Movement, Action, and Situation: Presence in Virtual Environments

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Abstract

Presence is commonly defined as the subjective feeling of "being there". It has been mainly conceived of as deriving from immersion, interaction, and social and narrative involvement with suitable technology. We argue that presence depends on a suitable integration of aspects relevant to an agent's movement and perception, to her actions, and to her conception of the overall situation in which she finds herself, as well as on how these aspects mesh with the possibilities for action afforded in the interaction with the virtual environment.

1. Introduction

What about presence? Many a prominent view in current research and literature focus on what presence is and how it develops. Presence is commonly defined as the subjective feeling of "being there" [1] [2] [3]. Several authors considered this feeling of presence as mainly deriving from the immersion in a virtual environment [4] [5] [6]. They defined presence as the result of subjective involvement in this kind of highly interactive virtual environment; presence would be strong inasmuch as the virtual system enables an inclusive, extensive, surrounding and vivid illusion: the immersive quality of a virtual reality system would be enhanced by the perceptive features and the proprioceptive feedback provided by the system. Within this perspective, different authors have developed apparently different conceptions of presence.

Sheridan [7] and Zeltzer [8], for example, described the sense of presence as the sense of being placed in a place different from the physical one. Sheridan, in particular, defined virtual presence as the subjective feeling or mental state in which a subject has the belief of being "physically present with visual, auditory, or force displays generated by a computer". Heeter [9] defined an environmental presence which is yielded by the perception that an environment exists that modifies depending on what you do and seems to consider you as present. Witmer & Singer [2] also took presence to be due to immersion, but related it to the tendency to direct attention toward selected information that is meaningful to the individual. Presence would then be comparable to selective attention, and the sense of presence would be yielded by the allocation of attentional resources. According to these authors, both involvement and immersion are needed to experience presence. This approach, while focusing on immersive properties, also emphasized the role that activity plays in directing attention within complex interactive situations.

The importance of activity in the support and the enhancement of presence in virtual reality was investigated by Flach & Holden [10], who emphasized the necessity that interaction with objects be introduced in virtual environments. On a similar vein, Zahorik & Jenison [11] focused on the role of plausibility in perception/action behaviors; the latter are dealt with in terms of affordances. Mantovani & Riva [12] highlighted the importance of freedom in the actor's action within a virtual environment, as well as the need of a thorough consideration of the social and cultural dimension of actions in both the simulated and the physical world.

In an attempt to combine immersion-based theories with activity-based ones, Sheridan [13] proposed Estimation Theory. It claims that we can never have true knowledge of objective reality; instead, we are continuously making and refining a mental model which estimates reality. This process is made possible by sensing reality and interacting with it. Immersion in virtual reality is a source of stimuli, starting from which a user would create a mental model of the virtual environment and of how she relates to it. It would be the structure of this mental model that determines whether or not the user experiences a sense of presence. Thus, even when she is uncertain about the reality of her perceptions in the virtual environment, such perceptions would be anyway close relatives of those she has in the physical world.

The specific role of interaction with technology in creating presence was firstly considered by Lombard & Ditton [14], who defined presence as the "perceptual illusion of non-mediation". In particular, according to Lombard [15] presence should be divided into those aspects which involve the perception of a physical environment (where the sensory features correspond to those of the physical world), those which involve the perception of social interaction (where the social features correspond to those of the physical world), and those which involve both. In this perspective, presence occurs when a person misperceives an experience mediated by technology as if it were a direct (that is, non-mediated) one. Presence, thus, would not be a property of technology; rather, it could vary depending on how much the user acknowledges the role of technology and could therefore be yielded by different kind of technologies.

We agree with Biocca [16] that all these aspects ought to be integrated within a more general perspective on the nature of mind and agency. It is our aim in this paper to outline such an integrated perspective. We will argue that presence depends on a suitable integration of aspects relevant to an agent's movement and perception, to her actions, and to her conception of the overall situation in which she finds herself, as well as on how these aspects mesh with the possibilities for action afforded in the interaction with the virtual environment.

2. Perception and movement

Imagine you are observing a soccer player. His kicking the ball toward the goal is realized by the increased activation of certain muscles and the decreased activation of others. It, however, involves much more than just a sequence of motor commands. True, any action ultimately consists in the realization of body movements, but how such movements are programmed and executed is much more complex than it may seem.

As a first thing, the player has to take into account, and keep track of, a whole set of physical parameters dealing with his physical features — or, better yet, with the interaction between such features and the world in which he finds himself. Thus, a player who is 160 cm. tall will have to program his movements very differently from one who is 190 cm. tall; in both cases, of course, the movements will have to be programmed for an environment that provides a certain gravity pull, a certain density of the medium (think of the muscular effort needed to realize the same body movement in the air and under water), a certain adherence of the floor surface, and so on. While executing the kick, the player receives feedback information from his own body (proprioceptive feedback from the muscles, the joints, the organs of balance, and so on) as well as from the "external" world (variation in the patterns of brightness, for example, provided by the sun and other lights; variations in the visual landscape in front of him; variations in the relative direction of sounds which he knows are motionless, like the spectators, or moving, like the other players moving beside him; and so on).

Strictly speaking, this information is neither exclusively located within the player's body nor exclusively located in the outside world. Instead, it is, in each case, relational information. The player's feeling of the friction of his foot against the grass, for example, is neither in the foot nor in the grass: it is in the physical features of the ground (its roughness, softness, and so on), in the features of the movement of the foot (its force, its direction, and so on), and even in the player's expectations (a soccer player knows, for example, that to play on a rain-soaked ground will yield different information to those he will receive from a sunburnt one).

The management of such information depends on the creation, the maintenance and the moment-by-moment reactivation of sensorimotor schemes that "tell" the player how to appropriately program his movements in the specific situation in which he finds himself, what sorts of feedback to expect from the world, and so on. That way, his body will "know" what muscular power to exert in order to achieve a certain movement; analogously, while he turns his head, his body will "take it for granted" that the world will be turning in the opposite direction, and so on. Actually, it is also on the grounds of such feedback that he will be able to know how he is executing his kick, or which point in the sequence of movements he has reached.

If the relation between his body and the world is not the right one, that is, if the execution of the programmed movement is not accompanied by the right feedback from the body and the perceived environment, then the player has a problem. Sometimes this may be a surprise, maybe even an interesting one, as it happens when we expect to touch an object, only to find that it is just a hologram. Other times, the surprise may be far less pleasurable, as it would happen if we were to find out that it's not the glass that we wanted to grasp that is a hologram, but the floor upon which we wanted to thread.

If this is true of the real world, it has to be true also of a virtual environment that aims at looking like it or simulating it, and therefore has to take into account the structural coupling [17] [18] [19] of the organism and the world.

There are several aspects to this coupling. Some will be of a comparatively high level: these will concern, for example, the degrees of freedom allowed by the system, or its ergonomics and its cognitive ergonomics: in the very same way that a car had better have the steering wheel in front of the driver, rather than behind her back, so in a virtual environment it is better to be able to move by using the joystick than by pressing a complicated sequence of keys.

An aspect which is instead relevant at the level we are discussing in this section is that, wherever the steering wheel is located, when the driver steers her visual system ought to perceive a world which turns coherently in the opposite direction; her organ of balance ought to receive the appropriate proprioceptive feedback from the head's rotation, and so on. What Gibson [20] used to call the invariants of the physical world must remain invariant in the simulated world, if the minimal level of user's presence is not to be lost, because she cannot but take it for granted that the world will react to her actions in agreement with the basic relational laws of the body/environment interaction.

3. Action

Let us consider the soccer player again. A kick is, manifestly, the realization in the world of a certain sequence of sensorimotor programmes. It also is, however, much more than just that.

If described at a different level, the kick is an action, that is, an event which is consciously and deliberately brought about by the player as a way to physically realize an intention. That intention, in its turn, does not exist in isolation, but is born within a much more complex network of knowledge and plans.

The player inserts his kick within the set of schemes and strategies that he is forming and following instant by

instant. Not only does he know that he is participating in a soccer match, with a relevant set of rules, prohibitions, conventions, and so on; he also knows that he is participating in a specific collective action [21] within a specific strategy within a specific match. He therefore programs, knows, monitors, and controls his kick within this hierarchy of plans; he knows that, after the kick, he will have to find himself in the right position and with the right inertial push for a subsequent run or stop; he has an idea of what could happen after the kick (he may foresee, for example, that he will be able to enjoy a brief moment of rest, and therefore decide that he can afford to spend a supplementary amount of physical effort), and so on. This knowledge is not separated from the kick, and the kick is not independent of it; on the contrary, it contributes to determine, beside the motor programming of the kick and the expectation of a certain feedback, many features that are not intrinsic to the technique of the movement but to its use in a certain context.

It is not only the knowledge of the overall scheme behind the match, the specific strategy of that phase of it and of the specific moment, and the context in which it is realized, that have him choose to kick the ball toward a certain point. Moment by moment, other aspects come into the scene which concern the specific position of that player on the overall field, his ability to evaluate what promising opportunities he has available for his kick, and so on. Thus, if he thinks that the ball can reach a teammate who is both free and in a good position for kicking a goal, he will prefer, all other things being equal, to pass the ball to that mate, rather than to another one who is too far or too heavily hampered by the opponents.

The local goals of the player's actions depend on his general goals and on how he interprets them, and guide his perception of the possible opportunities for actions — in Gibson's terms [22], the affordances he has available. The opportunities that he perceives in the world, in their turn, guide his choice of local goals, as well as his revision or reinterpretation of the more general ones [23] [24].

Again, this all holds for the virtual world as well as for the "real" one. There are at least two factors to be considered here.

One is the sensibleness, and the meaningfulness, of the relations between the actions that the user can do and the effects that they have in the virtual environment. A forward movement of the joystick is better followed by a forward movement of the user in the virtual environment than by a movement to the right and slightly back.

More subtly, the definition of the possible spaces for action in the virtual environment ought to correspond somewhat reasonably to the user's expectations. We are not concerned here with the possibility of actions in the virtual world that are impossible in real life, such as flying, but with the need that such actions take place coherently and in agreement with the user's expectations. If, for example, a passage between two rooms of the virtual environment is too narrow when compared to the user's physical size, she will find it very surprising, and possibly somewhat discomforting, to be able to pass through it, because she will have the feeling that the world does not correspond to her expectations about possible and impossible actions.

What is at issue here is not the practical impossibility of certain actions, but their conceptual impossibility. A virtual environment in which the user can fly may be more sensible than one in which she can pass through a needle's eye, because our everyday experience with our body is more easily projected in the former kind of impossible experience than in the latter: we are accustomed to jumping, to seeing things below us, to viewing landscapes from high vantage points, to imagining what it would be like to be a bird, but not to perceiving sudden and dramatic changes in the size and the proportions of our body.

Another aspect that has to be taken into account is the possibility to choose between alternate courses of action, that is, the degrees of freedom granted to the user. All the rest being equal, an environment which affords several possible actions is more interesting than one which affords few. This happens because human beings need to feel that they are engaged, participating in interesting sequences of events, in interesting choreographies. If the world with which (or, better, *within which*) they are interacting, be it virtual or "real", is not interesting enough, humans will just get bored, and tend to move their presence toward different worlds, as it happens in daydreaming. The monotony of an environment, therefore, tends to decrease the feeling of presence within it, because the user will have the time, the space, and the cognitive necessity to imagine that she is elsewhere, so as to keep herself engaged in a sequence of actions and events capable of stimulating and maintaining her interest.

While the first aspect we have discussed here brought us back to the previous section, the latter brings us forward, to a further level of analysis of the interactions between the human beings and the world, which we will discuss in the next section.

4. Situation

Let us go back to our soccer player once again. We saw how he decides his actions according to the affordances he perceives in the world, and programs his movements according to the sensorimotor schemes that are part of his normal, and mostly unaware, abilities to move in the world. But this complexity still does not provide a full description of the player's presence and experience.

In the player's subjective perspective, each action that he performs plays a role within a narrative that he tells himself concerning what is going on, what he is doing there and why, with what further and future perspectives, and so on. More precisely, each action that he considers or performs plays a role within a complex weave of such narratives, each contributing to the overall meaning of his being there, on that field, in that very moment, choosing to perform a certain kick, as well as to the specific body movement which ultimately shapes the material counterpart of his mental state. Each narrative may be viewed as a choreography [25] in which the player features as the protagonist; each has an intrinsically autobiographical and social nature, and the overall weave thus results from the

whole previous history of that individual (which includes, of course, his current and past hopes, dreams, and expectations for the future).

Think of a player who is young and full of hopes, one who is so aware of his own talent as to just take it for granted that he deserves to play in a much better team, but who has always been kept on the bench by the coach. The first time he enters the playing field, that match will become hugely important. He might tell himself a story like "I'm here in this lousy arena, with these good-for-nothing mates, but in a few months I'll be playing in the Premier League — then they'll see". This story will contribute in letting this player see certain spaces for action rather than others. On the one hand, his choices will be affected by his eagerness to show his talent and worth; he might thus have a tendency to not pass the ball, keeping it for himself in the hope to draw everybody's attention, and to have the opportunity to goal. On the other hand, even when he passes the ball, the excitement and the anxiety given by the awareness of the importance of a good performance might worsen the performance itself, by hampering his ability to play in the smooth and precise fashion he has learned during his training. An older, more experienced player will probably behave very differently, because many crucial factors are different in him: his drives and motivations, his self-awareness, his aspirations, his knowledge of his own weaknesses, and so on. In a word, the stories he tells himself will be very different.

These considerations may be brought back to our discussion of virtual environments. A first remark concerns the different ways of interacting with technology that different users bring with themselves according to their narratives concerning the environment itself. A user with a sharp, and maybe a little anxious, awareness that she has to deal with a technological artifact will interact with it differently to one who is capable of letting such awareness go to the background and of focusing on what the environment affords. At least in part, thus, the "transparency" of technology depends on the user rather than on the artifact. While these differences may probably be made less sharp with suitable training, they can never disappear, if only because it is not always possible or worth giving a user such training.

There is, however, a second consideration, which has nothing to do with training or with anxiety caused by technology. The interaction that a user has with the virtual environment is driven by the narrative that she tells herself about her being there; such narration depends, in its turn, on her general and local reasons for interacting with the environment, as well as on her individual history and personality.

Think of a flight simulator and some of its possible users. The engineer who designed it will enter the environment in search of possible bugs and mistakes, so to be able to correct them before putting the simulator on the market. An officer, in charge of selecting which of several flight simulators available better fits the needs of the Air Force, will try to pick features like the smoothness and the believability of the interaction with the environment, or to assess the cost/quality ratio of the product. A pilot who uses the simulator to learn to fly a new fighter without the risks and expenses of a real test will focus on the limits of the airplane's maneuverability. When the simulator, now an obsolete model from the military viewpoint, will finally be launched in the electronic games market, a thirteen-years-old will use it with still a different set of purposes, paying no attention, for example, to how many flight accidents she may have, at least until her parents let her keep on playing.

Each of these users will experience a variable sense of presence, according to how much the environment will suit her needs, her interests, and the stories that she brings with herself in the interaction. Searching for bugs is something very different from trying to impress on one's friends.

Conclusions: Presence in virtual reality

We distinguished three levels in the interaction of an agent with her world, be it real or virtual: that of the situation, that of the action, and that of body movement and perception. These levels are not reducible to one another; instead, each of them contains the subsequent one, like the nesting Russian *matrioska* dolls, and returns as a feedback on the previous one. Thus, a circular relationship of co-determination exists between them.

Normally, an agent will not think of her movement in terms of a motor sequence (unless, of course, she has any reason to do so, in which case the motor sequence may become the action or the situation). Instead, she will choose and perform actions whose goals are part of a broader situation, which she represents as the activity, or the weave of activities, in which she is participating at each moment. This activities are, in their turn, supported by goals, values, knowledge, and roles that give them meaning, boundaries, a history, and possible directions of development.

Therefore, an individual will represent herself not as a monad with no history who "behaves" in an objectively given world, but as an agent who carries on a narrative about herself in the world. What is of interest to her is to follow complex flows of meaning relevant to the different choreographies in which she finds herself. Her representations and actions create her participation to such choreographies from moment to moment.

How does this conception of mind and agency, a constructivist and interaction-based one [19], affect our conception of experience and presence in virtual reality? The kernel of our position is that what is designed is interaction, or a landscape of possible interactions, rather than an environment.

This point may be reformulated by saying that the environment, even a virtual one, has a subjective, rather than objective, nature. The classic dichotomy between an external world, which is objectively given, and an internal world, which mirrors it faithfully (any discrepancy being a misrepresentation), does not capture the interactional nature of human agency. The meaning of the entities in the world lies in the affordances that they grant to the agent, and such affordances are not an intrinsic property of the entities alone, but a property of the interaction between the agent and the entities [26].

The availability of the affordances depend on the activities in which the agent is participating at each moment. Such activities result from the agent's previous history, which goes to constitute both her memory and the processes of recognition and reconceptualization that make such history immediately useful in the current interaction [27] [28].

Thus, what happens on entering a virtual environment is not that the user leaves behind the real world, whose role is, at most, that of an external disturbance which decreases or damages presence in the virtual environment. Instead, we bring our experience inside the virtual world, and, in turn, we integrate the virtual world in our experience, which will go to sediment in our overall future history and projects.

Something similar always happens in fiction. A book, a movie, or the tales that are told around a fire are familiar to us because we recognize their meanings in the light of our previous history, and integrate them in the weave of narratives in which we will live from that moment on.

Of course, a virtual environment differs from a book or a movie, in that, while the latter ask and afford us to just put ourselves in the characters' shoes, finding there a meaning of interest to us, in the virtual environment we can actually perform action and receive the corresponding feedback. The possibility of first-person action in the world, that is, the possibility of contributing to the generation and maintenance of world dynamics, and of receiving in turn the possibility (and the need) to generate and maintain our cognitive dynamics, is another crucial factor of presence, that is, of our capability to feel that we are participating in the world in which we find ourselves.

Beside this difference between fiction and virtual environments, our feeling of presence depends, in both cases, on the possibility for us to bring in some interesting meanings, and to integrate them in interesting ways with the meanings that the book, the movie, or the virtual environment proposes to us. In this respect, what counts is not necessarily the writer's or the designer's virtuosity: virtual, or fictional, worlds are not interesting because they provide a perfect duplicate of the array of stimuli that the real world provides, but because they grant us the possibility of recognizing stories that we feel as familiar, that is, stories in which we can bring our meanings, and as interesting, that is, stories which are worth integrating in our future experiences.

When the interaction is such that a good feeling of presence is generated and maintained, several other things will become possible. The first is that the mind supplies with its own capacities, at least to a certain extent, to the "low fidelity" of the simulated world. As we said above, what makes the difference is not technological perfection, but the type of interaction that technology permits.

Secondly, just as actions support presence, so does presence support actions. The feeling of presence is satisfactory when the user manages to make an overall sense of her interaction with the environment. When this happens, she will also manage to make it useful and interesting for her future narratives: in simple terms, she manages to learn something.

Thus, in experiencing a virtual reality environment, the user will bring with herself everything that she has been up to that moment, and her experience with the media will add to her "cognitive history". This may mean that she will have acquired knowledge (concerning the Qumran scrolls, or how to fly an airplane), or that she will have spent a few hours shooting nasty green aliens that want to invade the Earth, or, in the worst case, that she will have suffered from cybersickness — even this is an experience, however unpleasing, that will affect her possible futures.

What the designer does is thus to create an envelope within which interaction with the virtual environment may acquire a weave of narrative meanings. The goal of such enterprise is not intrinsic to the virtual environment, but is born out of the structural coupling between the user and the environment — and, sometimes, between the user, the environment, and a supervisor or a tutor who guides the interaction, as it may happen, for example, in an environment designed for neuropsychological or motor rehabilitation [29].

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