AI & Soc (2016) 31:17–28
DOI 10.1007/s00146-014-0543-x

ORIGINAL ARTICLE

Augmented reality and ubiquitous computing: the hidden potentialities of augmented reality

Nicola Liberati

Received: 13 January 2014 / Accepted: 22 April 2014 / Published online: 10 May 2014

Abstract The aim of this paper was to highlight the augmented reality's potentialities, depicting its main characteristics and focusing attention on what its goal should be in order to have a new technology completely different from those that already exist. From a technological point of view, augmented reality is still in its infancy and so even the general idea of what a good augmented reality should be is still uncertain. Commonly, augmented reality is identified as opposed to the virtual reality because augmented reality merges digital information with the real environment. However, there is another technology, with a different history, which has this same basic goal: ubiquitous computing. The absence of a clear distinction between ubiquitous computing and augmented reality makes it difficult to identify what these two technologies should pursue. I will analyse the main aspects of ubiquitous computing and augmented reality from a phenomenological point of view in order to highlight the main differences and to shed light on the real potentialities of augmented reality, focusing attention on what its goal should be.

Keywords Philosophy · Augmented reality · Ubiquitous computing · Phenomenology · Post-phenomenology · Philosophy of technology

1 Introduction

We can assume that AR first emerged in the year 1990.[1] Not so much time has passed, and a technology needs time to mature and to develop applicability and acceptability criteria. We can see it through a sort of vagueness in the definition of what is considered to be an AR. We have already an unlimited number of different conceptions. Almost everything that comprises an interaction between a digital "being" and the real environment is today labelled as "AR". The term augmented seems to be related to the interaction of physical objects with computers. For example, it is possible to consider AR the name of the calling person displayed on mobile phones.[2] The term AR could be used as well with the most advanced technology that produces objects interacting with the real environment (see, for example, Benko et al. 2012). Even Milgram's continuum [see Milgram's continuum (Fig. 1) and (Milgram 1994)] does not clarify very well what the augmentation consists of, but only states that AR is in a no-man's land where there is a sort of interaction between something digital (such as a computation activity, information, digital objects.) and the real environment in which this not well-defined digital activity is immersed.

To define AR's nature, its goals and, above all, its potentialities, it is necessary to introduce a clear definition of what AR should create and a parameter to classify if a device is an AR or not. Only by defining its nature is it possible to exploit its implicit potentialities and to create something new that does not mimic the style of other technologies or does not try to reproduce what other technologies are designed for. Without this clarification,

N. Liberati (✉)
Department of Discipline Umanistiche, University of Pisa, Via Paoli, 15, 56126 Pisa, Italy
e-mail: liberati.nicola@gmail.com

[1] This year is significant because it is the first time the term "augmented reality" was used. However, it is possible even to date back the concept to 1966 when Ivan Sutherland created the first head-mounted display.

[2] AR being a technology that merges reality and virtuality, even the simple connection between the person who is calling (reality) and his name (virtuality) on a mobile phone could be conceived an AR.

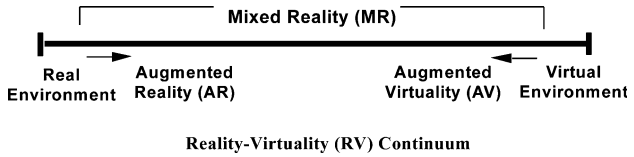

Fig. 1 Milgram's continuum

we could risk creating a technology, forcing it to do something that could be done by a different kind of technology and maybe in an easier way.

2 AR, ubicomp and VR

The distinction between virtual reality (VR) and AR is quite clear because while the first one is focussed on the creation of a second digital world, where the subject has to immerse themselves cutting off any kind of relation with the "original" everyday world, the AR is focussed on the intertwinement of digital objects, texts and information with the "original" environment. Therefore, the VR tends to create a duplicate of the world where the digital technologies can act freely without any relation to the "external" real world, whereas the AR tries to bring the technological action directly into our world without any duplication.

Someone could be tempted to consider this characteristic of bringing the computer and its computing action into our actual world the main path to follow in order to design a good AR. Moreover, we could be led to consider any kind of technology that merges a digital activity with our world an AR. Unfortunately, this kind of short cut is to be excluded because Mark Weiser already defined another kind of technology with this same characteristic: ubiquitous computing (ubicomp).

At the end of the 80s,[3] Weiser described ubicomp as an "embodied virtuality" (Weiser 1991, p. 8), a definition that gives the idea of a technology that works in our world. The concept of "embodied" has to be opposed to what was supposed to be "disembodied", such as cyberspace.[4] Our world is considered something where the subject acts with their body, something where the materiality of things is important, while cyberspace was considered the place where the subject lives having broken the "chain" of their material "shell". Cyberspace was considered the world "in" the computer[5] where any contact with the materiality of the real world is lost and, with it, even the materiality and the body of the subject. Obviously, today, this kind of distinction is no longer valid because even the non-phenomenologists agree on the fact that where there is a subject, there is also a living body of the subject. Therefore, cyberspace is not disembodied any more, even if the cyber living body can differ from the standard living body we have in our everyday world.[6] Even if now the scientific community agrees on this point, the formula "embodied virtuality" was coined in order to point out that this kind of technology acts in our everyday world and not in some immaterial place in the computer.[7]

We have to bear in mind the time frame when Weiser created this term. At the end of the 80s, the computer was somehow out of the common lives of common people and even the idea of a personal computer was only in its infancy. Ubicomp incarnated (and still incarnates) the will of introducing computers into the actual world of the subjects. It was created in order to be a "virtuality" only in the sense that there was a computing action, but the main focal point was the common world where people live.

And so we have two different kinds of technology, AR and ubicomp, that pursue the same goal: to intertwine the computer's capabilities and our everyday world.

3 Analysing ubicomp

We can analyse ubicomp in order to find out how it works in its main features and to understand how AR is different displaying AR's potentialities.

Ubicomp is described as a "calm technology".[8] It has to be "calm" because it must not be intrusive in the life of the subject. The shift is clear. While with the "old" technologies working on "personal computers" (Weiser 1991), developers try to improve the device boosting its computing power,[9] the idea of the "new" ubicomp is to improve the design of the device in itself, allowing the subject to

[3] Even in his first article, published in 1991, he had already developed prototypes (see Weiser 1991).

[4] Gibson defined cyberspace as a "Consensual hallucination experienced daily by billions of legitimate operators […]" (Gibson 1984). The term "cyberspace" firstly occurred in Gibson (1982).

[5] "Cyberspace—the world that lies beyond our computer screens in the vast network of computers" (Dodge 1999, p. 1).

[6] For example, in the case of a subject moving on a computer desktop, thanks to the mouse in their hand, we could think the cursor on the screen is the actual body image of the subject, while the whole body schema is related to the mouse and the subject's hand. On the distinction between body schema and body image (see Gallagher 1995, 2005; Poeck and Orgass 1971).

[7] The term "embodied" is related to the action in the everyday world and the term "virtuality" is related to its computing power.

[8] "Ubiquitous computing will require a new approach to fitting technology to our lives, an approach we call "calm technology" [my emphasis]" (Weiser 1996).

[9] We had an increasing growth of computing power. This is also one of the reasons why "Moore's law" was coined (see Kuniavsky 2010, chap. 1).

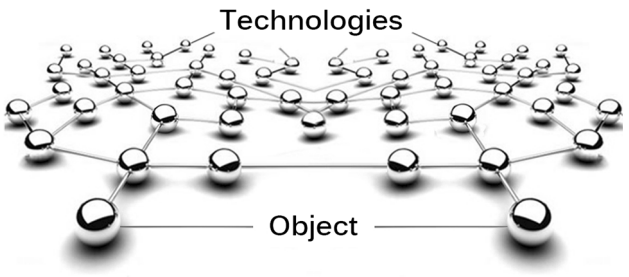

Fig. 2 Ubicomp's network

pay less attention to it and to focus their attention on the action in the everyday world.

A more powerful personal computer can process information in a faster way, but the way of accessibility to this information for the subject remains the same: there is a monitor in which the subject has to immerse themselves and to interact in some way to achieve the correct information. Otherwise, with ubicomp, the technology has to become "part of the environment" (Weiser 1991, p. 1). The whole idea of a personal computer is at stake because the technology should not be actively present as a device that monopolises the subject's attention, but it should be embedded in the environment.[10]

This technology is founded on three major points that enable it to fulfil this goal: it has to be peripheral, it must act in the background and it must be invisible.

Obviously, there are different classifications based on how the ubicomp is programmed following the technological and computational elements used to create it.[11] Nevertheless, we will follow the criteria based on the perceptual level without giving attention to these "technical" distinctions. We will use the perceptual level because, in this way, it is easier to analyse how the technology is present for the subject and how technological devices interact with the perception of the subject, without considering what is "running" into such devices.[12]

3.1 Peripheral and Husserl's horizons

Ubicomp is a technology that has to be peripheral (Weiser and Brown 1996a, b). Other technologies, as classical personal computers, are useful to the subject, thanks to their computing action in the moment when the subject is in front of them, and they are focussed on some interface in order to "communicate" with them. Ubicomp technology works at the border of the subject's attention. They are engaged in their action in the everyday world, and they are not bothered about any interface or any device at all.

While the object of interest for the subject is in the focal point of their attention, the ubicomp gravitates around it, providing whatever the technology is designed to provide. It acts as a network (Fig. 2).

The main object is at the centre, where the subject acts intentionally, and the ubicomp technologies are connected to it because in some way, they interact with them helping the subject in their action. The technology is passive, not in the sense that it is idle with no effects on the main object, but it is passive in the Husserlian sense:[13] it acts without the conscious activity of the subject. The technologies shape the object and mould the praxis related to it.

To understand how these technologies actually shape the praxis of the subject and the object itself without "touching" it, we can refer to Husserl's phenomenology.

3.2 Husserl's horizons

The perceived object is not constituted by the manifest aspects only.[14] That means that hidden aspects are important as well.[15] For the purpose of this paper, it is not important to understand if these "hidden" aspects are actually perceived by the subject along with the manifest ones or if they are only intended and consequently hidden and "absent" for the subject in some way.[16] What is relevant is to understand the importance of such hidden aspects for the constitution of the object and not if they are actually perceived or if they are completely hidden.

Husserl, after the first attempt in *Ideen I* (Husserl 1950, Sect. 35)[17] where he used terms such as "halo", "background" and "horizon" interchangeably,[18] developed a threefold theory in order to study and classify the

[10] "My colleagues and I at the Xerox Palo Alto Research Center think that the idea of a "personal" computer itself is misplaced and that the vision of laptop machines, dynabooks and "knowledge navigators" is only a transitional step towards achieving the real potential of information technology" (Weiser 1991, p. 1).

[11] As the article "A taxonomy of ubiquitous computing applications" shows (see Jeon et al. 2007).

[12] This case is similar to the case of a black box. It is important to the subject without considering what is actually inside this box. The box has some properties, and we are going to study these properties no matter what makes them.

[13] There is an action, but it is passive because it is an action out of the subject's consciousness (see Husserl 1939, 1966; Biceaga 2010).

[14] "The perceived object, the box before me, is more than its momentary appearance" (Kuhn 1968, p. 112).

[15] They are not the only perceivable aspects to be present in the horizon, but even the praxes related to such an object, on what can be done with it or what kind of modification we have in relation to a subject's action (see Walton 2002; Theodorou 2006).

[16] Dahlstrom identifies these two different positions (see Dahlstrom 2006).

[17] See also (Geniusas (2012), p. 12) in order to hava a wide panorama on the topic

[18] " 'Horizont' gilt hier also soviel wie in Sect. 35, S. 62 die Rede von einem 'Hof' und 'Hintergrund' " (Husserl 1950, paragraph 83); see also Geniusas (2012, p. 12, p. 46).

different hidden aspects of the perceived object. Therefore, following the Husserlian distinction, we have three kinds of different horizons: the inner, the outer and the world horizon.

The inner horizon entails the infinity of the possible perception we can have of the object. We can turn the object in order to make the hidden faces manifest on the back, or we can vary our position in order to get closer to the object and appreciate its details in a better way. In both these cases, the object shows something new while remaining the same object originally perceived (Dahlstrom 2006, p. 226).

The outer horizon is referred to every aspect of the object that is not related to its inner part. It is about where the object is immersed, such as the environment where the object lies. The object not only has a backside, but it also has a background. In order to understand immediately what it means, we can take into consideration the classical distinction foreground/ background. While the object is in the foreground, it has a background which is the space around it with everything that there is in such space (Dahlstrom 2006, p. 228). For example, in the case of a table covered with food and drinks, the subject focuses their attention on a dish but, in the meantime, every object on the table and in the room is "present" in the background. The subject does not only perceive the single dish in front of him, but, with it comes the perception of the background providing important elements about "where" the dish is. Another example could be the case of a tree in a line of trees or a single tree in the middle of nowhere. The background of a "line of trees" constitutes the content of the observed tree. Its position of "among trees" deeply modifies its content because it was not free to grow as it would have loved, but it grew according to the line of trees where it was. Its roots were not free to go where the tree wanted because there were other roots of other trees; it did not grow straight because it had to follow the sunlight avoiding the shadows created by the branches of the other trees. Therefore, its constitution reflects the type of background where it is, and so the outer horizon is a constitutive part of the object as well.

The third one is the world horizon. It is related to every possible experience of the subject and of the community where they live. The single object carries in itself not only the hidden faces on its back or the background where it is immersed, but it is immersed in the world where the subject lives with its goals and meanings. In a perception of an object, there is always the world horizon as a horizon of all horizons to which every possible praxes or experience are related (Geniusas 2012; Cho 2007; Brainard 2002).

3.3 Horizons and ubicomp

Having in mind this kind of tri-partition of the horizon, we can say that the calm technology, working in the peripheral

Fig. 3 Alice and the bottle

part of the subject's attention, is relevant to the constitution of the main object. The perceived object cannot be considered an isolated element any more because its constitution lies in the horizons. The whole "context" around it contributes to the constitution of the main object. The possibility to get information on the object, thanks to these devices, shapes the object itself providing, for example, new praxes.

In order to clarify how these technologies can shape the object, we can take into consideration a rudimental ubicomp explicitly suggested by Weiser as the post-it note that allows the subject to remember something.[19] While the subject is acting in the world, the post-it gives them information about what to do in the near future or provides information about the object on which it is attached.

Imagine the scene of Alice in Wonderland (Carroll 1869) where a bottle on a table has a label attached to it that says "drink me" (see Fig. 3).

Obviously, the praxis of Alice is deeply shaped by this label that explicitly suggests the usage of that specific item. We can extend this effect to any kind of information provided by any "label" such as any general information on an item or a manual explaining its usage. Thus, we can easily see how the peripheral space, where ubicomp is supposed to work, is involved in the constitution of the object, even if

[19] The example of post-it notes is made by Weiser (see Weiser 1993a, p. 1; b, p. 2).

not in a direct way, and it is "passive" in the classical phenomenological sense: it is not passive at all.[20]

Moving the technology to the peripheral space allows the subject to have more than one single technology working at the same time. Because, while the foreground is limited to be constituted by a single object, the background is intrinsically wider. Therefore, there is the possibility to enhance the environment with more than one single device (Weiser and Brown 1996a, p. 9) and, moreover, this configuration allows the subject to "reach" more information about the object, thanks to the defocalisation of such technology.

Another key concept of the peripheral technology is the possibility to turn this peripheralicity into the focal point of the subject. The peripheral aspect of ubicomp is not so clear on this point. Weiser seems to be quite clear: ubicomp is a technology that can be placed as the focal point of the subject's attention (Weiser and Brown 1996a, p. 9).

Unfortunately, this idea only allows us to conceive of the technology as something present and focussed. The information, in order to reach the subject, has to become the focal point of the attention. Alice, in order to have the information "drink it", has to read the label and so her attention falls necessarily on the piece of paper instead of the bottle.[21] The attention falls on the product of the technology rather than the original object. The subject's action, even though it is directed towards the external object, is mediated somehow by an "interface": the paper label in this case.

To appreciate this passage, we can reconsider the case of a personal computer. In this case, the subject has to deal with a very unintuitive and opaque system in order to have the information. This activity, through this opaque device, makes the technology monopolise the whole attention of the subject. If we examine closely the subject's attention, it is not captured by the computer only in the act of reading the information, but it is attracted in a deeper way because the subject actively searches for the information and interacts with the computer via the keyboard, the mouse or other means.

In the case of ubicomp, the "label" is given and the subject has "only" to read it. Thus, Weiser was right to consider this technology more "direct" than the classical personal computer. Nevertheless, the "label" still needs to attract the subject's attention, even if at a lesser degree. The subject reads a text while they are living in the world.[22]

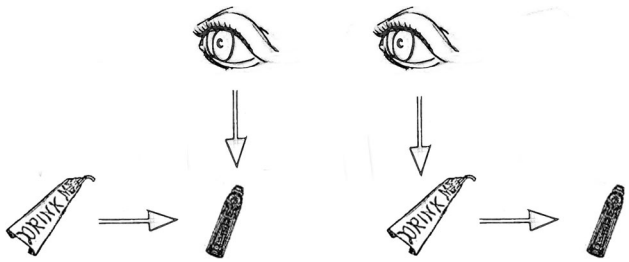

Fig. 4 On the *left* $Subject \rightarrow (\{Object\} - Technology)$. On the *right* $Subject \rightarrow (Object - \{Technology\})$

We can take into consideration the kind of schema we have among three important elements: the subject, the technology and the object.

As we have seen, there is a sort of network where the object represents the subject's central point of interest[23]. The subject is focussed on the object in the everyday world, such as the bottle in the case of Alice, and they can turn their attention to the label as something related to the perceived object (Fig. 4).

As we can easily see, the subject is related directly to the object and the technology is outside this kind of relation in the first case. The subject is focussed on another pole which consists of the object and the technology in the peripheral space. However, even in the second case, we have the same situation. The subject is now focussed on the label, but this label is not independent of the object so, in some way, the subject remains related to the nucleus (object plus technology) we had in the first case, even if now the element in the peripheral space has changed because the attention falls on the "label" and not on the original object.

Thus, identifying the position of the subject's attention with the curly brackets and the nucleus, to which the subject is directed, with round ones, we have:

In the first case:

$$Subject \rightarrow (\{Object\} - Technology)$$

In the second case:

$$Subject \rightarrow (Object - \{Technology\})$$

This is the classical distinction in post-phenomenology between background relations and hermeneutic relations. In the first case, the technology is in the background and the subject is not focussed on it, whereas in the second case, we have a subject focussed on the text, which is the

[20] Passive in the Husserlian sense. Passivity in phenomenology is not related to the absence of actions, but to the activities out of the ego's activity. Therefore, to be passive does not mean to be inert as dead matter, but only to act without the direct action of a subject. See also at page 3.

[21] Using the example we have previously given (see at page 4).

[22] Obviously, the action of the subject is not related to the perception of the technological device in itself, but to the perception of the production of such technology. The subject perceives the text and not the device that produced the text. This is important because it helps to identify this technology as something hidden to the subject even if its production needs attention.

[23] See the Fig. 2 at page 3.

"product" of the technology, a text talking about the original object and providing information about it.[24]

The technology in both cases is related to the object, and it is conceived of as a part of the object, while the subject is maintained completely "pure" and "untouched" by such devices.

Alice is the same girl with her original skills. What has changed is the information displayed by the label. It is the environment that changes directly, and only in the second instance do we have the change of the girl's praxes related to the object in front of her that now has turned into a "smart object". It is the environment that becomes "smart" and any modification of the subject occurs afterwards and in a mediated way only.

Summing up, a peripheral technology is identified by its position "near" the original object that can become the focal point of the subject's attention in order to provide information.

3.3.1 Background and the "ontological" perspective

Ubicomp, following Weiser's ideas, has to be in the background.[25] This aspect is strictly related to the conception of background we have found in Husserl's phenomenology.[26] The technology is out of focus, and so it is part of the background and it is not the foreground, at least most of the time when the subject does not look at any label.

The technology, being in the background, is part of the environment, and it is invisible. Even if this concept of background follows the idea of peripheriсity, there is the introduction of a different kind of element: the technology is supposed to be invisible. A peripheral technology can be considered invisible in some aspects, but it is not invisible at all for some others.

In the previous case, the peripheral technology was invisible because the subject's action was directed towards the object and the technology was out of focus in the peripheral space. Yet, at the same time, the technology was not invisible at all because the subject had to focus their attention on the product of the technology in order to get the information. Alice had to "read" the label "drink me" in order to get the information that shapes her praxes. The power of such a label lies in its visibility. Differently, with this conception of a technology in the background, we have a technology that is invisible to the subject. How could this be possible?

The answer is "simple": the concept of invisibility is related to two different analyses. In the first case, the invisibility is related only to the main action of the subject, and the subject wants to act in the everyday world and get the information on the label in order to do that. However, the technology is not invisible at all because its function lies in its visibility. In the second case, the technology is conceived of as invisible in a more "ontological" way and no longer in a perceptual one. The technology is melted into the environment in the sense that each object becomes technologically embedded. It is not a question of the action of the technology any more, it is a question of the nature of the object as something with a computer in its viscera. The environment becomes a computerised environment.[27] Computers literally "disappear" because they become an inner part of every object.[28]

With peripheral technology, we had a technology that moulds passively the act of the subject. The subject was directed towards an object, but in some way their action was modified and shaped by the technology around them. With this conception of a background technology, we have a subject directed towards an object that is not a true, natural object. The whole attention falls on the non-naturality of the object and not on the action of the subject. The object is no longer a natural one because it brings a computer in itself, even though it looks natural. This conception refers to a world technologically saturated.[29] Every object becomes technologically embedded, and the distinction between natural and computerised object start to vanish.

Therefore, it is possible to combine these two conceptions. We can have a technology that is not invisible in the sense of its function as the subject has to focus on it in order to get the information, and a technology that is invisible in the sense that it is melted into the environment and it is not distinguishable any more. However, in our analysis, we have to consider this kind of technology as visible because we are considering the perceptual level and not the kind of world which is around the subject, whether it is "natural" or "computerised".

[24] On background relations and hermeneutic relations (see Ihde 1990, 2004, 2009; Verbeek 2005).

[25] "Ubiquitous computing takes place primarily in the background" (Weiser 1993a, p. 71). Moreover, "We are therefore trying to conceive a new way of thinking about computers, one that takes into account the human world and allows the computers themselves to vanish into the background" (Weiser 1993a, p. 71).

[26] See the outer horizon in Husserl's phenomenology at page 4.

[27] Weiser clearly explains this point saying that the "old" technology related to the personal computer could not become part of the environment, while he was looking for it. "Silicon-based information technology, in contrast, is far from having become part of the environment" (Weiser 1991, p. 1), "Such machines cannot truly make computing an integral, invisible part of people's lives" (Weiser 1991, p. 1).

[28] "The most profound technologies are those that disappear" (Weiser 1991).

[29] "Certainly, this collective envisioning of a future saturated technology has been a defining characteristic of ubicomp research" (Dourish and Bell 2011, p. 34).

$$Subject \rightarrow (\overbrace{\{Original\ object\} - Tech\ product}^{Technology})$$

$$Subject \rightarrow (\overbrace{Original\ object - \{Tech\ product\}}^{Technology})$$

where *Tech product* is the technological product of ubicomp, such as a label, and *Technology* is used to show where the technology acts.

In conclusion, we can say that ubicomp is a technology that is peripheral and invisible if we consider the device in itself. The computer is invisible, but the "product" of such device[30] is not invisible at all.[31]

4 Analysing AR

AR was born in the late 90s, and so it is even less well delineated than ubicomp. To talk about the already existing AR is a mistake because the actual ARs are so different from each other that we risk losing ourselves in such analysis. What can be taken into consideration are "dreams" and the possible "proximate future" delineated by developers (Dourish and Bell 2011, p. 23) and sci-fi writers (Vinge 2006). Even if there are many different ARs, there is the common idea that glasses and their kin, such as contact lenses, represent one of the best ways to have such technology. The reason why such an idea concerns the visual field and not other senses, such as smell, can reasonably be found in our visual, dominated world where the vision is elected as the most important sense. However, the reason of such a choice is not important for our analysis.

Using a post-phenomenological terminology, the glasses are transparent.[32] This transparency is not related to the transparency of their material, but is related to the symbiosis created between the subject and technology. Glasses become embodied into the perceiving nucleus of the subject because the action flows through them towards the external object without any resistance.

$$(Subject - Technology) \rightarrow Object$$

Without technology, we would have a perceiving nucleus made up of the sole subject, while, with an embodied technology, this nucleus also has to comprehend the technological device. The technology falls within this nucleus and the action, in its main feature, is unmodified by it. The subject with glasses sees the object in the same way as a subject without them, even if there is a huge difference in detail related to the content of the object.[33] The subject perceives directly the original object without any kind of substitution.[34]

Fig. 5 AR glasses providing a textual information about an object

We can easily see how this "dream" concerning the use of glasses is different from the one of ubicomp. In ubicomp's proximate future, the world in itself becomes computerised displaying information and acting according to the subject's action, while in AR's dream, it is the subject that, "through" a device, enhances their skills.

Even if we have a "dream" of what kind of device AR should be, it is still not clear what such a device should create.

4.1 Possible augmentations

4.1.1 Alice in Wonderland

There are two main ideas or possibilities. The first one is to display information about the external world. The main focal point here is to provide any kind of textual information about the objects "recognised" by the device.

Alice in Wonderland can summarise this position very well with a little change in the story. The "label", in order to have AR glasses, should not be attached directly to the bottle, but it should be displayed by the AR glasses as a text window. However, the situation is unmodified (Fig. 5).

Alice looks at the original object and at the "augmented label" as just the paper one. The subject's attention can be focussed on the label for some time in order to provide the information to the subject, but, after a while, the attention falls within the original object, and the label returns in the background of perception. We have the same framework of ubicomp's peripheral space and, as in ubicomp's case, this

[30] Where Tech product is the displayed "product" of the technology such as the label.

[31] We still have

$$(Subject - Technology) \rightarrow (\{Tech\ product\} - Original\ Object)$$

and not

$$(Subject - Technology) \rightarrow Original\ Object.$$

[32] On transparency (see Ihde 1990, p. 86; Verbeek 2005).

[33] There are different interpretations about what the noema is; however, in this paper, we are not interested in a deeper analysis of this term. For more details (see Sokolowski 2000; Føllesdal 1969; Zahavi 2004).

[34] We have this kind of substitution in the case of a radio-telescope where the subject looks at the image in the monitor and not at the original celestial object up in the sky.

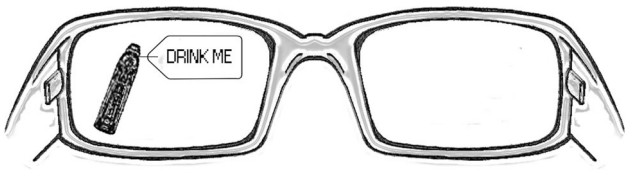

Fig. 6 AR glasses providing the object "label"

"label" modifies the subject's praxes and the content of the object.[35]

In ubicomp's case, when the subject looks at the label, we have the following structure:[36]

$$Subject \rightarrow (\{Technology\} - Object)$$

or, if the subject is directed to the original object:

$$Subject \rightarrow (Technology - \{Object\})$$

Now, with the AR glasses displaying textual information, we have the embodiment relations where the technology "glasses" is integrated into the subject's perceiving pole:[37] with some aspects of ubicomp's case.

$$(Subj - Tech) \rightarrow (\{Technological\,product\} - Obj)$$

or

$$(Subj - Tech) \rightarrow (Technological\,product - \{Obj\})$$

in case the subject is directed to the original object and not to the text displayed by the device.

We have a modified perceiving nucleus, but, at the same time, we have the fallout of the technology due to the presence of the technological product in peripheral space. Moreover, we could even cut the technology of the perceiving nucleus because every modification added by the device is related to the technological product only. Thus, the fact that the device is originally a pair of glasses becomes totally unimportant. However, we will continue to take the technology inside the perceiving pole in order to maintain the trace of the presence of glasses.

Trying to improve this rudimental AR technology, we can consider a technology that creates a "digital label" related to the bottle instead of a simple text (Fig. 6).

This label is not a paper label, but a digital one; it is created as though it were a paper one. What has changed is not the text "drink me", but the way this text is given to the subject. While in the previous case, the subject has a text that comes from nowhere and was displayed on the lenses, now the text is something that is in the external world because it is written on the label attached to the bottle. The subject now can interact with it because it is embedded in the world by being written on a label which is a "physical" object in the world, even though it is a digital object. The subject can touch it and "reach" it, at least in theory.

Still, this is not enough to have a good AR, because we have demonstrated[38] that to provide information about the object is an ubicomp goal. Even creating information by using perceivable data, such as false colours (Ihde 2010, p. 5), does not solve the problem. Even if with false colours the object is perceived as an original object because the information does not gravitate around the original perceived object, it is still an information about the object.

AR should not be used in order to have information about the object as this information is provided by texts or by false colours. AR should be used to shape our world introducing new digital objects.

4.1.2 Kasparov and Deep Blue

We can take into consideration another example in order to see how a technology could be shaped to become an AR.

The chess match between Gerry Kasparov, the world chess champion, and Deep Blue, the IBM super computer, is one of the most challenging topics that has amazed the scientific and philosophical community (Hsu 2002; Nagataki and Hirose 2007, p. 222).

Usually Deep Blue is considered an artificial intelligence (AI) (Newborn 2011), the AI that defeated the world chess champion, or something that can only mimic the AI because it cannot actually "understand" its "actions" (Irion 1997; McDermott 1997; Schueler 1996; Korf 1997). Scientific articles concern its level of "intelligence".[39]

We will follow a different path. We do not consider the IBM computer a singular thing, but we consider it in the subject–technology relation according to the post-phenomenological analysis (Selinger 2006; Ihde and Selinger 2004). The IBM computer, following this point of view, is no longer an AI in the sense that it is something that "thinks", but it is something that helped the player to have an advantage over Kasparov.

[35] See at page 4.

[36] See at page 7.

[37] Embodiment relations are identified by the incorporation of the technology into the perceiving pole of the subject

$$(Subject - Technology) \rightarrow Object$$

For example we have this relation in the case of glasses because they withdraw and allow the subject to perceive the external object directly without posing themselves as perceived. On embodiment relations (see Ihde 1990; Verbeek 2005).

[38] See Sect. 3.3.

[39] Another important subject is if there was a human support. On this subject (see Jayanti 2003).

Following this idea, we have Kasparov at one end of the chessboard in his loneliness,[40] while, at the other end, we have the player helped by the Grandmaster, Joel Benjamin, an entire IBM team and the monstrous (at that time) computing power of its computer.[41]

$$Kasparov \rightarrow Chessboard \leftarrow (Deep\ Blue - IBM\ team - Grandmaster)$$

However, as in the case of glasses, where the "team" that actually created the lenses is not taken into account in our relation among the subject technology and the world, the "team" that created the computer has to be excluded from this schema. The only subject that has some importance is the player that actively stays at one end of the chessboard.

Behind the player, there is a Grandmaster that "trained" Deep Blue[42] and the IBM team that created the best performing computer.[43] While thinking of Deep Blue as a computer that thinks how to beat Kasparov, we can easily imagine the player who uses Deep Blue in order to win and Deep Blue, in this conception, is only the final product of the Grandmaster and IBM teamwork.

$$Player - \overbrace{Deep\ Blue}^{Grand\ Master - IBM\ Team} - Chessboard$$

In this perspective, Deep Blue is a device that enables any player to win against the world champion.

However, this is a very strange kind of technology because it does not clearly fall within ubicomp or AR. We can modify this technology as we have done with the label in Alice's case in order to highlight the differences and to show what an AR should look like.

We can imagine the player moving chess pieces with the help of a computer that provides information about the actual status of the board, for example, providing possible moves or strategies that can be unseen in the "heat" of the "game" because of pure distraction. In this case, the computer would be a ubicomp because the computer provides information about the object without being in the perceiving nucleus of the subject.

$$Subject \rightarrow (Technology - \{Object\})$$

or

$$Subject \rightarrow (\{Technology\} - Object)$$

and

$$Player \rightarrow (Deep\ Blue - \{Chessboard\})$$

or

$$Player \rightarrow (\{Deep\ Blue\} - Chessboard)$$

Another step would be to turn the computer into AR glasses where the text would be displayed on the lenses. In this case, as in the case of Alice in Wonderland, we would have the same information as before with ubicomp, but it is displayed on the lenses. In this case we would have an AR instead of an ubicomp; we would perceive the same goal with a different technology in respect of AR.

The next step we should take in order to have a better AR is to create an object that embeds the textual information. In this case, the "augmentation" is turned into something in the world, despite providing a text that has to be read.

However, even in these attempts of ours, with the cases of Alice and Kasparov, we fail to create an AR completely different from ubicomp because these technologies still mimic the function of ubicomp. They use new objects not for their novelty of being new objects in the world, but as a base on which to apply the old label. Therefore, with these technologies we have created something new, peculiar to AR, and we forced it to provide the old goals of ubicomp.

This conclusion is inevitably yielded by our attempt to use the technology to provide information, and therefore, it is the way in which we use this technology itself that turns AR into a bad AR. We should use AR in new ways in order to have new goals.

4.1.3 A good AR

The second "AR dream" is related to the creation of glasses that provide entire digital objects to the subject instead of "simple" information. Differently from the previous case, there is no longer text, but the world is enhanced by the introduction of digital objects.

The schema of the embodiment relations[44] is not modified because the only difference we can introduce is the adjective "digital" to the perceived object.[45]

[40] On this feeling and his psychological break down (see Jayanti 2003).

[41] "Yes, Kasparov lost the series, but it was not human versus machine; it was human versus humans-plus-machine, a rather unequal contest to say at least!" (Ihde and Selinger 2004, p. 372).

[42] He trained the computer giving a value to each possible position on the chessboard in order to make the computer move to get a better score.

[43] Deep Blue, the second version of 1997, was created to play chess only and it could evaluate 200 million positions per second (Litch 2002, p. 91).

[44] See at page 8.

[45] Using the curly brackets in order to identify where the attention falls, we have

$$(Subject - Technology) \rightarrow \{Digital\ object\}$$

$$(Subject - Technology) \rightarrow Digital\,object.$$

The technological product, which is the digital object created by the technology, is autonomous and not peripheral. It does not gravitate around the main and original object in the classic focusable shift of the peripheral space. This kind of device is not peripheral at all and this "non-peripheral" enables it to be an invisible technology. The digital object is autonomous because it is not strictly related to the original object to which it has to provide information, but it is "important" in itself. Thus, the "object pole", identified by the right part of the arrow, is composed of a single element and not by two different elements.[46]

Summing up, AR is not interested in modifying the environment making it technologically embedded, such as in the case of ubicomp, but it is focussed on enhancing the subject's skills. This kind of shift enables it to become an invisible technology because the "augmentations" are not peripheral anymore and they are autonomous.

A good AR is an AR that creates an augmented object just in order to produce it, without any further goals related to what this object carries with it.

For example, in order to have something strictly related to the post-notes in ubicomp and thus related to the goal of providing information, we can think of an augmented wall on which it is possible to attach post-its. What is written on these post-its is not important at all for the wall in itself. The wall is an augmented object present to the subject as other objects around them. The fact that it carries a lot of post-its with information is excluded from the function of the wall in itself because it is present to the subject as the perceivable object "wall" without taking into consideration any post-its on it.[47]

Another example, more detached from the ubicomp and its informational goal, could be the creation of an object such as a digital pet, which is a digital domestic animal created, thanks to the AR devices used.[48] The subject sees the digital animal, thanks to the AR device as a "common" animal, even if it is produced by a technology. In this case, the difference with ubicomp results clear. The digital pet is not important because it is something that carries information, but for its presence itself. Its "goodness" or "badness" is not related to its ability to provide the subject with information, but it lies in the "goodness" or "badness" of the pet as a domestic animal.[49]

5 Conclusions

I have analysed how AR and ubicomp seem to have the same root because both of them are created to escape the cyber vacuum of VR. They try to bring the computing power to our world and thus to merge it with the real environment around us. However, there is not a clear distinction between the two, and this unclearness yields the problem of overlapping fields making it difficult to identify what an AR should be.

We cannot consider AR and ubicomp as two names identifying the same technology, even if there is a difference in what is used by the device such as a post-it or AR glasses. AR is not only another name for ubicomp, but it should entail different potentialities and pursue different goals.

I studied how ubicomp works and its goal from a phenomenological perspective. Ubicomp is a technology that needs an external object to be applied to. This characteristic makes ubicomp very different from AR, at least in theory. AR can create autonomous digital objects, and so it has a different field of application. Ubicomp tends to help the subject shape their action towards an object by providing information. AR should not follow this path because it has different potentialities, thanks to its capacity to create an autonomous object. It is possible to create something "digital" without being related to the "original" object in the non-digital world. While in ubicomp we have an original object to which the technology is applied, in AR there is not this necessity. The AR's creation can be an autonomous object. Even if AR can mimic ubicomp's goal, it can create the object towards which the subject is directed.

[46] This is the main difference between this schema ($(Subject - Technology) \rightarrow Digital\,object$) and the previous one related to ubicomp (see at page 7):

$$Subject \rightarrow (\overbrace{\{Original\,object\} - Tech\,product}^{Technology})$$

or

$$Subject \rightarrow (\overbrace{Original\,object - \{Tech\,product\}}^{Technology}).$$

[47] In order to have an example of a technology which will be in the market soon, we can refer to *META* Glasses (see the website https://www.spaceglasses.com/ or the video on youtube http://www.youtube.com/watch?v=b7I7JuQXttw). This technology can provide textual information about the surrounding and the visualisation of digital 3D objects in our world as objects among other objects. Therefore, it provides a "bad" AR and a "bad" AR at the same time.

[48] We can see this particular case in the anime *Dennō Coil* by Mitsuo Iso. Densuke, a small dog, is created by AR. He barks, runs and he gets ill as common dogs do. Children play with him as if he were a common dog made of flesh.

[49] It is possible to provide an example of an existing technology which produces an "augmented pet". Georgia tech developed an application for the iPhone which visualises a small dog in front of the subject. See the project "ARf: an Augmented Reality Virtual Pet on the iPhone" (http://ael.gatech.edu/lab/research/art-and-expression/arf-iphone/).

This "simple" difference changes the nature of the technology.

This creation enables us to change our idea of "technology" we had with ubicomp. It is no longer a technology that "helps" the subject in their life by providing information that shapes the subject's action, but it is a device that allows the subject to reach parts of their world. AR is not an auxiliary technology.

Therefore, AR should not be limited to the provision of information for the subject, but it should be used in order to embed our world with a different kind of materiality. It enables us to modify the world where we live. AR technology should no longer be something that helps the subject, but it should be something that allows us to perceive whole new parts of the world.

References

Benko H, Jota R, Wilson A (2012) Miragetable: freehand interaction on a projected augmented reality tabletop. In: Proceedings of the SIGCHI conference on human factors in computing systems (CHI '12), ACM, New York, NY, USA, pp 99–208. doi:10.1145/2207676.2207704

Biceaga V (2010) The concept of passivity in Husserl's phenomenology, contributions to phenomenology, vol 60. Springer, New York

Brainard M (2002) Belief and its neutralization: Husserl's system of phenomenology in ideas I. Religions of mankind. State University of New York Press, Albany

Carroll L (1869) Alice's adventures in wonderland. Mac Millan, New York

Cho KK (2007) History and substance of Husserl's logical investigations, Contributions to Phenomenology, Vol. 55, chap 1, Springer, Netherlands, pp 1–20

Dahlstrom D (2006) Lost horizons: an appreciative critique of enactive externalism. Edizioni ETS, Pisa, pp 211–231

Dodge M (1999) The geographies of cyberspace. http://discovery.ucl.ac.uk/266/1/cyberspace.pdf

Dourish P, Bell G (2011) Divining a digital future. MIT Press, Cambridge

Føllesdal D (1969) Husserl's notion of noema. J Philos 66:680–687

Gallagher S (1995) Body schema and intentionality. MIT Press, Cambridge, pp 225–244

Gallagher S (2005) Dynamic models of body schematic processes. John Benjamins, Amsterdam, pp 233–250

Geniusas S (2012) Origins of the horizon in Husserl's phenomenology, contributions to phenomenology, vol 67. Springer London, London

Gibson W (1982) Burning chrome. Omni, New York

Gibson W (1984) Neuromancer. HarperCollins, New York

Hsu FH (2002) Behind Deep Blue: building the computer that defeated the world chess champion. Princeton University Press, Princeton

Husserl E (1939) Erfahrung und Urteil: Untersuchungen zur Genealogie der Logik. Allen and Unwin, London

Husserl E (1950) Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie. Erstes Buch: Allgemeine Einführung in die reine Phänomenologie, Husserliana, vol III. Martinus Nijhoff, Den Haag

Husserl E (1966) Analysen zur passiven Synthesis aus Vorlesungs- und Forschungsmanuskripten, 1918–1926, Husserliana, vol XI. M. Nijhoff, Den Haag

Ihde D (1990) Technology and the lifeworld. From garden to earth. Indiana University, Bloomington

Ihde D (2004) A phenomenology of technics. Rowman & Littlefield, Lanham, pp 137–160

Ihde D (2009) Postphenomenology and technoscience. The Peking University lectures. State University of New York Press, Albany

Ihde D (2010) Stretching the in-between: embodiment and beyond. Foundations of science. http://www.springerlink.com/content/24r1t57p7w252862

Ihde D, Selinger E (2004) Merleau–Ponty and epistemology engines. Hum Stud 27(4):361–376

Irion R (1997) "Deep blue" inspires deep thinking about artificial intelligence. http://www.sciencedaily.com/releases/1997/05/970501194114.htm

Jayanti V (2003) Game over: Kasparov and the machine (film)

Jeon NJ, Leem CS, Kim MH, Shin HG (2007) A taxonomy of ubiquitous computing applications. Wirel Pers Commun 43(4):1229–1239. doi:10.1007/s11277-007-9297-9

Korf RE (1997) Does Deep Blue use AI? In: Collected papers from the 1997 AAAI workshop in Deep Blue versus Kasparov: the significance for artificial intelligence. AAAI Press, pp 1–2. http://www.aaai.org/Papers/Workshops/1997/WS-97-04/WS97-04-001.pdf

Kuhn H (1968) The phenomenological concept of "horizon". Greenwood Press, Westport, pp 106–123

Kuniavsky M (2010) Smart things: ubiquitous computing user experience design. Morgan Kaufmann, Amsterdam. http://www.sciencedirect.com/science/book/9780123748997

Litch M (2002) Philosophy through film. Routledge, London

McDermott D (1997) How intelligent is Deep Blue? http://www.psych.utoronto.ca/users/reingold/courses/ai/cache/mcdermott.html

Milgram P (1994) Augmented reality: a class of displays on the reality–virtuality continuum. SPIE Telemanip Telepresence Technol 2351:282–292

Nagataki S, Hirose S (2007) Phenomenology and the third generation of cognitive science: towards a cognitive phenomenology of the body. Hum Stud 30:219–232. doi:10.1007/s10746-007-9060-y

Newborn M (2011) Beyond Deep Blue: chess in the stratosphere. Springer, New York

Poeck K, Orgass B (1971) The concept of the body schema: a critical review and some experimental results. Cortex 7(3):254–277

Schueler G (1996) How could a computer beat Kasparov fairly? http://www.cis.umassd.edu/~ivalova/Spring08/cis412/Papers/CBTKAS-F.PDF

Selinger E (2006) Normative phenomenology: reflections on Ihde's significant nudging, chap 6. State University of New York Press, Albany, pp 89–107

Sokolowski R (2000) Introduction to phenomenology. Cambridge University Press, Cambridge

Theodorou P (2006) Perception and action: on the praxial structure of intentional consciousness. Phenomenol Cogn Sci 5(3–4):303–320

Verbeek PP (2005) What things do. Philosophical reflections on technology, agency, and design. Penn State University Press, University Park

Vinge V (2006) Rainbow's end. Tor Books, New York City

Walton RJ (2002) The horizons of cultural objects. In: Cheung CF, Chvatik I, Copoeru I, Embree L, Iribarne J, W HRS (eds) Essays in celebration of the founding of the organization of phenomenological organizations. http://www.o-p-o.net/essays/WaltonArticle.pdf

Weiser M (1991) The computer for the 21st century. Sci Am 265(3):66–75. http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html

Weiser M (1993a) Hot topics—ubiquitous computing. Computer 26(10):71–72. doi:10.1109/2.237456
Weiser M (1993b) Some computer science issues in ubiquitous computing. Commun ACM 36(7):75–84. doi:10.1145/159544.159617
Weiser M (1996) Open house. Review, the web magazine of the interactive telecommunications program of New York University (film). http://www.ubiq.com/hypertext/weiser/WeiserPapers.html
Weiser M, Brown JS (1996a) The coming age of calm technology
Weiser M, Brown JS (1996b) Designing calm technology. PowerGrid J 1. http://www.ubiq.com/hypertext/weiser/calmtech/calmtech.htm
Zahavi D (2004) Husserl's noema and the internalism–externalism debate. Inquiry 47(1):42–66