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Abstract

The aim of this chapter is to systematize the discussion regarding robotization of mobile communication. The chapter begins by clarifying the fundamental role of both robot hardware and robot software in this process. This is followed by a critical overview of existing research, which is classified into three categories. First, robotization is understood as the hybridization of the human body with existing ordinary mobile devices. Second, the incorporation of new robotic software, such as algorithms, artificial intelligence, and virtual assistants, into mobile devices is seen to robotize them from inside. Third, the convergence of smart communication devices, typically as user interfaces with robot hardware, is seen to contribute to the robotization of mobile communication. The chapter is concluded by clarification of the boundary between quasi-robot and robot and outlining the ways in which the robotization of smart mobile communication will proceed in the future.

12.2

Robotization of Mobile Communication

Sakari Taipale, Tuuli Turja, and Lina Van Aerschot

Mobile communications research has come a long way from the study of feature phones, allowing one-to-one voice calls, text messages, and personal decoration of mobile handsets (e.g., Baron & Ling, 2007; Oulasvirta & Blom, 2007; Wilska, 2003), to the study of smartphones and other multifunctional mobile devices that support multimodal, one-to-many interactions and social networking (e.g., Fortunati & Taipale, 2014; Ling & Lai, 2016). In contrast to feature phones, the personalization of such smart mobile devices occurs largely inside the hardware, by means of personal tailoring of applications, photos, videos, and other content (Barile & Sugiyama, 2015). Another new feature is mass personalization—or better mass customization—of mobile content that is vigorously pursued by the mobile communications industry through algorithms that are based on the commodification of user data (Bolin, 2012). Following these changes with a watchful eye, mobile communications researchers have extended the focus of their work from the adoption of devices (e.g., Rice & Katz, 2003; Verkasalo, López-Nicolás, Molina-Castillo, & Bouwman, 2010) to the practices of using mobile devices, mobile applications, and services, which are increasingly influenced not only by the user but by the commercial recommendation systems and algorithms (Barile & Sugiyama, 2015; Fortunati & Taipale, 2014; Zillien & Hargittai, 2009). These developments indicate that the automation and robotization of mobile communication are among the most fruitful areas of research in mobile communications research (Fortunati & Taipale, 2016).

This chapter involves a critical overview of the existing research in which mobile communication and robotics research intersect. What characterizes this line of research is a varied application of neologisms and robot terms such as *personalized social robots* (Vincent, 2013), *quasi-social robots* (Sugiyama, 2013), *quasi-interpersonal*, and *pseudo-social robots* (Böhlen & Karppi, 2017; Höflich, 2013). Many of these notions have been coined and applied to describe what kinds of robotic devices new smartphones actually are but, we argue, without a deliberate consideration of what kind of approach to robotization they presume. Hence, the ultimate aim of this chapter is to systematize the use of this terminology and then provide a reasoned view on the ways in which the robotization of mobile communication proceeds on various fronts.

In order to systematize the use of the vocabulary of robotics in mobile communications research, some of the key concepts and conceptual distinctions must be explained and defined. First, it is pivotal to understand the difference between robot software and robot hardware since, as we will show, a large majority of research on the robotization of mobile communication is accounted for in the former. *Software robotics* refers to robotic process automation and to all other computer programs that are necessary for the operation of robotic machines (Gohner, 2009). This said, it involves artificial intelligence (AI) that aims to make machines perform even higher cognitive tasks typical of humans and other animals (Millington & Funge, 2009, p. 4).

AI refers to "[t]he ability of a machine system to perceive anticipated or unanticipated new conditions, decide what actions must be performed under the conditions, and plan the actions accordingly" (Nof, 1999, p. 1263). In contrast, *hardware robotics* is about the physical components of a machine; anything that can be touched counts as hardware (Gohner, 2009). AI can be divided into three layers: (1) action intelligence, coordinating sensory and behavioral information and actions; (2) autonomous intelligence of planning, problem-solving, and pattern recognition that require logical behavior and even self-learning; and (3) human-based intelligence of higher cognitive abilities such as abstract thought (Bostrom & Yudkowsky, 2014). In order to make conscious decisions or decide what is right or wrong, AI needs human-based intelligence, which is still decades away (Weng, 2018). This has become evident in cases such as Microsoft's AI chatbot Tay absorbing improper language from Twitter and Uber's self-driving car crash in Tempe, Arizona.

In practice, robot software and robot hardware are interwoven in various ways. There are software robotics that are not tied to specific hardware and which can be used on different hardware platforms (e.g., online search engines and software bots). There are also scripts and algorithms that are designed to instruct specific hardware to do certain tasks. Robot hardware alludes to robots as material artifacts interacting with the material world, while software robotics points to operations that can be implemented at the immaterial level of action.

While we have discussed the differences between robotic software and robotic hardware, it is also important to understand what a robot in general is made of. The International Organization for Standardization (2014) notes that a fully fledged robot combines both software-based reprogrammability and hardware-based multifunction mechatronics. However, in the absence of a widely spread and agreed scientific definition of robots (Nourbakhsh, 2013), what can be done is to identify some of the most common denominators. In the 1980s, it was presented that robots are "general purpose mechanical machines" that are "programmable to perform a variety of work within their mechanical capabilities" and that "operate automatically" (Poole, 1989, p. 15). At that time, an ability to operate automatically was considered a starting point for robots' intelligence and connection with their physical environment. Regardless of major advancements in both hardware and software robotics, roboticists who design, fabricate, program, and experiment with robots (i.e., academics, engineers, and innovators) today still widely accentuate the decisive role of these same properties. For instance, roboticist Anca Dragan of the University of California Berkeley has stated that a robot is a "physically embodied artificially intelligent agent that can take actions that have effects on the physical world," and Kate Darling of the MIT Media Lab argues that a robot is "a physical machine that's usually programmable by a computer that can execute tasks autonomously or automatically by itself" (Simon, 2017). Hence, it can be concluded that in general roboticists do not consider mere software as a "complete robot," and a "robot" with only one reprogrammable functionality is just an automaton.

What is even more complicated to define are the attributes "personal" and "social" (Böhle & Pfadenhauer, 2013), which are variously used in front of the term *robot*, also in the research exploring similarities between robots and smart communication tools (Sugiyama, 2013; Sugiyama & Vincent, 2013; Vincent, 2015). We argue that these properties of robots are important but only secondary to robot hardware and software. What makes them secondary is that they are not decisive of whether smart communication devices can be regarded as robots or not, but they define whether the device is personalizable/personalized and whether it can be considered as social, sociable, socially interactive, or not (see also Fong, Nourbakhsh, & Dautenhahn, 2003). A widely applied definition of *social robot* also presented by Fong et al. (2003; see also Dautenhahn & Billard, 1999) can be used as an example:

> Social robots are embodied agents that are part of a heterogeneous group: a society of robots or humans. They are able to recognize each other and engage in social interactions, they possess histories (perceive and interpret the world in terms of their own experience), and they explicitly communicate with and learn from each other. (p. 144)

Additionally, this definition implies that the robotization of mobile communication requires a tangible robotic body as well as robotic software that makes it capable of interacting with and learning from other actors, be they other devices or humans. A robot's ability to interact socially is premised on both its hardware and software components. Höflich (2013) notes that to be a social robot, a robotic device should understand social action as reciprocal meaningful behavior. This has made researchers discuss them as quasi-social or quasi-interpersonal robots, also in connection with smart phones (Sugiyama, 2013).

The chapter continues with an overview of the existing literature presenting the driving forces behind the robotization of mobile communication devices. The robotization of mobile communication is described as a reciprocal process of two molding forces, the technology and the user, pointing out the strengths and weaknesses of these approaches in relation to robot software and robot hardware. Thereafter, the chapter conducts an overview of studies representing three different views on how the robotization of mobile communication occurs. The overview begins from the studies that highlight the intertwining of the human body with portable smart communication devices. A second branch of studies notes that smart communication tools already contain the necessary robotic software to transform these preexisting tools and their users into some sort of robotic machines or hybrids. The third category of studies is perhaps the most acceptable for roboticists. It portrays that the robotization of mobile communication emerges from machine–machine convergence, in which smart mobile communication devices are incorporated into robotic machines, not just temporarily but also as permanent solutions. The chapter ends with remarks concerning the appropriate use of terminology and the most likely future of robotization of mobile communication devices.

Driving Forces of the Robotization of Mobile Communication

The process of robotization is difficult to define, even for roboticists, since what counts as a robot changes continuously with rapid technological advancements in both hardware and software robotics. Nourbakhsh (2013, pp. xiv–xv) identifies three functionalities that are common to robots, which according to him work as a “new form of living glue between our physical world and the digital universe." These technical functionalities relate a robot to its physical environment, through perception, action, and cognition. *Perception* refers to a robot's ability to collect information about the world through various sensors, such as cameras, microphones, and infrared, touch, and pressure sensors. An ability to *act* points to a robot's capacity to effect changes in its immediate surroundings. Nourbakhsh's third characteristic of a robot is *cognition*: its ability to reason and make decisions based on its own perceptions about the environment and the success of its actions.

Given this or other definitions, it is clear that the robotization of mobile communication is driven, on the one hand, by scientific innovations and discoveries. On the other hand, these technology-centered approaches easily overlook robotization as an outcome of social and political processes; robots are objects that open some social options and close others, reflecting the views and values of their designers, users, and political advocates (Fortunati, 2017). For example, transferring the booking of a doctor's appointment or a care worker's visit to digital environments and the replacement of human employees by virtual online assistants make accessing these services easier for some (socially restricted, tech-skilled young) but more difficult for others (older people, technology non-users).

This lesson about the social shaping of technology and users' capability to personalize their mobile communication tools is well learned by social scientists and communication scholars. It has also made some consider it justifiable to think that users could relatively freely define their own smartphones and other appliances as their personally regarded robot (e.g., Fortunati, 2013; Höflich & El Bayed, 2015; Sugiyama, 2013; Sugiyama & Vincent, 2013; Vincent, 2015). However, there is no solid empirical evidence showing that mobile users would have systematically started to reconsider or rename their mobile communication tools as personal(ized) robots. Although this strongly user-centered approach deviates considerably from technology-driven definitions of roboticists, and possibly creates frictions between disciplines, it is particularly valuable in raising the question of who has the power to define what a robot is and what it is not.

Considering both driving forces behind robotization, it appears that contemporary mobile communication devices may be viewed as robots yet only with some considerable provisos. Regarding hardware, smart communication devices typically contain multiple sensors like front and rear cameras, microphone, gyroscope, and GPS receiver that enable perception of the surrounding world. However, the actions they can implement based on their own perceptions are limited to the immaterial level of action; mobile devices can provide written, audial, or haptic feedback for the user and coded feedback for other smart devices nearby. The cognitive capacity of smart devices, in turn, is typically dependent and based on cloud-based AI services (e.g., virtual assistants like Apple's Siri, Microsoft's Cortana, Amazon's Alexa, or Google Assistant). However, manufacturers like Apple and Huawei have recently started integrating AI chips directly into their smartphones, making these devices more autonomous and hopefully less vulnerable to Internet connectivity problems. The next sections present three different views on how the robotization of mobile communication that is influenced by both social shaping and technological advancements proceeds in contemporary societies.

Hybridization of the Human Body and Mobile Communication Devices

Mobile phones as portable, small personal tools have a special and close relationship with the human body. This particular bond inspired a group of scholars to explore the hybridization of the human body and mobile phones at the turn of the 21st century (e.g., Fortunati, Katz, & Riccini, 2003; Katz, 2002). The ways in which mobile phones were held in the hand and on the ear and carried in pockets and special cases inspired them to talk about mobile phones as extensions of the human body or even as prosthetic tools (e.g., Campbell, 2008; Katz & Sugiyama, 2006; Oksman & Rautiainen, 2003). It was seen that the human body becomes the machine that manipulates the device (Pertierra, 2005). Fortunati (2002a) highlighted that the human body should be considered as a natural machine, which when conjoining with the mobile phone—an artificial machine—had some completely new implications: For the first time an ordinary communication technology provided information both on the move and when stationary, which prompted users to move and alter their preplanned routings. Smartphones lifted this capacity to the next level, providing more personalized, automated, and real-time information about a user's physical activity and patterns of movement (e.g., mobile navigators, virtual health assistants). In this connection, Fortunati (2002b) talks about the humanization of the machines, in which the human body becomes the true place of the mobile phone.

This research tradition also inspired mobile communication scholars to revive the concept of the *cyborg*, the biological body augmented with mechanical elements (Clark & Erickson, 2004), and to take the smartphone–body relationship on their research agenda (e.g., Sugiyama, 2013; Sugiyama & Vincent, 2013). However, the major advancements in this tradition are difficult to reach as far as the focus is limited to the perceptible sides of the smartphone hardware. This is because smartphones are much like feature phones; they are held in the hand and on the ear (but less than before); they are carried in pockets, cases, and armbands; and they are connected to headphones that are closely attached to the body. What has changed in visible and palpable hardware is a bigger screen and removal of a physical keyboard. A possibility to control a smartphone using its voice commands has reduced, at least in theory, the need to separate it from the body. In contrast, the major hardware advancements (gyroscope, accelerometer, magnetometer, GSP, etc.) are well hidden behind the sleek exterior of smart mobile devices; and therefore, they easily escape the attention of researchers interested in human–machine hybridization. Although marginal in the smartphone market, the Fairphone is an interesting exception in this regard due to its modular design and transparent exterior.

This symbiotic relationship between the smartphone and its user forms the premise of Vincent's (2013) analysis. She argues that constant connection and emotional attachment to the mobile phone result in both physical and emotional association with a device, transforming the mobile phone eventually into a personalized social robot. Unlike preprogrammed robots, Vincent argues, the smartphone is filled with personally meaningful content and memories; and it provides multiple affordances to deal with almost every eventuality. For her, the smartphone as a personalized social robot is a co-construction of this preexisting multifunctional technology and the individual emotions the user associates with the device. As such, this conceptualization endows the user with complete sovereignty to define his or her personal relationship with a smartphone as a kind of robot. Other scholars like Bayer, Dal Cin, Campbell, and Panek (2016) and Gardner (2015) later presented that smartphone communication is related to a user's personality in more nuanced ways, including practices of use that range from highly intuitive and automated to more conscious and emotionally charged ones.

Human–machine hybridization offers one vantage point to contemplate what the robotization of mobile communication is all about. However, the vantage it provides is limited at least in two respects. First, when the human body is considered as part of the human–machine hybrid that provides all movement and environmental connection, such a hybrid is largely dependent on the agency of the human body. Without any moving parts, the element of mechatronics typically considered as a decisive part of fully fledged robots is neglected. Second, this vantage point omits the importance of specific robot software as constitutive of the robot since the focus of analysis is clearly on the attachment of the existing hardware—in this case, the smartphone to the human body.

Hybridization of Robot Software/AI and Mobile Communication Devices

A vivid discussion on human–machine hybridization has stirred researchers to consider the role of software and AI developments for the robotization of mobile communication (Barile, 2013; Fortunati, 2013; Sugiyama, 2013; Sugiyama & Vincent, 2013). Smartphones and wearable devices include more sophisticated software technology and contain more personal content, transforming technologies "from a hard and utilitarian conception to a softer ideal based on the emotional value of new devices" (Barile, 2013, p. 102). In general, this line of thinking is also premised on the idea that the robotization of mobile communication does not require any specific new robot hardware or mechatronic components, but it can take place inside existing smart mobile technologies. Fortunati (2013) encapsulates this, when writing about ubiquitous social roboting:

> The hidden and ubiquitous robot implies that robots must renounce their hardware. They will fertilize and strengthen the old and the new media with their

> software. It is the robot, whether it is an avatar[1] or a social believable agent, that will work, in a saprophyte way, inside the already available technologies such as the mobile phone. (p. 126)

The same mindset is incorporated in the studies of Sugiyama and Barile. Sugiyama (2013) notes that young people's tendency to make their mobile phones as lively as possible in Japan signals that the mobile device has gone through the process of anthropomorphization and is hence turning into a quasi-social robot. In their joint article, Barile and Sugiyama (2015, p. 415) write that "the process of automation that algorithms and robotic functions yield is often covert, hiding behind the face of familiar devices." According to them, these automated functions of the smartphone have the power to shape and to animate our emotions and taste. Because automation and algorithms alone do not fully correspond with conventional ideas of a social robot, Barile and Sugiyama propose calling the smartphone and its applications a quasi-social robot.

Studies on specific mobile applications, intelligent virtual assistants, have boosted the discussion on software-led robotization of mobile communication. A recent book edited by Gehl and Bakardjieva (2016) defines virtual robots—used in mobile and many other platforms—as robots without embodied presence in a physical world. Perhaps the most famous and studied of them is Apple's virtual assistant, Siri. Guzman (2016) rightly relates Siri as a mobile virtual assistant to the field of AI and software robotics. Virtual assistants are molding and robotizing the device from inside, providing a sense of personality and communicative reciprocity between the user and the device. Other scholars, like Phan (2017), go further, arguing that the gendered female voice and personality programmed in Siri unfold the hidden materiality and tangibility of the device. Leaning on the principles of new materialism that consider inanimate objects having agency, she argues that robotic assistants are always intertwined with material processes, making it justifiable to talk about them as “a kind of robot” (Phan, 2017, p. 25).

In summary, all of these studies are premised on the idea that the robotization of mobile communication does not presume any specific hardware, but it can take place within existing smart communication devices. What facilitates the robotization of mobile communication are algorithms and cloud-based AI that automatize, customize, and personalize content and mobile communication, making researchers represent these devices as robots.

Convergence of Mobile Communication Devices and Robotic Machines

What remains to be analyzed and discussed are the ways in which older technologies shape and integrate into newer ones. New technologies are seldom completely new inventions, rising out of nowhere (MacKenzie & Wajcman, 1999). In this respect, smartphones and robots are no exception. Quite the contrary, they represent a gradual technological change, especially robots, which are typically combinations of old and new technology—both hardware and software.

There are already several robot technologies on the market, and many more on the design table, which use smartphones, table computers, or mobile applications as their user interface. The rationale behind this design approach is that the interfaces utilizing existing technologies are most user-friendly and intuitive as people have previous experience of using them (Taipale, Vincent, Sapio, Lugano, & Fortunati, 2015). Good examples of this convergence strategy come from the field of telepresence robots and robotic assistants. Both telepresence and personal assistive robots can provide a robotic body for virtual assistants, which can be the same as (e.g., Siri) or similar to those already embedded in smartphones and other mobile devices. In some cases, the marriage of smart device and robotic body is not made permeant, and the two machines can be disconnected if needs arise (e.g., Double). Assistant robots, like Nao or Pepper, aim for even more natural and intuitive robot–human interaction, taking the shape of a humanoid with several human-like features, such as face, arms, and voice, which can be readily recognized. Sometimes a physical appearance is crucial. It has been shown that software-based coaching in physical activation does not motivate as much as instructions coming from an embodied robot (Fasola & Mataric, 2013) and that people follow better health instructions that are given by a robot than a table computer (Mann, MacDonald, Kuo, Li, & Broadbent, 2015).

Compared to a mere smartphone, the movable base of the telepresence robot allows remote manipulation of the place of the "mobile communication device on wheels." Just like the virtual assistant of a smartphone, telepresence robots and robotic assistants are able to help their users when connected to the Internet. For example, Siri can be activated from afar to ask for assistance when interacting with the mobile telepresence robot Double, which has wheels for legs and an iPad for brains. In the context of healthcare, mobile telepresence robots are used both in home care, to allow remote connection between a patient, care staff, and relatives (Koceski & Koceska, 2016), and in hospitals, as an alternative to ordinary doctor rounds (Marini et al., 2015).

Although robotic assistants and basic telepresence robots are visible in their environment, they do not otherwise manipulate it, move around independently within in, or react to it. They can be part of the Internet of things and, to a limited extent, move around in a physical environment but have only minor capacity to affect their physical surroundings. This poses a question of whether or not a mobile communication device combined with a movable base really qualifies as a robot. The telepresence robot Origibot, which uses an Android table computer as a user interface, has been equipped with a robotic arm and gripper. This combination of an ordinary smart communication device and a robotic limb already approaches the definition of a robot as "an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks" (International Organization of Standardization, 2012).

It is worth noting that even if telepresence robots and robotic assistants include some regular smart communication technology and software, in general, they are not made for mobile use in the same way as mobile communication devices. When integrated with a robotic body, off-the-shelf mobile communication devices lose some degrees of freedom in terms of portability. However, some smaller robot assistants, like the pocket-sized robot RoBoHon, are designed as alternatives to traditional smart communication devices (Kamiwada, Imai, Kanaoka, & Take, 2017). In addition to phone, email, and other applications, they have humanoid features such as limbs and allow different postures, an ability to walk, and even face recognition.

These examples indicate that the robotization of mobile communication takes perhaps its most advanced form when smart communication devices, involving robotic software such as algorithms, AI, a personal assistant, or an avatar, converge with specific robotic hardware. While existing mobile communication software involves some automatic data-processing and personalized features, ordinary smart communication technologies are connected to the environment only at the level of communication and information exchange. Specific material extensions or more complete robotic bodies are required to extend the environmental connection to the material level of interaction. Ubtech Lynx takes a step in this direction by integrating Amazon's virtual assistant Alexa, which can control a smart home system, into a robotic body.

Future of Mobile Communication and Robotics

In this chapter, we have argued why it is logical to locate mobile communication on the side of software robotics/AI and defined smart communication devices as material artifacts and as potential components of a robot machine on the side of hardware robotics. By so doing, it has been possible to clarify and systematize scholarly discussion on robotization of mobile communication in this rather new field of study.

What we have shown is that the robotization of mobile communication devices proceeds on many fronts, and therefore researchers should be cautious when labeling mobile communication devices as robots. The greatest share of this robotization takes place within the smart mobile device and perhaps in the minds of users who might begin considering their mobile phones as robotic devices. However, without solid empirical evidence on users' changing perceptions of mobile communication devices, this aspect of robotization remains unverified. Future research should follow closely the possible changes in user perceptions since more and more software robotics is being embedded in smart communication devices. Just as the smartphone is no longer primarily a phone but an instant messaging and social media tool for today's teenagers and young adults, its meaning and main functionalities may also change along robotization in the near future.

Based on the present critical overview, it is argued that if nothing changes in the mobile communication hardware and only new and improved robotic software and AI are included in prevailing mobile communication devices, it may be fair to speak about smartphones and other mobile communication tools as quasi-robots but no more than that. When researchers zoom in on software robotization, the properties that also require robot hardware and that are constitutive of fully fledged robots are easily overlooked (e.g., locomotion, manipulation of physical surroundings). A higher sensitivity for the differences between robotic software and robotic hardware could help avoid communication gaps between the disciplines involved in the study of robotization.

Lastly, there seems to be a lot of untapped potential in mobile communication hardware regarding robotization in general. Smartphones and other mobile communication devices contain multiple technologies that allow the integration of additional robotic hardware with them (e.g., USB, Bluetooth, and Wi-Fi). This would make the smartphone not only an artificial extension of the human body but also part of a more complex configuration of human, mobile technology, and robotic extensions. Together with emerging use of AI and virtual assistants embedded in mobile communication devices, these new configurations may shape users' perceptions of their smartphones even in the near future. This calls for new research efforts aimed at separating the robotic dimension of mobile communication technologies from users' perceptions.

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[1] An avatar is a digital representation of a person in any digital environment that has agency and is controlled by a human agent (Bell, 2008).