Speaking Spaces: Virtual Reality, Artificial Intelligence and the Construction of Meaning

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ABSTRACT

This paper explores how linguistic methodologies can be used to analyse virtual reality applications. VR environments function in ways that are similar to instances of human languages in that both are endowed with some form of signification through the construction of meaning. We can, therefore, describe the syntax of a VR world. By combining syntactic analyses of VR with a consideration of other factors such as culture and discourse, we can develop a “grammar” of VR. This grammar can be used in AI/VR applications. It can also become an important factor in understanding how the human mind works.

Keywords: virtual reality, artificial intelligence, VRML, virtual environments, linguistic analysis, semiotics, culture, discourse

1 INTRODUCTION

In the folklore of computer technology, two icons have emerged as its holy grails. One is the HAL 2000: the artificial intelligence (AI) from Stanley Kubrick's 2001: A Space Odyssey. The other is the holodeck: the virtual reality (VR) system from Star Trek: The Next Generation. There are, of course, no HALs or holodecks among today's computer applications. However, this situation has not diminished interest in AI and VR development. Corporations and research institutions are spending millions of dollars to develop natural language systems that provide computers with a more “human-like” interface. VR is coming into the mainstream through games and business applications. Indeed, HAL and the holodeck are so embedded in the popular psyche that they have become the touchstones by which current AI and VR applications are assessed.

The buzzword that underlies this interest is interactivity. Both HAL and the holodeck represent the most engaging forms of human-computer interfaces. The former not only can beat you at chess, but will also engage you in a lively conversation while doing so. The latter immerses you in a virtual environment that is full of visual, tactile and auditory stimuli that are indistinguishable from the real world. The level of interactivity they depict continues to fuel the public's—and researcher's—interest in AI and VR.

At first glance, the kind of interactivity found in AI seems very different from that of VR. AI focusses on cognitive interactions involving language. People become engaged with the computer by speaking to it and having it talk back. AI's components are phonemes, lexicons, syntactic and semantic systems, and knowledge representation. Interaction in VR, on the other hand, seems to be primarily physical in nature. People walk through a virtual environment, grab and move objects, and listen to spacialized sound cues. The terminology associated with this technology involves actions and physical materials: objects, textures, events and behaviours.

However, interaction in today's VR applications—and those of the foreseeable future—is not physical at all. We do not actually walk through a virtual environment; we use input devices to navigate through it. We do not really pick up a virtual object, we activate a behaviour that simulates our picking it up. Our interactions with VR applications have less to do with kinesiology and more to do with cognitive processing.

In fact, our responses to VR are similar in many ways to those of AI. We provide linguistic inputs to an AI application and interpret its language-based output. In VR, we view what is happening on the screen or head-mounted display, interpret what we are seeing and then respond to it. Indeed, we can have a better understanding of interactivity in VR if we view it in light of the work being done in linguistics and artificial intelligence.
2 VR AS LANGUAGE

The cognitive aspects of VR are readily apparent. We view a scene, analyse the information, and then react to it. However, this system does not end with visual processing. We also interpret what we see in the virtual world in order to make sense of it. In many respects, a virtual world takes on the characteristics of a linguistic utterance.

The idea that VR has some relationship to language is not new. Indeed, researchers have drawn parallels between linguistic and visual processing for some time. In 1970, R. L. Gregory attempted to show how Chomsky's Transformational Grammar is related to visual processing. He states:

The deep structure surely represents hypothetical meanings allowed by the words and the surface structure in a sentence. This is very similar to the meaning given to retinal patterns in terms, ultimately, of the structure of the world of objects. (165)

Gregory's application of Transformation Grammar to an understanding of visual processing is, admittedly, rather tenuous. However, he raises an important point. The cognitive processes involved in understanding the world that we see are directly related to how we understand language.

This view is adopted by many of the commentators on VR. Brenda Laurel, for example, argues that VR is more than a visual medium. She notes:

While it is true that its principal lines of research all began before VR had a name, VR was the nexus that revealed new synergies and gave each of them new impetus and a new arena of expression. Although vision is certainly the means by which we perceive text and numbers on computer screens or hard copy, the primary activity is not sensory or perceptual but cognitive (202-03)

N. Katherine Hayles echoes this view when she defines virtuality as "the perception that virtual structures are interpreted with informational patterns" (4-5).

Both Laurel and Hayles believe that our experiences with VR are not limited to sensory or visual aspects. According to them, it is not enough for us to see a virtual world and navigate through it. We must also mentally process it in order to endow it with meaning. In other words, we need to assign some kind of signification within a virtual world in the same way that we impose signification on a linguistic event such as a conversation or a novel.

When we navigate through a virtual environment, our expectations are very different from the ones that we have while walking down the street to buy a liter of milk. In the real world, we view our surroundings looking for visual cues to establish our position relative to our destination. We may or may not appreciate the weather, notice someone walking on the street, or any number of other possible stimuli. We may choose to take a different route to alter the sensory inputs that we receive. However, our experiences while navigating through a real space are different from those we experience in a virtual one. No person or group of people have set up the particular set of stimuli that we experience as we go to buy milk. The people, sights, sounds and smells that we perceive are the result of a myriad of random elements coming together at a particular moment.

A virtual environment, however, has a specific creator or group of creators, and the events and stimuli experienced in it have been planned to the smallest detail. Moreover, the creators of such a world generate a desire among users to interact with this space. In other words, a virtual environment must be created with a purpose. Users interact with the virtual space and interpret these experiences in order to fulfill this purpose.

This act of interpretation involves the construction of meaning. Indeed, we can compare how we react to a virtual environment to how we read a novel. A writer creates a text that must have some qualities that attract people to read it. It also has some underlying purpose that may, or may not, be made explicit. Readers interact (that is, read) with the text in some manner and interpret their experiences. During this process, they impose a structure for signification on the text and may, or may not, gain some form of satisfaction.

In a VR application, a developer creates a virtual world that entices people to interact with it. Like the novel, it has an underlying purpose that may, or may not, be made explicit. Users navigate through the space manipulating objects and triggering events as they go along. They will also be cognitively processing their experiences and imposing some kind of significance on what they see and do. The success of the virtual world depends on whether or not this signification generates a sufficient level of satisfaction among users.

We can, therefore, draw a direct link between the cognitive processes used in understanding language and those involved in interpreting VR. In fact, one can argue that language is an underlying component of this technology. In discussing landscape and narrative in virtual environments, Margaret Morse asserts that cyberspace is “not merely a scenic space where things could happen; it also incorporates the artificial intelligence or agency that orchestrates the virtual scene” (198). Morse goes on to describe how Ivan

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1Morse equates cyberspace with virtual environments.
Sutherland’s concept of the “ultimate display” is very similar to the concept of the holodeck:

Note that the realism of the ultimate display does not depend on appearing like reality or verisimilitude or referential illusion… but on the power of language or the display to make reality itself, or enunciative illusion (that is, appears to call a symbol forth into existence by speaking or drawing it; or what is known in linguistics as performative speech). (207-08)

For Morse, our experiences in VR are directly associated with our interpretation of the symbols that are presented by the virtual environment. In fact, she goes on to state that “the very notion of an environment or landscape… becomes more and more difficult to distinguish from the symbolic field itself” (227).

If we accept Morse’s premise that a virtual environment is indistinguishable from the “symbolic field,” it is possible to see VR as a form of language. Moreover, this language can be examined and interpreted using the same paradigms we use to understand human languages. In other words, we can apply a syntactic analysis to VR.

3 THE SYNTACTIC ANALYSIS OF VR

If VR is a language, we can assume that there is a production system that governs how objects, events and behaviours can be combined in various applications: that is, there must be a grammar of VR. This grammar, like those of human languages, would allow us to generate an infinite number of possible virtual environments. Moreover, these environments will have meaning and a recognizable stream of signification for other users.

But how do we establish the rules that govern a grammar of VR? While we can question VR developers about their methodologies for creating a virtual environment, they will not have a full comprehension or awareness of all the factors that influenced their decisions. In discussing a speaker’s knowledge of the rules of a language, Chomsky notes:

A person who knows a language has mastered a set of rules that assigns sound and meaning in a definite way for an infinite class of sentences… Of course, the person who knows the language has no consciousness of having mastered these rules or of putting them to use, nor is there any reason to suppose that this knowledge of the rules of language can be brought into consciousness. (103-04)

The same conditions apply to our knowledge of the linguistic rules governing VR. Let us say that we wish to create a virtual world that contains a table and chair. We know that under normal conditions, both the bottom of the table’s legs and the bottom of the chair’s legs lie along the same horizontal plane. We also know that there is a physical relationship between the two objects. There must be a certain distance between the top of the chair’s seat and the lower edge of the table. The chair should not be wider than the length of the table. However, how do we determine where to place the chair relative to the table? What angle should the chair’s orientation be in comparison to that of the table? How do we know when the positions of the two objects are “just right”?

Given that we cannot gather direct evidence for the linguistic rules governing VR, we need to work by observation and analysis. We must work in the following three stages:

1) collect a set of data relevant to the phenomenon we are studying,
2) develop a set of rules that will account for that data, and
3) test our rules against other sets of data.

As with linguistic investigations of human languages, the ideal source for our corpus would be virtual environments that are already in existence. This criterion is not as restrictive as it may seem. It is true that early VR applications were few in number because of the requirements of the computer hardware needed to render a virtual world and the level of programming needed to create the application. However, a remarkable drop in the cost of computer hardware with 3D-accelerated graphics and the proliferation of applications such as 3D games and the Virtual Reality Modeling Language (VRML) have resulted in an exponential increase in the number of VR applications that are currently available.

Once we have determined the source for our data, we must find a way to describe it in linguistic terms. On the surface, linguistic description seems ill suited for describing VR applications. We are not dealing with nouns, verbs and modifiers; instead, we are dealing with objects, textures, materials, events and behaviours. Nevertheless, it is possible to apply a syntactic analysis to VR.

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2 In 1965, Sutherland described a computer interface that is very similar to the concept of the holodeck:

The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display would literally be the Wonderland into which Alice walked. (As quoted in Morse, 207)
Consider a simple red sphere in an otherwise empty virtual environment. The sphere is one meter in radius. We will label this sphere as a *noun*. If we use a system such as Transformational Grammar for our analysis, we would say that we have a *noun phrase (NP)* with a noun (N) with the value *sphere*. We must also note that N is modified by an adjectival phrase (AP) consisting of two adjectives (A): one representing the radius and the other representing the colour *red*. Figure One shows the tree diagram depicting this structure.

**Figure One: The Syntactic Parse for a Red Sphere with a One Meter Radius**

At this simple level, we can begin to see how a linguistic description of a virtual environment can work. This is not to say, however, that the application of these methods to VR will be transparent. We can label objects such as a ball or a globe as *spheres*. However, what happens when the globe is not a texture-mapped sphere but a model of the Earth complete with geometry depicting mountain ranges, oceans and cities? We cannot simply categorize it as a sphere. We need to make a distinction between the two.

A key component of our syntactic study of VR will be to establish a criteria for labeling objects. These labels have to be both flexible and detailed. For example, the NPs for a texture-mapped sphere and a complete model of the Earth can be both labelled as *globes*. However, N for the former will have the value *sphere* while the latter can be called *geographic model of the Earth*.

The issue of describing objects becomes more complex when we are dealing with models that have different parts. For example, we will usually agree whether or not an object is a chair. However, how do we distinguish between a chair with round legs versus a chair with square ones?

One solution is to treat a chair not as a single object, but as an NP made up of several NP components. Under this rubric, a chair would be NP” and each of it different parts—the back, the seat and the legs—would be NPs that are subsets of NP”.

The back of the chair (NP’) is comprised of N, representing the geometry, and a number of APs that define its attributes (colour, size, et cetera). The seat is another NP’ that has N (geometry) and AP (attributes). The legs are also represented by NP’. However, this noun phrase is divided into four separate NPs. Each NP defines one of the chair’s legs and is comprised of N (geometry) and AP (attributes).

We can now draw a diagram depicting the structure for our chair (see Figure Two). While this method of description is cumbersome (and in the case of complex objects, practically overwhelming), it provides a degree of accuracy that enables us to develop a more complete hypothesis for the rule governing a grammar for VR.

**Figure Two: Syntactic Parse for a Chair**

Describing our adjectival phrases will also be problematic. When you read “the red sphere,” the task of parsing this phrase is not difficult because all the data is readily apparent. When presented with a red sphere in a virtual environment, however, you must deal a number of factors that are not easily discerned. How do we describe the quality of the colour? Is it shiny? Does it glow? Moreover, what is the sphere’s position in relation to the rest of the environment? What is its orientation? Standard language-based descriptions cannot adequately make these distinctions. We need to find a way of classifying and describing these modifiers using a methodology that can be applied to any VR application.

The Virtual Reality Modeling language (VRML) provides one such a solution. VRML is a scripting language that is a standard format for creating virtual environments and objects. Its goal is to be flexible so that any type of object or behaviour can be created using its system of nodes and fields. It consists of a set of nodes that instructs a VRML browser to render objects, textures, behaviours and events. Each node has a number of fields that delineates its attributes. For example, we can assign a colour to an object by using
the Material node. This node has a set of fields that controls the colour of the object, states its level of transparency, defines its shininess, and whether or not the object emits a colour. To make our sphere appear red, we can set the Material fields as follows:

diffuseColor 1 0 0
emissiveColor 0 0 0
specularColor 0 0 0
ambientColor 0.2
shininess 0.0
transparency 0

These values will give our sphere a solid bright red colour with no reflections. We can also specify the position of an object relative to the entire environment using the field values of the Transform node. For example, we can position the sphere in the center of the world along the x and z axes and raise it one meter along the y-axis by using the following field:

translation 0 1 0

If we use these field names and values to describe our adjective phrases, we can provide a consistent, accurate and complete categorization of all the descriptors that are modifying an object. Figure Three shows the tree diagram for this example.

Figure Three: Syntactic Parse Using VRML Nodes and Fields

Describing events and behaviours poses the greatest obstacle to our syntactic analysis. These elements function as verb phrases (VP). However while we can say that an avatar walks from Point A to Point B, the number of variables involved in rendering this image makes such a description totally inadequate. How quickly is the avatar walking? What direction is it going? How do we describe its gait? These elements are not clearly defined by the term walking.

Moreover, employing VRML to describe events and behaviours will not provide us with an acceptable solution. It uses keyframes and keyframe values to define these elements for a virtual environment. For example, we can set our sphere to rotate 45 degrees at a particular moment of time by setting a OrientationInterpolator with the appropriate key and keyValue. We then use the ROUTE node to define which object is affected by the interpolator. In this way, we are able to create a wide range of behaviours and events in a VRML world.

Using key and keyValue to define our verb phrases, however, is not a practical method for describing a VP. While simple behaviours can be created using a relatively small number of keyframes, these values are simply a set of numbers denoting time signatures as well as translation, scalar, rotation and colour field values. They will appear to be meaningless to a researcher. Even with a trained eye, someone examining such a description would have no idea as to what the verb phrase was actually denoting. Moreover, complex behaviours and events can require hundreds or even thousands of keyframes. Trying to draw a tree diagram with this number of values would render any analysis impossible.

A compromise solution would be to establish a standardized set of labels that can account for the majority of events and behaviours. These labels must provide a certain level of accuracy. They will also need to be descriptive enough so as to allow someone looking over the data to visualize the event or behaviour. If our red ball was to fall slowly for one meter, for example, we might describe this event as follows:

The red ball falls one meter for 2 seconds

Note that we have added the duration of the fall as well as its distance in order to clarify the nature of the event. These elements function as an adverbial phrase (ADVP) with an adverb representing the distance of the fall (one meter)3 and an NP with N representing the type of modifier (time in seconds) and a determiner (D) representing the value of N (2). We can represent this event in a graphical manner using a tree diagram (see Figure Four).

Figure Four: Representing Behaviours in a Syntactic Parse

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3Although the ADVP in this case would be parsed as an NP if we were examining English syntax, it functions more like an adverb modifying a VP in our analysis of VR.
The above description is, of course, only a preliminary model for a linguistic description of VR. A number of issues still need to be determined. The model needs a way of dealing with triggered events (such as clicking on a box to make it float in the air). It also requires a method for dealing with dialogue and ambient sounds. Nevertheless, we can see that a linguistic description of VR is possible.

4 THE NEXT PHASE: VR AS A SOCIAL SEMIOTIC

We have so far explored the methodology for determining a grammar of VR, but not the reason for taking on such an endeavour. For Chomsky, exploring the linguistics of human languages is a way to discover the nature of the human mind. He notes:

Personally, I am primarily intrigued by the possibility of learning something, from the study of language, that will bring to light properties of the human mind. We cannot not say anything particularly informative about the normal creative use of language itself. But I think that we are slowly coming to understand the mechanisms that make possible the creative use of language, the use of language as an instrument of free thought and expression. (103)

An exploration of the linguistics of VR, therefore, can provide us with another avenue through which we can understand the construction of meaning. Moreover, it will allow us to link visual and other sensory elements with language-based ones. By combining these two areas, we can begin to establish a unified model of cognition. We will learn not only how we derive meaning and significance from human language, but will also establish paradigms for understanding how this process is related to the ways in which we interact with the world around us.

However, a syntactical analysis of VR alone is not sufficient for a cognitive model of the mind. The former tells us about the structures that are possible in VR, but it does not explain why they are significant to us. Therefore, we must also consider ways to extend our analysis.

An important component of this extension is to consider the social aspects of language. In Language, Context, and Text, M. A. K. Halliday and Ruquiya Hasan argue that language is a “social semiotic”; that is, language can be understood in terms of its relationship to social structure. Halliday notes:

A text, then, is both an object in its own right … and an instance—an instance of social meaning in a particular context of situation. It is a product of environment, a product of a continuous process of choices in meaning that we can represent as multiple paths or passes through the networks that constitute the linguistic system. (11)

Hasan argues that if a text can be described as “language doing some job in some context,” we can also declare that it is “the verbal expression of a social activity” (56).

We can certainly point to areas where visual elements in one culture do not have the same connotation in another. In most Western countries, the colour white can denote purity and innocence. It is not unusual, therefore, to see a white dress on the bride during a wedding. However in Chinese cultures, white is the colour of death and is considered bad luck. Traditional bridal garb in this social context is red. If we place a white wedding dress in a virtual environment, a Western viewer will probably have a positive reaction to seeing it. A Chinese viewer, however, will find this image disturbing. The latter’s cultural knowledge would alert her to the fact that certain assumptions—a wedding is a celebratory event; a wedding should bring good luck; red is the colour that signifies good luck; white signifies bad luck—are being broken.

This kind of cultural coding is present in any form of communication, but it is particularly important in visual forms. Gunther Kress and Theo van Leeuwen argue that as we move from a verbally-oriented society to a visually-oriented one, the need to understand the cultural influences on our interpretation of visual communication becomes even greater. They note:

Visual communication is always coded. It seems transparent only because we know the code already, at least passively—but without knowing what it is we know, without having the means for talking about what it is we do when we read an image. A glance at the “stylized” arts of other cultures should teach us that the myth of transparency is indeed a myth. We may experience these arts as “decorative,” “erotic,” “mysterious” or “beautiful,” but we cannot understand them as communication, as forms of “writing,” unless we are, or become, members of these cultures. (32)

In order for VR to work as a language, the “speaker” (the person or persons who created the virtual environment) and the “receiver” (the user of that environment) must belong to the same culture. Seeing a man dressed in black tights contemplating a human skull may initiate a flurry of meanings and associations to someone with a knowledge of English-speaking culture, but it is doubtful that the same image will have a similar resonance to someone with an awareness of only Bedouin culture.
Moreover, we cannot limit our understanding of the social aspects of VR to the study of specific icons. Our cognitive model of VR must also deal with virtual worlds on a discoursal level. If we can say that a VR environment is a linguistic act—that it can be used to express some kind of meaning—we need to determine the rules that govern how its various components can be linked to generate some form of signification. Indeed, much of a VR application’s impact depends on the narrative structures that underlie it. Laurel notes that the study of how we “construct contexts and narratives in VR is a recent but equal partner to the study of human sensation and perception as we ponder what is going on in virtual worlds” (206). According to her, our reactions to VR are dependent on dramatic forms. She notes:

Our experiences with VR to this point also confirm that human experiences in virtual environments are enhanced by dramatic forms and structures that support complex emotional textures. Indeed, these characteristics emerge from the constructive activities of human interactors even when they are not purposefully embedded in the potentialities of the virtual world. (207)

The detection of these forms in VR does not mean that the creator of a virtual world intentionally included them. They may have been subconsciously inserted, or the viewer’s own biases and idiosyncrasies may have imposed them on to the world. However, the rationale for the presence of these dramatic forms is not important. What is important is that a common set of cultural assumptions must be shared between the creator of a virtual environment and its users in order for that world’s communicative potential to be fulfilled.

An early attempt to use VR as a discursive medium is “Construct(s) and Même-ing.” It is a series of five virtual worlds that form an “essay” on new media and virtual reality. It is also an experiment to see if virtual reality can function as the “text” for making an argument. Each of the five virtual environments in “Construct(s)” deals with a particular issue relating to virtual reality and new media. In the third environment, for example, a transparent model of a human brain floats above the ground (see Figure Five). Within this model, three spheres are linked to a cube. Behind it are five pairs of panels that alternate position (see Figure Six). Each of these panels contains an image that is linked to the other in the pair. The environment also contains a large model depicting the characters “2B.” When a user approaches these characters, a gong sounds, the models sink into the ground and another pair of characters (“D4”) rises to the surface. The different elements in this environment are meant to convey the idea that new media is dependent on fixed cultural assumptions. Users wandering through the virtual environment must make a number of connections between a variety of elements in order to comprehend this pattern of thought. The brain model with its fixed spheres and cube contrasts with two other environments in which models of a brain have spheres orbiting a rapidly spinning cube. The image panels deal with allusions and their referents: Mishima and the samurai; Proust and Wagner; T. S. Eliot and Shakespeare; Kurosawa and Van Gogh; Mrs. Peel (from the television series The Avengers) and the Gunpowder Plot. The characters “2B” and “D4” are the hexadecimal equivalents of the line from Hamlet: “To be or not to be.”
However, the success of this environment is entirely dependent on the ability of the users to recognize the various references associated with the various objects. They must have a certain level of cultural knowledge in order to find any significance in what they see: Eliot’s use of Shakespeare, Kurosawa’s film *Dreams*, Proust’s references to Wagner’s *Parsifal*, British television of the 1960s, and the works of Mishima. It is readily apparent that these referents all have a specific cultural bias. Users without the appropriate knowledge of English, European or Japanese culture would not be able to identify the different elements. More importantly, they would not be able to make the cognitive links necessary to perceive the underlying message of this environment.

Therefore, a cognitive model for a VR grammar must find ways to incorporate the social and cultural factors that influence the production of meaning. Moreover to achieve this goal, we have to consider a grammar that not only can account for the relationship between syntax and semantics, but will also deal with the technology’s discoursal function. It is not enough to understand how different elements come together to create an object and its behaviour. We also need to understand how all the elements in a virtual environment work together to fulfil a certain purpose. In essence, we must endeavor to turn our model of the language of VR into a model of the mind.

5 VR, AI AND BEYOND

The ultimate goal of a VR grammar would be to create an AI application that can generate original and compelling virtual worlds. This AI would have its own form of the Turing Test. We would place users in a room with a computer display and the appropriate input devices. They would be told that several virtual environments will appear on the display for them to try out. They would also be informed that some of these worlds are created by humans and the others by the AI. The users would then be asked to evaluate whether a particular virtual environment is man-made or generated by the computer program. The AI would pass the test if every user is fooled into believing that its worlds were created by a human.

While this goal would prove that our VR grammar is an accurate model of the human process, it would not find many practical applications. However, practical applications can be developed by applying a VR grammar to AI. We could, for example, create AI systems that translate virtual environments from one cultural context to another. The AI would determine the culture of the user and then replace certain objects and behaviours with ones that are more appropriate. VR developers would not have to worry that a user from a different culture would not be able to use their creations. This kind of application will become more important with the continued growth of the Internet and as globalization affects more markets.

Another possible application would be an AI system that translates virtual worlds and objects into signals that can be understood by the visually impaired. This type of AI would use a VR grammar to analyze a virtual environment and then translate its analysis into sounds and tactile feedback. It could also enable this group of people to create their own VR applications.

We can see that the linguistic analysis of VR is more than an academic exercise. It has implications for understanding the workings of the human mind. It also has real-world applications that can greatly expand the ways in which we communicate with each other.

However, the immediate result of this kind of analysis will be to expand our understanding of VR and its impact on us. If a virtual environment can be seen as a linguistic act, then we must first determine what we want to say and then design how we want to say it. If signification is achieved not by visual cues alone but by also incorporating narrative and dramatic forms, then we must be sensitive to the social and cultural influences that affect these forms. In the end, it is not enough to make our VR worlds visually pleasing; we must endow them with meaning. We must learn how to make our virtual spaces speak.

REFERENCES


