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Editors:
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Bonnie Mitchell, Martin Kocur

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Understanding Hybrid Spaces: Designing a Spacetime Model to Represent Dynamic Topologies of Hybrid Spaces

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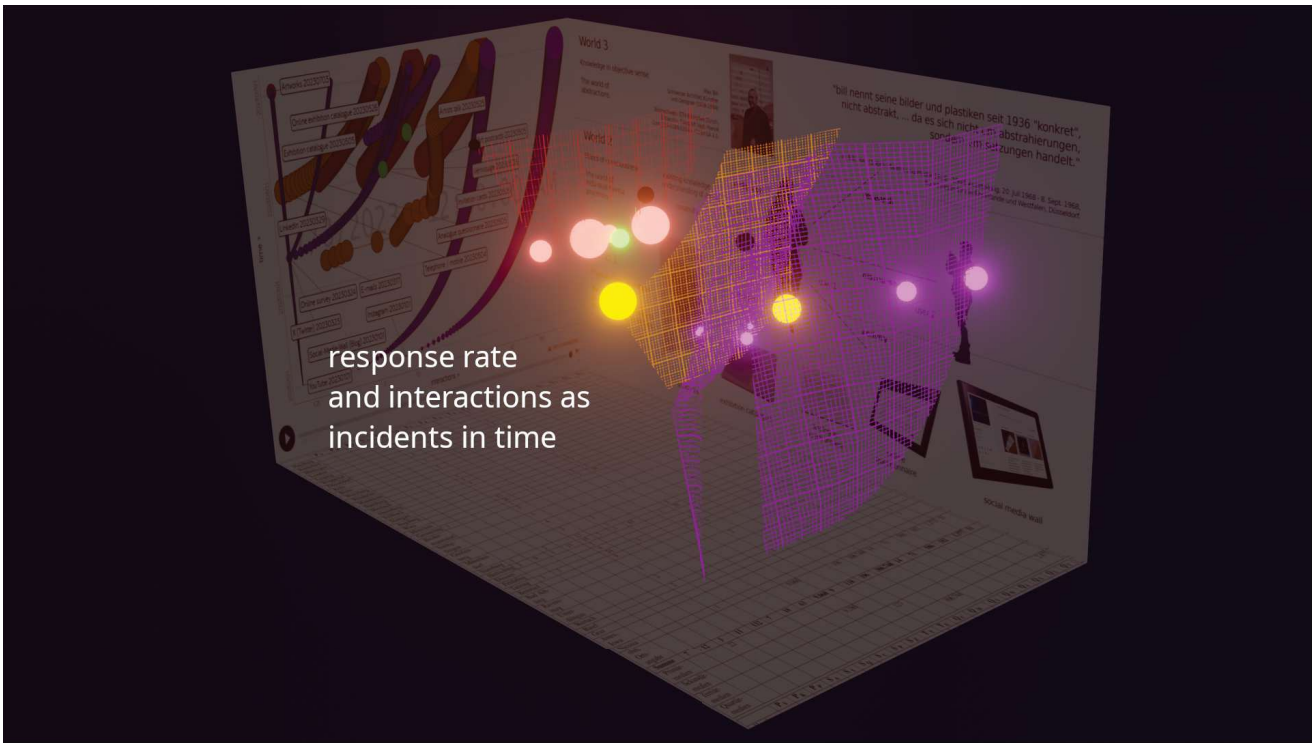

Figure 1: Dynamic topologies according to media types, response rate and interactions in time (Still image from computer generated animation)

Abstract

This paper develops a spatiotemporal model for visualizing dynamic topologies of hybrid spaces. The joint representation of spatiotemporal data is a well-known problem, for example in digital twins and urban planning. There is also a lack of a basic ontology for understanding hybrid spaces. Existing concepts and types of representations of hybrid spaces are presented. The spatiotemporal model is developed in three layers. The model was tested on the occasion of an art exhibition. Range, number of interactions and response rates were recorded. Various dynamic topologies of hybrid spaces could be successfully represented. An online survey provided a positive correlation between modality and individual activity. The three-leveled model structure helps to improve class formation and software architecture in serious games or digital twins.

The joint representation of real and virtual places also revealed that range and urban density are equivalent concepts. Media can be described as places. Multilocality could successfully be mapped. Modality of hybrid spaces shows new relations between media and transportation. Combinations of the examination parameters allow a large number of different dynamic topologies to be represented. Pattern recognition in hybrid spaces enables further research and user experience studies. The results of this study convey a new understanding of urban space.

CCS Concepts

• **Human-centered computing → Interaction design theory, concepts and paradigms**; **Visualization design and evaluation methods**; • **Applied computing → Arts and humanities**.

Keywords

Hybrid space, Digital twins, Urban planning, Spatial perception, Data visualization, Media theory.

Reference Format:

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1 Introduction

We live in hybrid spaces today. The display of our smartphones shows the weather forecast. Navigation systems inform us in real time about traffic jams and obstructions. Museums provide virtual guided tours or online talks. Cities and municipalities are developing digital twins for energy management, urban planning and architecture. The use of media is changing our conventional understanding of space. Most of the existing interactive applications are three-dimensional and object-based. Spatial and temporal data often remain separated. The joint visualization of spatiotemporal data therefore remains a problem. The pervasion of real and virtual spaces cannot be mapped operably and satisfactory in today's software applications [46]. There is also a lack of a basic ontology for a common understanding of these two, often separately depicted domains. Therefore this paper develops a spatiotemporal model for visualizing dynamic topologies of hybrid spaces. The present version is an abridged version of previous work published as a preprint [13], supplemented by a new additional computer-generated 3D animation. Figure 1 shows a still image from this computer-generated animation. This paper contains a discursive part and a creative part with an accompaning empirical study. The discursive part deals with the most important existing concepts of hybrid spaces and presents a selection of seven types of representations of hybrid spaces. This is followed by a creative section in which the three-leveled spatiotemporal model for the representation of dynamic topologies of hybrid spaces is developed. The evaluation parameters (media types, modality, range, interactions, response rate and completion rate) are presented. The spatiotemporal model is then applied and tested in the context of an art exhibition. The hybrid setting of the art exhibition is described. The results of the examination and an accompaning online survey are presented. Attached you will find a computer generated 3D animation showing one of many other possible dynamic topologies of the examined hybrid space.

2 Literature review

The literature review revealed three different concepts of hybrid spaces.

- real spaces and virtual places
- places of individual perception and open space
- ambivalent space through anticipation and interaction

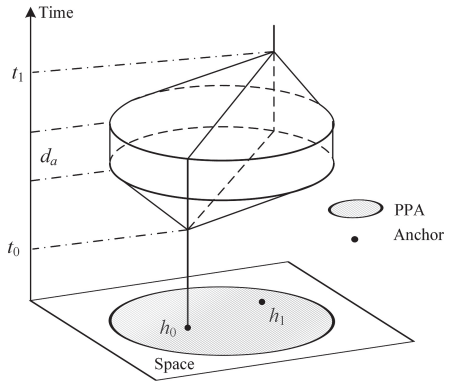

Figure 2: Space-time prism according to Lenntorp (1976), Reprinted from Qin and Liao (2021), CC-BY 4.0 license [18].

Many authors dealt with the dialectics of real spaces and virtual places [15] [7] [10] [42] [26] [29]. A second group examined places of individual perception and open space [4] [44] [6] [8] [41] [36] [17] [35] [30] [11] [39]. And a third group focused on concepts of ambivalent space through human anticipation and interaction [16] [5] [20] [19] [1] [45] [31] [25] [34] [43]. Additionally seven general types of representations of hybrid spaces could be identified. These representations include so-called (1) time maps (isochrone maps and cartograms) [40] [28], (2) cognitive maps and network diagrams [21] [22] [14], (3) space-time representations in computer games (collaborative storytelling and authoring tools), (4) psychogeographic maps [3] [24] [2] or mind maps, (5) layer models and activity maps, such as in the "locative arts" [32] [38]. And there are (6) space-time prisms of time geography [12] [37] [18] and (7) space-time diagrams in the natural sciences, such as the Minkowski and Penrose diagrams. They especially focus on physical events [23]. Most interesting for this work revealed the distinction between space and place after Kraan [15], Dourish and Harrison [7] and also the concept of the topology of a space, as mentioned by Bernhard Tschumi [43]. Moreover the representations of space-time prisms in time geography and the space-time diagrams in the natural sciences proved to be interesting for our following spacetime model. Figure 2 shows a space-time prism with the potential path area (PPA) according to Lenntorp [18] .

3 Materials and Methods

According to the three aforementioned concepts of hybrid space (real spaces and virtual places, places of individual perception and open space, ambivalent space through anticipation and interaction) our spacetime model joins three levels: (A) real and virtual places and media types, (B) perception and (C) time and interaction. Figure 3 shows the spatiotemporal model structure. The level of places and media types is organized according to the reality-virtuality continuum according to Milgram and Colquhoum [27]. It comprises both, real and virtual places joined together on one level and the four media types (primary, secondary, tertiary and quarternary media) according to Faulstich [9]. Individual perception is mapped in the level of perception. This level is structured according to Karl R. Popper's model of the three worlds: from top to bottom - world 3

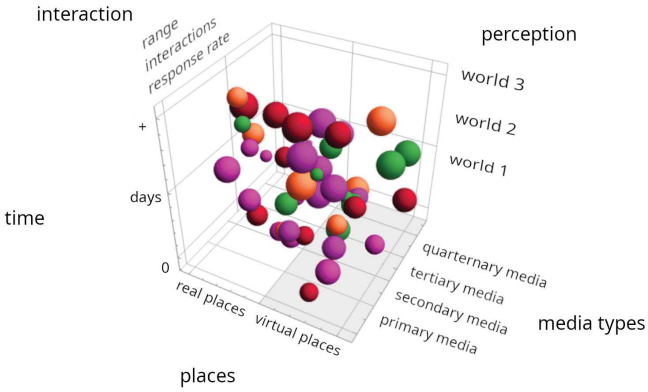

Figure 3: Spatiotemporal model structure

(knowledge and abstractions), world 2 (consciousness and mental processes) and the world 1 (physical objects and states) [33]. The third level of time and interaction corresponds to the representations of space-time diagrams in time geography and in the natural sciences. Within this three-leveled domain, various dynamic and three-dimensional topologies can be mapped according to the given parameters of places, media types, range, response rate, completion rate, time and interactions.

This model was tested on the occasion of an art exhibition. Places and media types were mapped in the level of places and media types. All media events were depicted in the level of time and interaction. The hybrid media setup of the exhibition was illustrated in the level of perception. Figure 4 shows a detailled illustration of the level of perception with all elements of the hybrid perceptional setting of the art exhibition. A total of 19 different media were used, including face-to-face events, print-, online- and interactive media as shown in table 1. The project lasted 184 days, the exhibition period lasted 61 days. 177 people were involved at 39 different locations in Europe and the USA. An online survey with 14 participants examined the correlations between the levels of perception and time and interaction. Following parameter were recorded: the modality (M_{OD}) of used media types, the media range (R_{NG}), number of medial interactions (M_{IA}), the response rate (M_{RQ}) and the completion rate (C_{OR}). Equations 1-5 show the calculation factors of the parameters.

$$M_{\mathrm{OD}} = \frac{MediaTypes}{TotalNumberOfMedia} \tag{1}$$

$$R_{\mathrm{NG}} = \frac{Persons}{Place/Medium} \tag{2}$$

$$M_{\mathrm{IA}} = \frac{Interactions}{Place/Medium} \tag{3}$$

$$M_{\mathrm{RQ}} = \frac{M_{\mathrm{IA}}}{R_{\mathrm{NG}}} \tag{4}$$

$$C_{\mathrm{OR}} = \frac{Completers}{Participants} \tag{5}$$

Table 1: Media types and used media

	Media types	Used media
P_V	Primary media	Vernissage
P_A		Artist's talk
P_P		Privatissimum
S_A	Secondary media	Artworks
S_I		Invitation cards
S_Q		Questionnaires
S_C		Exhibition catalogue
S_P		Art postcards
S_N		Newspaper article
T_T	Tertiary media	Telephone/Mobile
T_E		e-mails
Q_C	Quarternary media	Online exhibition catalogue
Q_M		Online media portal
Q_S		Online survey
Q_W		Social media wall (Blog)
Q_I		Instagram
Q_X		X (Twitter)
Q_L		LinkedIn
Q_Y		YouTube

The correlations between these parameters were first depicted in two dimensional bubble diagrams at the level of time and interaction. Figure 5 shows a sample of the level of time and interaction with the correlation between response rate, interactions and time. On the basis of this single case a computer-generated 3D animation was created, showing a dynamic topology of this selected hybrid space. Figure 1 shows a still image from this computer-generated animation.

4 Results and Discussion

The online survey provided a positive correlation between media use (modality) and individual activity (creativity). Participants with higher media usage showed greater individual activity. However, due to the low response rate by only 14 participants (M_{RQ}=7,9%) and an average completion rate (C_{OR}=21,43%) unfortunately the online survey is not very representative. The online survey and all other used media turned out as two different hybrid spaces. These two could be distinguished according to the total number of participants (users), the media used and the mix of media types (modality). Table 2 shows the generally used mix of media types.

The media range (R_{NG}) could be successfully mapped in the level of places and media types. Figure 6 shows the level of places and media types with the range data of the individual media. The number of people reached is shown in colored circular areas (1 person $\widehat{=}$ 1 pixel diameter). The media types are displayed in color, as in Figure 3 (Primary media = green, Secondary media = red, Tertiary media = orange, Quarternary media = purple). Immediately recognizable there is the enormous range of the quaternary media (purple) over all real and virtual places. The secondary media (red) and tertiary media (orange) are just behind it.

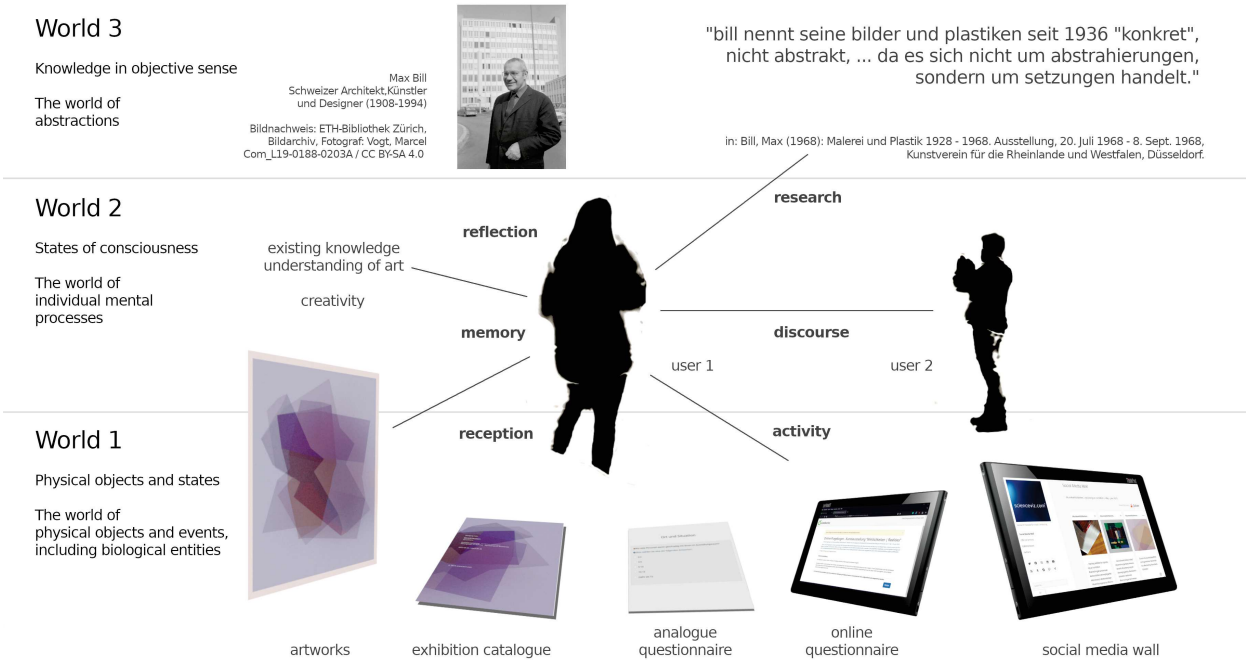

Figure 4: Level of perception - elements of the hybrid perceptional setting of the art exhibition

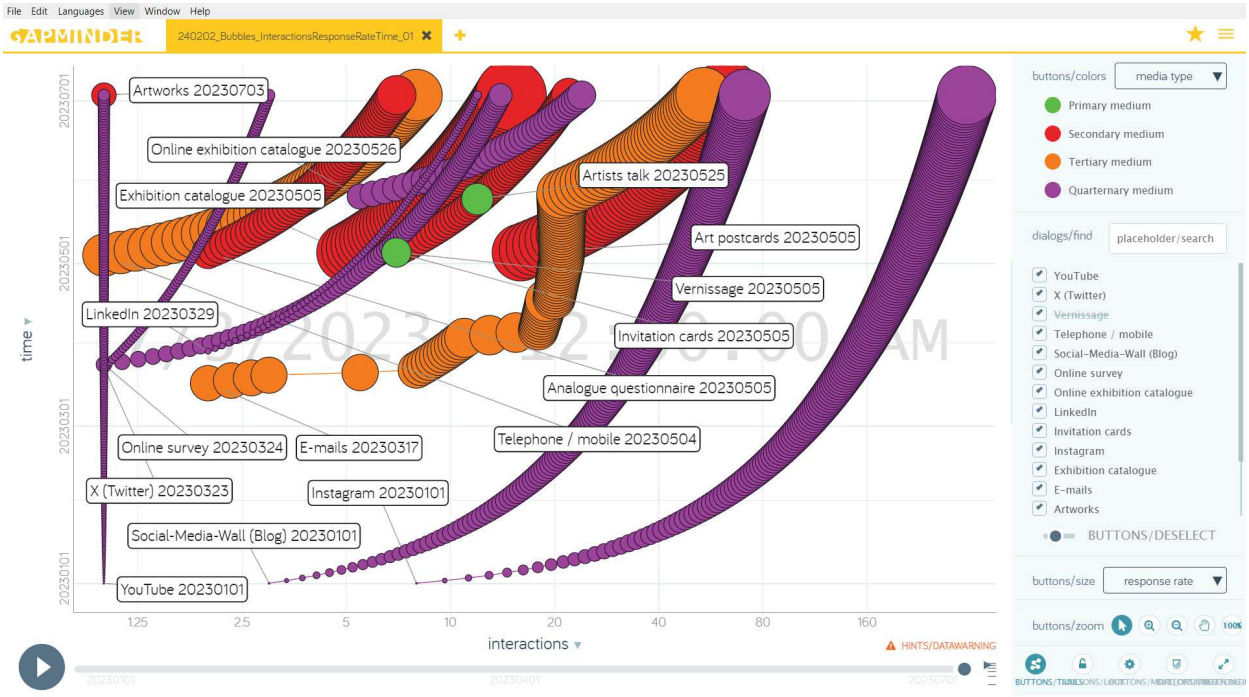

Figure 5: Level of time and interaction - response rate and interactions as incidents in time

Table 2: Modality (M_{OD})

	Media types	Used media	M_{OD}
Q_C	Quarternary media	Online exhibition catalogue	42,10%
Q_M		Online media portal	
Q_S		Online survey	
Q_W		Social media wall (Blog)	
Q_I		Instagram	
Q_X		X (Twitter)	
Q_L		LinkedIn	
Q_Y		YouTube	
S_A	Secondary media	Artworks	31,58%
S_I		Invitation cards	
S_Q		Questionnaires	
S_C		Exhibition catalogue	
S_P		Art postcards	
S_N		Newspaper article	
P_V	Primary media	Vernissage	15,79%
P_A		Artist's talk	
P_P		Privatissimum	
T_T	Tertiary media	Telephone/Mobile	10,53%
T_E		e-mails	

The small green dots of the primary media appear only occasionally. The concept of range describes the distribution of people reached across all places. Range can be considered as an equivalent to spatial or urban density. Urban density is one of the fundamental parameters of urban and spatial planning. It is usually expressed in inhabitants (I) per unit area (e.g: hectares of land (I/ha)). With the media range (e.g.: number of people reached/medium), we thus have an equivalent to the concept of urban density joining and combining real and virtual places.

Media range (R_{NG}), number of interactions (M_{IA}) and the response rate (M_{RQ}) could also be successfully depicted in the level of time and interaction. Figure 5 already has shown a sample of the level of time and interaction with the correlation between response rate, interactions and time. On this basis the computer-generated 3D animation was created. Additionally another four other combinations of the aforementioned research parameters could be depicted as two dimensional bubble diagrams. All these figures and the computer-generated animation are available in the online resources in appendix A. All research data of the online survey, all tables and graphs can be found in the preprint version [13].

The three leveled spatiotemporal model proved to be very operational. Various dynamic topologies of hybrid spaces can be successfully represented. It also allows to recognize patterns in the dynamic topologies of different hybrid spaces. When developing interactive applications, the three-leveled structure helps to better classify code elements. It is capable to improve the software architecture and to create clearer software structures.

5 Conclusion and Perspectives

The joint presentation of real and virtual places revealed three interesting results: range and urban density proved to be equivalent concepts and media can be successfully described as places. The concept of place itself loses its spatial primacy and can be described as a function of the range of a medium. The depiction of range and urban density in Figure 6 impressively shows the phenomenon of simultaneous multilocality of media events in hybrid spaces, which we experience in our daily lives today.

Different dynamic topologies of hybrid spaces can be mapped according to various combinations of range, interactions and response rate. Further representations of dynamic topologies between the levels of places and perception would also be possible. These could be interesting for upcoming user experience (UX) studies in a future research project. According to the specific patterns of dynamic topologies of hybrid spaces, interactive applications, social media or even urban developments can thus be better analyzed, simulated, evaluated and compared. The attached computer-generated 3D animation shows only one of several possible dynamic topologies of hybrid spaces between the levels of places, time and interaction, using the example of response rate and interactions. Even further combinations of parameters can be visualized using the presented spatiotemporal model.

Modality of hybrid spaces questions the usual relations between media and transportation. They suddenly appear in a new light. When you decide for a certain mix of media, simultaneously you have made the decision for the referring means of transport. The means of transport suddenly turn into a minor subfunction of media range in the whole communication process. All this leads to a new understanding of urban space.

Acknowledgments

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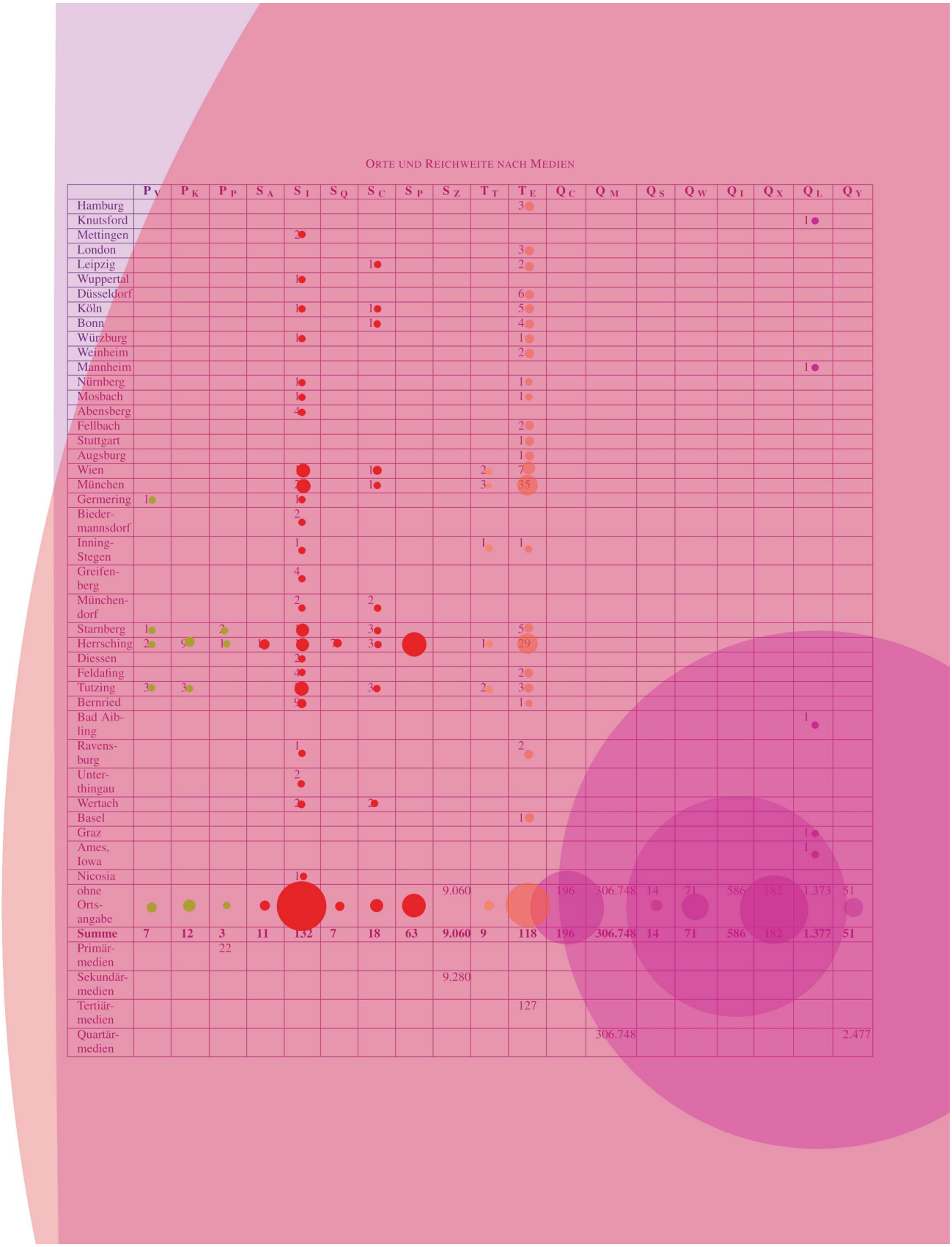

	PV	PK	PP	SA	SI	SQ	SC	SP	SZ	TT	TE	QC	QM	QS	QW	QI	QX	QL	QY
Hamburg											3								
Knutsford																		1	
Mettingen					2														
London											3								
Leipzig							1				2								
Wuppertal					1														
Düsseldorf											6								
Köln					1		1				5								
Bonn							1				4								
Würzburg					1						1								
Weinheim											2								
Mannheim																		1	
Nürnberg					1						1								
Mosbach					1						1								
Abensberg					4														
Fellbach											2								
Stuttgart											1								
Augsburg											1								
Wien					1		1			2	7								
München					2		1			3	35								
Germering	1				1														
Bieder-mannsdorf					2														
Inning-Stegen					1					1	1								
Greifen-berg					4														
München-dorf					2		2												
Starnberg	1		2		1		3				5								
Herrsching	2	9	1	1	1	7	3			1	29								
Diessen					2														
Feldafing					4						2								
Tutzing	3	3			1		3			2	3								
Bernried					9						1								
Bad Aib-ling																		1	
Ravens-burg					1						2								
Unter-thingau					2														
Wertach					2		2												
Basel											1								
Graz																		1	
Ames, Iowa																		1	
Nicosia					1														
ohne Orts-angabe									9.060			196	306.748	14	71	586	182	1.373	51
Summe	**7**	**12**	**3**	**11**	**132**	**7**	**18**	**63**	**9.060**	**9**	**118**	**196**	**306.748**	**14**	**71**	**586**	**182**	**1.377**	**51**
Primär-medien			22																
Sekundär-medien									9.280										
Tertiär-medien											127								
Quartär-medien													306.748						2.477

Figure 6: Level of places and media types - real and virtual places and media range

References

[1] Jacqueline De Jong. 2022. The Ultimate Kiss. *Kunstmuseum Ravensburg* (2022).
[2] Guy Debord. 1957. The Naked City. *in: McDonough, T. (2007). Situationistischer Raum, in: ARCH+ Nr. 183* (1957), 54–58. https://iw.tugraz.at/iw/tl_files/I_W/LV%20Unterlagen/ss2016/workshop%202/mcdonough_situationistischer-raum_archplus183.pdf
[3] Guy Debord. 1978. Die Gesellschaft des Spektakels. *Nautilus* (1978).
[4] Gilles Deleuze and Felix Guattari. 1993. Tausend Plateaus. Kapitalismus und Schizophrenie. *Merve* (1993).
[5] Christopher Dell. 2007. Die Performanz des Raumes. *in: Arch+ Nr. 183* (2007), 136–143.
[6] Jacques Derrida. 1986. Positionen. *Böhlau* (1986).
[7] Paul Dourish and Steve R. Harrison. 1996. Re-Place-Ing Space: The Roles of Place and Space in Collaborative Systems. *in: Computer Supported Collaborative Work, Boston ACM* (1996).
[8] Peter Eisenman. 1995. Aura und Exzess - Zur Überwindung der Metaphysik der Architektur . Essays und Gespräche. *Passagen Verlag* (1995), 90.
[9] Werner Faulstich. 2011. Die Mediengeschichte des 20. Jahrhunderts. *Wilhelm Fink Verlag* (2011).
[10] William Gibson. 1984. Neuromancer. *Ace Books* (1984).
[11] Dietmar Harhoff and Karim R. Lakhani. 2016. Revolutionizing Innovation: Users, Communities, and Open Innovation. *MIT Press* (2016). https://doi.org/10.7551/mitpress/9439.001.0001
[12] Torsten Hägerstrand. 1970. What about people in regional science? *Papers Reg. Sci. Association 24* (1970), 7–21.
[13] Wolfgang Höhl. 2024. Understanding Hybrid Spaces: Designing a Spacetime Model to Represent Dynamic Topologies of Hybrid Spaces. (2024). https://doi.org/10.48550/arXiv.2403.05221
[14] Bart Kosko. 1986. Fuzzy cognitive maps. *in: Int. J. of Man-Machine Studies* 24, 1 (1986), 65–75. https://doi.org/10.1016/S0020-7373(86)80040-2
[15] Assia Kraan. 2006. To Act in Public through Geo-Annotation. *in: Eric Kluitenberg, Jorinde Seijdel, Liesbeth Melis (2006): Open No. 11: Hybrid Space, NAi Publishers* (2006).
[16] Henri Lefèbvre. 2009. The production of space. *Wiley-Blackwell* (2009).
[17] Blake Lemoine. 2022. Is LaMDA Sentient? - an Interview. *in: Medium, June 11th* (2022). https://cajundiscordian.medium.com/is-lamda-sentient-an-interview-ea64d916d917
[18] Bo Lenntorp. 1976. Paths in space-time environments. A time-geographic study of movement possibilities of individuals. *Lund studies in geography. Serie B, human geography, in: Jing Qin, Feixiong Liao (2021). Space–time prism in multimodal supernetwork, Communications in Transportation Research, Volume 1, December 2021* 1 (1976). https://doi.org/10.1016/j.commtr.2021.100016
[19] Niklas Luhmann. 2021. Die Gesellschaft der Gesellschaft. *Suhrkamp* (2021).
[20] Niklas Luhmann and Dirk Baecker. 2004. Einführung in die Systemtheorie. *2. Aufl., Wissenschaftliche Buchgesellschaft* (2004).
[21] Kevin Lynch. 1964. The Image of the City. *MIT Press* (1964). https://mitpress.mit.edu/9780262620017/the-image-of-the-city/
[22] Kevin Lynch and György Kepes. 1954-1959. The Perceptual Form of The City. *MIT Library* (1954-1959). https://dome.mit.edu/handle/1721.3/33656
[23] Maschen. 2012. Lorentz Transformations on a Minkowski Lightcone Diagram. *in: Wikimedia Commons* (2012). https://commons.wikimedia.org/wiki/File:Minkowski_lightcone_lorentztransform.svg
[24] Sebastian Meier and Katrin Glinka. 2017. Psychogeography in the Age of the Quantified Self. *in: Michael P. Peterson (eds) Advances in Cartography and GI-Science. ICACI* (2017). https://doi.org/10.1007/978-3-319-57336-6_35
[25] Hannes Meyer. 1928. Die neue Welt. *in: Kritisk Revy, H. 1* (1928), 16.
[26] Joshua Meyrowitz. 1987. Die Fernseh-Gesellschaft. Wirklichkeit und Identität im Medienzeitalter. *Beltz Verlag* (1987).
[27] P. Milgram and H. Colquhoum. 1999. A Taxonomy of Real and Virtual World Display Integration. *in: Ohta, Y., Tamura, H. (eds.)(1999): Mixed Reality - Merging Real and Virtual Worlds, Springer* (1999).
[28] Johannes Moser et al. 2023. Visualising Transformations of Geographical Time-Space by Transport Systems. The Case of Germany, 1990–2020. *KN J. Cartogr. Geogr. Inf.* (2023). https://doi.org/10.1007/s42489-023-00151-9
[29] Michael Müller and Franz Dröge. 2005. Die ausgestellte Stadt, Zur Differenz von Ort und Raum. *in: Ulrich Conrads und Peter Neitzke (Hrsg.). Bauwelt Fundamente, Birkhäuser* 133 (2005).
[30] Harrison Owen. 2008. Open Space Technology: A User's Guide. *Berrett-Koehler Publishers* (2008).
[31] Ute Poerschke. 2014. Funktionen und Formen: Architekturtheorie der Moderne. *transcript* (2014). https://doi.org/10.1515/transcript.9783839423158
[32] Esther Polak and Jeroen Kee. 2002. Amsterdam REALTIME. Dagboek in Sporen / Diary in Traces. *in: Eric Kluitenberg, Jorinde Seijdel, Liesbeth Melis (2006): Open No. 11: Hybrid Space, NAi Publishers* (2002). https://www.artbook.com/9056625365.html
[33] Karl R. Popper and John C. Eccles. 1977. The Self and Its Brain. *Springer* (1977).
[34] Helmut Richter. 1984. Bad S. Sares. *in: UM BAU 8, ÖGfA* (1984), 78.
[35] Saskia Sassen. 2006. Public Interventions – The Shifting Meaning of the Urban Condition. *in: Jorinde Seijdel and Liesbeth Melis (eds.)(2006). Open No. 11: Hybrid Space, NAi Publishers* (2006).
[36] Jesse Schell. 2019. The art of game design : A book of lenses. *3rd ed., CRC Press LLC.* (2019), 167–170.
[37] Shih-Lung Shaw and Hongbo Yu. 2013. Towards a GIS-based Analytical Time-geographic Framework for Physical and Virtual Activities. *University of Tennessee* (2013). https://web.utk.edu/~sshaw/NSF-Project-Website/
[38] Elizabeth Sikiaridi and Frans Vogelaar. 2006. Soft Urbanism - Neighbours Network City (NNC) in the Ruhr Region. *in: open! - Platform for Art, Culture & the Public Domain* (2006). https://onlineopen.org/soft-urbanism
[39] Gilbert Simondon. 2012. Die Existenzweise technischer Objekte. *diaphanes* (2012).
[40] Klaus Spiekermann and Michael Wegener. 1996. New Time-Space Maps for Europe. *Arbeitspapier 132. Dortmund Institut für Raumplanung* (1996). https://www.spiekermann-wegener.de/de/zeitkarten
[41] Larry Squire and Eric R. Kandel. 1999. Gedächtnis. Die Natur des Erinnerns. *Spektrum Akademischer Verlag* (1999), 7.
[42] Udo Thiedeke. 2004. Wir Kosmopoliten: Einführung in eine Soziologie des Cyberspace. *in: Thiedeke, Udo (eds.) Soziologie des Cyberspace. VS Verlag* (2004). https://doi.org/10.1007/978-3-322-80482-2_1
[43] Bernhard Tschumi and Andreas Ruby. 1993. Die Aktivierung des Raumes - Bernhard Tschumi im Gespräch mit ARCH+. *in: ARCH+ 119/120* (1993), 70–72. https://www.archplus.net/home/archiv/artikel/46,877,1,0.html
[44] Kaja Tulatz. 2011. Technikinduzierte Räume bei Deleuze und Guattari. *XXII. Deutscher Kongress für Philosophie* (2011). https://doi.org/10.5282/ubm/epub.12570
[45] Otto Wagner. 1896. Moderne Architektur. *Anton Schroll & Co.* (1896), 109.
[46] Qing Yu et al. 2023. Web-based spatio-temporal data visualization technology for urban digital twin. *Handbook of Mobility Data Mining* 1 (2023), 185–201. https://doi.org/10.1016/B978-0-443-18428-4.00002-5

A Online Resources

All supplemental materials are available on OSF at https://osf.io/sfqmc/ released under a CC BY 4.0 license. In particular, they include (1) an MP4 file containing the computer-generated animation and (2) figure images in multiple formats.