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Felix Carros

Design, Development and Sensemaking of Human-Robot Interaction in Care Settings

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Acknowledgements

This document is my dissertation titled “Design, Development and Sensemaking of Human-Robot Interaction in Care Settings,” and describes my research activities between 2018 and 2022 at the Institute for Information Systems and New Media, University of Siegen. It was influenced by my involvement as a student in the research cooperation between the university and a care home in the period from 2015 to 2018.

Although my name appears on the front page of this document, it could not have been accomplished without the cooperation and assistance of others. I am grateful to everyone who helped me reach this point. I believe this is a shared achievement. I received assistance in various areas for an extended period, and it is impossible to name everyone who helped me along the way because there were so many of you. As a result, I will refrain from using names and hope that each of you understands that I am referring to you. This support extended beyond immediate assistance with my research; it included meaningful conversations, feelings of connection, and moments of discovery. I’m sure I received assistance that I was not even aware of, people opening doors or helping me to overcome obstacles I was not aware existed. The assistance I received allowed me to create this work, and it would not have been possible without you.

I would like to express my gratitude to all the participants and institutions who granted me access to their resources. Special thanks to those individuals I have pseudonymized, you were critical to the success of this project. I understand that I have made significant demands at times, and I appreciate the effort you have put in to make our work possible. Your insights have been invaluable, and I am honored to have been a part of your lives. I acknowledge that this is not the norm.

I recognize that this was only achievable due to your efforts. You made me see, and I am grateful for that.

Although I am profoundly thankful, I think I also need to express regret. This thesis has consumed a significant amount of my time and energy. As a result, I might have neglected personal relationships and missed important events, conversations, and visits. I deeply appreciate the patience and understanding shown by my friends and family during this period and know that I was not the only one that has been investing time and nerves to create this work. Thank you for enabling this work.

Abstract

Western societies' demographic shift toward an older population has been a long-term trend. Consequently, the number of people in need of care services has increased. The number of people employed in the care sector is not increasing at the same rate. As a result, the existing workforce and the system are under strain. At the same time, technology has advanced rapidly. Social robots are one of these innovations that are gradually becoming a part of everyday life. Social robots' new functional and interactive capabilities make them relevant in care settings.

This dissertation investigates the potential of a social robot in care homes to assist the workforce and contribute to the well-being of residents. Several studies are presented that use a socio-informatics approach to make sense of social robots in care homes. They investigate how residents and caregivers interact with social robots, analyze and shape their appropriation, and how informed decisions can be made for the development of the software and hardware of the robots. The findings indicate that social robots can play a role in care homes. However, they can only assist and not replace care workers. They broaden the possibilities for social care workers and, when integrated into daily work practices, can provide small breaks. They can also have a positive impact on residents by motivating them to engage in cognitive and physical training.

We chose to explore the field using a participatory approach to design the robot's functionalities. Research and development was done within care homes together with the people working and living there. The findings aim to contribute to the HCI and HRI community by demonstrating the benefits, challenges, and ambiguities of long-term use of social robots in care homes.

List of Publications

This dissertation consists of an accumulation of publications that have been accepted and published. Chapter 4 corresponds to P1, Chap. 5 to P2, Chap. 6 to P3, Chap. 7 to P4, Chap. 8 to P5, and Chap. 9 to P6. The list of all publications is in Table 1 below. The publications are a shared result. I thank all my co-authors for the collaboration on these.

Table 1 List of publications that are part of this dissertation

No.	Publication Details	Outlet	Status
P1	Carros, F., Meurer, J., Löffler, D., Unbehaun, D., Matthies, S., Koch, I., Wieching, R., Randall, D., Hassenzahl, M., Wulf, V. 2020. *Exploring Human-Robot Interaction with the Elderly: Results from a Ten-Week Case Study in a Care Home* Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. (April, 2020). https://doi.org/10.1145/3313831.3376402 [Reference in bibliography: [69]]	Conference Proceedings	Published
P2	Carros, F., Schwaninger, I., Preussner, A., Randall, D., Wieching, R., Fitzpatrick, G., Wulf, V. 2022. *Care Workers Making Use of Robots: Results of a Three-Month Study on Human-Robot Interaction within a Care Home*. Proceedings of the 2022 CHI Conference on Human Factors in Computing System. (May, 2022). https://doi.org/10.1145/3491102.3517435 [Reference in bibliography: [71]]	Conference Proceedings	Published

(continued)

Table 1 (continued)

No.	Publication Details	Outlet	Status
P3	Schwaninger, I., Carros, F., Weiss, A., Wulf, V. and Fitzpatrick, G. (2022). *Video connecting families and social robots: from ideas to practices putting technology to work* Proceedings of the Universal Access in the Information Society. https://doi.org/10.1007/s10209-022-00901-y [Reference in bibliography: [276]]	Journal	Published
P4	Carros, F., Langendorf, J., Randall, D., Wieching, R., Wulf, V. (2022). *Citizen Participation in Social Robotics Research* Published in the Book "Meaningful Futures with Robots—Designing a New Coexistence" [Reference in bibliography: [68]]	Book Chapter	Published
P5	Störzinger, T., Carros, F., Wierling, A., Misselhorn, C., Wieching, R. (2020) *Categorizing Social Robots with Respect to Dimensions Relevant to Ethical, Social and Legal Implications* Proceedings of the i-com Journal, Vol. 19 (Issue 1), pp. 47–57. https://doi.org/10.1515/icom-2020-0005 [Reference in bibliography: [295]]	Journal	Published
P6	Carros, F., Störzinger, T., Wierling, A., Preussner, A., Tolmie, P. (2022). *Ethical, Legal & Participatory Concerns in the Development of Human-Robot Interaction—Lessons from eight research projects with social robots in real-world scenarios*. Proceedings of the i-com Journal, Vol. 21 (Issue 2), pp. 299–309. https://doi.org/10.1515/icom-2022-0025 [Reference in bibliography: [73]]	Journal	Published

Contents

Part I Foundations

1 Introduction 3
1.1 Problem Definition 3
1.2 Motivation for this Work 5
1.3 Main Contribution of the Dissertation 6
1.4 Structure of Thesis 7

2 Related Work and Context 9
2.1 Related Work 9
2.1.1 Evolution of Robotics 9
2.1.2 Social Robots in Care Settings 13
2.2 Context 15
2.2.1 Aging Population 15
2.2.2 Societal Conditions of Care 16

3 Methodology 19
3.1 Understanding Practice 19
3.1.1 Participatory Design 19
3.1.2 Grounded Reflections 21
3.1.3 Work in COVID-19 23
3.1.4 Wizard-of-Oz 24
3.2 Data Collection and Analysis 24
3.3 Citizen Participation 26

Part II Publications

4 Exploring Human-Robot Interaction with the Elderly: Results from a Ten-Week Case Study in a Care Home 31
4.1 Introduction 32
4.2 Related Work 33
4.2.1 Studies of Social Robots in Residential Care 33
4.2.2 Perspectives of Caregivers and Care Homes 34
4.3 Method 35
4.3.1 Study Design and Setup 35
4.3.2 Data Collection and Analysis 36
4.3.3 Participants and Setting 37
4.4 System Overview 38
4.4.1 Technical Infrastructure 38
4.4.2 Robotic Intervention Course Setting and Concept 38
4.5 Findings 40
4.5.1 Getting Engaged with the System 40
4.5.2 Attitudes and Feelings towards the Robot 42
4.5.3 Social and Ethical Issues 44
4.6 Discussion 45
4.6.1 Accessibility of the Robotic System 46
4.6.2 Attitudes Related to the Robot and Course Setting 46
4.6.3 Social Consequences 47
4.6.4 Ethical Issues 48
4.6.5 Lessons Learned 50
4.6.6 Limitations 51
4.7 Conclusions 51
4.8 Acknowledgments 52

5 Care Workers Making Use of Robots: Results of a Three-Month Study on Human-Robot Interaction within a Care Home 53
5.1 Introduction 54
5.2 Related Work 55
5.2.1 Social Robots in Care Settings 55
5.2.2 Care Workers Attitudes Towards Technology and Robot Usage 57

5.3 Methods 57
5.3.1 Study Design 57
5.3.2 Participants and Setting 58
5.3.3 Robotic System and Software 59
5.3.4 Appropriation 61
5.3.5 Data Collection, Analysis and Ethical Evaluation 61
5.4 Findings 62
5.4.1 Usage Time and Usage Distribution of the Robot 62
5.4.2 Appropriation of Robot Usage 64
5.4.3 Burden of Using a Robot 66
5.4.4 Work Relief through Usage of Robotic System 68
5.5 Discussion 69
5.5.1 Sustainable Work Process Integration 69
5.5.2 Overcoming Uncertainties 70
5.5.3 Interaction Design of Usage 71
5.5.4 Usage Preferences 72
5.5.5 Reflections on Appropriation in Regard to Daily-Work Habits 74
5.5.6 Work Relief Effects 75
5.6 Lessons Learned 75
5.7 Limitations 78
5.8 Conclusion 78
5.9 Acknowledgement 79

6 Video Connecting Families and Social Robots: From Ideas to Practices Putting Technology to Work 81
6.1 Introduction and Background 82
6.2 Methodology 83
6.2.1 Chronological Account and Context of the Study 83
6.2.2 Research Setting and Participants 84
6.2.3 Data Collection and Analysis 86
6.3 Findings 87
6.3.1 Effects of the Pandemic on the Care Homes 87
6.3.2 Use of Communication Technology 90
6.3.3 Attitudes Towards Future Technology 93
6.4 Discussion 94
6.4.1 Values in Social Interaction 95
6.4.2 Readiness to Engage with CT 96
6.4.3 Lessons Learned from shifting Crisis Situations 97

6.4.4 Outlook: Implications for the next Generation of CTs ... 99
6.4.5 Methodological Remarks and Limitations ... 100
6.5 Conclusion ... 101

7 Citizen Participation in Social Robotics Research ... 103
7.1 Introduction ... 103
7.2 Why Citizen Science ... 104
7.3 Our Own Experience with Citizen Science ... 105
7.4 Challenges of Citizen Science ... 108
7.5 Citizen Science—Further Methods and Resources ... 110

8 Categorizing Social Robots with Respect to Dimensions Relevant to Ethical, Social and Legal Implications ... 113
8.1 Introduction ... 113
8.2 Categories to Distinguish Different Types of Social Robots ... 114
8.3 Categories as Gradable Dimensions ... 116
8.4 Degree of Autonomy ... 117
8.4.1 Ethical Issues ... 118
8.4.2 Participatory Issues ... 118
8.4.3 Legal Issues (Privacy) ... 119
8.5 Degree of Emotionality ... 120
8.5.1 Ethical Issues ... 121
8.5.2 Participatory Issues ... 121
8.5.3 Legal Issues (Privacy) ... 122
8.6 Degree of Sociality ... 123
8.6.1 Ethical Issues ... 123
8.6.2 Participatory Issues ... 123
8.6.3 Legal Issues (Privacy) ... 124
8.7 Impact on (Social) Competences ... 126
8.7.1 Ethical Issues ... 126
8.7.2 Participatory Issues ... 127
8.8 Conclusion ... 128

9 Ethical, Legal & Participatory Concerns in the Development of Human-Robot Interaction—Lessons from Eight Research Projects with Social Robots in Real-world Scenarios ... 129
9.1 Introduction ... 130
9.2 Participatory Aspects ... 133

9.2.1 User Involvement ... 133
9.2.2 Methodological Aspects ... 134
9.2.3 Trust Relationships ... 135
9.2.4 Sustainable Development ... 136
9.2.5 Lessons Learned and Possible Measures ... 137
9.3 Ethical Aspects ... 139
9.3.1 Ethical Methods Used ... 139
9.3.2 Lessons Learned and Possible Measures ... 140
9.4 Legal Aspects ... 142
9.4.1 Early Familiarization with Data Protection ... 142
9.4.2 Handling GDPR-based insecurities ... 144
9.4.3 Lessons Learned and Possible Measures ... 145
9.5 Conclusion ... 146

Part III Making Sense

10 Discussion ... 151
10.1 From Social Robots to Practice Research ... 151
10.2 Perception of Social Robots in Care Settings ... 152
10.3 Attitudes toward Robotic Systems in Care Settings ... 154
10.4 Effects of Social Robots on Daily Work Practices ... 157
10.5 Appropriating and Developing Social Robots in Care ... 160
10.6 Sustainability in Robot Usage ... 164
10.7 Grounded Reflections and Lessons on Practice Research ... 167
10.7.1 Lessons on Development ... 167
10.7.2 Lessons on Usage ... 168
10.7.3 Lessons on Methods ... 170

11 Limitations ... 173

12 Conclusion and Outlook ... 175
12.1 Conclusion on our Findings ... 175
12.2 Conclusion on the Field ... 176
12.3 Outlook on Future Research ... 178

Bibliography ... 181

Abbreviations

AI	Artificial Intelligence
COP	Community of Practice
COVID-19	Coronavirus Disease 2019
CSCW	Computer-Supported Cooperative Work
ELSI	Ethical, Legal and Social Implications
EU	European Union
EUD	End-User Development
GDPR	General Data Protection Regulation
HCI	Human–Computer Interaction
HRI	Human–Robot Interaction
HTML	HyperText Markup Language
ICT	Information and Communication Technology
IS	Information Science
IT	Information Technology
MEESTAR	Model for the Ethical Evaluation of Socio-Technological Arrangements
NGO	Non-Governmental Organization
NRW	North Rhine-Westphalia
OHRI	Older Human–Robot Interaction
PD	Participatory Design
RRI	Responsible Research and Innovation

List of Figures

Fig. 2.1 NAO Robot 12
Fig. 2.2 Age structure of the population in Germany: Comparison from 1990 to 2018 [234] 15
Fig. 2.3 Number of people over 60 exceeds the number of people under 30 16
Fig. 4.1 Group setting with the Pepper Robot 39
Fig. 5.1 Care worker and resident sitting together for coffee with robot 54
Fig. 5.2 Set up provided for the participants—Pepper Robot, Smartphone with App for remote control, portable router and printed instruction manuals 60
Fig. 5.3 Total usage distribution of the Application of the Robot 63
Fig. 5.4 Two pictures illustrating the activities with the robots 64
Fig. 6.1 A chronological account of the restrictions and data collection phases 84
Fig. 6.2 A postcard a resident has written to the researchers describing the visits in containers: *"[...] I will be visited by my Son Christian today at 4 p.m., the visit will be in front of the home in a container [...]"* 88
Fig. 6.3 An advertisement at H2 to communicate with relatives via CTs like Skype and WhatsApp 92
Fig. 6.4 Two postcards a resident sent to the Pepper robot 93
Fig. 7.1 Explaining the functions of the robot 107

Fig. 7.2 Example of an application area developed by citizen in a design workshop 107
Fig. 7.3 The ECSA website 110
Fig. 8.1 Examples of social robots 115
Fig. 8.2 Method used for categorization 116
Fig. 8.3 Dimensions relevant to ethical, social and legal implications 117
Fig. 10.1 Examples of robot Pepper 155
Fig. 10.2 Interface of the Robot Pepper that we developed 161

List of Tables

Table 4.1 List of participants (*dropped out of the study early) 37
Table 5.1 The participants' codes as referred to in this paper, their age, sex, and position in the care home 59
Table 5.2 Overview of applications provided for the study 60
Table 5.3 Usage Time of the Robot per Month and in Total 62
Table 5.4 Overview of developed applications for care home 65
Table 6.1 The participants' names as referred to in this paper, their age, gender, care home facility (pseudonymised) and role in the respective care homes 85
Table 9.1 Overview of Projects with their objectives and approach 131
Table 9.2 Lessons Learned on Participatory Design 138
Table 9.3 Lessons Learned on Ethical Aspects 140
Table 9.4 Lessons Learned on Legal Aspects 145

Part I
Foundations

The first section of the dissertation presents its foundations and context. Chapter 1, the introduction, explains the subject and my own motivation, as well as its limitations. Chapter 2 places the dissertation's work in the context of related work and demonstrates the need for change within the sector, and explains why social robots can contribute to this change. In Chap. 4, the last chapter of this first part I present the methodology of this work, how I approached the field and learned from it and reflect on the experiences in the field.

1 Introduction

1.1 Problem Definition

Today we can say with certainty that the care system in Western societies, and specifically in Germany, is under pressure. In the coming decade this pressure is likely to increase, not decrease. The reasons for this trend are manifold, but the main driving force of this development is demographic change. German society is growing older and has fewer younger people. The number of people in Germany older than 80 years is predicted to grow from 6.2 million in 2022 to 8.9–10.5 million in 2050. By comparison, in 1970 Germany had 1.15 million people over 80 years old [54, 117]. Another reason is that the number of people working in care is not growing at the same pace; in fact, many positions remain unfilled [19]. In summary, the number of people in need of care grows while the number of people working in care does not, resulting in a shortage of workers and a need for assistance. Far from being a surprising development, this has been projected since decades past, but today we have a clearer picture of it.

This raises a question: How can care work be assisted, and can technology play a role in this assistance? In this work, we look at social robots and how they can (or cannot) be of assistance in the care field. Social robots in care settings are not new; they existed long before this work was written and appear in a range of topics including nutrition, entertainment, loneliness or hygiene. The global research community has worked intensively on social robots in care settings as it is a common vision to help the care sector with robots. The general idea is to assist the care sector with robotic systems in order to relieve the work force, something that previously was done in the industrial sector [112]. In the industrial sector, it is nowadays not uncommon to see a variety of robots working together to create a product, sometimes fully automated. Human workers do not have the same jobs as they used to in places

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