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The Third Wave of Human Computer Interaction: From Interfaces to Digital Ecologies

Sebastiano Bagnara
Istituto di Scienze e Tecnologie della Cognizione, CNR
Roma, Italy

Simone Pozzi
Master Degree in Design
University of San Marino
San Marino

Abstract

This is an historical moment where machines play an increasing role in all the aspects of human life, with the digitisation of nearly everything and the increasing automation of sectors that were traditionally human-centred. In this contribution we present the forms of innovation that characterise this period, using a distinction introduced by Verganti. We then review the role that the discipline of human-computer interaction can play (and have traditionally played) in this scenario. We end the contribution by highlighting how the complexity of the current situation demands for a discipline that can assist in identifying the questions to be answered, rather than in solving well-defined problems.

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Correspondence should be addressed to Simone Pozzi, University of San Marino. Email: simone.pozzi@unirsm.sm

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Introduction

The recent book of Brynjolfsson and McAfee "The second machine age. Work, progress, and prosperity in a time of brilliant technologies" (Brynjolfsson and McAfee 2014) gives a very interesting overview of current technological trends, trends that are crucial to understand the role of Interaction Design in the design of new technologies, and also more broadly speaking in ongoing innovation processes.

Brynjolfsson and McAfee analyse the recent drivers of digital innovation, maintaining that digital technologies have eventually reached the stage of full maturity and are now disrupting all the human activities, work and leisure. This claim can be seen in relation with the ongoing debate in the Human Computer Interaction community, where practitioners and academics are discussing the goals of the discipline, approaches and methods. For this debate, two papers are especially relevant: Susanne Bodker "Third-wave HCI, 10 years later - participation and sharing" (Bødker 2015) and Harrison, Tatar e Sengers "The three paradigms of HCI" (Harrison, Tatar, and Sengers 2007).

This contribution will discuss the main claims of these works, offering our reading of the role that Interaction Design (ID) could play in these innovation processes. Our main claim is that ID can play a key role in understanding technological innovation in conjunction with social aspects, not only fixing interaction problems and breakdowns, but also enlarging the discussion to values and high level needs, thus setting the agenda and identifying which problems need to be tackled.

Incremental and Radical Innovation

Brynjolfsson and McAfee use Schumpeter's definition of innovation, as "the market introduction of a technical and organisational innovation, not only its discovery". Innovation is achieved only when technological and scientific discoveries are coupled with their social adoption, when they create value by enriching existing practices and methods of work.

Moving from this definition, Brynjolfsson and McAfee maintain that innovation can deliver high impact, i.e. create substantial productivity gains and have a profound impact on society, only when they transcend the boundaries of a specific industrial sector or market segment. High impact innovations need to be general purpose "ideas or techniques and new technologies that have a significant impact in more economic sectors" (Gavin Wright, cit. in Brynjolfsson e McAfee, pg. 84). The hallmarks of these technologies are:

- They are pervasive, as nearly every aspect of human life is now (being) digitised;
- They keep improving incrementally, for instance computational power or bandwidth;
- They can be the basis for other new innovations. The typical case is electricity of the internet, which acted as enablers of other innovations.

Brynjolfsson and McAfee make this point to argue in favour of technology as a driver of well-being and productivity for the next future. Other authors are more pessimistic, stating that all of the increases in productivity and well-being of the last 150 years have been achieved thanks to the maturity of technologies created during the first and the second industrial revolutions, like the combustion engine, or big distribution grids of electricity and water. These technologies have lost momentum from the seventies, after which only small incremental improvements have been made. As compared to the previous phase, these improvements did not significantly alter human well-being, bring about only minor benefits.

To counter this point, Brynjolfsson and McAfee analyse how Information and Communication Technologies comply with all the defining features of revolutionary innovations. ICT are transversal and can be applied in various sectors, their power is increasing exponentially (as described by Moore's law), and they are currently at the core of many other innovations.

Brynjolfsson and McAfee see the latter as the real key advantage of ICT and digital technologies, because it is the prerequisite for the recombination of existing innovations into new ones, with ever increasing impact. Examples include the Google Car: it is a combination of many (relatively) low cost sensors, an internal computer to process this data stream, the enormous

database of information about streets and crossings acquired by Google first by satellite images, then by actually driving on the streets and error reports generated by users of Google services. No one of these elements has been revolutionary by itself, but their combination can have a much greater impact, bringing about drastic changes in one of the key aspects of Western society, i.e. mobility by car. A similar pattern works for services like Waze, where average travel time are calculated by combining street maps, the localisation and speed of Waze users via smart phones, reports sent by users on problems and traffic jams.

Other innovations combine computational power with other elements to perform their work. A typical match is the one with big data, i.e. the capability to record and process a huge number of data. Many of the present applications seem to perform an excellent service because of some form of advance artificial intelligence, whilst the reality is that a large part of the value comes from data that we have provided ourselves (as users). Search engines change their answers by learning where we clicked in the past, or where other users clicked after searching the same terms, car navigation systems learn our preferred routes and log in our actual driving times. E-commerce sites like Amazon or streaming services like Netflix customise their offering analysing what "people like us" is buying and watching. This combination between computational power and big data is the main reason why speech recognition has improved so much in the last years, to the point that now we use voice input to seamlessly send commands to personal assistants like Apple Siri, Microsoft Cortana, Amazon Alexa, or Google Now. In all of these examples, computational power is one of the elements, with real innovation delivered by effective combination with other elements.

Another typical building element is the miniaturisation of sensors. Ambients have become "intelligent" and "aware", by recording our position in space, our movements, by measuring aspects of our daily life like energy consumption, physical exercise, or sleep quality. This interaction with our technologies is "poor", very basic. But it acts as the enabler of more complex and satisfying interactions, as computers now know where we are and, in some cases, also what we are doing: are we standing still at the airport, walking in a touristic area just before dinner time, or driving back home? Interaction has become context-aware. For instance, Google Now can perform searches in the surroundings on the basis of our position and time of the day, trying to guess our needs and search for a good thai restaurant in the area, or notifying us that our flight has been delayed, or giving us the directions and walking time to our new gate.

The key point of Brynjolfsson and McAfee's claim is that all the recent innovations did not bring about any spectacular change, if considered in isolation. While drastic productivity changes and impact on society can be achieved by combining one with the others. Our society does not need a new revolutionary invention to progress, like it was the combustion engine, or electricity. We can be optimistic about the future because we have plenty of minor innovations at hand, with almost unlimited combination among them.

Underlying Brynjolfsson and McAfee's definition of innovation, there is an idea of progressive refinements, a slow process of combining together existing technologies, till society adopts the innovation and makes it widespread. First electrical power gets discovered, then society adapts tools and production methods to it, tries out different combination, to eventually get the maximum value after some years, typically at least 20. Technology does not change, what changes is the combination among technologies, focusing and refining its use and value. It happened for the steam engine, then for the combustion engine, it is happening now for ICT.

Norman and Verganti (Norman and Verganti 2014; Verganti 2009) propose a different conception of innovation, defining two main types of innovation processes (among others):

- Incremental innovation: the progressive improvement of what already exists, "doing better what we already do";
- Radical innovation: it changes the overall framework, "starting to do what we were not doing before".

The incremental innovation refers to small changes to a product, to improve its performance, lower its price, increase its appeal to customers, or introduce new features. According to Verganti, this is by far the most widespread type of innovation. Maybe not as fascinating as radical innovation, but useful indeed.

On the contrary, it is often the other type of innovation – the radical one – that gets referred to whenever designers speak of innovation. Verganti notes how radical innovation is actually very rare. Most of the times, attempts to achieve radical innovation lead to failures, either for

unfavourable market conditions, or for lack of appreciation by customers. Moreover, most of radical innovations do not happen all of a sudden and require the contribution of supporting incremental innovation processes to succeed. As a case in point, Verganti mentions multi-touch interfaces, recently brought to market success by Apple. Apple did not create those interfaces, that had been in use for more than 2 years in research centres of computer science and design. Other competitors had launched similar interfaces before Apple did [REF: Buxton 2007]. The successful introduction of multi-touch interfaces has become an example of radical innovation only because users were finally ready to start using them. But it tools years before that. In the same way, networks like the power grid or the telephone required building a large infrastructure and a critical mass of users before delivering the impact of a radical innovation.

These examples show how the two innovation types are both necessary and bring the highest benefit when combined. Radical innovation often does not achieve their potential and disappoint. They are too expensive, hard to deploy, or too limited in focus. In all of these cases, processes of incremental innovation are needed to refine the initial idea and bring it to something acceptable for customers. Radical innovation creates new frameworks, a potential for change. But this potential turns into reality thanks to incremental innovation: “Without radical innovation, incremental innovation reaches a limit. Without incremental innovation, the potential enabled by radical change is not captured.” (Norman and Verganti 2014, pg.6).

The Three Waves of Human-Computer Interaction

As digital technologies play a key role in today innovation process, disciplines like Human-Computer Interaction (HCI) should be on the forefront of innovation. To understand the role of HCI in innovation processes, Susanne Bodker (Bødker 2015) has proposed to distinguish three waves of HCI.

The first wave is about Human Factors, and it spans the Eighties and the Nineties. In this phase, HCI aims to optimise the interaction between humans and computers, striving for the “best fit”. The analysis focuses on all the interaction problems and breakdowns, of anything that could disrupt the “optimal flow”. The expected end result is a pragmatic “solution” that fixes the problem. Improvements can be measured with performance indicators, or by using formal methods, in structured validation and testing sessions. The typical context of application is the workplace, with users performing well defined and clear tasks.

The second wave is that of the *Human Actors* (Bannon 1991), spanning from the Nineties to the beginning of the next decade. The aim is to improve the work quality and overall effectiveness by optimising the support given by computers. Computers are first seen as tools, primarily to communicate rather than to perform calculations. The analysis focuses on professional communities and work groups, using methods like participatory design, contextual enquiries, and ethnographic study. The expected end result is the optimisations of communication and cooperation flows, improving the support given by computers

The third wave is marked by a multiplicity of approaches. It starts in the year 2000 and it is still lasting. The aim of HCI is now less well defined and the issues being tackled are typically ill-defined ones. Contexts being studied have little structure, e.g. entertainment and free time, arts, home, urban mobility, and so on. The same is for the subjects of study, with topics like culture, emotions, experiences, motivation, and aesthetics… Every project needs to redefine its scope, aim, methods and tools. This third wave is still very dynamic, and there is no shared vision of the role that HCI could play and for which goals.

Adding to Bodker’s analysis, each wave has its own understanding of innovation.

- The first wave seeks innovation by being user-centred. Achieving the best fit is a matter of incremental innovation, eliminating problems one by one.

- The second wave sees the ample participation of users as the key to innovation. Things are changed only by shared action and consensus. We are still talking of incremental innovation, as shared proposals are typically grounded in the current situation, in current practices and communities.

- The complexity of the third wave demands for a different approach to innovation. HCI can now ask questions, rather than answering them, changing the framework and resetting

the problem. It is about a disciplined understanding of what technologies can bring, of the endless combination mentioned by Brynjolfsson and McAfee's.

This key change in the role of HCI is engendered by the redefinition of the object of study. Where yesterday the focus was on the interaction between a specific user with a specific computer (for specified goals), nowadays the interaction is many to many. Humans interact with technologies as part of a digital ecosystem, where the interface is everywhere and every move can be part of the interaction (Pozzi and Bagnara 2015).Our body can be the interface, as we can interact with a computer simply by walking and moving around.

A digital ecosystem cannot be optimised, as there is no clear workflow to improve, there are no clear and stable goals for the interaction. Such a complexity raises more questions than answers: "My health data… If I had access to all these of your data, I could be making a lot of processing about your person… I think that one day something awful is going to happen. At that moment, we will all stop and ask ourselves: why did we let all of this happen? How did it happen?" (Tim Cook, online interview – 11 November 2015).

The point of Tim Cook's reasoning is that we have endless technological possibilities, so we need to confront ourselves with value choices rather than technical ones. These questions cannot be solved by incrementally improving the interactions. We need to set the framework, pick our goals, deciding WHAT we want to do with technologies, critically seeing the implications at the societal level of these choices. "Design is about people. It is about our lives, our hopes and dreams, our loneliness and joy, our sense of beauty and justice, about the social and the good." (Overbeeke 2007). These are questions about the meaning of human-computer interaction, as described by Verganti for radical innovation.

Trends and Emerging Topics in HCI

From the authors' perspective, there are two key topics to be addressed in the current scenario. First, understanding the human body as an interaction means. Second, seeing interactions as distributed in a digital ecosystem. We think that HCI can contribute on both topics, providing concepts and tools to frame the situation and identify the problems and issues to be solved.

The human body is today a key element for the human-computer interaction, thus demanding HCI to go beyond traditional paradigms of cognitive psychology, mostly focused on the mind an information processor, with clearly separated sequential steps of input-processing-output, and with sight and hearing as the predominant input channels. HCI needs to link again with current studies in cognitive psychology and understand the whole human being, body and mind, cognition and emotion.

The human body is a design object, in a certain sense, given that we can easily internalise any tool. So far, we do not know yet if there is a technology that is too diverse from us, to the point that it cannot be internalised. We do not know the boundaries of human body, we do not know which technologies can become second nature and which cannot. Being provocative (but not too much really), David Kirsh asks what is the real difference between a prosthetic leg and "two sets of nine fingered claws that operate in articulate and continuous ways?" (Kirsh 2013).

We also know from embodied cognition studies (Caruana and Borghi 2013) that any change to human body is not neutral from the cognition point of view. Our body gives shape to cognition and two sets of nine fingered claws may change the shape and the contents of cognition in unexpected ways. An integrated understanding of body and mind is a prerequisite also for the effective personalisation of tools and technologies. Every user will use her/his tools differently depending on contexts and her/his own goals, but also considering her/his physical characteristics, including existing disabilities, or new ones (Pozzi and Bagnara 2013).

The second emerging topic is about seeing interactions as distributed in a digital ecosystem, where human-computer interactions happen beyond the interface. We use the term *ecosystem* because human-computer interactions have nowadays a degree of complexity similar to that of natural systems, and because all the system elements are to some extent involved in the creation and exchange of value. A system is alive and healthy if all the elements are alive and healthy, i.e. if value flows across all the system elements and brings benefit to all the elements, not to a limited subset. For instance, when a user is logging to an e-banking system to pay a bill, the bank is getting value from the transaction itself, the user is saving time and gains in flexibility, as s/he can do the operation outside of the bank office hours. But there is more. The session logs will be useful to the home banking system developers to improve the user experience and remove

usability issues, or to better design the system for specific mobile phones or laptops. As a case in point, *service design* speaks of *service ecology*, stressing the analogy with a living system.

In digital ecosystems, interactions happen through a number of touchpoints, different among themselves and dynamically evolving. These touchpoints are "woven together" by social practice, more than by a technological infrastructure. In such a scenario, humans need to possess (or develop) capabilities to read and understand complex situations, ill defined, detecting pattern and anomalies as they emerge. These capabilities are even more challenging as a large part of these ecosystems is not visible, surfacing only when there are breakdowns (Bagnara and Pozzi 2013). HCI can contribute to the design of means to explore this complexity, in order to understand their functioning before breakdowns happen.

We are not referring uniquely to a new technological scenario. Digital ecosystems transform social practice and bear a profound impact on the way we think, we live, we learn. It is a point well captured by the French philosopher Michel Serres in a recent book (Serres 2012). Serres points out that the old fashioned ideologies are no longer capable of providing a unifying perspective on reality. Digital natives see themselves as individuals, whose sociality is made of interactions with other individuals. What is the role of digital technologies in this transition? According to Serres, they have changed our way of learning, our way of acquiring knowledge. After the invention of writing and printing, digital technologies now make virtually all the knowledge available from virtually everywhere, disrupting the traditional learning paths. Such a possibility has undermined the mediating role of the traditional communities and ideologies. The "natural" way of interacting with technologies is now a flow, different every time, where the only structure is given by the way the user chooses to carry out the interaction.

Conclusions

Our society moved away from the use of computers to perform calculations and obtain results - from classic HCI - to a phase where technologies form a real digital ecology - to interaction and service design. Interacting with computers, giving input to screens is only one way of interacting with the digital ecosystems. The interface is everywhere, is fragmented in the environment.

In this scenario, the old fashioned analysis methods of HCI are becoming obsolete, as they focus on "hard" indicators like efficiency or productivity. HCI is now a discipline that should identify the key questions to be tackled, that should define the scope of the technology impact on our everyday life, that should anticipate the future changes brought by technology. It is about themes like what our society wants to achieve collectively, which values we want to be reflected in new technologies, which changes we want to trigger. Today, most of the HCI methods are still intervening tactically, on well-defined topics of limited scope. There are few methods to anticipate and manage future changes, to be able to affect what society is going to do with a certain technology. This transition is needed as we can no longer think of technological innovation as something different and separate from social innovation. The two proceed together, on two separate, but highly dependent, planes.

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