Useful Uselessness? Teaching Robots to Knit with Humans

Pat Treusch
Zentrum für Interdisziplinäre Frauen- und Geschlechterforschung (ZIFG)
TU Berlin, Berlin, Germany
p.treusch@tu-berlin.de

Arne Berger
Anhalt University of Applied Sciences
Computer Science and Languages
Köthen, Germany
arne.berger@hs-anhalt.de

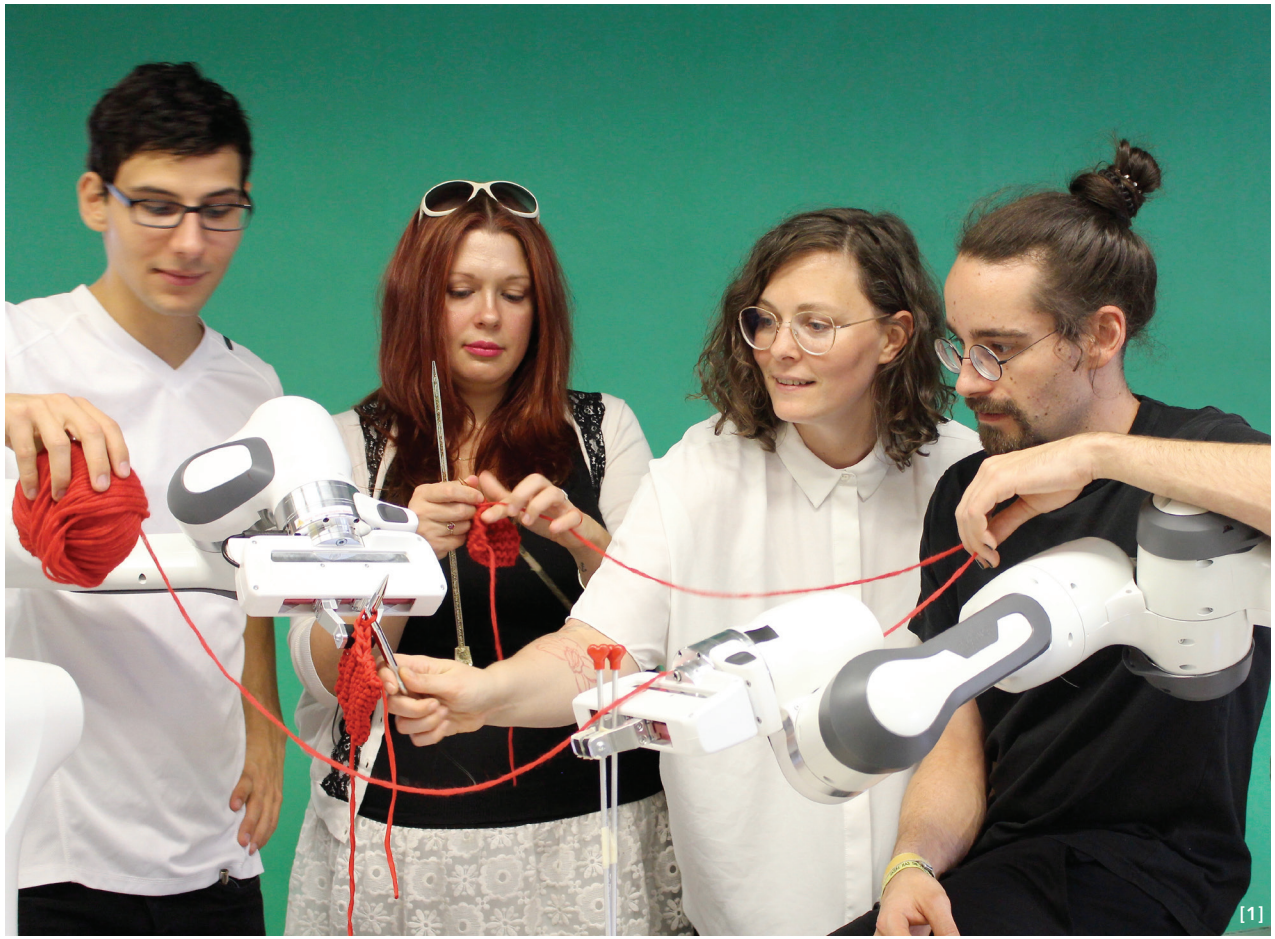
Daniela K. Rosner
Human Centered Design & Engineering
University of Washington
Seattle, Washington, United States
dkrosner@uw.edu

ABSTRACT
This pictorial uses imagery of human-robot collaboration, or cobots, as a site to examine the potential of queer use within design research. Through close documentation of our process, we reflect on acts of teaching a commercially available robot to knit with us—a messy and seemingly unproductive process. However, this uselessness of the chosen task allows us to re-consider the idealization of robotic collaboration. We question the optimization of a largely human labor force and the associated drive to increase efficiency within a range of sectors, from the service industry to industrial production. Building on non-use literatures examining technological limits, and drawing on performative explorations and critique, we show how knitting enlarges our capacity to visualize what might be a suitable use case for cobots.

Authors Keywords
human-robot-interaction; entanglement; queer use; knitting

CSS Concepts
• Human-centered computing~Interaction design~Interaction design process and methods~Participatory design
• Human-centered computing~Collaborative and social computing~Empirical studies in collaborative and social computing

DIS '20, July 6–10, 2020, Eindhoven, Netherlands
© 2020 Copyright is held by the owner/author(s).
ACM ISBN 978-1-4503-6974-9/20/07.
https://doi.org/10.1145/3357236.3395582



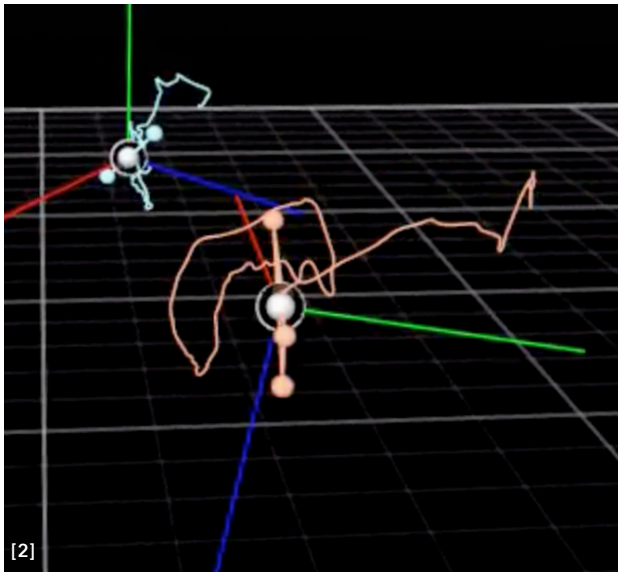
INTRODUCTION: HOW HUMANS & ROBOTS KNIT

A wide range of work has considered the pitfalls and possibilities of technology that goes unused. Termed undesign or non-use, this literature reveals that the benefits to technology deployment are often uneven across varied sites and settings [6,15]. Somewhat unintuitively, scholars discuss how non-design becomes a mode of design.

This pictorial takes a step back from this literature of mapping non-use to consider its generative potential. We consider how what might be seen as useless becomes a tool for examining our assumptions around the tool itself. This generative quality aligns with what feminist scholar Sara Ahmed recently termed queer use [1], or alternative use situations of use that stretch beyond predominant human encounters. Keeping in mind Ahmed's queer use, we explore taken-for-granted assumptions around technology's role in people's lives. We argue that an approach to queering use allows designers to inquire into existing standards of usefulness such as the ableist norms. To make this argument, we examine the act of teaching a robot to knit with humans as a mode of examining the relationships we assume, expect, coerce, and supplant from some of our most common (and increasingly prevalent) technologies.

When it comes to knitting, technological assistance is nothing new. Knitting machines have existed since at least 1863—and arguably, the stocking frames existed already almost 100 years earlier. People have knit with and without assistance for centuries. Knitting needles themselves may be considered a type of assistive technology [12]. Likewise, the robot collaboration we explore holds serious possibilities for people with motor-impairments, limb-loss, or other disabilities. However, a concern for optimization—making tasks more efficient—underlies each of these existing and potential efforts. Our project expands this task-based concern by examining the impracticality, implausibility, and perhaps impossibility of seeking non-optimization as a place to begin.

In what follows, we display the practices and practicalities of what we frame as a case study of designerly queer use. After a backdrop, we illustrate how we taught the commercially available robot PANDA from FRANKAEMIKA to knit with humans and came to reconceptualize this setting. We end by widening the lens of this documentation to include the immediate space around, behind, and beneath the collaboration to foreground some of the invisible and neglected labors of this specific human-robot collaboration.


[2]

Unravelling the Tensions Between Human Knitting and Robotic Knitting

The juxtaposition of human knitting (left) and robotic knitting (right) exposes some of the tensions emerging from a potential collaborative knitting practice.

The motion capture analysis (left image) of the practice of knitting reveals rather intricate and complex movements of a skilled human knitter.

The right image shows a piece of knitwear produced in collaboration of human and robot. The robot appears to perform poorly at the practice of knitting.

More specifically, the left hand of the human knitter had to adapt to the trained movements of the right needle which the robot is executing. Sometimes the needle turned out to be too slippery or not slippery enough — in both cases, a stitch might get lost and holes are produced.


[3]

BACKGROUND

Cobots

Before we explore the particulars of our intervention, we wish to contextualize the machines with which we design. While the idea of the "cobot" has existed for more than 20 years, it is only with current advances in "interconnected, intelligent, adaptive" robot technologies that they seem to be, in Sabine Pfeiffer's words, "beginning to emerge from their protective cages" [14]. The emergence of a mobile, adaptive, and interconnected new generation of light-weight cobots opens up several research questions for design around how these machines shape and will continue to shape forms of human-machine collaboration. Notably, the capacity to leave their protective cages not only affects work in the realm of factory halls, but enables multiple visions of cobots being made "useful" in everyday life. Cobots have the potential to penetrate every sphere of human activity, especially the service sector and realms of care work. How would such collaborations work out for all humans involved?

To address this question, we suggest understanding cobots as both as powerful contributors to a workforce and as powerful cultural figures. This involves investigating omnipresent visions of a human-robot collaboration in everyday life and how they prescribe what the future of collaboration with robots might be. Envisioned as a co-worker and not as a substitute worker, the cobot exposes the possibility of building new interfaces of proximity between humans and cobots. While narratives of a "robotic invasion" [11] are ubiquitous and a future with cobots seems evermore inescapable, designers still have little knowledge of how such a collaboration might be explored, how it could work, and what kind of tasks, capacities, and forms of human engagement might be required. Here, new imaginations and images seem timely and necessary. As such, we explore this space by realizing the seemingly useless task of knitting with a robot, FRANKAEMIKA's PANDA. By working with PANDA, we ask: *Which collaborations are possible and feasible? Who collaborates with whom? Who does which labors and how is power distributed between collaborators?*

Towards Robotic Knitting

To understand the promise of robotic knitting for design inquiry, we first consider how people have already taken up knitting for exploration and critique. Historically, knitting has occupied vastly different purposes. People have deployed it as a formal language of 2D and 3D construction as well as a coded form of feminist protest. In this sense, textile craft and the political participation of marginalized citizens have been tightly interwoven [13,18,19]. Already during the time of the French Revolution, the tricoteuses (knitting women) embodied "knitting as public political demonstration" [10]. Looking across these sites and movements, we understand knitting as a cultural technology with a certain political momentum. We bring robots to knitting to explore this momentum within current work to imagine collaborative human-machine relationships.

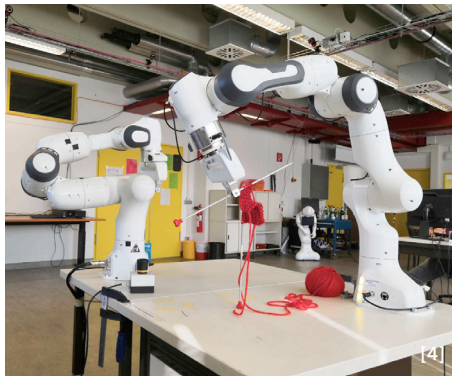
Performative Explorations of Human-Robot Collaborations

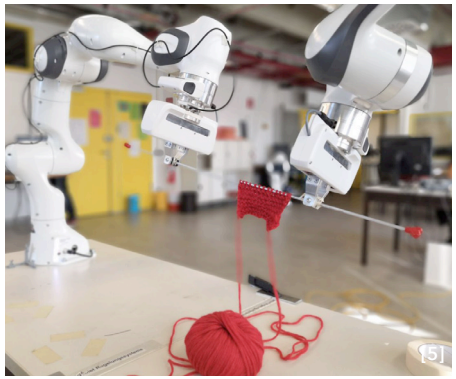
Over the past decade, a rich literature on the non-use of technology has begun to articulate the stakes and provisions of interventions within HCI. Much of this work seeks to provide empirical accounts of non-use such as mis-use, re-use, or neglect (e.g. [3,4,5,8]).

Termed undesign [15], some experiments devise material manifestations of breakdown, retrofitting, or remainders as sites to remake design ideas in the present. For example, Laura Devendorf and colleagues' Being the Machine project [9] is an alternative 3D printer that operates in terms of negotiation rather than delegation. It takes the instructions typically provided to 3D printers and presents them to human makers to follow – essentially creating a system for 3D printing by hand with whatever tools and materials one deems necessary. In so doing, Being the Machine turns widely accepted aims for machine efficiency and control on their head.

We build on these moments of unfit/misfit machines to explore prevalent assumptions about how robots and machines work together. In particular, we extend common understanding of such relationships in the realm of knitting informed by Ahmed's notion of queer use [1] For Ahmed, an act of queer use delves into the question "What's the use?"—questioning the positionality and value of something. This phrase holds a queer-feminist impetus to make a difference in what we are used to or should get used to. For us, this involves a mode of design inquiry that enacts a form of resistance against status quo robot design.

By teaching robots to knit with us, we explore the scrutinizing force of asking, with Ahmed, "about the point of anything by asking about the point of something" [1] —that is, we examine the motivations behind contemporary robotic technology development.


[4]


[5]

In our lab, the Panda robot arms are mounted to mobile tables and therefore can be moved around. The lab itself is a quite spacious room with many computer working spaces that allow researchers to work on different projects at once.

THE PIVOTS OF ROBOTIC KNITTING

At first it may seem odd to explore a technology that Time magazine declared to be one of the central innovations of 2018 in relation to the apparently "most boring cultural technology of the world" [10] , namely knitting. Cobots are often culturally coded as requiring particular and rarified expertise while knitting appears to many as non-technical, simple or unthinking — a feminized hobby that has no relevance at a place like a robotics research lab. But it is precisely this sociotechnical paradox that we aim to examine through our design process.

[6]

A person who collaboratively knits with Panda has to constantly follow the movements of the arm, understand the rhythm of back and forth movements, handle the knitting needles and perform the movements necessary to operate the left knitting needle.

[7]

DESIGN RATIONALE

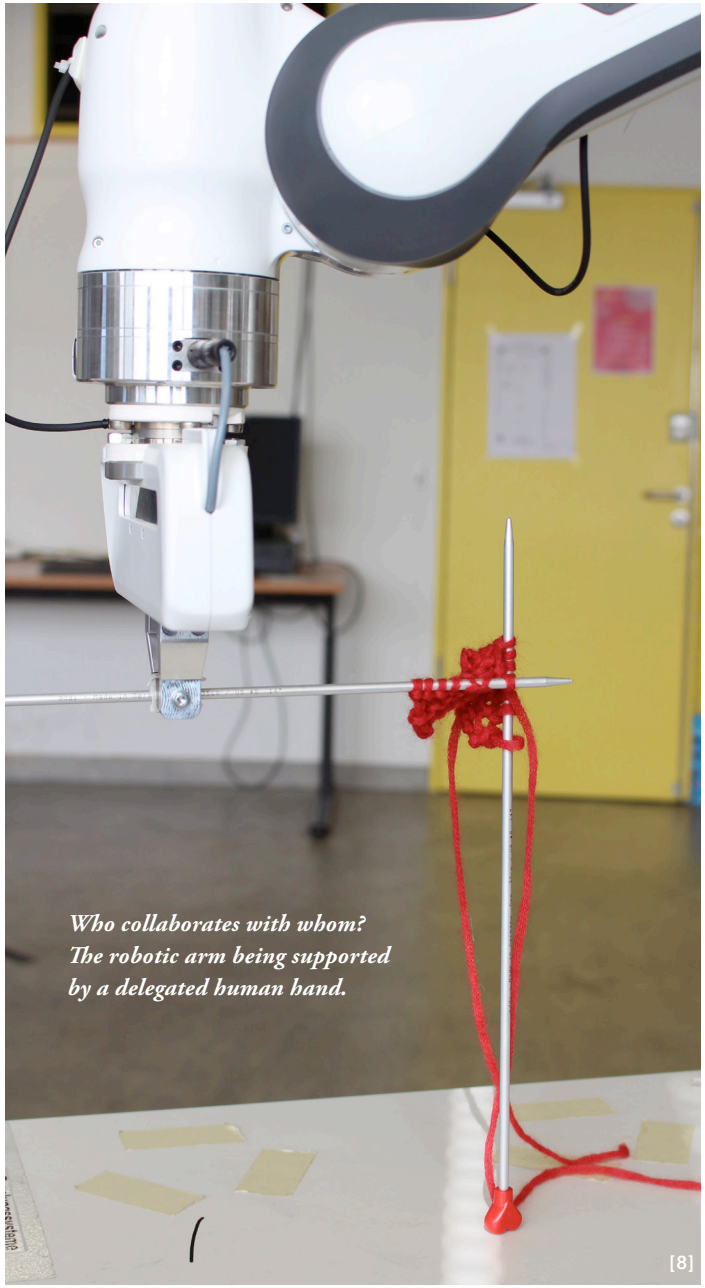
At its core, robotic knitting not only helps tackle questions around the use of a cobot raised in the previous sections, but also, and importantly, explores a performative stance through which a different vision of human-cobot-relating might be enacted.

Using knitting, we seek to imagine what a cobot future might look like. But additionally, we investigate the very particular and corporeal modes of collaboration that are possible at existing interfaces.

With this focus, we explicate some of the design decisions and necessities in making a cobot possible and—related to this—shed light onto the conditions in which the cobot can actually become a collaborator.

Realizing collaborative knitting with a robot helps us critically probe current actualizations and realizations of cobots. Through one particular case study, we question how delegations of design/use, production/consumption and human/machine move across the varied actors of human-machine collaboration.

These shifting delegations push our thinking beyond the pessimistic or dualistic.

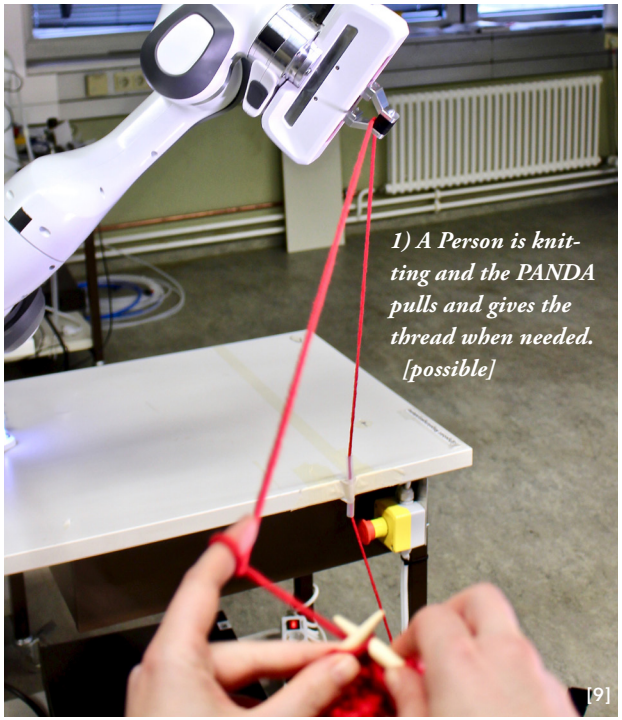


Who collaborates with whom? The robotic arm being supported by a delegated human hand.

[8]

POTENTIAL SCENARIOS – A FEASIBILITY ANALYSIS OF WHO COLLABORATES WITH WHOM.

We developed three scenarios of robot-human-collaboration. Below we briefly discuss their feasibility and our decision of which scenario to implement. The three scenarios are characterized by different degrees of collaboration and by different actors.



In **scenario 1**, we imagine a knitter needing a kind of 'third hand' that helps unravel the ball of yarn while knitting rows. The flow of yarn is a crucial factor in achieving a uniform fabric knit structure. Without a 'third hand', one might have to put down both needles in order to unravel the yarn further. Thus, the cobot's task is to pull the thread when needed. This situation allows the human to keep a certain distance from which they can watch how the robot arm moves through space and to become familiar with the robot arm as cobot.

In **scenario 2**, a person is knitting with the left needle and the PANDA takes over the right needle. The cobot's needle is empty and all the stitches are on the left needle. Then the cobot has to perform the movements of continental knitting: pierce through a stitch, take the yarn through the stitch (forming of new stitch), let the 'old' stitch slip from the left needle. At the same time, stitches, yarn, and knitted piece are permanently moving when knitting while it seems impossible to predict how they will move. Splitting the activity "to knit" between a person and the PANDA not only shows how complex knitting is, including the many different smaller movements which are naturally to a used knitter, but also the complexity of realizing this mode of collaboration between humans and a cobot.

Scenario 3 at first seemed to be a very obvious idea: Instead of a human and a PANDA knitting together, now two PANDAs supposedly knit together and the role of the human would be to give and guide the thread. This scenario involves the most human preparatory effort in terms of realizing the collaboration between cobots and human. In this scenario, the human must also collaborate by becoming the "eyes & ears" of the PANDAs and thus allows for a form of sensory guidance.

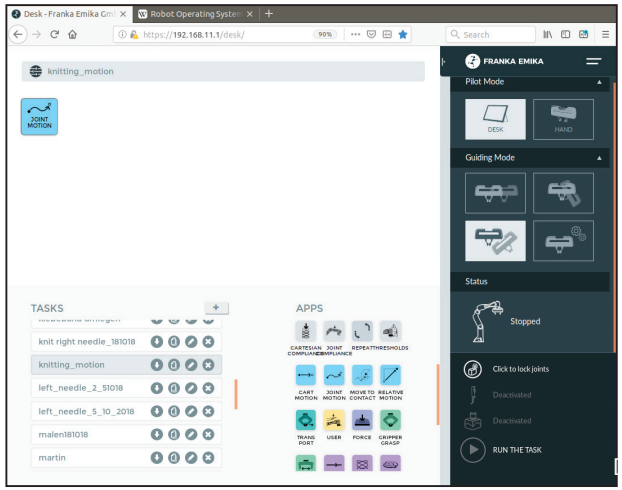
ESTABLISHING COLLABORATION: GETTING TO KNOW EACH OTHER

The main work consisted of understanding how to realize the task of collaborative knitting, and to continuously experiment and to test how to bring the cobot and knitting together in practice.

At first, the team (Feminist Science and Technology Studies, Computer Science, Robotics, Electrical Engineering, Psychology) had to become familiar with each other: the different disciplinary backgrounds, the differing terminology, our different modes of working, but also each person with the PANDA. The latter involved to learn the right position between robot and human that is needed to be able to operate this machine as well as learning how to operate the graphical user interface (GUI) with its different apps.

In addition, it also meant to understand the difference between an idea of what task the robot should be able to perform and how, training the robot and how the task will then be executed.

The team proceeded through different steps of getting familiar and decided then that the most interesting scenario to realize for us would be to have a person knitting with two needles and to then bring the cobot in by handing the empty right needle to it in order to take it over (scenario 2). Here, the humans and the PANDA truly have to collaborate in order to realize the task.



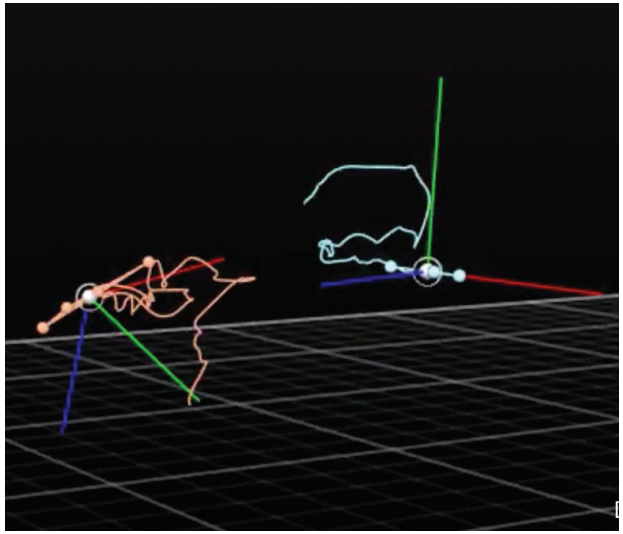
The graphical user interface of the PANDA to set and orchestrate repetitive motions of the PANDA. This orchestration and automation exists in a stark contrast to the unforeseeable compensatory movements that are usually required in knitting. These regular, irregular, linear and non-linear movements are exemplified in the motion capture of knitting performed by a skilled human knitter below.

ESTABLISHING COLLABORATION: COORDINATING MOVEMENTS

The Motion Capture Picture underlines that the coordinative work between the two hands while knitting is especially ambitious. The knitting movement consists of a set of sub-movements, like inserting the right needle through a stitch on the left needle, wrapping the yarn around the right needle and pulling this loop through the stitch while letting the old stitch slip off the left needle.

The objects of knitting: needles, yarn and a knitting pattern have to be controlled and brought into coherent relations. Indeed, quite a large amount of unforeseeable compensatory movements is needed: if the yarn moves in another direction than indicated in a specific pattern, human hands with needles have to redirect the yarn.

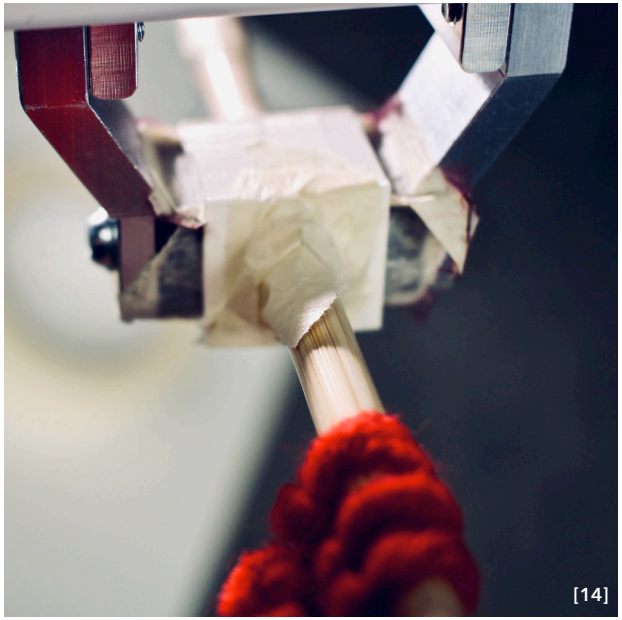
This is why the Motion Capture Picture does not show a linear, repetitive knitting movement: the movement of the needles does not describe an ellipse or the like. Rather, knitting involves various sets of regular and irregular movements that are divided between the two hands with needles. Thus, to knit collaboratively by dividing the knitting needles between two entities became the ideal scenario for probing human-cobot-interaction.



Reconfiguring the Gripper to Grip

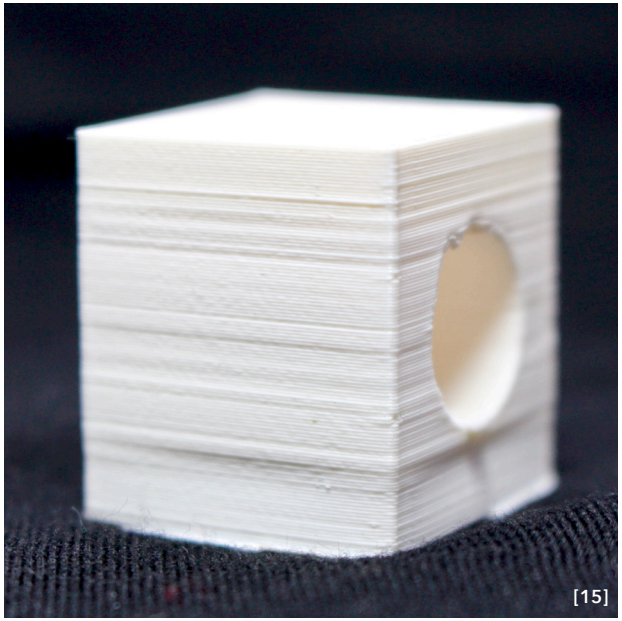
We also discovered that the PANDA's grippers are made for gripping things in a specific shape and with a certain texture, namely box-shaped things. In addition, in order to be able to perform a strong grip, the robot's gripper's inside, the surface with which it grips, is endowed with plastic grooves. Despite the fact that it was designed to ensure that the machine could grip, this surface is obstructive for working with round-shaped things like knitting needles. In response, we used masking tape to cover the grooves, but still the needles had too much slack. We also tried various reconfigurations of the knitting needle to better fit the gripper. Only after 3D-printing a box-shaped holder for the needle, we got the the gripper to hold the needle without any slack.

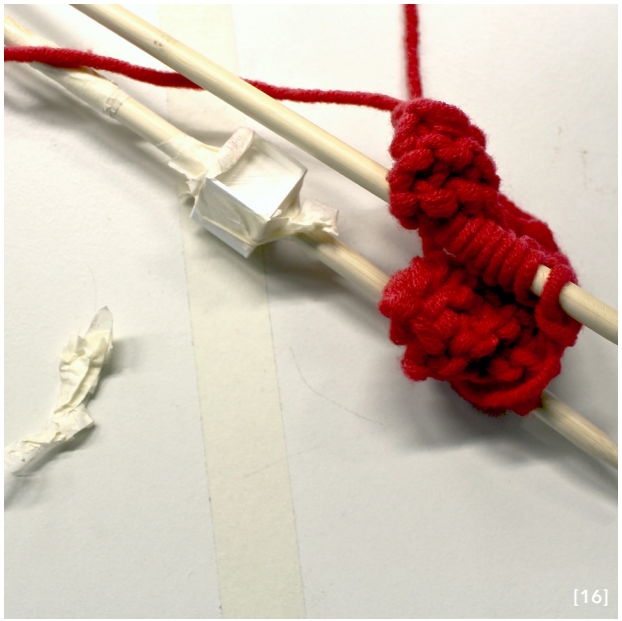
Various attempts at reconfiguring the gripper to grip as well as reconfiguring the needle, so that it can be better gripped by the gripper


[14]

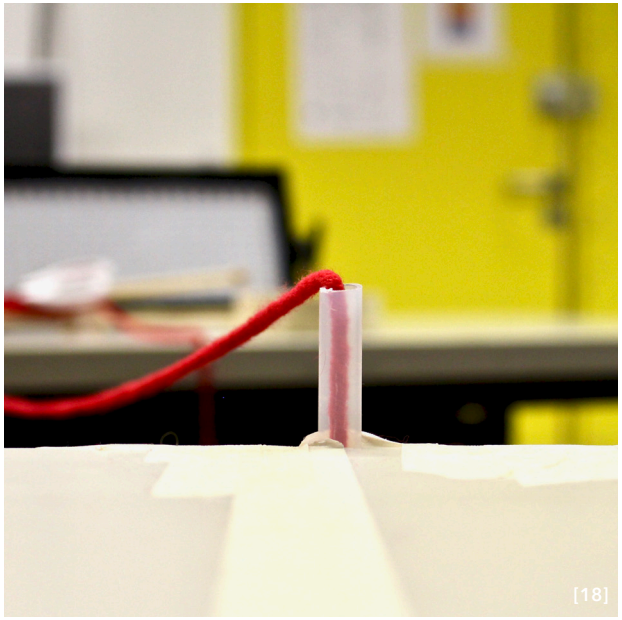
Short Handed Collaboration by Design

We also faced problems with the PANDA's visual programming paradigm and its color-coded buttons. The applications "Cartesian Motion" and "Joint Motion" teach the robot arm a movement. They allow people to record a movement on the cobot by allowing someone to take the robot arm and execute a desired movement with it. Teaching the cobot a movement by demonstrating is called 'guiding', and PANDA is endowed with a guiding button. The guiding has to be enabled by the person working with the PANDA by constantly pressing the physical guiding button on the pilot of the robot arm. Once a movement is trained, one 'only' has to press the play button on the computer screen in order to have the PANDA execute the movement. At the same time, another person has to safeguard the human-robot-interaction by observing it and, if needed, to press the "emergency stop" button—a huge button that one has to hold in their hands. The process of training the robot to do a movement, and the execution of this movement both require human teamwork with the robot and with each other. As such, human-cobot interaction is collaborative in more than one way.


[15]


[16]


[17]


[18]


[19]


[20]

Invisible human labor of adaptations and ergonomics for the robot arm to perform.

FROM NON-USE TO QUEER USE

Early in the project it became clear to everyone—those who were knitters before and those who learned knitting during the project—that knitting is a complex form of handicraft that is not easily transformed into a collaborative activity. We asked ourselves often why we wanted to collaboratively knit in the first place. We correspondingly questioned why engage in such a seemingly useless task with such an expensive machine.

However, overtime the asserted uselessness of the chosen task revealed multiple ways that human-robot interaction is often idealized. We saw how collaboration of humans and robots becomes a mean to optimize performance and output in numerous realms of human labor, ranging from the service sector to large scale industrial production.

As feminist Science and Technology Studies Scholars have shown, almost all configurations of human-robot interaction are highly dependent on a network of people, things, space and cultural meanings. In order to work, these human-robot interactions emerge in highly situated manners, as situated and socially meaningful networks between technology and people. Suchman [20], Alač [2], and Treusch [21,22] have given detailed accounts of how sociotechnical networks are configured to be considered "successful" human-robot interaction.

Within these practices, invisible labors and also neglected labors of enabling and securing human-robot interaction are deeply concealed [7,17]. Such invisible and neglected labors may have many forms. They are often practices of tinkering, fixing or supporting that remain invisible or become neglected, even though they are essential for particular human-robot interactions to actually work. Robotic knitting thus challenges not only the idea of usefulness, but also the system of labor valuation at work in robotic laboratories.

Challenging these notions is of a queer nature because it explores, in Ahmed's words, "how things can be used in ways that were not intended or by those for whom they were not intended" [1]. Robotic knitting is just such a queer use. It works against the grain of both an urge for optimization in human-robot interaction as well as an idealized frictionless in the use of the cobot.

DISCUSSION

With this pictorial we have shown what it means to become familiar with a cobot technology, and how this work necessitates interdisciplinary perspectives. Robotic knitting brings a feminist, critical momentum into the robotics' lab by propelling a re-coding of collaboration. As a practice, robotic knitting brings together the seemingly disparate spheres of robotics and knitting. Thus, our explorations show that robotic knitting—a practice meant to assemble people and things in a collaborative manner—contained much more than a human operating a robot. They showed how collaboration between human and robot might not result from individual work or work that could be described as simply pushing buttons on a screen (or on the robot itself). Rather, collaboration encompassed a research collective and practices of becoming familiar with varied materials: needles, yarn, a GUI and a robot arm.

These multidisciplinary modes of engagement were also cognitive, embodied and affective, as they involved multiple forms of tinkering. They prompted us to understand and question how robot and human knitters might work together. This working together was put into practice not on an abstract level, but rather through experiencing and experimenting with what is possible and how a research collective might realize a chosen scenario. In this way, robotic knitting shows that the seemingly clear boundaries between the cobot and knitting have to be thought of as enmeshed and fluid. These insights are not entirely new: from a technofeminist perspective multiple overlappings – if not an equiprimordality – exist between the fields cobotics and textiles.

There exists an equiprimordiality between textile industry and the first model of a computer the Analytical Engine proposed by Charles Babbage and Ada Lovelace in 1837 [16]. The relevance of punch cards developed as a mode of operation for the weaving loom heralded the mode of operation for the first computers. Sadie Plant [16] famously re-traced the historical proximity between femininity, weaving machine and computer from the Analytical Engine until the mass production of silicon chips at the end of the 20th century. She writes: "Hardware, software, wetware – before their beginnings and beyond their ends, women have been the simulators, assemblers, and programmers of the digital machines" [16]. With this, she re-works the hegemonic gendered coding: despite being held as a field of invention and innovation associated with men, Plant displays the ways in which the labor as much as the ideas of women were foundational for the success of (digital) computer technologies. Plant furthermore reconstructs in detail the ways in which network technologies question what has been established as patriarchal values in science, technology and society such as linear thought, efficiency, universality and the idea of central control.

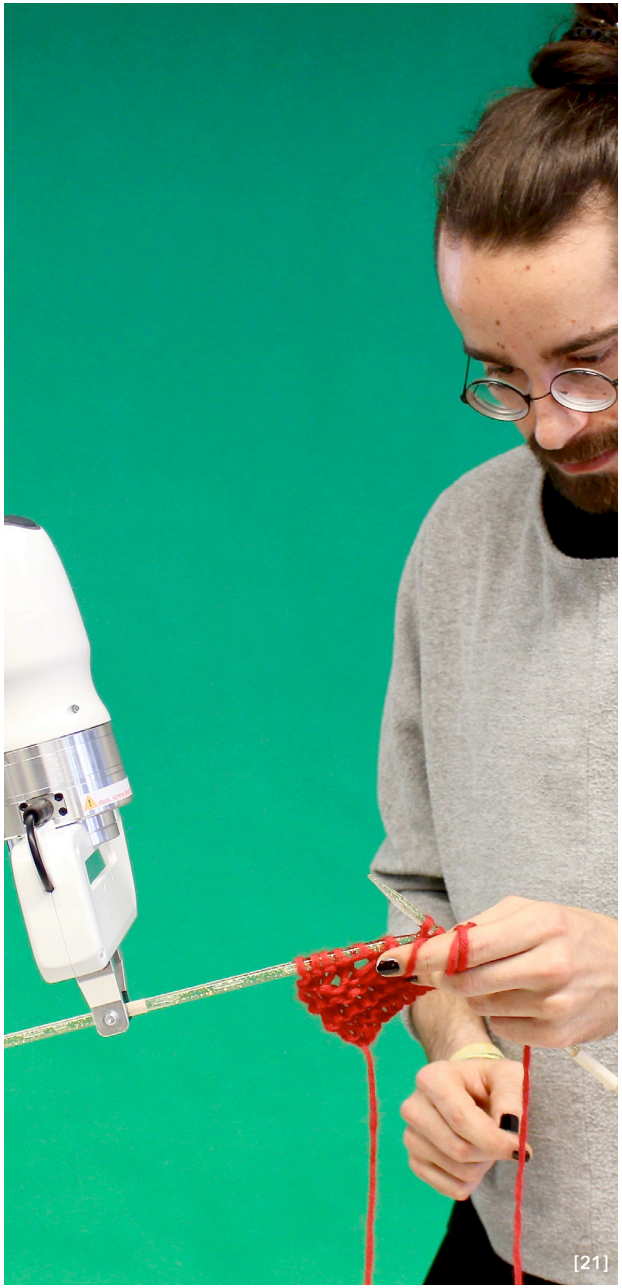
The design of cobot technologies—including the envisioning of a context of use and particular capacities to collaborate—are also always imbued with these codes. Robotic knitting challenges not only hegemonic discourses such as optimization and higher efficiency in work productivity. Robotic knitting also challenges the very material practice of collaboration between human and cobot—re-posing the question of use/ful/less/ness.

CONCLUSION

This pictorial used imagery of human-cobot interaction as a site to examine the practicalities of collaboration within design research.

By teaching a commercially available robot to knit with us—a messy and seemingly unproductive process—we query the very division between unproductive and productive uses of such a technology. We cast this work as queer use, as it entails a performative intervention into the idealization of robotic collaboration and the optimizing of a human labor force.

The notion of cobots is often envisioned as increasing efficiency within a range of sectors, from the service industry to industrial production. In this sense, we deployed knitting as a queer use case of one possible cobot technology. In so doing, we illustrated the possibilities and limits of the implemented usefulness of this technology while also performing our own re-coding of hegemonic presentation forms. Engagement in a seemingly useless task of collaboration (namely, handing a needle to a cobot) also reveals the ways in which human-cobot-interaction still evolves.


[21]

ACKNOWLEDGMENTS

This pictorial centrally builds on the findings of the project "Do robots dream of knitting? Re-coding human-robot collaboration" that was funded by the VolkswagenFoundation and situated at the Technical University Berlin from September 2018—August 2019 [23]. The project was headed by the first author (feminist techno-science studies scholar) who worked with an interdisciplinary team which made it possible to realize this project: Melanie Irrgang (computer science), Anne Jellinghaus (psychology), Jan Martin (electrical engineering), Philipp Graf (sociology) and Raphael Deimel (robotics). We also thank our colleague Katrin M. Kämpf, who contributed as a feminist technoscience scholar and as a photographer to the project. *Images 1, 3, 6–11, 14–22 by Katrin M. Kämpf*

BIBLIOGRAPHY

[01] Sara Ahmed. 2019. What's the Use?: On the Uses of Use. Duke University Press.

[02] Morana Alač. 2016. Social robots: Things or agents? AI & society 31, 4: 519–535.

[03] Morgan G Ames. 2015. Charismatic technology. Proceedings of the fifth decennial Aarhus Conference on Critical Alternatives, 109–120.

[04] Kristina Andersen, Andy Boucher, David Chatting, et al. 2019. Doing things with research through design: with what, with whom, and towards what ends? Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems, 1–8.

[05] Eric PS Baumer, Morgan G Ames, Jenna Burrell, Jed R. Brubaker, and Paul Dourish. 2015. Why study technology non-use? First Monday 20, 11.

[06] Eric PS Baumer and M Six Silberman. 2011. When the implication is not to design (technology). Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2271–2274.

[07] Käthe von Bose and Pat Treusch. 2019. Keime, Zeitdruck und Roboter als ‚Helfer für alle': Interferenzen zwischen materiell-diskursiven Fürsorgepraktiken in Krankenhaus und Robotiklabor. Care: Praktiken und Politiken der Fürsorge: Ethnographische und geschlechtertheoretische Perspektiven. 191

[08] Jenna Burrell. 2012. Invisible users: Youth in the Internet cafés of urban Ghana. Mit Press.

[09] Laura Devendorf and Kimiko Ryokai. 2015. Being the Machine: Reconfiguring Agency and Control in Hybrid Fabrication. Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, Association for Computing Machinery, 2477–2486.

[10] Elke Gaugele. 2011. Revolutionäre Strickerinnen, Textilaktivistinnen und die Militarisierung des Sockenstrickens. Handarbeit und Feminismus in der Moderne. In E. Gaugele, S. Eismann, V. Kuni, and E. Zobl, eds., Craftista! Handarbeit als Aktivismus. Ventil Verlag.

[11] David J Gunkel. 2018. Robot rights. MIT Press.

[12] Sara Hendren. 2017. All Technology Is Assistive: Six Design Rules on Disability. In J. Sayers, ed., Making things and drawing boundaries: experiments in the digital humanities. University of Minnesota Press, Minneapolis ; London.

[13] Tania Pérez-Bustos. 2018. "Let Me Show You": A Caring Ethnography of Embodied Knowledge in Weaving and Engineering. In C. \AAsberg and R. Braidotti, eds., A Feminist Companion to the Posthumanities. Springer International Publishing, Cham, 175–187.

[14] Sabine Pfeiffer. 2018. Industry 4.0: Robotics and Contradictions. In Technologies of Labour and the Politics of Contradiction. Springer, 19–36.

[15] James Pierce. 2012. Undesigning technology: considering the negation of design by design. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 957–966.

[16] Sadie Plant. 1997. Zeros and ones: Digital women and the new technoculture. London.

[17] Daniela K Rosner. 2018. Critical fabulations: reworking the methods and margins of design. MIT Press.

[18] Daniela K. Rosner and Kimiko Ryokai. 2010. Spyn: Augmenting the Creative and Communicative Potential of Craft. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, 2407–2416.

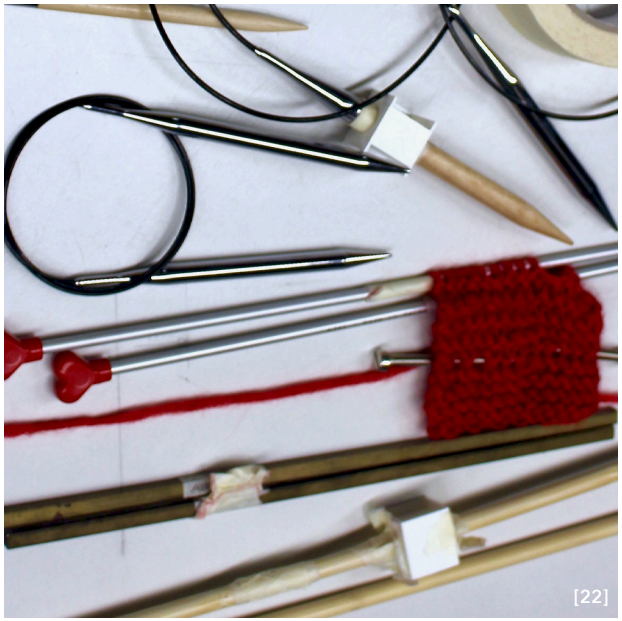
[19] Daniela K. Rosner, Samantha Shorey, Brock R. Craft, and Helen Remick. 2018. Making Core Memory: Design Inquiry into Gendered Legacies of Engineering and Craftwork. Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery.

[20] Lucy Suchman. 2011. Subject objects. Feminist Theory 12, 2: 119–145.

[21] Pat Treusch. 2015. Robotic companionship: The making of anthropomatic kitchen robots in queer feminist technoscience perspective. .

[22] Pat Treusch. 2019. Performing the Kitchen: Becoming a Queering Witness to the Enactments of Subject-Object Relations in a Robotic Kitchen Lab. In C. Hasse and D.-M. Søndergaard, eds., Designing Robots — Designing Humans. Routledge, London and New York.

[23] Pat Treusch. 2020. Robotic Knitting Re-Crafting Human-Robot Collaboration Through Careful Coboting. transcript Verlag, Bielefeld.


[22]