Abstract

The objective of this work concerns the design and the implementation of a zoomable interface implying the haptic modality. The initial postulate is that the zoom experience is not a natural, a direct experience, but supposes instrumentation and learning. In other words, the zoom experience is built by the appropriation of a technical substitution which makes it possible to modify the properties of the space-time flow; these properties which bind the subject to his (real or virtual) world are relational. To conceive this new interface, directly inspired from technologies known as of sensory substitution, we carried out a set of experiments allowing to define and to qualify the technical conditions and of use which favour the emergence of a perceptive experience of the zoom type. More generally, it concerns the proposition of more intuitive or immediate modes of instrumental interaction engaging explicitly the body in action.

1. Introduction

By using sensory substitution theories [1, 2, 3, 12], this work resumes the principle results allowing: i) to define a “haptic zoom” which encourages an active perceptive constitution and ii) to determine factors which are susceptible to lead to this perception. The choice of sensory substitution devices is crucial insomuch as they allow studying percept and space constitution through the subject activity and they underline the essential role of the technique which contributes tightly to this perception. Thus, a perception through a technical device is possible but it is constrained by the mediation of this device during the subject activity. The zoom, as a subject of study, is interesting and pertinent in the perception field since a zoomable perception exists only through the technical device. In other words, it supposes a mediation which is actively manipulated. And if this zoomable perception seems nowadays “direct” and “natural”, one always forgets that it was the subject of a collective construction (from the 16th century) and a technogenesis. The zoom is a constituted modern perceptive experience, leading the subjects to forget the device creating this experience.

In one hand, while using a visual 2D½ or 3D zoom (prospective information on the depth is present), our body is engaged in this zoomable landscape and we have the feeling to advance, to move or to navigate in this landscape. In the other hand, while using a visual 2D zoom (zooming on a fixed image), the device is of course forgotten, but we have the feeling of being motionless relatively to the zoomable object. We are static but the object is not, it is approaching or moving away. In this case, the prospective information [8] informs on the magnification but not on the depth.

From these observations, we were interested by a numerical zoom implying the haptic modality. Our first hypothesis is that a zoom, which is generally visual, can be transposed to other perceptual modalities. We have tried to design a “haptic zoom” and to define its conditions of appropriation and use.

The designed zoom can be virtual or real1 and the both present disadvantages and advantages which will be developed in the following sections.

2. Haptic zoom

In this study, the zoom is either an image expansion (real zoom) or an expansion of the virtual sensor (see below). Indeed, we can consider that the zoom function is a relative ratio between the perceived image and the sensor. While zooming, one modifies this ratio either by increasing the image size inside the capture

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1 The two zooms are operated in the numerical (virtual) space. However by “real zoom” we mean a real expansion (change of size) of the objects on the screen which is perceptible in term of distances. In the case of the “virtual zoom”, the object size remains fixed because the size change is carried out on the virtual sensor. This last is considered as virtual because the perception of distances is possible only under certain conditions.
windows or, by decreasing the windows size and keeping the image size fixed (see figure 1).

Figure 1. a) Initial image, b) real zoom, c) virtual zoom.

3. Experimental device

Tactos [10, 11] is a platform which allows the exploration of digital 2D shapes on a computer screen using tactile stimulations of the index finger. It includes three parts: a computer, a graphics tablet with stylus, and tactile stimulators (see Fig. 2). The stimulators are two electronic Braille cells, each including eight tactile pins. They are connected virtually to a sensor able to distinguish figures from the background on the computer screen. In other words, when the virtual sensor is on the outline of the figure a signal is transmitted to the stimulators and the corresponding pin is raised. The idea is to move the stylus on the graphical tablet so that a figure on the computer screen can be explored and recognized even though the user is blindfolded.

4. Main results

Different experimental situations have been led in order to define factors which encourage a zoomable perception through the haptic modality.

4.1. The smallest perceptible

The zoom is a variation on the axis of scales [5] which is infinite but which is limited by the perceptual capacity of the human being. At the haptic level, the zoom experience is submitted to the same conditions: human movements which allow this perception are limited by physiological characteristics.

The first result of the first experiment [16] shows that the perceptual limit of subjects through a sensory substitution device is between 0.03 and 0.05 mm. These values correspond to the smallest displacements that a human being can produce. This result indicates that the motor resolution of 0.069 mm [7] can be risen above. In our case, the absence of the visual modality can explain this rise.

4.2. Space perception

The haptic zoom implicates two spaces: it can be corporeal (real), i.e. the scale variation in on the shape (zoom on image); or it can be virtual (numerical), i.e. the scale variation in on the matrix (zoom on sensor). In the first case, the zoomable experience is happened in the corporeal space of the subject where their exploratory movements are adjusted according to the scale change of shapes. In the second case, the zoomable experience is happened in the virtual space, i.e. the screen space which is the space of interaction of objects and matrix which is displaced by the subjects; in this case, object sizes change relatively to the other virtual objects but stay unchanged in the corporeal space [17].

4.3. Speed reduction

The reduction of the speed displacement during the exploration activity is an important factor in the case of the virtual zoom. Indeed, for this last, any scaling is operated in the virtual space and the object size does not change in corporeal space.

To make this zoom “palpable”, the subjects reduce spontaneously their exploration speed at each zoom-in (reduction of the matrix size) and thus live the scaling experience. This speed reduction was already noticed during a precedent experiment [16] where the subjects changed their speed from 0.12 m/ms to 0.05 m/ms in order to be able to perceive the smallest sizes of letters.

This point was the subject of a more detailed study [19], and allows to release two profiles of subjects: i) the subjects which perceive a scaling, in this virtual case, because they succeeded in reducing sufficiently their movements according to the reduction of the matrix size and ii) the subjects which did not live the scaling experience because their speed remained quasi constant even higher according to the reduction of the matrix size.
4.4. Nature of task

The performances of the subjects vary according to the chosen task. Indeed, during different experiments, subjects were to carry out tasks of recognition of two types: a task limiting only to the recognition [16, 19, 20, 21] and a task requiring an additional estimation of distance [15, 17, 18].

The Table 1 summarizes the performances obtained according to the nature of task (OD: without distance estimation, WD: with distance estimation).

As shown on Table 1, performances in task OD are largely higher than the performances requiring distance estimation. Moreover, if we notice that the use of a virtual zoom is as efficient as a real zoom during a OD recognition task (1, 2a, 4a and 4b) it is not the same for a WD recognition task (3a and 3b); a zoom on image seems much more judicious for this type of task. This is due to the ambiguity between the corporeal space and the virtual space. Moreover, the performances for a real zoom are definitely higher because the change is palpable in the corporeal space (3c) and allows more precise distance estimation.

Table 1. Subject performances according to the nature task (WD and OD), (R for real zoom and V for virtual zoom)

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Task nature</th>
<th>Conseq.</th>
<th>Perfor.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 [16]</td>
<td>R &amp; V</td>
<td>↑</td>
<td>62 %</td>
</tr>
<tr>
<td>2a [19]</td>
<td>R &amp; V</td>
<td>↑</td>
<td>70 %</td>
</tr>
<tr>
<td>3a [15]</td>
<td>V</td>
<td>↓</td>
<td>33 %</td>
</tr>
<tr>
<td>3b [17]</td>
<td>V</td>
<td>↓</td>
<td>33 %</td>
</tr>
<tr>
<td>3c [18]</td>
<td>R</td>
<td>↑</td>
<td>67 %</td>
</tr>
<tr>
<td>4a [21]</td>
<td>V</td>
<td>↑</td>
<td>80 %</td>
</tr>
<tr>
<td>4b [20]</td>
<td>R</td>
<td>↑</td>
<td>80 %</td>
</tr>
</tbody>
</table>

4.5. Proprioceptive experience

The proprioceptive experience is in close relationship to the range of selected scale. Indeed, the range of scales plays an essential part in the zoom perception. Subjects do not perceive the scaling for objects whose size is lower than 2.4mm because they have the impression to cross the same distance [19]. These small movements request hand and wrist movements. Contrary, for higher object sizes, scaling are perceived proprioceptively because the movements also request the front-arm.

4.6. Zoom-in, zoom-out and intermediate levels

When the subjects handle a haptic continuous zoom [20, 21] as on visual zoomable interfaces [4, 9, 13], they do not have any difficulty in make the distinction between a zoom-in and a zoom-out. In the same manner to a visual zoom, the zoom-in gives access to the detail and to position with precision on the object whereas the zoom-out, little used, is it used only to give a global view of the scene and allow them to centre the cursor on the objects present in the space of perception.

Another result showed that the maximum number of handled levels seems to be of 25. Indeed, subjects do not handle more than 25 levels and this, even if they have the possibility of handling some more (100 and 1000 levels) [20, 21].

5. Conclusion

In one hand, these experiments helped us to better understanding the constitution of a zoomable perception which corresponds to an alternation of expansion and depth when it is visual and by either a real displacement on a surface or the displacement of an object relatively to another when it is haptic. In the other hand, they reinforced us in the idea that a prosthetic perception is submitted to the same laws than the others perceptual modalities. Perception by means of prosthesis is a new perceptive experience which can be subscribed in our collective experience (at the enactive meaning, see [14]) by its learning as well as a “natural” perceptive modality.

The study of the zoom, as a perceptive experience mediated by the technique, enabled us to release that, when this last contains prospective information on the depth, it “affords” (In the Gibsonian meaning, see [6]) the locomotion, and that the subject, if he/she does not move, is engaged with his/her body in this virtual landscape. It is one of the essential reasons which make that the subject is in a perception of type “I approach / I move away from the object” and not of the type “I increase / I reduce the object”. This last case is the case of a zoom which do not contain any prospective information on the depth such as for example a 2D zoom.

We also highlighted that, if the zoom is a perceptive experience often conceived as visual, it is possible to constitute this perception with another perceptive modality (haptic in our case) whereas the tactile is not favourable to a depth perception in the real world since this sense requests enormously the contact with the object. In other words, the depth experience can be the subject of a true substitution within the framework of the interaction of the subjects with virtual objects.

Finally, we noticed that, even if a virtual haptic zoom is theoretically equivalent to a real haptic zoom, the two situations prove to be different and even contradictory in certain situations. Equivalence is true only when the subject is confronted to task recognition.
but disappears when the task integrates a distance estimation.

References


