A new service composition method in the cloud-based internet of things environment using a grey wolf optimization algorithm and MapReduce framework, Concurr. Comput.: Pract. Exp. 36 (16) (2024) e8091.
[71] K. Zanbouri, M. Darbandi, M. Nassr, A. Heidari, N.J. Navimipour, S. Yalcin, A GSO-based multi-objective technique for performance optimization of blockchain-based industrial internet of things, Int. J. Commun. Syst. 37 (15) (2024) e5886.
[72] A. Heidari, H. Shishehlou, M. Darbandi, N.J. Navimipour, S. Yalcin, A reliable method for data aggregation on the industrial internet of things using a hybrid optimization algorithm and density correlation degree, Clust. Comput. 27 (2024) 7521–7539.