Springer Series in Design and Innovation 27

Nuno Martins
Daniel Brandão *Editors*

Advances in Design and Digital Communication III

Proceedings of the 6th International Conference on Design and Digital Communication, Digicom 2022, November 3–5, 2022, Barcelos, Portugal

Springer

Springer Series in Design and Innovation

Volume 27

Springer Series in Design and Innovation (SSDI) publishes books on innovation and the latest developments in the fields of Product Design, Interior Design and Communication Design, with particular emphasis on technological and formal innovation, and on the application of digital technologies and new materials. The series explores all aspects of design, e.g. Human-Centered Design/User Experience, Service Design, and Design Thinking, which provide transversal and innovative approaches oriented on the involvement of people throughout the design development process. In addition, it covers emerging areas of research that may represent essential opportunities for economic and social development.

In fields ranging from the humanities to engineering and architecture, design is increasingly being recognized as a key means of bringing ideas to the market by transforming them into user-friendly and appealing products or services. Moreover, it provides a variety of methodologies, tools and techniques that can be used at different stages of the innovation process to enhance the value of new products and services.

The series' scope includes monographs, professional books, advanced textbooks, selected contributions from specialized conferences and workshops, and outstanding Ph.D. theses.

The volumes of the series are single-blind peer-reviewed.

Keywords: Product and System Innovation; Product design; Interior design; Communication Design; Human-Centered Design/User Experience; Service Design; Design Thinking; Digital Innovation; Innovation of Materials.

How to submit proposals

Proposals must include: title, keywords, presentation (max 10,000 characters), table of contents, chapter abstracts, editors'/authors' CV.

In case of proceedings, chairmen/editors are requested to submit the link to conference website (incl. relevant information such as committee members, topics, key dates, keynote speakers, information about the reviewing process, etc.), and approx. number of papers.

Proposals must be sent to: series editor Prof. Francesca Tosi (francesca.tosi@unifi.it) and/or publishing editor Mr. Pierpaolo Riva (pierpaolo.riva@springer.com).

More information about this series at https://link.springer.com/bookseries/16270

Nuno Martins · Daniel Brandão
Editors

Advances in Design and Digital Communication III

Proceedings of the 6th International Conference on Design and Digital Communication, Digicom 2022, November 3–5, 2022, Barcelos, Portugal

Springer

Editors
Nuno Martins
Research Institute for Design, Media and Culture, School of Design
Polytechnic Institute of Cavado and Ave
Barcelos, Portugal

Daniel Brandão
Communication and Society Research Centre, Institute of Social Sciences
University of Minho
Braga, Portugal

ISSN 2661-8184 ISSN 2661-8192 (electronic)
Springer Series in Design and Innovation
ISBN 978-3-031-20363-3 ISBN 978-3-031-20364-0 (eBook)
https://doi.org/10.1007/978-3-031-20364-0

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This book gathers the proceedings of Digicom 2022—the 6th International Conference on Digital Design and Communication: 67 best papers were selected out of 94 submissions, upon a rigorous double-blind peer-review process. Digicom was held on November 3–5, 2022, in a hybrid form, at Teatro Gil Vicente, Barcelos, Portugal, and also online.

Digicom is an annual event organized by the Design School of the Polytechnic Institute of Cavado and Ave, and by ID+, Research Institute for Design Media and Culture, in cooperation with CECS-UM, which has been bringing together researchers, academics, and designers from around the world.

"Digital" is becoming increasingly ubiquitous and prevalent in our networked and global society. Digicom has aimed to be a space for reflection and analysis on the constant challenges digital communication poses to society, institutions, and brands. Despite its strong focus on the area of Communication Design, the objective of the conference—which is very much reflected in the present book—is the promotion of an open, broad, and plural discussion, aggregating different areas of knowledge, namely arts, technology, communication sciences, education sciences, and branding, among others. The conference thus seeks to stimulate interdisciplinary relationships that contribute to a solid development of scientific activity.

Digicom 2022 received three keynote speakers:

Adérito Fernandes-Marcos is graduated in Computer Science Engineering from the Nova University of Lisbon, Portugal; holds a Ph.D. in Computer Graphics from the Technical University of Darmstadt, Germany; and Habilitation (agregação) in Techn. and Information Systems from the University of Minho. He is currently Full Professor at the Faculty of Arts and Humanities of the University of Saint Joseph, Macao, China. He is also Full Professor at the Portuguese Open University, where he founded and was first Director during 8 years of the Doctoral Program in Digital Media Art, a transdisciplinary joint offer together with the University of Algarve taught in e-learning mode. He is Researcher at the Research Centre for Arts and Communication and collaborates with INESC TEC and LE@D. He is President of the Artech-International Association with activities in all over the world in the

field of digital media art and Founder of the ARTECH (Int. Conf. on Digital and Interactive Arts) and ARTeFACTo (Int. Conf. on Digital Creation in Arts and Communication) conf. series. He is Regular Consultant of international boards (e.g., European Commission, Macao Science and Technology Development Fund). His research interests embrace different fields from (post-)digital media arts, arteology, media, and human rights to digital education. He is Author/Co-author of more than 120 publications in journals, conference proceedings, chapters, and science promotion booklets. He is Editor-in-Chief of International Journal of Creative Interfaces and Computer Graphics (ISSN: 1947-3117).

Catarina Lelis began her professional experience in 1997 as a graphic designer. She co-founded a publishing start-up and the Portuguese Association for Innovation and Creativity in Organizations. In academia since 2007, she won two national entrepreneurship competitions. For six years, she taught and researched Brand Design and Innovation in the UK, where she won a teaching fellowship. Currently, she teaches at the University of Aveiro. Her research interests include Brand Design and Smartness, Dynamic/Flexible Visual Identities, Design Literacy, Employability in the New Media and Creative Industries, and Anticipation of Impact.

Matthias Laschke heads a research group at the University of Siegen and leads the BMBF research group MOVEN. His research focuses on behavior change in HCI, with a focus on sustainability and transformation. Other foci of current and past research are various topics in human–computer interaction (HCI), such as experience design, affective computing, and interaction with agentive technologies (i.e., otherware), both in the form of digital and tangible artifacts.

Projects he has worked on over the last twelve years have addressed challenges in the following areas, among others: persuasive technologies addressing diverse topics such as sustainability, procrastination, willpower or adherence, design theory and methodological approaches, autonomous and learning systems (e.g., in cars), work motivation (e.g., in health care), innovation strategies, and technology development.

He publishes on the mentioned research and design areas in relevant national and international conferences and journals (peer-reviewed). His work has been published and discussed in various national and international blogs, books (e.g., Evgeny Morozov's bestseller "To Save Everything, Click Here."), and magazines such as the New York Times, Wired, Fast Company, and the R&D Salon of the Museum of Modern Art, New York. Moreover, his work is part of the Deutsche Museum's permanent collection, the world's largest science and technology museum.

In addition to the guest speakers, we also had the opportunity to attend a set of approximately 70 communications, strictly selected by Digicom's Scientific Committee, from different international researchers and designers.

The three days event resulted in extensive debate sessions, where the participants' personal and professional perspectives and experience encouraged the discussion, showing the importance of this kind of events.

The promotion of a panoramic vision of Digital Design and Communication is a trademark that Digicom has been affirming and reinforcing through its five editions, and that organizers and participants will continue to build and consolidate in their future works and the upcoming conference editions.

With this book, we would like to transmit this message to a broader audience and to attract contributors who share our vision and/or are willing to join our discussion in future conference editions. We would also like to acknowledge all those who have believed in Digicom so far and contributed to its success in many ways.

Again, a big thanks to all participants of Digicom 2022 and to all the readers of this book, hoping that you will enjoy and find it useful for your future research.

Looking forward to seeing you next year!

Nuno Martins
General Chair, Digicom
Daniel Brandão
Co-chair, Digicom

Organization

General Chair

Nuno Martins — Research Institute for Design, Media and Culture, School of Design, Polytechnic Institute of Cavado and Ave, Barcelos, Portugal
nmartins@ipca.pt

Co-chair

Daniel Brandão — Communication and Society Research Centre, Institute of Social Sciences, University of Minho, Braga, Portugal
danielbrandao@ics.uminho.pt

Team

Ana Catarina Silva
Cátia Vidinhas
Jorge Ribeiro
Isabel Xavier
Leonardo Pereira
Sérgio Dominique

Scientific Committee

Albert Inyoung Choi	College of Design—Hanyang University, Korea
Alberto Sá	Universidade do Minho, Portugal
Álvaro Sousa	Universidade de Aveiro, Portugal
Ana Catarina Silva	Escola Superior de Design IPCA, Portugal

Ana Filomena Curralo	IPVC, Portugal
Ana Carla Amaro	Universidade de Aveiro, Portugal
Ana Clara Roberti	CITCEM, Portugal
Ana Correia de Barros	Fraunhofer Portugal AICOS, Portugal
Ana Filomena Curralo	IPVC, Portugal
André Rangel	FBAUP CITAR, Portugal
Andreia Sousa	Universidade Lusófona do Porto, Portugal
Camila Soares	FBAUP, Portugal
Catarina Lelis	University of West London, UK
Catarina Moura	Universidade da Beira Interior, Portugal
Cátia Rijo	Escola Superior de Educação IPL, Portugal
Cláudia Lima	Universidade Lusófona do Porto, Portugal
Cristina Sylla	Universidade do Minho, Portugal
Daniel Brandão	Universidade do Minho, Portugal
Daniel Raposo	Politécnico Castelo Branco, Portugal
Dario Lanza	Universidad Complutense de Madrid, Spain
Derek Lackaff	School of Communications Elon University, USA
Dina Riccò	Politecnico di Milano, Italy
Doris Kosminsky	Universidade Federal do Rio de Janeiro, Brazil
Eliana Penedos	Universidade do Porto, Portugal
Elizete de Azevedo Kreutz	Universidade Univates, Brazil
Emília Duarte	IADE, Portugal
Fabrício Fava	Faculdade de Belas da Universidade do Porto, Portugal
Fernando Moreira da Silva	Faculdade de Arquitetura da Universidade de Lisboa, Portugal
Fernando Olivares Delgado	Universidad de Alicante (ES)
Fernando Suarez Carballo	Universidad Pontificia de Salamanca, Spain
Francisco Paiva	Universidade da Beira Interior, Portugal
Filipe Lopes	Escola Superior de Media Artes e Design IPP, Portugal
Frederico Braida	Universidade Federal de Juiz de Fora, Brazil
Gerry Leonidas	University of Reading, UK
Hande Ayanoglu	IADE, Portugal
Heitor Alvelos	Universidade do Porto, Portugal
Ildo Francisco Golfetto	Universidade Federal de Santa Catarina, Brazil
João Abreu	Politécnico de Lisboa, Portugal
João Alves de Sousa	Universidade Lusófona do Porto, Portugal
João Brandão	Faculdade de Arquitectura, Universidade de Lisboa, Portugal
João Neves	Politécnico Castelo Branco, Portugal
João Tiago Santos	Escola Superior de Artes e Design, Portugal
Jorge Pereira	Escola Superior de Design IPCA, Portugal

Jorge dos Reis	Faculdade de Bela Artes U. Lisboa, Portugal
Jorge Vazquez Herrero	Universidade de Santiago de Compostela, Spain
José Gago Silva	Universidade de Évora, Portugal
Juan Ra Martin	Universidad Pontificia de Salamanca, Spain
Karel van der Waarde	Swinburne University of Technology, Melbourne, Australia
Krasimira Borisova Drumeva	ST Cyril and St. Methodius, University of Veliko Tarnovo, Faculty of Fine Arts, Bulgaria
Leonardo Pereira	Universidade de Aveiro, Portugal
Letícia Pedruzzi Fonseca	Universidade Federal do Espírito Santo, Brazil
Lev Manovich	City University of New York, USA
Luís Leite	ESMAD-IPP, Portugal
Luís Paschoarelli	Universidade Estadual Paulista, Brazil
Luís Santos	Universidade do Minho, Portugal
Maria João Félix	Escola Superior de Design IPCA, Portugal
Mario Buono	University of Campania, Italy
Marta Fernandes	Politécnico do Porto, Portugal
Manuel Montes Vozmediano	Universidad Rey Juan Carlos, Spain
Miguel Carvalhais	INESC TEC and FBAUP, Portugal
Nelson Zagalo	Universidade de Aveiro, Portugal
Nuno Coelho	Universidade de Coimbra, Portugal
Nuno Martins	Escola Superior de Design IPCA, Portugal
Patricia Ranzo	Università degli Studi della Campania, Italy
Pau Garcia	Domestic Data Streamers/Elisava, Spain
Pedro Amado	Universidade do Porto, Portugal
Pedro Beça	Universidade de Aveiro, Portugal
Pedro Cardoso	Universidade de Aveiro, Portugal
Pedro Portela	Universidade do Minho, Portugal
Priscila Farias	Universidade de São Paulo, Brazil
Ricardo Melo	Fraunhofer Portugal AICOS, Portugal
Rita Almendra	Universidade de Lisboa, Portugal
Rita Espanha	ISCTE, Portugal
Rita Santos	Universidade de Aveiro, Portugal
Rodrigo Carvalho	ESMAD-IPP, Portugal
Rui Rodrigues	ESMAD-IPP, Portugal
Sara Balonas	Universidade do Minho, Portugal
Sara Goldchmit	Universidade de São Paulo, Brazil
Sara Santos	Universidade de Aveiro, Portugal
Sérgio Dominique	Escola Superior de Hotelaria e Turismo IPCA, Portugal
Susana Barreto	Universidade do Porto, Portugal
Teresa Ruão	Universidade do Minho, Portugal

Tiago Navarro Marques	Universidade de Évora, Portugal
Vanda Sousa	Politécnico de Lisboa, Portugal
Vania Baldi	Universidae de Aveiro, Portugal
Vera Barradas Martins	Politécnico Portalegre, Portugal
Virgínia Tiradentes Souto	Universidade de Brasília, Brazil
Vítor Quelhas	ESMAD-IPP, Portugal

Contents

Digital and Interaction Design

Data Visualization in Hybrid Space—Constraints and Opportunities for Design

Ana Beatriz Marques[1,2(✉)], Vasco Branco[1,2], Rui Costa[1,2], and Nina Costa[1,2]

[1] Department of Communication and Art, Aveiro University, University Campus of Santiago, 3810-193 Aveiro, Portugal
abmarques@ua.pt

[2] Media and Culture [ID+], Research Institute for Design, University Campus of Santiago, 3810-193 Aveiro, Portugal

Abstract. It is intended to investigate the hybrid space, as a determining attribute of the experience and interaction with augmented reality systems, to assess the potential and limitations of this space for information design, specifically in the context of data visualization. This paper presents a study which focused on the use of augmented reality in data visualization, in cases where there is no direct semantic relation between the virtual content and the real setting where the visualization will be displayed. For this study, a practice-based methodology was adopted, supported by the development, implementation and testing of a prototype of an augmented reality application for mobile devices. This prototype, which allows to visualize data related to design companies in Portugal, was assessed in real context. The data collected in this process sparked a reflection on the achieved results, but also on the challenges inherent to the application of this technology in the design of data visualizations.

Keywords: Immersive analytics · Augmented reality · Data visualization

1 Introduction

In recent years, Augmented Reality (AR) technologies have experienced great progress, both in accessibility and in hardware resources, encouraging their application to various domains [1], namely in data visualization. In the context of information design, AR has primarily been used to present information about real spaces (e.g. Visits to historic sites). Currently, its application is also expanding into more exploratory domains, in which the objective is not to provide in-situ information, but to support analytical reasoning—"Immersive Analytics" [2]. By adding a layer of AR to data visualization, the most obvious difference regarding traditional visualization forms has to do with the immersive perception of the virtual space where the data is visited. Despite the relevance that space assumes here, there are few bibliographical references about the design for the hybrid space—which results from the combination between real space and virtual space—in the

N. Martins and D. Brandão (Eds.): DIGICOM 2022, SSDI 27, pp. 3–15, 2023.
https://doi.org/10.1007/978-3-031-20364-0_1

context of data visualization. With a few exceptions (e.g. [3, 4]) there are few empirical studies that allow, on the one hand, to disseminate and sustain an appropriation of this technology by information designers and, on the other hand, to verify the effectiveness of the use of AR in the context of immersive Analytics to support different audiences (non-experts) to explore data. This justifies the research work we have been conducting to understand the strengths and limitations of AR technologies from the perspective of Information Design, namely in data visualization. This work has been framed by the Project "Design OBS—Towards a Design Observatory in Portugal" as research of new possibilities for the representation of data collected, analyzed, and interprete on the various sectors of the Portuguese Design ecosystem. This study addresses data visualization with AR in cases where there is no semantic relationship between the data to be visualized and the real space where this visualization will take place, a space that will only serve as an expository setting. This study was based on the development of an AR application – "Floating Companies" (FLOC) – and in its test in real context, carried out in Portugal within the scope of an itinerant exhibition of the DesignOBS Project (FBAUL 2021). This circumstance enabled to observe and qualify the perception of the hybrid space in the data visualization process based on the prototype developed. This article presents the design and assessment process of this application. The data collected during the performed tests serve to reflect on the results achieved as on the challenges inherent to the use of AR in the construction of data visualizations. Therefore, it is intended to contribute to identify strategies allowing a greater appropriation of AR technology by designer(s), trying to overcome existing gaps and identifying guidelines for action.

2 Literature Revision

Situated Analytics and Immersive Analytics are complementary techniques that have emerged at similar times. While situated analytics uses augmented reality to support a new form of in-situ interactive visual analysis, i.e. Where real space plays a fundamental role as referent; immersive analytics covers a wider spectrum of techniques and technologies, not implying the visualization of information at the location of its physical referent [5]. The term Immersive Analytics (IA) was proposed for the first time in 2015 by Chandler et al. (2015) to designate a multidisciplinary field which integrates analytical reasoning and immersive virtual spaces.

'Immersiveness' is a central theme in Immersive Analytics as the name implies. But despite this characteristic having an endemic relationship with the space perspective, there are few references to studies on hybrid space in this context. Bach et al. (2017) testify the lack of a systematic description of the design space and the resulting implications, despite of some research on embedded data visualization [6]. Marriott et al. (2018) approach the space in IA applications to evaluate their added value for the visualization of 3D information. The authors point that currently there is no agreed windowing metaphor in mixed mode applications, and this is a research topic that warrants attention.

Hackathorn and Margolis (2017) reflect on what might be a data visualization in the hybrid space and conceive a data space as a botanical garden by opposition to a movie. While the botanical garden is a three-dimensional space with several layers of information, the movie is a sequence of images controlled by the author. While the

interpretation of a garden follows a non-linear path and is based on the experience of the 'lived body', the interpretation of a movie is much more linear, being mainly supported by vision and aimed at the immobile body.

Within media studies, Ryan (2015) analyses space in interactive digital narrative according to two particularly relevant concepts: emotional space and strategic space. Emotional space is characterized by an experience of space associated with affective reactions, whether positive or negative, and its representation is based on a horizontal perspective, ie. a perspective that "captures the perception of the human body, and therefore comes closest to the lived, embodied experience that produces emotions" (p. 106). In contrast, the strategic space is related to the possibilities of action in order to achieve certain objectives (e.g. chessboard), being typically represented through the map view, as it favors an overall view and planning.

Based on this binomial, Ryan (2015) distinguishes two modes of experiencing space in an interactive narrative—flânerie and quest. "While a quest is a deliberate search for specific objects, flânerie is a free wandering open to chance meetings and random discoveries. In a quest, space only exists to be traversed (…) in flânerie, it is enjoyed for its own sake and becomes the object of aesthetic pleasure" [7].

The duality between different perspectives of space has also been studied in information design. The contrast between a macro and micro perspective of the dataset was addressed from the standpoint of the content and not so much from the standpoint of space. In one of the pioneering books on information visualization, Card et al. [21] mention the need to simultaneously provide two perspectives over data—the overview (context) and the detail view (focus), pointing out several interaction techniques to enable this coexistence. More recently, within the scope of research on visual representations of historical time, Davis et al. (2013) identified the modes of observation and immersion. What distinguishes these two modes is the perceived distance from the observer to the information. "Seeing the full scope of a comprehensive data-set, patterns emerge for the observer stands outside time; but when the user moves closer and studies individuals in their context, instead a sense of immersion is promoted." [8].

3 Research Gap

Despite AR being a totally different medium from the desktop environment and the press medium, authors who approach AR in data visualization frequently use the traditional language of 2D graphics. Augmented reality in information design still does not seem to have its own culture, which facilitates its appropriation by designers. To understand the reason behind this gap, to demonstrate the interest of that appropriation and to point out ways in that direction are central objectives of the research project that includes this study. In this study we start from the assumption that to establish itself as a medium, augmented reality needs to develop its own language, anchored in the features that distinguish it from previous media, in particular the combination of the following particularities: continuous integration between real and virtual, control over the point of view by the user and inherent interactivity. Despite the importance of space in augmented reality experiences, theoretical references on design for hybrid space are scarce. Thus, it is essential to consider the way of perception in hybrid space when designing data visualization for

that environment. Ryan (2015) addresses space from the perspective of Interactive Digital Narrative, however the author does not explicitly mention data visualization. Davis et al. (2013) approach the user perspective on space in the scope of information design, but without the layer of augmented reality.

4 Methodology

This study intends to answer the following research question – 'from the design standpoint, what are the strengths and limitations that hybrid space presents for data visualization, particularly in cases where there is no semantic relation between that data and the space where it will be inserted?'. One of the objectives pursued is the development of guidelines for the design of data visualizations with augmented reality, allowing to minimize the limitations and maximize the potential of this technology, namely in the specified cases in which the real space is merely an exhibition setting without any semantic relation with data. Pursuing this goal implies: (1) characterization of the perception of hybrid space in a data visualization; (2) recognition of the strengths and limitations of using augmented reality from the perspective of data visualization where there is no semantic connection to space; (3) identification of the aspects in which augmented reality might complement traditional forms of data visualization.

For this purpose, an information artifact was developed enabling to conduct a research based on the design practice, where the iterative process progresses through the evaluation of the artifact in real context and the resulting reflection [9, 10]. While design practice aims to generate new solutions, design research reflects on the usefulness and effectiveness of the artifact created to solve the class of problems identified, thus contributing to the production of new knowledge in Design [9]. The design of this artifact followed the "double-diamond" approach (Design Council, 2004) triggered, supervised, and driven by research objectives that are not limited to the artifact itself.

The development of this artifact was sparked during the preparation of the first exhibition of the DesignOBS project [11], whose purpose was to publicly present the achieved results, both in terms of data collected and processed regarding the Portuguese Design ecosystem, as in terms of research on data representation. This exhibition, which was intended to be itinerant, seemed to be an opportunity and the ideal context to test, with interested publics, the relevance and potential of AR technologies for Information Design and to evaluate the suitability of concepts that were in the experimental phase [12, 13]. The initial phase focused, on the one hand, on (1) the exploration of artifacts that use augmented reality and the collection of contributions from other research projects (analyzed in the previous section) that could constitute theoretical and practical foundations to support the design and reflection on the artifact being conceived; and, on the other hand, (2) the study and selection of the dataset, within the Portuguese Design ecosystem, that could be exploited by various stakeholders in the design field through an AR application. In this sense, we chose the database originated in SABI [14] and curated by the DesignOBS project about design companies registered in Portugal with the economic activity code 7410 (design activity), in the year 2019. It contains information on 2,714 companies, including contacts, location, turnover, number of employees, profit, exports, among other relevant economic and financial indicators. When converging on the definition of a briefing to guide the development of the AR application other decisions were

taken, particularly the representation of the entire database, implying the immediate perception of the size of the companies and their georeferencing. It was intended to give the public a direct notion of the distribution of Design companies throughout the country, not only in number, but also in relative size.

The design and development of the application was carried out iteratively, involving the exploration and materialization of data through the employment of different analytical techniques and representation support software such as Tableau or Rawgraph. Each of the indicators in the database was analyzed and described. This first step allowed us to explore how some variables might relate to each other, enriching the primary analysis, and supporting the formulation of questions. This iterative analysis and reflection were fundamental in defining the guidelines for data visualization—form, color, typography, interaction modes and styles, among other aspects belonging to the design field. This project cycle ended with the testing and evaluation of the developed prototype.

5 Floating Companies (FLOC)

The prototype of the AR application that visualizes data about the set of Design companies in Portugal was developed using Unity and Vuforia for Android mobile devices. The experience is targeted by an area target—a tracking feature developed by Vuforia enabling to track and augment spaces – in this case, a room with about 2,20 × 5,90 m at FBAUL, previously scanned by a mobile device with LIDAR. It is an empty space without any semantic complementarity with the data that would be presented there, an essential condition to ensure that the application could accompany the exhibition in itinerant situations. Once the application recognizes the space, a set of spheres that seem to float over a map of Portugal appears on the screen of the mobile device, justifying the name given to the artifact: Floating Companies (FLOC) (Fig. 1).

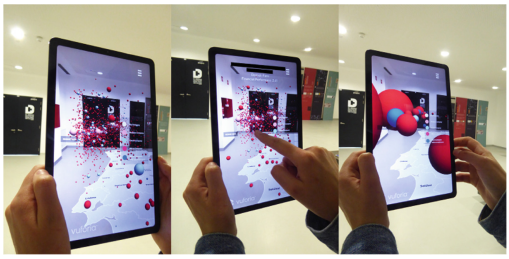

Fig. 1. FLOC trial on android tablet, University of Aveiro. (a) FLOC main view. (b) Interaction with spheres. (c). FLOC resume view.

Each Design company corresponds to a sphere, whose diameter translates its size (in number of employees) and whose color indicates its class according to the same variable (micro, small, medium, big, etc.). The position of the spheres in space allows us to have an approximate notion of the distribution of the companies throughout Portugal, but also of their relative performance since the height (the distance to the ground) at which each company is located is an indicator of its profit per employee. By tapping a

sphere, information about the company is displayed, such as its name, the district where it is based, and its profit per employee. On the floor plan is a map of Portugal, showing its administrative division by districts, reinforcing the perception of the location and distribution of Design companies throughout the country. It is also possible to choose a data visualization—'resume view'—in which the number of companies by class in number of employees, for each district, is represented based on a sphere chart that synthesizes this information, allowing to compare reality among the various districts (with each chart positioned above its respective district). With the two views of the same information, we tried to explore new logics of representation that were not fully anchored in the traditional grammar of two-dimensional representation, while providing an overview of the data.

5.1 Data Gathering

FLOC (Floating Companies) integrated the exhibition "Towards a Design Observatory in Portugal—situation", at the Gallery of the Faculty of Fine Arts of the University of Lisbon between the 3rd and the 10th of December 2021, where it was tested by 21 visitors, using a hand-held device: an android tablet. Their feedback was collected using the Thinking Aloud method, a user experience test in which participants are asked to interact with the system while verbalizing their thoughts out loud in a continuous monologue [15]. The tests were preceded by a brief presentation of this research, contextualizing it in the scope of the DesignOBS project, and by the request for filling out both the informed consent to audio record and a sociodemographic characterization form. These tests allowed the collection of two types of data about the application's use: audio recording of people's comments during their experience and participant observation fixed in field notes. Among the 21 participants (11 female and 10 male) the most represented age group was between 21 and 30 years old. The most common academic level is secondary education, with the participants attending a degree course in Art or Design at the institution where the tests took place. The great majority of the participants are Portuguese (90.5%), with only 9.5% being foreigners. Although all participants indicated that they were completely comfortable with using smartphones or tablets (71.4% indicated a score of 5 and 28.6% indicated a score of 4 out of a maximum of 5), they were not familiar with augmented reality technologies (42.9% indicated a score of 3 points out of a maximum of 5).

5.2 Data Analysis

The analysis of the audio transcripts was methodologically inspired by Jung et al. (2022) proposal for the analysis of semi-structured interviews which deconstructs informants' discourse along 5 steps to establish categories of information, identify the main topics present in those categories, and determine themes from related topics [16]. In this case, the analysis process did not go through the 5 steps inscribed in the mentioned proposal, because the type of object under analysis is not the same. Compared to semi-structured interviews, the think aloud method used typically leads to much shorter, spontaneous, and unstructured discourses. The analysis of the transcripts facilitated the identification of observations and themes that were repeated by different participants and supported an overall analysis of the experiences, allowing their results to be compared with the

field notes. The audio transcripts analysis followed the next process: 1) Transferring the transcripts to a table and sectioning each participant's transcripts by episode or segment. Different ideas correspond to different segments. 2) Exclusion of segments not relevant for this evaluation. 3) Assigning a descriptive code to each segment. The descriptive code is a phrase that describes and circumscribes a segment. 4) Subcategorization of the descriptive code into a category related to the purpose of the article—data visualization in hybrid space. Some of the categories extracted from the descriptive codes are space perception; interaction techniques; or artistic nature of the experience. In this way, a category can have several descriptive codes.

Based on this table (see attached table) it was possible to verify the most repeated categories and descriptive codes related to the experience of space and its perception. From here, a general description of the transcripts was made and, subsequently, triangulation of this information with field observations [17] was carried out as will be seen in the 'Results' part.

5.3 Results

The observation of participants while interacting with FLOC application enabled to witness the perspective that this medium conveys on information in the hybrid space using a hand-held device, as well as the aspects that affect the ease and fluidity of interaction with augmented reality content. On the other hand, the most frequent topics extracted from the comments collected during the tests with the FLOC application were the following: (1) Difficulty in matching physical space and virtual space; (2) Dichotomy between the aesthetic experience and the informative experience; (3) Limitations identified and presentation of suggestions or other possibilities; (4) Usefulness of the content and engagement; (5) Surprising character of augmented reality.

People expressed (1) difficulty in making the correspondence between real space and virtual space, but also between different virtual objects, verbalizing difficulties at three levels: (a) perceiving the location of the spheres in the physical space of the room: "I don't quite understand where [the sphere] is. I can see it's over there, sideward Lisbon. But from here I can't figure out where it is exactly."; (b) establishing the relationship between the spheres and the corresponding location on the map of Portugal: "I can't see the relationship between the map and the distribution of spheres in space."; (c) understanding their own position in virtual space: "— Can't you perceive your own location in space?—Yes, in space. Not in the living room space, in the virtual space.".

While for some participants reading the information in the hybrid space provoked curiosity and a desire to explore—a strong playful and exploratory component was observed in the interaction with FLOC—for others the application caused some agitation for not being able to quickly synthesize or overview the overall data. This limitation has to do with the positioning of the participants within the information, which does not favor a strategic perspective, but rather an immersive one. Several users mentioned that it would be nice to access a distant perspective of the data—either by bringing the spheres down or moving away from the spheres. "A farther view of the spheres would be better if the space was bigger."; "Only if I moved farther away would I be able to understand."; "It would be interesting to see this from above.".

Two participants spoke of the application in aesthetic terms as if it were an art installation, (2) opposing the aesthetic experience to an informational or utilitarian experience: "In visual terms it is quite interesting but in practical terms it turns out not to be as effective as would be intended (…) as would happen with a pie chart capable of representing percentages.". One of the participants mentioned the following: "As a plastic work it works very well, it is visually very appealing, but as an object of analysis it is not accessible. It's too much.".

Interaction with the virtual content depends on the user's movement in the space—zooming, browsing, and searching, among other actions, depend on their movement in the space dedicated to the experience. If the recognition of the area target by the application is not completely stable, the fluidity of the interaction is compromised, since the participants tend to avoid moving around to prevent the information from disappearing.

(3) The limitations pointed out by users were mostly related to the direct interaction with the spheres: for example, about the difficulty of simultaneously holding the tablet and touching the spheres, or about not being able to select a specific sphere (when they accumulate in a large number in a small space) to learn more about the associated company. But suggestions were also made for some of the problems detected: for example, the possibility of filtering the information by district or the possibility of creating a history for previously selected spheres.

Some participants referred to the application—not as an analysis tool—but as (4) a more engaging way of exploring a database than its more traditional excel table form, which does not arouse curiosity. One of the participants mentioned that this application can be a more engaging way of looking at information, and that if it were in text form she probably would not have read or be interested in it. After understanding how the application works, several users spent some time trying to find companies they knew amidst the array of spheres. Other users showed interest and asked questions about the companies that were 'higher', reporting higher profits.

During the experience, (5) expressions of astonishment and enthusiasm were heard, denouncing the ludic character of the application, but also the technological 'novelty' that augmented reality still represents. Some participants pointed out aspects of this technology, namely the possibility of adding 'things' to the physical space that would not exist without the device, or the possibility of incorporating information in a space without saturating it. "In the case of augmented reality, the technology not only shows what is directly in front of a user, directly observable with their own eyes, but also what hides behind the building, architecture and other view-obstructing geometry." [18].

Finally, it was found that the textual information about the application made in the descriptive ('about') is not sufficient to support the interpretation of the data. Only one participant selected this option and did not get to read the explanatory text. The assistance in interpreting the visualization should be done through a linear narrative (text, audio, video) that precedes, intersperses, or concludes its free exploration by people.

6 Discussion

The hybrid space is a digital, interactive space where the control of the viewpoint is inherently done by the user. It is possible to analyze hybrid space based on the distinction

between emotional space and strategic space proposed by Ryan (2015) to classify space in interactive narratives (Fig. 2).

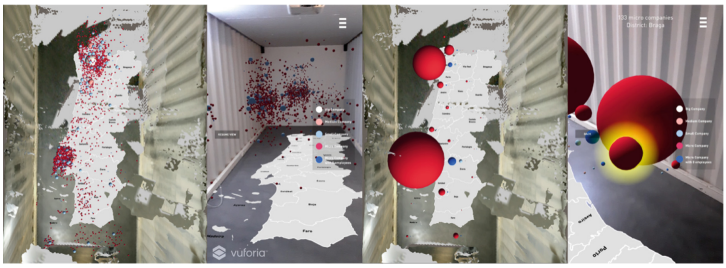

Fig. 2. FLOC activated by FBAUL's area target. (a) Vertical view on Unity editor. (b) Tablet screen capture at FBAUL exhibition. (c) FLOC vertical view on Unity editor (resume view). (d) Tablet screen capture (resume view).

The hybrid space, characteristic of mixed realities in which there is a fusion between real and virtual environments, fits into the concept of emotional space and favors a horizontal, immersive perspective that positions the user in the same space as the virtual content. This proximity with the virtual content favors immersiveness and focus, providing a perspective that simulates the lived experience.

6.1 Strengths of Data Visualization in Hybrid Space

The horizontal perspective in data visualization promotes aesthetic pleasure, wandering and curiosity, stimulates exploration and discovery. Thus, the engagement generated by immersiveness, stands out as one of the great assets of using augmented reality in data visualization where there is no semantic connection to the physical space. The conception of the hybrid space as an emotional space meets the concept of immersive data space as a botanical garden [4]—a permanent installation designed and curated in constant change, an information-rich landscape that offers various levels of resolution and serves various purposes—from wandering to research.

Hybrid space allows bringing reality to data, in the sense that it makes it possible to make abstract numbers concrete by inserting their simulation in a real environment. For instance, if we want to represent 50 trees, we can introduce the simulation of 50 trees in the real environment. The invention of graphics for the print medium came from an abstraction of reality onto the two-dimensional page, encoding reality and representing it on a plane. If graphics are an abstraction of reality, the return of this abstraction to the real world through augmented reality can follow the opposite path, from abstraction to materialization, from the strategic space to the emotional space, from the vertical perspective to the horizontal perspective closer to being in the world, to the perception of the human being. Through simulation, visualization in hybrid space promotes proximity to the data, the focus, and in this way brings you closer to specific cases, to reality, rather than providing an overview.

The presence of virtual content in a real environment that the user 'inhabits', allows comparisons to be made between that virtual content and visual aspects of the real

environment—for example size, volume, or positioning—without requiring a semantic connection to the site of experience. A case study that represents what can be the simulation of virtual content in the real environment for the purpose of communicating information is the New York Times Inflation Shrink Ray (April 20, 2022) [19]. It is an augmented reality effect for Instagram that simulates through objects placed in the user's real environment the effect of inflation on consumer goods by shrinking them.

Although the simulation itself can assign meanings to the physical space—in the case of the FLOC application an empty floor becomes Portugal—this space will continue to act as a referent of the real. Thus, in addition to semantic connotations, this type of experience can and should allude to connotations of a physical or corporeal nature to create visual metaphors useful for communicating information: for example, the corner of the empty room may become 'a' system of Cartesian axes.

6.2 Constraints of Data Visualization in Hybrid Space

Even when trying to convey an overview or strategic view of the data—the resume view in the FLOC application—the immersive perspective still dominates, in the way that we are still in the same hybrid space. By privileging an approximation to the data, the emotional space does make it difficult to get an overview, which is essential to understanding a data set as a whole. This limitation is evident in the dichotomy between aesthetic experience and informational experience mentioned by some participants.

Data communication in hybrid space might induce disorientation if that space is not credible enough, i.e. if there isn't a complete match between the real and virtual environments. To properly work, people should have no difficulty perceiving the position of a given virtual object in the physical space. Only this way will it be possible, on the one hand, to perceive the spatial relationship between different virtual objects, and on the other, to perceive one's own positioning relative to those objects, i.e. to be able to position oneself in the hybrid space.

Although it is easier for a user to deal with occlusion situations when viewing virtual objects in hybrid space as navigation relies on natural interactions, namely their own movement, data representation in hybrid space offers more challenges regarding occlusion situations or poor visibility of information than the desktop environment. The immersive perspective proper of the hybrid space leads more easily to situations of information occlusion as the user is virtually in the same place of that information—he doesn't read the information from a vertical perspective, but from several perspectives; on the other hand, the visibility of the virtual content always depends on the real environment and on the positioning of the user, making it difficult to predict all situations.

Human occlusion is a feature that enables virtual content to be occluded with people. In the conducted tests an android tablet was used which does not support this feature and, therefore, the user's body appears hidden by the virtual content. In the tests performed an android tablet was used that does not support this feature and therefore the user's body appears hidden by the virtual content. This form of registration, in which the virtual object is in the foreground, momentarily breaks the integration between reality and virtuality, shattering the interpretation of space as hybrid. The difficulties reported by participants in understanding the location of a sphere on the map may relate to the use of a handheld display to see spheres floating in space.