Exploring the nature of electronic space through semiotic morphism

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ABSTRACT
Electronic spaces present endemic properties and structural relationships that are difficult to decode. Using these spaces to their full potential for effective communication and expression is difficult without understanding how they signify meaning. Combining theories of digital media language, electronic space, computational semiotics and formal languages, semiotic morphism may be adopted as a new approach to understanding the nature of electronic space. This process is demonstrated in an electronic game, entitled *Semiomorph*. Semiotic morphism may lead to new understandings of existing electronic spaces, provide a framework for the creation of new space, and demonstrate structures and relationships that are unique to digital media.

KEYWORDS
electronic space, semiotics, digital media language, formal languages, installation, electronic games, architecture, new media, virtual reality, semiotic morphism

INTRODUCTION

Electronic space has been clearly identified as significant new form of representation. It is experienced in many different applications of interactive media, and through a range of different types of interface. However, it is characterized by complexity and specific problems in terms of perception, structure, and representation which make it difficult to decode. There are many levels to decoding, this paper defines it as the analysis of how an interface creates and communicates meaning. Insight into the unique ways that electronic spaces signify meaning is needed in order to develop further their potential for effective communication and expression.

Using these spaces to their full potential for effective communication and expression is difficult without understanding how they signify meaning. Recent theories of digital media have described electronic space as a significant structure in their language. The emergence of these new ideas has coincided with research into computational semiotics – the application of semiotic theory to digital media. Formal languages and systems for manipulating symbols that exist within the discipline of computer science provide insight into the computational nature of electronic space. This paper uses an interdisciplinary approach that considers these elements in its exploration of electronic space.

An approach that is inclusive of these elements is that of semiotic morphism, which proposes a formal system for the translation of sign systems. This will be examined as a methodology for discovering and analyzing endemic properties of electronic space. *Semiomorph*, a game situated in an electronic space based on semiotic morphism, is discussed in terms of the application of the theory presented in this paper.

This paper draws upon these sources, the author's experience of both experimental and commercial digital media, and the author's new media art practice that actively engages with themes addressed by the paper.

ELEMENTS

An interdisciplinary approach to electronic space reflects the various elements that have influenced and contributed to its development. These include a range of historical, cultural, and technological factors. In this case, the elements most relevant to establishing an understanding of electronic space are digital media language, computational semiotics, and formal languages.

Digital media language

Since the arrival of interactive media, there has been debate on what it is and how it functions. It has been described as a hybrid of traditional media, a medium of context and relationships, or as a system for manipulating symbols. Theorists have proposed a number of models for analyzing and deconstructing interactive media. Lev Manovich describes at length a language of new media that "use(s) the word *language* to signal the different focus of this work: the emergent conventions, recurrent design patterns, and key forms of new media." [20]

Stephen Holtzman sets out to "establish an aesthetic foundation for the use of computers for creative expression in language, music, art, and virtual reality." [11] Stephen Johnson explores the new relationships made possible in electronic space "Representing all that information is going to require a new visual language … If the interface medium is indeed headed toward the breadth and complexity of genuine art, then we are going to need a new language to describe it, a new critical vocabulary." [15] Jay David Bolter and Richard Grusin's theory of remediation discusses space in terms of "virtual reality is now refashioning the computer into a processor of perceptions." [2]

Each of these authors makes special reference to electronic space as having particular significance and opportunity in new media. Furthermore, it is described in terms of a new form of representation featuring unique opportunities for communication and expression. Holtzman states "At the same time that computers have opened up explorations of new visual languages, computers have also created a new *medium* for creative expression: virtual worlds." [12] Manovich comments "the computer database and the 3-D computer-based virtual space have become true cultural forms – general ways used by the culture to represent human experience, the world, and human existence in this world." [21] He also states "navigable space is a form that existed before computers, even if the computer becomes its perfect medium." [22]

Computational semiotics

This coincides with an interest in applying semiotic theory to interactive media, such as the research documented at COSIGN, a conference on computational semiotics for games and new media, that "explored areas of overlap (or potential overlap) between semiotics and new media". [3].

The chairs of COSIGN 2001, held in the Netherlands during September of 2001 expressed interest in the "development of systems in which we are creating new forms of meaning, new modes of expression, and potentially new forms of aesthetic function." [16] In order to analyze these new forms, the particular challenge for computational semiotics is recognized as "Understanding these systems (therefore) requires approaches that may identify principles of semiosis from a perspective from which form is fluid and highly variable." [17]

They also recognize the complex issues surrounding the analysis of electronic space from the point of view of computational semiotics in that "symbols already carry meanings that must be distinguished from the supplementary language of spatial symbolism that could include many specialized and new associations." [18]

Formal languages

Computer science has established a number of formal languages and systems for manipulating symbols [28, 29, 30]. These are well documented in a series of books on the subject edited by Grzegorz Rozenberg and Arto Salomaa who say, "The *modeling* of certain objects of phenomena has initiated large and significant parts of formal language theory. A model can be expressed by or identified with a language. Specific tasks of modeling have given rise to specific kinds of languages. A very typical example of this are the L systems introduced by Aristid Lindenmayer in the late 1960s, intended as models in developmental biology." [31] The computational nature of new media is highlighted as contributing to the new potential of electronic space by Manovich, Holtzman, and Johnson. Holtzman suggests that "the foundation for building these new worlds will be the explicit description of the structure of these worlds: the basic elements, the rules for combining and sequencing elements, deep structures, surface structures, as well as fractal representations." [13]

THE NATURE OF ELECTRONIC SPACE

Electronic spaces have specific problems in terms of their perception, structure and representation. Conventions for virtual objects and navigation, new forms of narrative using space and time, and dynamic iconography are beginning to emerge. A combination of direct engagement, an illusion of space, and identification with an avatar often result in significant engagement with electronic space. All of these attributes are active parameters that can be interconnected, made interactive, or algorithmically generated.

Electronic space

Numerous forms of digital media can be described as electronic spaces. This research is interested in digital media that uses a spatial representation as the primary interface for the user(s). This includes virtual and augmented reality, interactive artworks, electronic games, 3D MUDs, interface design, scientific visualizations, and architectural simulations. The defining properties of these electronic spaces may be described in terms of four main areas:

Feedback loop. A combination of direct control and immediate feedback create a strong sense of engagement between the user and the electronic space. The two are interconnected in a feedback loop that involves realtime exchange of information describing the actions and reactions of each party. As a result, navigating and manipulating the space feels natural. The user's awareness of any hardware interface recedes in their mind, and they experience a direct engagement with the virtual world.

On the other side of this feedback loop, the space that the user is engaged with is interpreting the users input and adjusting its representation and behavior in response. When compared with a static sign system, even a complex and multi-layered sign system, such as a shop interior or museum, this relationship between the user and the space creates a unique situation. A real space may incorporate digital media into itself, providing points of feedback and engagement, but electronic spaces are directly connected all the time. If the user of the space is interpreting it as a sign system, engaged in ongoing semiosis, so too the space is interpreting the user and the user's actions as signs to be decoded and given meaning. As a result of this dynamic relationship the representation, or interpretant, can alter the associations between signs and their signifiers in response to its reading of the users actions.

Mode of perception. Electronic spaces behave quite differently from real spaces. They exist in a realm where everything must be modeled and programmed – the starting point is a void. This presents a significant limitation in that to simulate reality in great detail needs to include complex models of physics, behavior, materials, flora and fauna, and so on. However, these spaces do not need to follow the rules of the real world – fantastic new experiences may be created based on their own rules of existence.

Electronic spaces are intensified by the mode of perception in which the user experiences them. When the feedback loop is working and the simulation is convincing, the user is successfully engaged with the space – this is often described as a state of immersion. This term describes an experience where intense focus is placed on the user's immediate experience of the virtual world. This connection is often strong enough that, psychologically, the user is inside that world.

This sense of immediacy is partly to do with the way these spaces are perceived. Engaging with the real world is an experience that immerses the body in their surroundings. Direct and peripheral vision, sound resonating within the environment, being able to move over, around, through, in and out of spaces, and the ability to observe and manipulate solid objects all contribute to this feeling of being in the world. It is a very immediate and intense experience. When this is recreated in an electronic space this intense mode of perception is also, in part, recreated. Although these spaces are entirely symbolic worlds, they are experienced in a mode of perception usually reserved for real experience.

Transmutational space. Electronic spaces are artificial constructions – simulations where the entire virtual world is a code, every part of the space is a re-representation. They allow multiple forms of representation to easily coexist and be blended with one another, creating hybrid systems of signs.

This could be described as a dynamic iconography where every node in a space can potentially be represented in many different ways. The underlying functionality and content may be mapped to different systems of representation. These include a diverse range of forms, such as text labels, simulated models, stylized iconic images, emulated behavior, photographic images, symbols, figurative and abstract forms. In addition, different viewpoints may be selected, data streamed from a range of sources, and visualization options toggled on and off. The same data can be represented in many different forms. These forms may be given active parameters that can be interconnected, made interactive, or algorithmically generated.

This is a kind of transmutational space, where representation is not fixed, but instead fluid and malleable depending on the relationships established between the numerous parameters. This process is potentially infinite, as these relationships may also be process driven and parameterized, meaning the entire representation of the space is constantly undergoing mutation and change.

World as sign system. In semiotic terms, a virtual world is simultaneously an index and an icon. Delving deeper into its structure it may be defined as a high order, complex sign consisting of web of many other complex signs. The study of semiotics has extended well beyond that of writing systems to include visual languages, spoken languages, biology (biosemiotics), plant life (phytosemiotics), and languages of animal behavior (zoosemiotics). Practically every aspect of the known world has been analyzed from the perspective of semiosis. Many of these systems are relevant to electronic space as it is rich in different forms of representation, including more unconventional forms such as that of the behavior of animal and plant life through the use of generative systems and artificial life.

Given it is an artificial construct, governed and defined by its own rules and laws of existence, an electronic space can be seen as an expression of a subset of known semiotic systems. The various processes of semiosis associated with different forms may be modeled such that the space becomes an expression of these processes.

In a good simulation all of signs are coordinated to work together to express that particular model of the world. Quite literally, nothing is without meaning or without an intended message. In this way electronic space is made of language.

Semiotic morphism

Joseph Goguen has proposed a formal language based on semiotics that can be used to describe digital media language. This system is called algebraic semiotics [4], and the basic premise is the adaptation of semiotic structures into functions and theorems using algebra and set theory. After definition in this system, mathematical operations may be applied allowing computational transformation of the semiotic relations.

The primary goal of this system is its application in user interface design, where it may be used as a tool for both generating new interface metaphors and evaluating existing designs. A clear distinction is made between the system, the computer program and its functions, and its representation, the graphic user interface. Goguen explains this as:

> "A user interface can be considered as a *representation* of the underlying functionality to which it provides access, and thus user interface design can be considered a craft of constructing such representations, where both the interface and the underlying structure are considered as (structured) sign systems. In this setting, representations appear as mappings, or *morphisms*, between sign systems, which should preserve as much structure as possible." [5]

A sign system is defined as structure of sets of sorts, data sorts, and constructors, ordering of these sets, relationships between signs, and a set of axioms, which are defined as sentences. Once a sign system is defined using algebraic semiotics, then semiotic morphisms where one sign system is mapped to another may be defined. In these morphisms the sets of sorts, data sorts, and constructors, ordering of these sets, relationships between signs are all mapped to "compound terms in the target system".

Essentially, this results in a structure and set of rules for the translation of a message expressed in one sign system to another. The new representation of the message occurs automatically. Goguen proposes this system as a tool primarily for interface design, as a way to describe the quality of a given interface metaphor in terms of "the precision that its approach can bring to applications". This is accomplished by:

> "Building on an insight from computer science, that discrete structures can be described by algebraic theories, **sign systems** are defined as algebraic theories with some extra structure, and **semiotic morphisms** are defined as mappings of algebraic theories that preserve the extra structure to some extent; the quality of representations was found to correlate with the degree to which structure is preserved." [6]

The preservation of structure is an important feature of semiotic morphism. [8] Although the same process can be done intuitively, this formalization introduced by algebraic semiotics results in more accurate mapping. Given a sign system may be extremely complex, with many different levels and relationships between individual elements in the system, using a computer to calculate all the translations makes a lot of sense.

Goguen makes a point of the importance of language in the system:

> "Just as we defined sign systems to be theories rather than models, so their morphisms are between theories, translating the *language* of one sign system to the language of another, instead of just translating the concrete signs in the models." [7]

In terms of semiotic theory, semiotic morphism allows the signified message to be mapped to various signifiers resulting in a system that generates different instances of semiosis. This strategy reflects the nature of the computer both as a manipulator of language and computational machine.

Semiotic morphism and electronic space
Can semiotic morphism be applied to electronic space? How can it be used to decode the properties of that space outlined earlier? Is it a useful tool for the construction of transmutational spaces?

As this theory of semiotic morphism has been developed for interactive media, it naturally includes terminology and concepts that reflect feedback and interaction. The feedback loop of an electronic space may be fed into the algebraic theory defining the sign system of an electronic space.

The idea of the user interface being a re-representation of the underlying functions of the program may be applied to electronic space. In this case the interface is the space itself, including characteristics such as its immediacy and immersion in relation to the user's mode of perception.

Furthermore, semiotic morphism creates a scenario where transmutation is a feature of the system, resulting in a structure suited to the creation of transmutational spaces.

As the system is defined in semiotic terms, the idea of the world as sign system is easily expressed in the terms of semiotic morphism.

This approach introduces a number of applications that provide further insight into the nature of electronic space:

Electronic space as an immersive sign system. The interface is defined in semiotic terms, and then translated into a theory that uses these terms and their structure. If this is applied to an electronic space then that space is treated as a sign system and can be addressed as such. Given that the experience of electronic spaces are often reported as being "immersive" then we can say that the user is immersed in signs in a very literal sense.

Inbetween and mixed spaces. Capturing "inbetween" states of an electronic space during the process of morphing could provide some interesting opportunities. As the process allows for morphisms to be generated using computation, different stages in the process may be observed and saved if desired. This may produce unusual hybrids of communications that may not have been produced by design – being ruled out as unconventional or too difficult to realize. Even if these hybrids proved to be dysfunctional in terms of interface design, they still may provide interesting insights into the nature of electronic space.

Multiple modes of representation. Blended and hybrid spaces that feature multiple modes of representation are typical of electronic space. Semiotic morphism provides a structure to formally articulate these hybrids, and (in theory) be able to computationally generate further hybrid spaces. As both the functionality of the space and its content are separated from their representation in the interface, switching between multiple modes of representation is technically and conceptually easier to achieve.

Conflicting modes of representation. Electronic spaces that use the juxtaposition of different systems of representation to highlight differences in them, particularly how a given message may take on a different meaning when translated. These spaces explore the process of meaning construction by demonstrating where it breaks down, enabling the exploration of how successful communication or expression occurs. Viewing these spaces of difference in terms of semiotic morphism provides a tool for the formal analysis of communication breakdown.

New aesthetics. These mixed spaces, spaces using multiple or conflicting modes of representation, and spaces that deliberately immerse the user in signs all introduce the potential for new aesthetics. These digital aesthetics, derived from the unique properties of electronic space, contribute to the sense of "new experiences" that was noted earlier. This supports the notion of the medium's potential as an original form of creative expression.

Emulation. Often, what is being represented by an electronic space goes beyond simulation. The behavior of entities, evolution and growth of life, interdependent relationships between objects in the space, and systems layered within systems are details that create a sense of the emulation of a complete environment within the computer. This is not a simple, static demonstration - other possible combinations of the representation are introduced, derived from the behavior and structure encoded in the system.

Generation of new meanings. Differences in the way sign systems operate in electronic space, such as their transmutational nature and immediate mode of perception introduce the opportunity for novel instances of semiosis. The process of semiotic morphism demonstrates one of the primary forms of this new meaning production. Each particular form of communication or expression affects the message it carries through its method of transmission and representation. Once this is known, it can be used to good effect. In this case, the strengths of electronic space, such as its immediacy, multiplicity and transmutational nature, may be exploited.

These observations on the nature of electronic space are demonstrated in new forms of software, electronic games, animation, and new media art.

NEW FORMS
Skins and mods
The idea of changing the appearance of a software application, such as an MP3 player or operating system, by applying a new "skin" has become a popular pastime in recent years. This involves replacing the images used to represent the controls, buttons and other elements of the Graphic User Interface to create a new feeling or style. In some instances the sounds are also replaced. The changes are purely superficial – in most cases the function, location, and behavior of the interface remains the same.

However, although the change is superficial, the meaning of the interface may be changed. *Rebirth* [27] is a music production and composition tool that emulates three well known analog bassline and drum machines that were produced by Roland in the 1980's. Shortly after its release, hacked forms of the software – called "mods" – began to appear that used the basic template of the software, but changed the graphics and sound. The Roland drum machines were replaced with other classic analog gear, and the interface given various thematic treatments. Later versions of the software included this process as a feature, and there is an extensive library of *Rebirth* mods currently online.

So, it has become common practice for function and the representation of that function to be separated. What is perhaps occurring here is the emergence of a cultural understanding of the basic principle of semiotic morphism – a set of meanings may be encapsulated in a system (the software) that may then be expressed in an infinite number of possible ways (the interface).

Digital media are obviously mutable, and in fact, invite mutation. However, although these skins demonstrate both the mutability of digital media and the separation of meaning and representation, the relationships built into the software remain the same, so it has limited application. This approach is taken further in electronic games in which the same process of hacking by users to make their own versions has led to mods being included as a feature of the software. Both the *Half-Life* [9] and *Quake* [26] game engines may be used in this way, with many amateur mods available on-line. This process has extended further to include the use of the game engines as a means to create narratives that are not playable at all, but viewed as a short film. Machinima [19] is a term that describes this practice, where game engines are used to create sets for scripted sequences of action. The story is performed by cast members linked across a network, recorded, and edited using the "demo playback" features of the game engine to create a movie.

Electronic games

The juxtaposition of different modes of representation is not unique to electronic space, or for that matter, to digital media. Maps, photographs, text, diagrams, and so are routinely combined in print, television, and other media. However, in electronic space they may be combined dynamically or the user may switch rapidly between them as required. Map, data and simulation coexist in the screen designs of many electronic games and scientific visualizations.

Mechwarrior, a game that simulates combat between giant military robots called "mechs", is now in its fourth version. [23] Similar to a military grade flight simulator, *Mechwarrior* combines a realistic view of scenes outside the player's mech with information displays that extend right across the field of view. A number of display options allow different ways of reading the game space, including the player's immediate field of view, radars and other sensors, auditory cues, virtual cameras, maps and measurements. The immersive virtual space overlayed with graphs allows the player must combine strategy with high speed reaction. Continuous movement through the simulated space is punctuated with checks of status and displays, creating the experience of piloting a complex machine in a futuristic battlefield.

Another game of this genre is Capcom's *Steel Battalion* [33] for Xbox. It extends the onscreen simulation out into a customized set of controls, complete with indicator lights and other feedback. They include two joysticks, a throttle, numerous labeled buttons, switches, and knobs. This interface allows direct control of a huge number of parameters in the game, and is complemented by a complex screen display.

Generative systems

Electronic spaces may be generated dynamically in response to user interaction and other inputs. *Riding the Net* is an artwork created by Christa Sommerer and Laurent Mignonneau [32] that generates a space of associative images. Key words of conversation by two users who sit with the work are recognized by the system, which retrieves images from the World Wide Web in response. A wide variety of images associated with each key word stream onto the screen and position them dynamically in the space. The users may also touch the screen and stop the flow of images so that they may be more closely inspected.

The space of this work is infinite, with the multiple representations of each keyword creating a texture of meaning in the space. Unlike the constructed spaces in electronic games, it is generated continuously by a system. New combinations of images in the space are possible in reaction to the speech and touch of the users. Hybrids and blends occur easily in the work as it constantly regenerates itself.

Multi-modal space

Operation of 3D modeling and animation software involves dealing with multiple modes of representation similar to the mech simulation in *Mechwarrior*. The user shifts between different modes of interaction and representation as they create spaces with the software. In the modeling of architecture, different representations of a building can be used to test and evaluate its design before it is built.

Marcos Novak has developed the fluid nature of electronic spaces into a form he has labeled "liquid architecture". [25] These structures can only exist within the space of the computer – they are physically impossible in the real world. He combines constructed and generated geometry, parametric design, and user interaction with the forms in the space. These structures shift and change in response to this interaction, allowing the entire space to mutate from one configuration to the next.

Animation experiments by the artist Meta [24] create ambiguous spaces whose structure does not seem fixed at all, but undergoing constant reconstruction. The parameters of geometrical elements and images filters are connected by mathematical functions. The values of the parameters are altered in realtime so that as one value begins to change, there is an effect to all parts of the space. This process can be described as the spatial expression of algorithmic process.

Semiomorph

The author's recent work, *Semiomorph,* is an immersive, virtual world that investigates the language of computer games. In this world typical modes of representation - text, data, iconographics, or simulated reality - coexist in the virtual space. Each mode is personified by a group of game characters competing for screentime. Both the objects and the space can be represented using any of the four modes of representation, either at a local or a global level. Semiotic morphism is used to generate the

Figure 1: Semiomorph **– game characters. Left to right: Specular, Mt.Ke,I-t, D-Glypha and Realamon**

representation of the game space, and also as the basis of the gameplay.

Modes of representation. *Semiomorph* explores semiotic morphism in an immersive environment, using the visual language of video and computer games as the starting point for its sign system. This environment consists of a 3D space, game objects and characters, and the player. Each of these may be represented using one of four systems:

1. *Word:* text labels appear on spaces and game objects. Represented by the Mt.Ke,I-t character.

2. *Diagram:* spaces and game objects are represented in wireframe mode. Represented by the D-Glypha character.

3. *Icon:* simple stylized representation of space and game objects. Represented by the Specular character.

4. *Simulation:* spaces and objects are texture mapped and made more complex to increase realism. Represented by the Realamon character.

The game characters explore how each mode of representation has shifted simply by becoming digital. These game characters are archetypal artefacts, capturing aspects of digital media and electronic game language.

Game objects. The four main game objects have a different sound and style of rendering associated with each of the four modes of representation. Their functionality in the game is as follows:

1. *Energy:* increases the player score by 1 point. The four types of energy (word, diagram, icon, and simulation) change the representation of the player's avatar – if the player has collected mostly "word energy" then the avatar is represented as word, and so on.

2. *Power-up:* makes the player invincible for a short period of time.

3. *Blast:* the player may fire blast icons in order to defend themselves against enemy characters. The game characters may also fire these at the player.

4. *Muticon:* these icons instantly transform the player's avatar to one of the four modes of representation. The mode depends on the type of muticon (word, diagram, iconic, simulation).

Avatar. The player is represented as a simple orange figure. A particle system, connected to the avatar's right hand, indicates the current score. Number of remaining lives is indicated by a row of figures mapped onto the avatar's back. The current mode of representation is indicated by the symbol used for the head of the avatar.

Gameplay. The environment also employs the narrative structure of video and computer games, with rules and goals determining the gameplay:

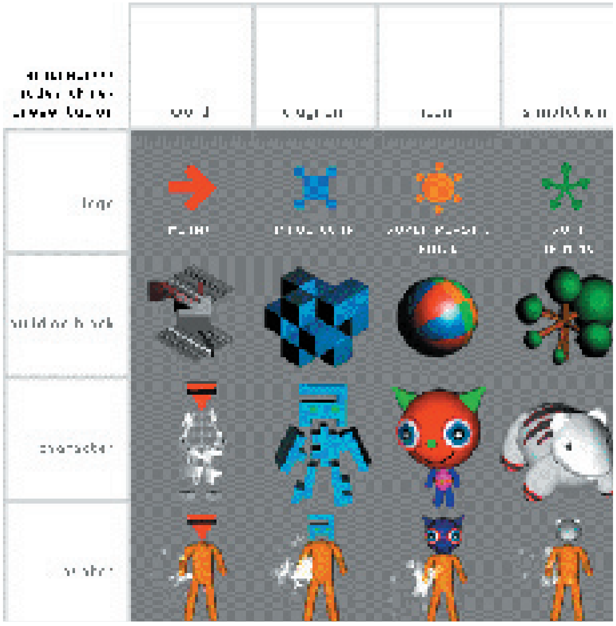

Figure 2: Game elements shown in the four modes of representation in Semiomorph

"The goal of the game is to collect enough energy to create a significant shift in the graphical representation of the world. This is a semiomorph. During play you may shift your mode of representation, which will change the rules of play. You must avoid opposing entities and blast icons. The relationships within the world can change suddenly through activation of power-ups and muticons." [14]

The player moves about the space collecting energy that is either represented as word, diagram, icon, or simulation. This is also connected to the way the player is represented. If they player mostly collects "diagram energy" then they will be represented using the matching avatar. This also morphs the immediate space around them.

When enough energy has been collected the current stage of the game is complete, and the entire space is gradually shifted to match the player's final mode of representation.

The players mode of representation may also be altered if they collect a muticon. This results in a sudden shift of their mode of representation to match that of the

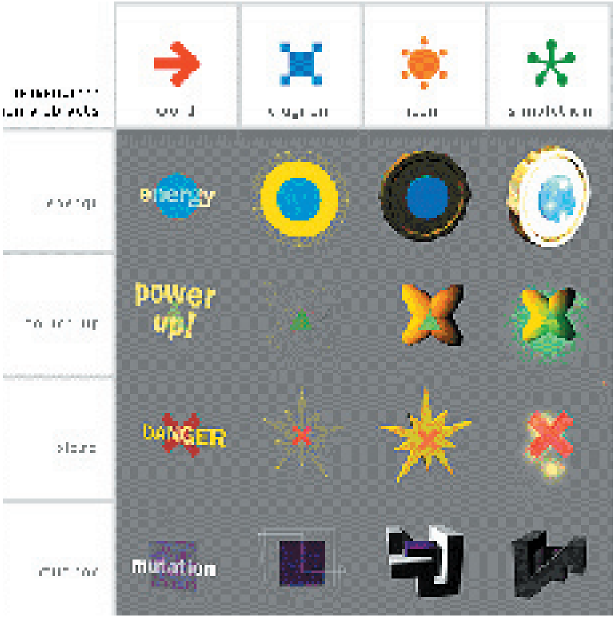

Figure 3: Game objects shown in the four modes of representation in Semiomorph

collected muticon game object.

The behavior of the game characters also change in relation to the avatar's mode of representation. During play one of the four types of characters will pursue the player and attempt to attack them. Which character (word, diagram, iconic, or simulation) is currently pursuing the player depends on their mode of representation. Word attacks simulation, diagram attacks icon, icon attacks word, and simulation attacks diagram.

Figure 4: Semiomorph **game world represented as word**

This means that if the player switches from word to icon, then Specular (the icon game character) would stop pursuing the player, and D-Glypha (the diagram game character) would start. If D-Glypha happened to be nearby at the time, then this would clearly create a problem for the player.

Interacting with the space. The player's mode of representation causes their immediate space to match their mode of representation. First of all, the walls, ground or floor, and immediate scenery are switched to the new mode. This is followed by a gradual change in the main structural components of the space, the building block objects. These objects slowly change into arrows, blocks of pixels, spheres or small trees depending on the required mode of representation.

This shift in representation causes the player to immediately start reading the space differently. Word game objects are more visible when the space is represented in word mode, diagram objects are easier to see when the space is represented in diagram mode, and so on. The player is more likely to find energy objects that match their mode of representation as they are more visible. This process continues as the player moves about the game world, it constantly shifts in reaction to their avatar.

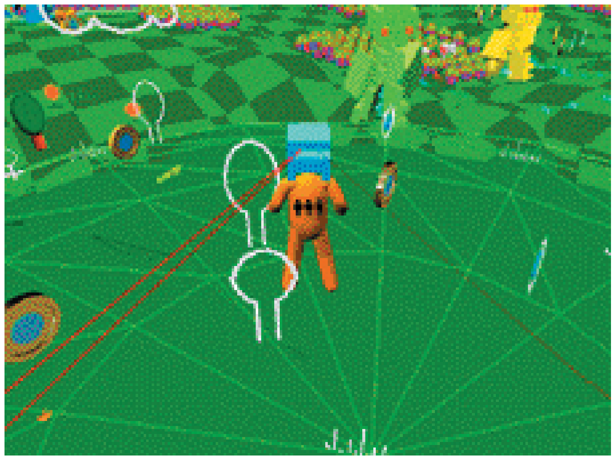

Figure 5: Semiomorph **game world represented as diagram**

The following four figures show the same space expressed in terms of four different modes of representation. The player can be seen standing in the middle of the space.

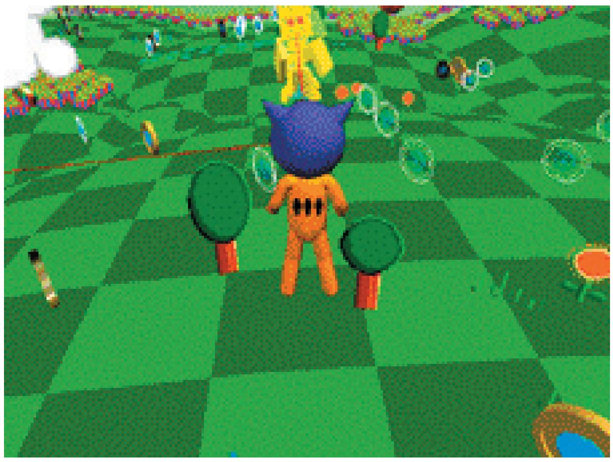

Figure 6: Semiomorph **game world represented as icon**

Word mode uses texture maps filled with labels that relate to each model. The space fills with overlapping patterns of words. Game icons are shown as simple shapes accompanied by the appropriate label.

Diagram mode is represented as wireframe models, outlines of trees and game icons.

Iconic mode uses flat colors, checkerboard texture maps, stylized models, and pixelated icons for clouds and trees.

Figure 7: Semiomorph **game world represented as simulation**

Simulation mode features photorealistic texture maps on all of the objects in the space. Hills become covered in grass, trees have leaves, and the game icons use reflection maps and particle systems.

Stages. The four stages of *Semiomorph* each feature a particular mode of representation. Further opportunities for the expression of each mode as an electronic space are explored in these stages. Each stage takes the same gameplay, entities and game objects and places them in a different kind of space – both in terms of structure and aesthetics.

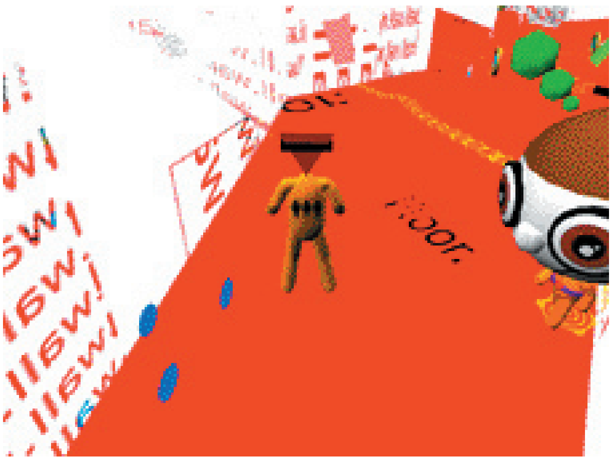

Figure 8: Word stage of Semiomorph

Artefact. *Semiomorph* draws attention to the shift between the real and the virtual by accentuating "artefacts" or errors, the sound glitches and aberrant visual patterns which are the unintended side-effects of the algorithms used to construct virtual worlds. It is also an expression of "semiotic morphism", as signified messages are mapped onto various signifiers, multiplying and mutating instances of semiosis. The work aims to capture the shape-shifting plasticity of relationships between sound, image, text, and users in virtual worlds; the interactions through which meaning is made, transformed and remade dynamically and synaesthetically in real time.

CONCLUDING REMARKS

Semiotic morphism offers a unique method for constructing and analyzing electronic space that applies semiotic theory to interactive media, and captures one of its key properties – the transmutation of media. New insights into the nature of electronic space were established by analyzing it in terms of this theory. *Semiomorph* demonstrates the potential of a space constructed with these understandings in mind. However, semiosis is a complex process and is characterized by exceptions and special cases. Further work is required on the individual elements that make up these spaces to analyze in more detail how they signify meaning in the context of semiotic morphism.

The area that demonstrates the most potential is the use of semiotic morphism as a system for the creation of electronic space. Further development of the approach demonstrated in *Semiomorph* could lead to spaces where the structure and navigation of the space is also altered by morphing between different modes of representation. A more extensive implementation of this system could generate electronic spaces based on a body of text or visual language. Clearly, there is further potential to be explored in the application of semiotic morphism to electronic space.

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