Human Computer Interaction Research Through the Lens of a Bibliometric Analysis

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Abstract. Human Computing Interaction (HCI) is an expansive research field that covers various disciplines from computer science and engineering to human factors and social science. Navigating in this multidisciplinary field researchers and developers intensively seek to master the capability to understand the dialogue between humans and computers, reflect on the behaviour change caused by this interaction and encapsulate their knowledge to design, develop and maintain systems. Our paper aims to put in context and highlight the research done on the HCI field so far. To do so we choose a method that can provide a well-carved piece of literature and assure legitimacy in the representation of the research, i.e. a bibliometric analysis. Following this research path, we retrieved a data set of 962 publications covering the period from 1969 to early 2017. The analysis revealed a core set of forty-six articles structuring four main factors of HCI. Preliminary analysis highlights HCI design aspects, data management, user interaction, psychology and cognition and more recent trends in HCI in the workplace, sensors and wearables.

Keywords: Human-Computer interaction · Factor analysis · Bibliometric analysis

1 Introduction

Human Computer Interaction (HCI) has expanded rapidly and steadily for more than four decades. From its origins in human factors engineering and cognitive science into an acclaimed discipline, attracting academics and industry professionals into a multi-discipline dialogue integrating diverse methods, theories and practices. Methodology, theory, and practice in the field of HCI all share similar goals of producing interactive artefacts that can be utilised efficiently, effectively, safely, and with additive user-satisfaction.

Nevertheless, since the early years and the emphasis on usability, HCI has been constantly denoted as the discipline where different epistemologies and paradigms can be reconciled and integrated in an innovative and dynamic intellectual project. Examples of HCI projects may include social and organizational computing, artificial intelligence, computer vision, face recognition, motion tracking, accessibility for the

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elderly as well as the cognitively and physically impaired, and for all people, and for the widest thinkable spectrum of human interactions (Carroll 2013; Sebe et al. 2005). In more detail, HCI quickly extended from early graphical and desktop office applications to include medical and pedagogical applications, gamification of education, business and innovation, sustainability and resilience, emergency planning and response, and systems to support collaboration and community to name a few.

HCI is cross-disciplinary in its conduct and multi-disciplinary in its roots (Hartson 1998). Hence, the vast body of literature that accumulated the last four decades originates from various disciplines and is disseminated in a wide range of outlets. Publications that include myriad research paradigms and methods, frameworks and models, interface design techniques and devices, technologies and digital artefacts, multi-modal interactions, tool support for model-based user interface specification, and a host of emerging ubiquitous, handheld and context-aware and virtual interactions.

Therefore, taking as a point of departure the need to comprehend and analyse the body of HCI literature, the authors proceeded in a systematic literature research and bibliometric coupling analysis to investigate the issue at hand. The actual selection of relevant literature in this case as in any review is a non-trivial task; yet many literature reviews do not offer clarity about how and why they obtained their specific samples of literature or adequately explicitly express the methods of analysis that were used (Wolfswinkel et al. 2013). The bibliographic analysis not only satisfies the aforementioned good literature review ingredients of clarity and rigorousness, but also delivers greater legitimization of the process. The researcher is unbiased and does not intervene in the choice of the representative publications (the ones that form the representative set), s/he only sets the qualitative constraints (e.g. number of citations) (Waltman et al. 2010). We believe that our choice to apply a bibliometric analysis, a well-established methodology but quite new and undiscovered in the HCI research discipline, enhances the value and originality of this paper.

With this Sect. 1 representing the Introduction to the research, Sect. 2 depicts the Methodology utilised and the parameters and constraints used. Next, Sect. 3 analyses the Findings from this process, Sect. 4 contains the discussion and finally Sect. 5 presents the Conclusions.

2 Methodology

This research aims to enhance the readers' understanding of the research published in the HCI field. To do so, initially we proceeded to a literature investigation and analysis by exploring Elsevier' Scopus database and retrieved a dataset with research publications and citation data for a period from 1969 to early 2017. Previous research has shown that Scopus can be used as a sole data source for citation-based research and evaluation in HCI (Meho and Rogers 2008). In our case in order to ensure the credibility of selected documents, the search was restricted to journal and conference publications available in English language only. For the research the keywords "Human Computer Interaction" was utilised, focusing on the "title" and "keywords" fields of the publication. This process revealed 1,843 publications, spanning in a wide range of dissemination outlets and research interests. To this data, we imposed a

qualitative measure of at least-one citation and extracted a data set of 962 publications (depicted in Sect. 3). Progressing our investigation with a sophisticated bibliometric method, we retrieved four factors corresponding to an over 80% representation of our data set (depicted in Sect. 4). A brief account of the bibliometric methodology utilised herein is the subject of the next section.

2.1 Bibliographic Coupling Analysis

Recently, bibliometric methods have gained an increased appreciation as a prolific technique to understand the knowledge base of a research field, especially if the research field is vast and complex to analyse (Acedo et al. 2006; Di Stefano et al. 2010; Vogel and Güttel 2013). One may legitimately argue that the recent interest in the bibliometric analysis is realised due to the increasing accessibility of publication databases containing bibliometrics, such as the number of publications, citations, co-citations, bibliographic couplings etc. As in many sectors, technical and computational advancement has made it feasible to conduct analysis on very large and complex bibliometric data; data that previously would have been difficult to address with limited resources (e.g. time and human resources).

The bibliographic coupling (BGC) used herein is a bibliometric method that identifies the clusters of publications and those linked to each other through the same cited publication (Zupic and Čater 2015). In essence, the number of co-coupled documents defines the strength of links and association (Boyack and Klavans 2010). Following this technique, the bibliographic coupling data is analysed through a software computation (BibExcel) to generate a matrix comprised of the BGC frequency (Persson et al. 2009). Next, to gauge the strength of similarities between the publications, Pearson's correlation coefficient matrix is generated from the BGC matrix (van Eck and Waltman 2014). An advanced multivariate statistical technique of factor analysis is then applied to the correlation matrix to produce clusters (e.g. groups, sets) of publications representing distinguished sub-domains of the research field(s). The details and findings from this process are depicted in the following section.

3 Findings

3.1 Findings from Systematic Literature Search

The span of literature identified, covers a period of forty-seven years as depicted in Fig. 1, with a healthy exponential growth of publications each year (later 2017 data that are not covered herein present a normalization of the exponential growth of publications for year 2016).

Findings of main data set reveal that 42% of the publications hold a computer science subject, while 18% of the publications cover an engineering theme. An overview description of the subjects, their account in publications and their representation percentages are illustrated in Fig. 2. (NOTE: Each publication may hold more than one subject).

Fig. 1. Number of HCI publications per year

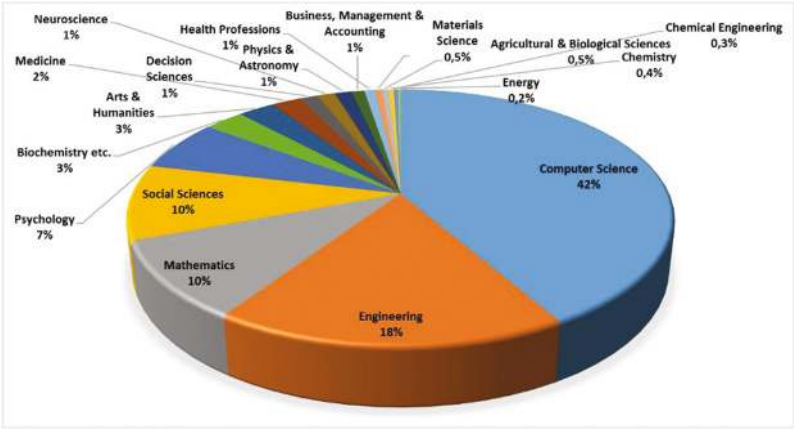

Fig. 2. Main themes

By inspection of the data set with focus on authors with the most publications (regardless of authors order in publication) and narrowing the inspection (for simplicity) to at least four research papers in the field of HCI, a set of twenty-two authors was produced. This is seen in Fig. 3.

Furthermore, the descriptive analysis provided details on the dissemination outlets, as seen in Fig. 4. "*The Lecture Notes Series"* journal and the proceedings from the *"Conference of Human Factors",* both outlets that welcome the technology and human behaviour themes, hold high places among the set of outlets.

To the aforementioned data set (e.g. 962 publications), we ran a series of analytical tests to highlight the authors that inspired the field and ultimately shaped the body of literature with their work. The analysis was based on the use of the 962 publications

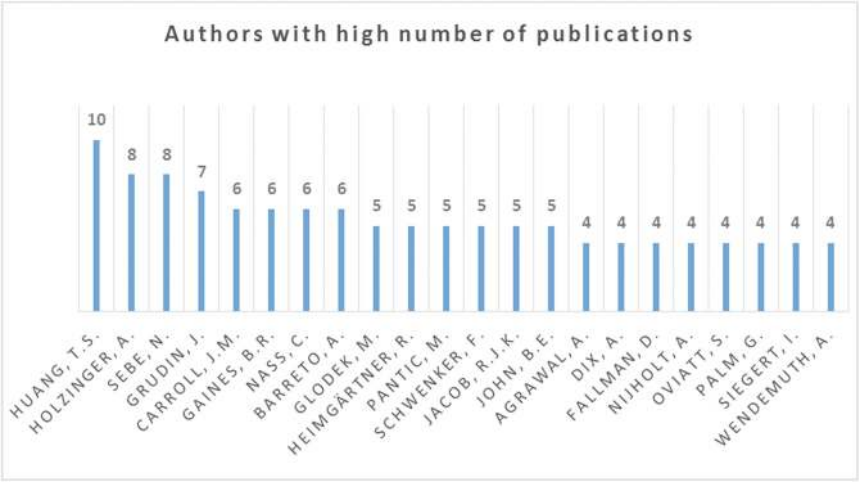

Fig. 3. Researchers with high numbers of publications

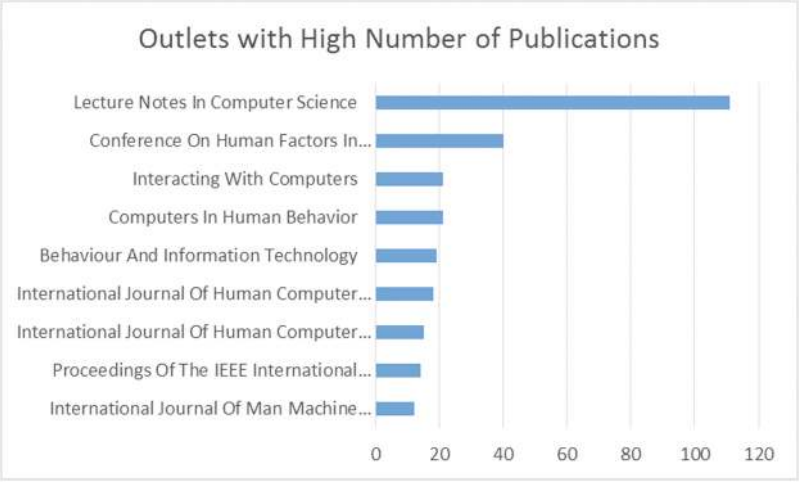

Fig. 4. Source journals of HCI research

(full data in .csv file), the utilisation of VOSviewer software tool and the condition of co-citation of author as a parameter (van Eck and Waltman 2014). The result of this process was a cluster-cloud of the 100 most influential researchers as seen in Fig. 5. In more detail, the figure depicts 100 authors matched in more than twenty clusters (the clustering symbolises authors that are tighter linked in-between them), holding a total number of 1344 links. The relative size of each author's depiction (diameter of cycle symbol) is significant and depicts its linkage strength. For example, Professor Palm

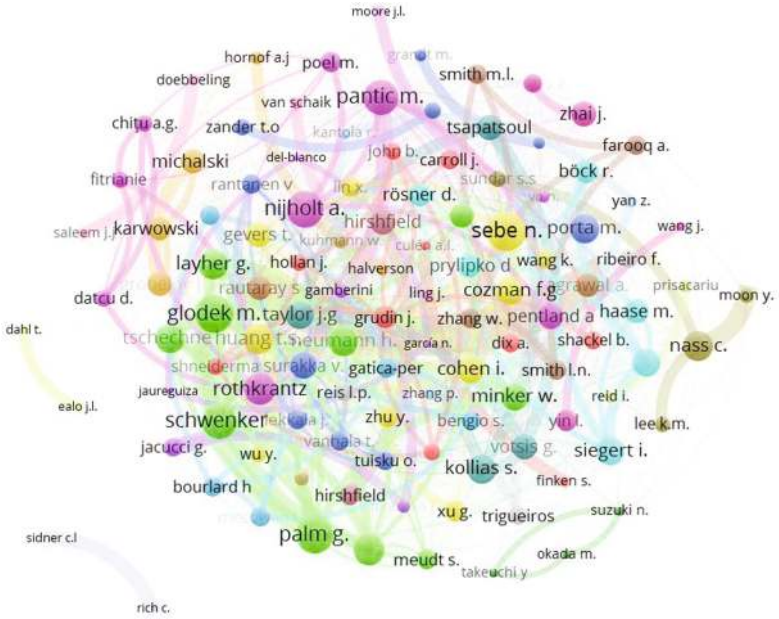

Fig. 5. Top 100 influential researchers of the PT field

from the Institute of Neural Information Processing at Ulm University seen in the bottom right part of the cluster cloud holds a bigger contribution strength compared to his colleague S. Meudt, who is also part of the same cluster.

Observing the results of this analysis, it is apparent that the data set is vast containing many interlinked contributors and intense research clusters that inspired the HCI field.

Additionally, when the focus placed on the co-citation of references (e.g. the references utilised by the authors of the 962 publications) the analysis resulted in a cluster-cloud of one hundred most referred publications, seen in Fig. 6. Moreover, the figure depicts publications matched in seven clusters, holding a total number of 367 links.

The value of this analysis lies not only in observing the impact of well cited publications like Cowie et al. (2001) and MacKenzie (1992) but also in identifying the point of departure for many of these researchers, like well-established reviews like Pavlovic et al. (1997).

Nevertheless, it is evident, that the relative size of the data set and the linkage in-between them, as depicted in the Figs. 5 and 6, provides limited opportunities to understand the HCI field by observation. Thus, in an effort to further explore and investigate this body of literature we proceeded in the use of factor analysis, a method presented in the following sections.

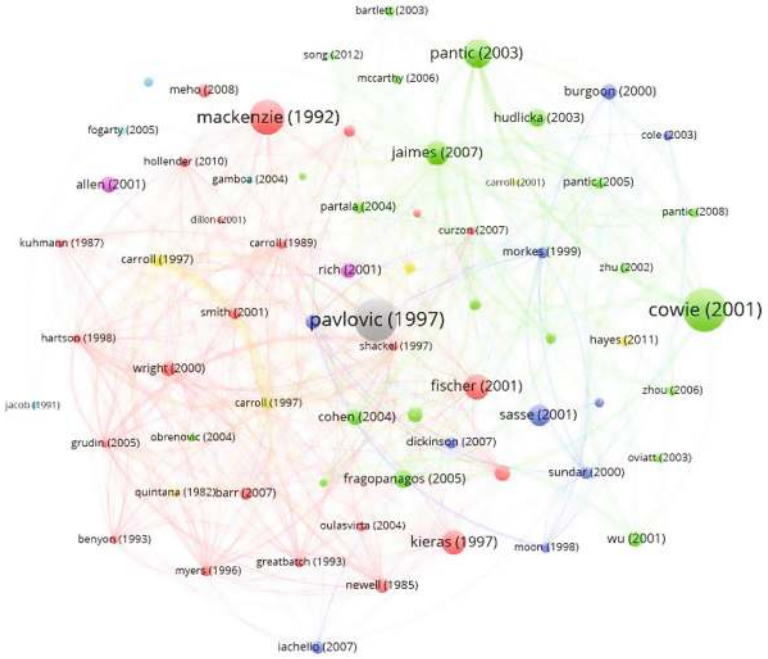

Fig. 6. Frequent *references of the HCI field*

3.2 Findings from the Factor Analysis

An advanced bibliometric coupling matrix was extracted from the Scopus dataset by using Bibexcel software (Persson et al. 2009). The generated coupling matrix comprised of Ri rows and Cj columns where the ricj matrix element shows the frequency of the number of articles cited by both ith and jth publications simultaneously. The bibliographic coupling matrix, was standardized by transforming into correlation bibliographic coupling matrix in order to retrieve coefficients of similarities/dissimilarities between the publications with common research theme and publications with Multivariate Technique (MV) of data reduction, Factor Analysis (FA), was used to extract the distinct aspects of HCI research, and to cluster the correlating articles contributing to a common knowledge base in the field. The correlation bibliographic coupling was analyzed by applying Principal Factor Analysis (PCA) method with Varimax rotation, rotated solutions, and four fixed number of factors, as seen in Table 1 (with the first holding ≈33.5%, the second ≈3.1%, the third ≈2.6% and the fourth ≈2.2% of the total).

The fixed number choice is opted because scree plot suggested a many distributions with each factor after the fourth having a relatively small contribution in explained percentage of variance (<2.0%). Thus, the PCA yielded a set of six factors containing forty-six articles with 81.383% explained variance. As each further incremental factor was explaining an insignificant variance and in order to perform a cohesive analysis, only four factors were retained. Table 2 provides the result core representative set of pattern matrix which is comprised of correlation coefficients associated with each publication.

Table 1. Findings of Factor Analysis (FA) with items and factor loadings

Total variance explained			
Component	Rotation sums of squared loading		
	Total	% of Variance	Cumulative %
1	33,562	65,808	65,808
2	3,103	6,084	71,892
3	2,586	5,071	76,963
4	2,254	4,420	81,383

Table 2. Findings of Factor Analysis (FA) with items and Factor loadings

Authors	Factor loading			
	F1	F2	F3	F4
May et al. (2008)	.994			
Plouznikoff et al. (2006)	.994			
Schwarz et al. (2011)	.994			
McCowan et al. (2003)	.994			
Palacios et al. (2013)	.994			
Carneiro et al. (2016)	.994			
Suzuki et al. (2004)	.993			
Schlick et al. (2010)	.993			
Chavarriaga (2010)	.993			
Yan et al. (2011b)	.993			
Fitrianie et al. (2007)	.993			
Plouznikoff et al. (2005)	.993			
Zhai et al. (2005a)	.993			
Suzuki et al. (2003)	.992			
Yan et al. (2011a)	.992			
Maeda et al. (2006)	.992			
Leiser et al. (1989)	.991			
Zhang et al. (2016b)	.991			
Schwarz et al. (2011)	.991			
Minami et al. (2007)	.990			
Schlick et al. (2003)	.990			
Avons et al. (1989)	.990			
Zhai et al. (2005b)	.990			
Elbahi and Omri (2015)	.990			
Alnuaim et al. (2014)	.990			
Palacios et al. (2013)	.990			
Chathuranga et al. (2010)	.988			
Pimenta et al. (2016)	.988			
Zhang et al. (2016a)	.988			

(*continued*)

Table 2. (*continued*)

Authors	Factor loading			
	F1	F2	F3	F4
Asare (2010)	.987			
Rantanen et al. (2011)	.986			
Deniz et al. (2004)	.874			
Siegert et al. (2014a)		–.718		
Prylipko et al. (2014)		–.698		
Siegert et al. (2014b)		–.648		
Siegert et al. (2014c)		–.648		
Sebe et al. (2005)			–.686	
Cohen et al. (2004)			–.593	
Sebe et al. (2005)			–.593	
Kächele et al. (2015)			.693	
Scherer et al. (2012)			.670	
Trigueiros et al. (2014)				–.663
Maqueda et al. (2015)				–.663
Schels et al. (2014)				.602
Glodek et al. (2015)				.598
Tang et al. (2015)				–.535

3.3 Factor Analysis

The core representative set of forty-six publications divided in four factors, was explored for common themes and patters. This resulted in four descriptions where each factor is analysed with the representative publications of each group:

F1–HCI Theories, Associations and Interaction with Devices. The first factor (F1) is the largest set with thirty-three publications from as early as 1989 to more recent ones as 2016. This set highlights work that emphasizes on theories, associations and devices. Moreover, the authors propose research models and identify theoretical issues (Yan et al. 2011a,b), discuss HCI in connection with effectiveness in education (Alnuaim et al. 2014) and workers' performance management (Carneiro et al. 2016) and associate HCI with specific theories as ambient intelligence (Maeda et al. 2006; Minami et al. 2007), complexity (Schlick et al. 2003; Schlick et al. 2010) and crisis management (Fitrianie et al. 2007). Furthermore, this set of publications includes research on the link between HCI and devices. For example input devices (Asare 2010) composite devices and systems (Chavarriaga et al. 2010), sensors (Palacios et al. 2013) and wearables (Plouznikoff et al. 2006).

F2–Communication Attributes and HCI. The second factor (F2), constitutes a condense but inspiring literature topic, the research on HCI and human linguistic attributes, or more specifically human speech and its underlining attributes like dialog events, feedback signals and interaction corpora. In more detail, in this four publications' set, published in 2014, the authors address issues of automatically detecting

significant dialog events (SDEs) in naturalistic HCI, deducing trait-specific conclusions relevant for the design of spoken dialog systems (Prylipko et al. 2014) and investigate the influence of specific feedback signals, known as discourse particles (DPs), with communication style and psychological characteristics within a naturalistic HCI (Siegert et al. 2014b). In addition, they depict their investigation for emotional annotated interaction corpora and present methods to improve the reliability (Siegert et al. 2014a) and provide design guidelines for future automatic designated "companion" systems (Prylipko et al. 2014).

F3–Data classification and User(s) issues for HCI applications. The publications in the third factor (F3) differentiate in comparison to the previous factors, as the authors place their focus on the aggregation and classification of data. In more detail they discuss training probabilistic classifiers with labelled and unlabelled data for HCI applications and show how the resulting algorithms are successfully employed in facial expression recognition, face detection and recognition and skin detection (Cohen et al. 2004; Sebe et al. 2005; Sebe et al. 2005). In the same lines additional research exposes the issue of evaluation of the results that are computed using statistical classifiers (Kächele et al. 2015). Yet, the authors also propose the use of fuzzy memberships in order to model affective user state and endorse respective fuzzy performance measures (Kächele et al. 2015). This set also includes a generic framework that may minimise difficulties associated with real world user behaviour analysis (i.e. uncertainty about the ground truth of the current state, subject independence, dynamic real-time analysis of multimodal information, and the processing of incomplete or erroneous inputs, e.g. after sensor failure or lack of input) (Scherer et al. 2012).

F4–HCI and Recognition Systems. The fourth factor (F4) includes publications dealing with HCI and hand-gesture recognition systems. Hand gestures are a powerful way for human communication, with lots of potential applications in the area of HCI. In this set of publications, the authors' propose various approaches with significant results. In more detail, one may observe a generic system architecture based on computer vision and machine learning, able to be used with any interface for real-time human-machine interaction (Trigueiros et al. 2014), a robust vision-based hand-gesture recognition system divided into three stages: detection, tracking, and recognition (Maqueda et al. 2015), and a technique for three dimensional non-contact sensing of hand motion through electrostatic field (Tang et al. 2015). In similar lines the information fusion principles (such as perception-level fusion, knowledge-based fusion and application-level fusion) in cognitive technical systems (CTS) architectures for Companion Technologies are illustrated with examples of characteristic algorithms (Glodek et al. 2015)

4 Discussion

Applying the Factor Analysis in the literature segment (e.g. forty-six publications with a 81.3% representation) provides a distinctive analytical lens into the past, current and future dimensions of HCI research. Through our analysis we observed that the majority

of authors and cases were resonating in Europe (32/46 publications), following Asia (6/46 publications), USA (5/46 publications) and the rest from Canada and Africa. This finding supports the notion of western and developing countries increased interest in HCI research.

Our analysis did not highlight any novel HCI approach but rather adds emphasis on well-document HCI sub-fields and research interests like gaze-tracking (Rantanen et al. 2011), face-recognition (Sebe et al. 2005) and affective computing (Kächele et al. 2015; Schels et al. 2014) and in more recent studies the utilization of sensors (Palacios et al. 2013) and wearables (Rantanen et al. 2011).

Supplementary to the aforementioned research and supportive to our own experiences with HCI, we identified some emerging trends relating HCI and the workplace. Especially, the utilisation of technology in the professional workspace and investigation of the underlined HCI issues like monitor and improving performance (Carneiro et al. 2016) and mental fatigue and efficient fatigue management initiatives, mainly in the context of desk jobs (Pimenta et al. 2016) seem to be trends that are scaling up on the research agenda.

5 Conclusions

Today, HCI is a vast and multifaceted community, bound by the evolving concept of usability, and the integrating commitment to value human activity and experience as the primary driver in technology.

Over the last decades, the interest in HCI has grown and so has the body of literature. A literature that spawns from and thus links, a variety of disciplines. We observed this dissemination flow in the form of productive discussions, experiments and results in an increasing collection of scientific conferences and journals. In an effort to outline, the multidiscipline body of HCI literature and formulate a deeper, more profound understanding of HCI issues we proceeded in a literature analysis through the lens of a bibliometric investigation. Our analysis started by covering the period from 1969 to 2017. The data was analysed in relation to their publication year (seen in Fig. 1), subject area (seen in Fig. 2), researchers (seen in Fig. 3) and publication outlet (seen in Fig. 4). Additionally, we investigated the body of literature and depicted the most influential authors (seen in Fig. 5) and the origins of HCI in terms of our data set (seen in Fig. 6) thus, providing a clear overview of the topic.

Nevertheless, the novelty of this research derives from the findings of the explorative focused analysis of the representative data set (forty-six publications), which revealed interesting facts about HCI as a developing research field. With factor analysis, we identified four core sets of research from theoretical concepts, design aspects and association to user issues, affective computing and recognition systems and sensors. Thus, one can follow the methodology utilised herein and investigate in depth one or more of the HCI intriguing aspects.

References

Acedo, F.J., Barroso, C., Galan, J.L.: The resource-based theory: dissemination and main trends. Strateg. Manag. J. **27**(7), 621–636 (2006)

Alnuaim, A., Caleb-Solly, P., Perry, C.: Evaluating the effectiveness of a mobile location-based intervention for improving human-computer interaction students' understanding of context for design. Int. J. Mob. Hum. Comput. Interact. **6**(3), 16–31 (2014). doi:10.4018/ijmhci.2014070102

Asare, P.: A sign of the times: a composite input device for human-computer interactions. IEEE Potentials **29**(2), 9–14 (2010). doi:10.1109/MPOT.2010.936235

Avons, S.E., Leiser, R.G., Carr, D.J.: Paralanguage and human-computer interaction. Part 1: identification of recorded vocal segregates. Behav. Inf. Technol. **8**(1), 13–21 (1989). doi:10.1080/01449298908914534

Boyack, K.W., Klavans, R.: Co-citation analysis, bibliographic coupling, and direct citation: Which citation approach represents the research front most accurately? J. Am. Soc. Inform. Sci. Technol. **61**(12), 2389–2404 (2010)

Carneiro, D., Pimenta, A., Gonçalves, S., Neves, J., Novais, P.: Monitoring and improving performance in human-computer interaction. Concurrency Comput. **28**(4), 1291–1309 (2016). doi:10.1002/cpe.3635

Carroll, J.M.: Human Computer Interaction-Brief Intro. The Encyclopedia of Human-Computer Interaction, 2nd edn. (2013)

Chavarriaga, R., Biasiucci, A., Förster, K., Roggen, D., Tröster, G., Del Millán, J.R.: Adaptation of hybrid human-computer interaction systems using EEG error-related potentials. In: Paper Presented at the 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC 2010 (2010)

Cohen, I., Cozman, F.G., Sebe, N., Cirelo, M.C., Huang, T.S.: Semisupervised learning of classifiers: theory, algorithms, and their application to human-computer interaction. IEEE Trans. Pattern Anal. Mach. Intell. **26**(12), 1553–1567 (2004). doi:10.1109/TPAMI.2004.127

Cowie, R., Douglas-Cowie, E., Tsapatsoulis, N., Votsis, G., Kollias, S., Fellenz, W., Taylor, J.G.: Emotion recognition in human-computer interaction. IEEE Signal Process. Mag. **18**(1), 32–80 (2001). doi:10.1109/79.911197

Deniz, O., Falcon, A., Mendez, J., Castrillon, M.: Useful computer vision techniques for human-robot interaction. In: Campilho, A., Kamel, M. (eds.) ICIAR 2004. LNCS, vol. 3212, pp. 725–732. Springer, Heidelberg (2004). doi:10.1007/978-3-540-30126-4_88

Di Stefano, G., Peteraf, M., Verona, G.: Dynamic capabilities deconstructed: a bibliographic investigation into the origins, development, and future directions of the research domain. Ind. Corp. Change **19**(4), 1187–1204 (2010). doi:10.1093/icc/dtq027

Elbahi, A., Omri, M.N.: Conditional random fields for web user task recognition based on human computer interaction. In: Paper Presented at the 23rd International Conference in Central Europe on Computer Graphics, Visualization and Computer Vision, WSCG 2015–Posters Proceedings (2015)

Fitrianie, S., Poppe, R., Bui, T.H., Chiţu, A.G., Datcu, D., Dor, R., Zwiers, J.: A multimodal human-computer interaction framework for research into crisis management. In: Paper Presented at the Intelligent Human Computer Systems for Crisis Response and Management, ISCRAM 2007 Academic Proceedings Papers (2007)

Glodek, M., Honold, F., Geier, T., Krell, G., Nothdurft, F., Reuter, S., Schwenker, F.: Fusion paradigms in cognitive technical systems for human-computer interaction. Neurocomputing **161**, 17–37 (2015). doi:10.1016/j.neucom.2015.01.076

Hartson, H.R.: Human-computer interaction: Interdisciplinary roots and trends. J. Syst. Softw. **43**(2), 103–118 (1998)

Kasun Chathuranga, S., Samarawickrama, K.C., Chandima, H.M.L., Chathuranga, K.G.T.D., Abeykoon, A.M.H.S.: Hands free interface for human computer interaction. In: Paper Presented at the Proceedings of the 2010 5th International Conference on Information and Automation for Sustainability, ICIAFs 2010 (2010)

Kächele, M. et al.: On annotation and evaluation of multi-modal corpora in affective human-computer interaction. In: Böck, R., Bonin, F., Campbell, N., Poppe, R. (eds.) MA3HMI 2014 Workshop. LNCS, vol 8757, pp. 35–44. Springer, Cham. doi:10.1007/978-3-319-15557-9_4

Leiser, R.G., Avons, S.E., Carr, D.J.: Paralanguage and human-computer interaction. part 2: Comprehension of synthesized vocal segregates. Behav. Inf. Technol. **8**(1), 23–32 (1989). doi:10.1080/01449298908914535

MacKenzie, I.S.: Fitts' law as a research and design tool in human-computer interaction. Hum.-Comput. Interact. **7**(1), 91–139 (1992). doi:10.1207/s15327051hci0701_3

Maeda, E., Minami, Y., Miyoshi, M., Sawaki, M., Sawada, H., Nakamura, A., Higashinaka, R.: The world of mushrooms - a transdisciplinary approach to human-computer interaction with ambient intelligence. NTT Tech. Rev. **4**(12), 17–24 (2006)

Maqueda, A.I., Del-Blanco, C.R., Jaureguizar, F., García, N.: Human-computer interaction based on visual hand-gesture recognition using volumetric spatiograms of local binary patterns. Comput. Vis. Image Underst. **141**, 126–137 (2015). doi:10.1016/j.cviu.2015.07.009

May, M., George, S., Prévôt, P.: A closer look at tracking human and computer interactions in web-based communications. Interact. Technol. Smart Educ. **5**(3), 170–188 (2008). doi:10.1108/17415650810908258

McCowan, I., Gatica-Perez, D., Bengio, S., Moore, D., Bourlard, H.: Towards computer understanding of human interactions. In: Aarts, E., Collier, René W., Loenen, E., Ruyter, B. (eds.) EUSAI 2003. LNCS, vol. 2875, pp. 235–251. Springer, Heidelberg (2003). doi:10.1007/978-3-540-39863-9_18

Meho, L.I., Rogers, Y.: Citation counting, citation ranking, and h-index of human-computer interaction researchers: a comparison of scopus and web of science. J. Am. Soc. Inform. Sci. Technol. **59**(11), 1711–1726 (2008). doi:10.1002/asi.20874

Minami, Y., Sawaki, M., Dohsaka, K., Higashinaka, R., Ishizuka, K., Isozaki, H., Maeda, E.: The world of mushrooms: human-computer interaction prototype systems for ambient intelligence. In: Paper Presented at the Proceedings of the 9th International Conference on Multimodal Interfaces, ICMI 2007 (2007)

Palacios, J.M., Sagués, C., Montijano, E., Llorente, S.: Human-computer interaction based on hand gestures using RGB-D sensors. Sensors (Basel, Switzerland) **13**(9), 11842–11860 (2013). doi:10.3390/s130911842

Pavlovic, V.I., Sharma, R., Huang, T.S.: Visual interpretation of hand gestures for human-computer interaction: a review. IEEE Trans. Pattern Anal. Mach. Intell. **19**(7), 677–695 (1997). doi:10.1109/34.598226

Persson, O., Danell, R., Schneider, J.W.: How to use Bibexcel for various types of bibliometric analysis. In: Celebrating scholarly Communication Studies: A Festschrift for Olle Persson at his 60th Birthday, pp. 9–24 (2009)

Pimenta, A., Carneiro, D., Neves, J., Novais, P.: A neural network to classify fatigue from human-computer interaction. Neurocomputing **172**, 413–426 (2016). doi:10.1016/j.neucom.2015.03.105

Plouznikoff, A., Plouznikoff, N., Robert, J.M., Desmarais, M.: Enhancing human-machine interactions: Virtual interface alteration through wearable computers. In: Paper Presented at the Conference on Human Factors in Computing Systems–Proceedings (2006)

Plouznikoff, N., Plouznikoff, A., Robert, J.M.: Object augmentation through ecological human–wearable computer interactions. In: Paper Presented at the 2005 IEEE International Conference on Wireless and Mobile Computing, Networking and Communications, WiMob 2005 (2005)

Prylipko, D., Rösner, D., Siegert, I., Günther, S., Friesen, R., Haase, M., Wendemuth, A.: Analysis of significant dialog events in realistic human-computer interaction. J. Multimodal User Interfaces **8**(1), 75–86 (2014). doi:10.1007/s12193-013-0144-x

Rantanen, V., Vanhala, T., Tuisku, O., Niemenlehto, P.H., Verho, J., Surakka, V., Lekkala, J.: A wearable, wireless gaze tracker with integrated selection command source for human-computer interaction. IEEE Trans. Inf Technol. Biomed. **15**(5), 795–801 (2011). doi:10.1109/TITB.2011.2158321

Schels, M., Kächele, M., Glodek, M., Hrabal, D., Walter, S., Schwenker, F.: Using unlabeled data to improve classification of emotional states in human computer interaction. J. Multimodal User Interfaces **8**(1), 5–16 (2014). doi:10.1007/s12193-013-0133-0

Scherer, S., Glodek, M., Layher, G., Schels, M., Schmidt, M., Brosch, T., Palm, G.: A generic framework for the inference of user states in human computer interaction: how patterns of low level behavioral cues support complex user states in HCI. J. Multimodal User Interfaces **6**(3–4), 117–141 (2012). doi:10.1007/s12193-012-0093-9

Schlick, C.M., Winkelholz, C., Motz, F., Brütting, M.: Complexity and human-computer interaction. In: Paper Presented at the Proceedings of the IEEE International Conference on Systems, Man and Cybernetics (2003)

Schlick, C.M., Winkelholz, C., Motz, F., Duckwitz, S., Grandt, M.: Complexity assessment of human-computer interaction. Theor. Issues Ergon. Sci. **11**(3), 151–173 (2010). doi:10.1080/14639220802609903

Schwarz, L.A., Bigdelou, A., Navab, N.: Learning gestures for customizable human-computer interaction in the operating room. In: Fichtinger, G., Martel, A., Peters, T. (eds.) MICCAI 2011. LNCS, vol. 6891, pp. 129–136. Springer, Heidelberg (2011). doi:10.1007/978-3-642-23623-5_17

Sebe, N., Cohen, I., Cozman, F.G., Gevers, T., Huang, T.S.: Learning probabilistic classifiers for human-computer interaction applications. Multimedia Syst. **10**(6), 484–498 (2005). doi:10.1007/s00530-005-0177-4

Sebe, N., Cohen, I., Huang, T.S., Gevers, T.: Human-computer interaction: a Bayesian network approach. In: Paper Presented at the ISSCS 2005: International Symposium on Signals, Circuits and Systems–Proceedings (2005)

Siegert, I., Böck, R., Wendemuth, A.: Inter-rater reliability for emotion annotation in human-computer interaction: Comparison and methodological improvements. J. Multimodal User Interfaces **8**(1), 17–28 (2014a). doi:10.1007/s12193-013-0129-9

Siegert, I., Haase, M., Prylipko, D., Wendemuth, A.: Discourse particles and user characteristics in naturalistic human-computer interaction. In: Kurosu, M. (ed.) HCI 2014. LNCS, vol. 8511, pp. 492–501. Springer, Cham (2014b). doi:10.1007/978-3-319-07230-2_47

Siegert, I., Prylipko, D., Hartmann, K., Böck, R., Wendemuth, A.: Investigating the form-function-relation of the discourse particle “hm” in a naturalistic human-computer interaction. In: Smart Innovation, Systems and Technologies, vol. 26, pp. 387–394 (2014c)

Suzuki, N., Kakehi, K., Takeuchi, Y., Okada, M.: Social effects of the speed of hummed sounds on human-computer interaction. Int. J. Hum. Comput. Stud. **60**(4), 455–468 (2004). doi:10.1016/j.ijhcs.2003.09.007

Suzuki, N., Takeuchi, Y., Ishii, K., Okada, M.: Effects of echoic mimicry using hummed sounds on human-computer interaction. Speech Commun. **40**(4), 559–573 (2003). doi:10.1016/S0167-6393(02)00180-2

Tang, K., Chen, X., Zheng, W., Han, Q., Li, P.: A non-contact technique using electrostatics to sense three-dimensional hand motion for human computer interaction. J. Electrostat. **77**, 101–109 (2015). doi:10.1016/j.elstat.2015.07.006

Trigueiros, P., Ribeiro, F., Reis, L.P.: Generic system for human-computer gesture interaction. In: Paper Presented at the 2014 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2014 (2014)

Eck, N.J., Waltman, L.: Visualizing bibliometric networks. In: Ding, Y., Rousseau, R., Wolfram, D. (eds.) Measuring Scholarly Impact, pp. 285–320. Springer, Cham (2014). doi:10.1007/978-3-319-10377-8_13

Vogel, R., Güttel, W.H.: The dynamic capability view in strategic management: A bibliometric review. Int. J. Manage. Rev. **15**(4), 426–446 (2013)

Waltman, L., van Eck, N.J., Noyons, E.C.: A unified approach to mapping and clustering of bibliometric networks. J. Informetrics **4**(4), 629–635 (2010)

Wolfswinkel, J.F., Furtmueller, E., Wilderom, C.P.: Using grounded theory as a method for rigorously reviewing literature. Eur. J. Inf. Syst. **22**(1), 45–55 (2013)

Yan, Z., Kantola, R., Zhang, P.: A research model for human-computer trust interaction. In: Paper Presented at the Proceedings of the 10th IEEE International Conference on Trust, Security and Privacy in Computing and Communications, TrustCom 2011, 8th IEEE International Conference on Embedded Software and Systems, ICESS 2011, 6th International Conference on FCST 2011 (2011a)

Yan, Z., Kantola, R., Zhang, P.: Theoretical issues in the study of trust in human-computer interaction. In: Paper Presented at the Proceedings of the 10th IEEE International Conference on Trust, Security and Privacy in Computing and Communications, TrustCom 2011, 8th IEEE International Conference on Embedded Software and Systems, ICESS 2011, 6th International Conference on FCST 2011 (2011b)

Zhai, J., Barreto, A.B., Chin, C., Li, C.: Realization of stress detection using psychophysiological signals for improvement of human-computer interactions. In: Paper Presented at the Conference Proceedings–IEEE SOUTHEASTCON (2005a)

Zhai, J., Barreto, A.B., Chin, C., Li, C.: User stress detection in human-computer interactions. Biomed. Sci. Instrum. **41**, 277–282 (2005)

Zhang, W., Smith, M.L., Smith, L.N., Farooq, A.: Eye center localization and gaze gesture recognition for human-computer interaction. J. Opt. Soc. Am. A **33**(3), 314–325 (2016a). doi:10.1364/JOSAA.33.000314

Zhang, W., Smith, M.L., Smith, L.N., Farooq, A.: Gender and gaze gesture recognition for human-computer interaction. Comput. Vis. Image Underst. **149**, 32–50 (2016b). doi:10.1016/j.cviu.2016.03.014

Zupic, I., Čater, T.: Bibliometric methods in management and organization. Organ. Res. Methods **18**(3), 429–472 (2015)