Natural Limits of Artificial Realities *

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Without hands and feet He goes fast and grasps; without eyes He sees; without ears He ears. He knows whatever is to be known, yet there is none who knows Him. They say He is the foremost, the great Infinite Being.

"S'vetas'vatara Upanishad"

The universe is information and we are stationary in it, not three-dimensional and not in space or time. The information fed to us we hypostatize into the phenomenal world.

Philip K. Dick, "VALIS"

Abstract

We propose a preliminary exploration of the outskirts of the research area concerned with the design of artificial reality systems. Our goal is to clarify the concept of artificial reality and its connections both with other kinds of computer systems and with the world we live in (natural reality). In order to provide a framework for such a discussion, we sketch a list of dimensions along which to classify artificial realities.

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1 Introduction

A complete definition of the concept of *artificial reality* (AR) seems to be an impossible (if not gratuitous) task. According to the Webster Dictionary [11], *real* means "not *artificial*, fraudulent, illusory, or apparent". So, in a way, the expression *artificial reality* is an antinomy. On the other side, we can find some support for the intuitive appeal of this concept in Berkeley's first principle of human understanding [2] *esse est percipi vel percipere* (being is either being perceived or perceiving). If *being* is *being perceived*, it is obvious that virtual objects presented by a set of sufficiently sophisticated output devices have (almost) the same ontological dignity as real objects (i.e. objects perceived in natural reality).

However, not all realities are possible. In other words, there are limits to the possibility of understanding and creating new realities. Such limits stem from the organization of human body (and in particular its brain and moto-sensorium), which is the result of thousands of years of interaction with the environment we live in (both from a phylogenetic and an ontogenetic perspective). Maturana and Varela [9] have provided a very detailed account of this issue. An implication of this observation is that it is impossible to get rid completely of natural reality (NR): it will always *be present* in the organization of the brain of the user (as well as of the designer) of any AR.

It has been argued (Wahlster *et al.* [10]) that in order to produce optimal multimodal output, we need a sophisticated representation of the contents to be communicated (No Presentation without Representation). This claim has even stronger implications if applied to ARs: an AR (presentation) requires a computational model of a reality (representation); so, only realities whose models belong to the class of decidable functions, are actually possible.

2 A Taxonomy of Artificial Realities

After these preliminaries concerning the ontological status of ARs, we will classify such systems along some relevant lines. We intend to clarify the relationships between NR and ARs in order to make explicit the constraints that the structure of NR imposes on the range of possible ARs. Such relationships are established (and exploited) in both the two phases during which people and ARs interact: viz design and use. The taxonomy we propose is organized along the following dimensions:

1. Kind of relationship with NR: the simplest kind of relationship is that of a duplication of NR (the case of TV, simstim);

   a further step is the case of an analogical link (e.g. a simulator used to train people in some skilled activity);

   a more abstract kind of relationship is that which embodies some kind of metaphor; in this case, the objects of the AR could also lack any kind of perceptual similarity with natural objects (e.g. Gibson's cyberspace);

   a system that uses apparently physical objects to represent abstract natural concepts (as described by Foley [5]) embodies an even subtler connection between the AR and the natural world (e.g. the visualization of a gravitational field as a tridimensional responsive object);

   it is also possible to conceive systems in which there is no obvious link between what is perceived and natural phenomena (some *abstract* videogames such as Sqix! [4] seem to suggest what an AR of this kind could be like).

2. Accuracy of the mapping from the user's natural actions to their counterpart in the AR: it is often the case that the input devices available to the user cannot be controlled by him/her in a satisfactory way. It is then necessary to filter the input data in order to approximate a certain standard: for instance, many drawing utilities have the option of mapping a movement of the mouse into the closest straight segment. Such a filtering can help with certain limitations in hardware and human precision.

3. Degree of interactivity: an AR can be as non-interactive as a TV set, or as completely interactive as NR. It is an arguable matter whether interactivity is one of the necessary characteristics of any reality (if so, simstim would not count as an AR and Berkeley would somehow be wrong).

   It is obvious that the degree of interactivity depends on the quality of the sensory feedback: it has to be very high, since perceptive adequacy definitely is a necessary characteristic of ARs.

4. Purpose of the user of the AR: ARs, as all artifacts, are designed and used for certain purposes. It is possible to classify ARs with respect to the kind of effects that the user intends to achieve in NR.

Use for entertainment is self-justified: i.e. it does not imply any permanent modification of NR.

Systems used for training are seen as means for the improvement of the user's behaviour in NR (i.e. they are only intended to modify his/her brain).

Also access to large amounts of abstractly structured information can be supported by reification in some sort of reality. We are going to explore this particular application area in the next section. In interface applications, ARs become powerful tools for the manipulation of physical or computational structures.

One might think that the peculiar perceptual characteristics of ARs prevent us from exploiting them as tools; however, this objection can be dismissed if we consider the heideggerian point of view: *the kind of dealing in the world which is closest to us is not a bare perceptual cognition, but rather that kind of concern which manipulates things and puts them to use* [7]. This remark implies that ARs will always be accessed for some definite purpose and (in this respect) will not be different from any other computer application.

It is worth noting that the dimensions of our classification are not independent from one another. A finer analysis of interactivity degree (dim. 3) has been provided by Laurel [8]. She points out three aspects for evaluating the degree of interactivity: frequency, range and significance.

- interactive frequency is a measure of how often user input is enabled.
- interactive range describes the range of choices available to users at a given moment in the interaction.
- interactive significance is a measure of the impact of the users' choices and actions upon the whole.

A comparison between Laurel's analyses and our taxonomy highlights some interactions between the dimensions we propose: the accuracy of the mapping of the user's actions into the AR (dim. 2), being strongly connected with interactive significance, overlaps with the degree of interactivity (dim. 3).

In the next section we provide an application of the proposed taxonomy. We use such a framework as a basis for analyzing an emerging technology which we think to be a potential paradigm for the design of AR-based human-machine interfaces: hypermedia.

3 From Hypermedia to Cyberspace ...

Halasz [6] defines hypermedia as *a style of building systems for information representation and management around a network of multimedia nodes connected together by typed links*. Such a paradigm allows interactive information access through a number of perceptually rich communicative channels. It actually seems to have many features in common with AR, which could be seen as the limit to which hypermedia systems will converge.

Hypermediality, more than other paradigms, puts an emphasis on the possibility of building an intelligent interface that exploits capabilities we have in nature for the execution of tasks which are only metaphorically related to them [3]: the relation between hypermedia and NR (dim. 1 of the above taxonomy) consists in the exploitation of the physical metaphor of navigation for the cognitive task of exploring an information base.

With respect to Laurel's analysis of the degree of interactivity, it is possible to connect the dimensions of range and frequency with the number of links per node and the fineness of granularity.

Granularity is a measure of the size of hypermedia nodes [1]. Actually, hypermedia seem to lack intrinsic temporal aspects: in general, the rate at which information is presented is determined by the browsing activity of the user; nevertheless, the average time required for exploring a node can reasonably be assumed to be proportional to the quantity of information it contains. Combining this assumption with Begoray's claim that *as node size decreases, the ratio of links per node (connectivity) increases*, we can conclude that a user will be allowed a number of choices proportional to the fineness of the granularity of the network.

The correspondence between the range of choices provided by an interactive system and the ratio of links per node of a hypermedia network is more evident, since the set of possible moves in the context of a specific node is exactly defined by the links outgoing from that node.

Existing hypermedia systems do not cover all the application areas for which it is possible to foresee AR-based interfaces: they are only used for the interactive presentation of static information. It is arguable whether this fact stems from intrinsic limits of hypermedia or could be denied by future systems.

Anyway, also within the area of information access, hypermedia could evolve (in a relatively short time) into something much more powerful. For instance, the quick development of ARs might soon make possible the design of a first version of Gibson's cyberspace: a tool for navigating

in an network of structured information (just like a *standard* hypermedia system) whose spatial metaphor is supported by an extremely rich perceptive output (comparable with that which is produced by current AR prototypes).

4 ... and Beyond

We have argued that not all ARs are possible or meaningful. The limits stem from the fact that ARs are artifacts: tools the user exploits or environments in which s/he acts. Both the user and the designer of an AR are forced to ground the process of generating and interpreting metaphors on their knowledge of NR. Such constraint imposes a set of limits which should not be perceived as negative, since they will probably prove to be a very precious guide for further advance of AR technology. Of course, a precise definition of such limits will require joint contributes from a number of different scientific areas.

A similar interdisciplinary effort will probably be necessary for the identification of all the application areas for a fully developed AR technology (most of which are still to be invented). Yet it is already possible to point out some applications that seem to be a natural outgrowth of current systems.

An area which needs further exploration is the exploitation of powerful spatial metaphors for designing interfaces to systems that allow to manipulate (and not only to access) complex information structures. Current AR systems (included those oriented to the manipulation of structures: flight simulators, environments for the analysis of complex chemical constructs, CAD systems) seem to be rather conservative with respect to dim. 1 of our taxonomy. We believe that the design of tools that combine a strong perceptive impact with a certain amount of indirectedness in their metaphorical linkage to NR is an area which definitely deserves at least some exploration.

References

[1] Begoray, John A. - *An Introduction to Hypermedia Issues, Systems and Application Areas* - International Journal on Man-Machine Studies, vol. 33, n. 2, 1990.

[2] Berkeley, George - *A Treatise concerning the Principles of Human Knowledge* - 1710.

[3] Carenini, G., Ponzi, M., Stock, O. - *Combining Natural Language and Hypermedia as New Means for Information Access* - Fifth European Conference on Cognitive Ergonomics, Urbino, Italy, September 1990.

[4] Dutil, Marc - Sqix! 2.1 - (c) IDMED inc. - 1988.

[5] Foley, James D. - *Interfaces for Advanced Computing* - Scientific American (special issue), October 1987.

[6] Halasz, Frank G. - *Reflections on NoteCards, Seven Issues for the Next Generation of Hypermedia Systems* - Communications of the ACM, vol. 31, n. 7, July 1988.

[7] Heidegger, Martin - *Being and Time* - 1927.

[8] Laurel, Brenda K. - *Interface as Mimesis* - In: Norman, Donald A. and Draper, Steven W. (eds) *User-Centered System Design* - 1986.

[9] Maturana, Humberto and Varela, Francisco - *Autopoiesis and Cognition: The Realization of the Living* - 1980.

[10] Wahlster, Wolfgang *et al.* - *WIP: The Coordinated Generation of Multimodal Presentations from a Common Representation* - NATO Workshop on Computational Theories of Communication, Castel Ivano, Italy, November 1990.

[11] *Webster's Seventh New Collegiate Dictionary* - 1976.