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Live visuals have become a pervasive component of our contemporary lives; either as visible interfaces that re-connect citizens and buildings overlaying new contextual meaning or as invisible ubiquitous narratives that are discovered through interactive actions and mediating screens. The contemporary re-design of the environment we live in is in terms of visuals and visualizations, software interfaces and new modes of engagement and consumption. This LEA volume presents a series of seminal papers in the field, offering the reader a new perspective on the future role of Live Visuals.

LIVE VISUALS

LEONARDO ELECTRONIC ALMANAC, VOLUME 19 ISSUE 3

Live Visuals

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When Moving Images Become Alive!

"Look! It's moving. It's alive. It's alive… It's alive, it's moving, it's alive, it's alive, it's alive, it's alive, IT'S ALIVE!"
Frankenstein (1931)

Those who still see – and there are many in this camp – visuals as simple 'decorations' are living in a late 19th century understanding of media, with no realization that an immense cultural shift has happened in the late 20th century when big data, sensors, algorithms and visuals merged in order to create 21st century constantly mediated social-visual culture.

Although the visuals are not actually alive, one cannot fail to grasp the fascination or evolution that visuals and visual data have embarked upon. It is no longer possible to see the relationship of the visual as limited to the space of the traditional screens in the film theater or at home in the living room with the TV. The mobility of contemporary visuals and contemporary screens has pushed boundaries – so much so that 'embeddedness' of visuals onto and into things is a daily practice. The viewers have acquired expectations that it is possible, or that it should be possible, to recall the image of an object and to be able to have that same object appear at home at will. The process of downloading should not be limited to 'immaterial' digital data, but should be transferred to 3D physical objects. [1]

Images are projected onto buildings – not as the traditional trompe l'oeil placed to disguise and trick the eye – but as an architectural element of the building itself; so much so that there are arguments, including mine, that we should substitute walls with projected information data, which should also have and be perceived as having material properties (see in this volume "Architectural Projections" by Lukas Treyer, Stefan Müller Arisona & Gerhard Schmitt).

Images appear over the architecture of the buildings as another structural layer, one made of information data that relays more to the viewer either directly or through screens able to read augmented reality information. But live visuals relay more than images, they are also linked to sound and the analysis of this linkage provides us with the opportunity "to think about the different ways in which linkages between vision and audition can be established, and how audio-visual objects can be composed from the specific attributes of auditory and visual perception" (see "Back to the Cross-modal Object" by Atau Tanaka).

iPads and iPhones – followed by a generation of smarter and smarter devices – have brought a radical change in the way reality is experienced, captured, uploaded and shared. These processes allow reality to be experienced with multiple added layers, allowing viewers to re-capture, re-upload and re-share, creating yet further layers over the previous layers that were already placed upon the 'original.' This layering process, this thickening of meanings, adding of interpretations, references and even errors, may be considered as the physical process that leads to the manifestation of the 'aura' as a metaphysical concept. The materiality of the virtual, layered upon the 'real,' becomes an indication of the compositing of the aura, in Walter Benjamin's terms, as a metaphysical experience of the object/image but nevertheless an experience that digital and live visuals are rendering increasingly visible.

"Everything I said on the subject [the nature of aura] was directed polemically against the theosophists, whose inexperience and ignorance I find highly repugnant. . . . First, genuine aura appears in all things, not just in certain kinds of things, as people imagine." [2]

The importance of digital media is undeniably evident. Within this media context of multiple screens and surfaces the digitized image, in a culture profoundly visual, has extended its dominion through 'disruptive forms' of sharing and 'illegal' consumption. The reproducibility of the image (or the live visuals) – pushed to its very limit – has an anarchistic and revolutionary element when considered from the neocapitalistic perspective imbued in corporative and hierarchical forms of the construction of values. On the contrary, the reproducibility of the image when analyzed from a Marxist point of view possesses a community and social component for egalitarian participation within the richness of contemporary and historical cultural forms.

The digital live visuals – with their continuous potential of integration within the blurring boundaries of public and private environments – will continue to be the conflicting territory of divergent interests and cultural assumptions that will shape the future of societal engagements. Reproducibility will increasingly become the territory of control generating conflicts between *original* and *copy*, and between the layering of *copy* and *copies*, in the attempt to contain ideal participatory models of democracy. The elitist interpretation of the aura will continue to be juxtaposed with models of Marxist participation and appropriation. [3]

Live visuals projected on public buildings and private areas do not escape this conflict, but present interpretations and forms of engagements that are reflections of social ideals. The conflict is, therefore, not solely in the elitist or participatory forms of consumption but also in the ideologies that surround the cultural behaviors of visual consumption.

Object in themselves, not just buildings, can and may soon carry live visuals. There is the expectation that one no longer has to read a label – but the object can and should project the label and its textured images to the viewer. People increasingly expect the object to engage with their needs by providing the necessary information that would convince them to look into it, play with it, engage with it, talk to it, like it and ultimately buy it.

Ultimately there will be no need to engage in this process but the environment will have objects that, by reading previous experiences of likes and dislikes, present a personalized visual texture of reality.

Live visuals will provide an environment within which purchasing does not mean to solely acquire an object but rather to 'buy' into an idea, a history, an ideology or a socio-political lifestyle. It is a process of increased visualization of large data (Big Data) that defines and re-defines one's experience of the real based on previously expressed likes and dislikes.

In this context of multiple object and environmental experiences it is also possible to forge multiple individualized experiences of the real; as much as there are multiple personalized experiences of the internet and social media through multiple avatar identities (see "Avatar Actors" by Elif Ayter). The 'real' will become a visual timeline of what the algorithm has decided should be offered based on individualized settings of likes and dislikes. This approach raises an infinite set of possibilities but of problems as well.

The life of our representation and of our visuals is our 'real' life – disjointed and increasingly distant from what we continue to perceive as the 'real real,' delusively hanging on to outdated but comfortable modes of perception.

The cinematic visions of live visuals from the 19th century have become true and have re-designed society unexpectedly, altering dramatically the social structures and speeding up the pace of our physical existence that constantly tries to catch up and play up to the visual virtual realities that we spend time constructing.

If we still hold to this dualistic and dichotomist approach of real versus virtual (although the virtual has been real for some time and has become one of the multiple facets of the 'real' experience), then the real is increasingly slowing down while the virtual representation of visuals is accelerating the creation of a world of instantaneous connectivity, desires and aspirations. A visuality of hyper-mediated images that, as pollution, pervades and conditions our vision without giving the option of switching off increasingly 'alive' live visuals. [4]

The lack of 'real' in Jean Baudrillard's understanding is speeding up the disappearance of the 'real' self in favor of multiple personal existential narratives that are embedded in a series of multiple possible worlds. It is not just the map that is disappearing in the precession of simulacra – but the body as well – as the body is conceived in terms of visual representation: as a map. These multiple worlds of representations contribute to create reality as the 'fantasy' we really wish to experience, reshaping in turn the 'real' identity that continuously attempts to live up to its 'virtual and fantastic' expectations. Stephen Gibson presents the reader with a description of one of these worlds with live audio-visual simulations that create a synesthetic

experience (see "Simulating Synesthesia in Spatially-Based Real-time Audio-Visual Performance" by Stephen Gibson).

If this fantasy of the images of society is considered an illusion – or the reality of the simulacrum, which is a textual oxymoron at prima facie – it will be determined through the experience of the *live visuals becoming alive.*

Nevertheless, stating that people have illusory perceptions of themselves in relation to a 'real' self and to the 'real' perception of them that others have only reinforces the idea that Live Visuals will allow people to manifest their multiple perceptions, as simulated and/or real will no long matter. These multiple perceptions will create multiple ever-changing personae that will be further layered through the engagements with the multiple visual environments and the people/avatars that populate those environments, both real and virtual.

In the end, these fantasies of identities and of worlds, manifested through illusory identities and worlds within virtual contexts, are part of the reality with which people engage. Although fantastic and illusory, these worlds are a reflection of a partial reality of the identity of the creators and users. It is impossible for these worlds and identities to exist outside of the 'real.' This concept of real is made of negotiated and negotiable frameworks of engagement that are in a constant process of evolution and change.

The end of post-modernity and relativism may lead to the virtuality of truism: the representation of ourselves in as many multiple versions – already we have multiple and concurrent digital lives – within the world/s – ideological or corporate – that we will decide or be forced to 'buy into.'

It is this control of the environment around us and us within that environment that will increasingly define the role that live visuals will play in negotiating real and virtual experiences. The conflict will arise from the blurred lines of the definition of self and other; whether the 'other' will be another individual or a corporation.

The potential problems of this state of the live visuals within a real/virtual conflict will be discovered as time moves on. In the end this is a giant behavioral experiment, where media and their influences are not analyzed for their social impact *ex ante facto*; this is something that happens *ex post facto*.

Nevertheless, in this ex post facto society there are some scholars that try to understand and eviscerate the problems related to the process of visuals becoming alive. This issue collects the analyses of some of these scholars and embeds them in a larger societal debate, hinting at future developments and problems that society and images will have to face as the live visuals become more and more alive.

The contemporary concerns and practices of live visuals are crystallized in this volume, providing an insight into current developments and practices in the field of live visuals.

This issue features a new logo on its cover, that of New York University, Steinhardt School of Culture, Education, and Human Development.

My thanks to Prof. Robert Rowe, Professor of Music and Music Education; Associate Dean of Research and Doctoral Studies at NYU, for his work in establishing this collaboration with LEA.

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Özden Şahin has, as always, continued to provide valuable editorial support to ensure that LEA could achieve another landmark.

Lanfranco Aceti
Editor in Chief, Leonardo Electronic Almanac
Director, Kasa Gallery

1. 3D printing the new phenomenon will soon collide with a new extreme perception of consumer culture where the object seen can be bought and automatically printed at home or in the office. Matt Ratto and Robert Ree, "Materializing Information: 3D Printing and Social Change," *First Monday* 17, no. 7 (July 2, 2012), http://firstmonday.org/ojs/index.php/fm/article/view/3968/3273 (accessed October 20, 2013).
2. Walter Benjamin, "Protocols of Drug Experiments," in On Hashish, ed. Howard Eiland (Cambridge, MA: Harvard University Press, 2006), 58.
3. " The point here is not to issue a verdict in the debate between Adorno and Benjamin, but rather to understand the debate between them as representing two sides of an ongoing dialectical contradiction." Ryan Moore, "Digital Reproducibility and the Culture Industry: Popular Music and the Adorno-Benjamin Debate," Fast Capitalism 9, no. 1 (2012), http://www.uta.edu/huma/agger/fastcapitalism/9_1/moore9_1.html (accessed October 30, 2013).
4. Paul Virilio, *Open Sky*, trans. Julie Rose (London: Verso, 1997), 97.

CHOREOTOPOLOGY

Complex Space in Choreography with Real-time Video

by

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ABSTRACT

Within this paper a new conceptual framework for considering space within choreography with real-time video projection is considered. Choreotopology encompasses the identification of four specific spaces and the relationship of these spaces. By drawing on the practice of choreography with real-time video and examining the transformation of movement across physical space, camera space, projection space and compositional space a complex, a topological space for movement occurs. Choreotopology is further defined by exploring frames for movement, interrelated and connected space, time in the form of continuity and spatio-temporal aspects. This framework is applied to a discussion of the author's own choreographic practice with real-time video projection.

This paper explores space within choreography with real-time video projection and how the emerging concept of choreotopology maybe used to consider the composition of stage and digital video technology. Topology has previously been utilised to discuss cultural practices, including choreography with various approaches. When applying topological ideas to choreographic works that use real-time video technology, choreotopology emerges as a conceptual framework. This approach to using topology in choreography with real-time video marks an attempt to create a dynamic structure to present live and mediated movement together, rather than choreograph two separate elements of performance that may be in tension with each other.

Choreotopology contains spaces for movement, considering the inter-relationships and connectivity found within these spaces. It also considers the spatiotemporal and continuity found within these spaces. Finally it considers the transformation of movement through the space, including physical space, camera space, projection space and compositional space. The discussion of a practical choreographic study created by the author is utilised to illustrate this concept further.

TOPOLOGY AND CHOREOGRAPHY

Topology may be used to conceptualise dynamic relationships in complex spaces and has recently been investigated in examining cultural practices. Different projects have provided insight into the shift from mathematics to other disciplines by exploring how concepts derived from mathematics may be applied in other settings. These projects do not aim to be scientific in their inquiry but use the qualitative methods of their disciplines along with concepts from topology to further examine complex spaces.

Topology is an area of mathematics, which focuses on non-Euclidean space or space that is not defined by its dimensions, but rather a qualitative model of space. In its most basic definition, topology includes connectedness and continuity, allowing distortions or deformations of space without disconnecting what was connected. General topology or point-set topology explores relationships between sets and continuous functions. [1] The basic notions of point-set topology are continuity, dimension, compactness, and connectedness. This continuity provides relationships between sets and subsets of space. The union of any collection of subsets in a topological space is the same. The intersection of any collection of sets is the same and both the subsets and sets are the same. The idea of the open set contributing continuously to subsets is an underlying concept within point-set topology. This notion of sets is reflected in choreotopology with the use of frames for movement.

Topology may be considered as "the process of arriving at a form through continuous deformation." [2] Some forms of topology, such as algebraic, use functions to provide mapping of points in a non-metric space. Within this research, spaces do transform movement, but the mapping is not homeomorphism. Because points are mapped from one transformation to another, due to of the continuous movement, there

is no way to measure the space. "To get a static, measureable, accurately positioned, visual form you have to stop the movement. This capsizes the relationship between movement and position." [3] Further to this, topology allows for the qualitative measurement of space because of movement. Position arises out of movement. Static form is extracted from dynamic space, as a quantitative limitation of it. An exact vector space feeds its self-variation results into the limitative conditions of quantitative, Euclidean space, populated placidly by the traditional geometric forms into 'plottable' configurations. [4]

Concepts from topology have been used in exploring relationships within cultural studies and practices, including the project *A Topological Approach to Cultural Dynamics* (ATACD). Part of this project was to examine "transformations, boundaries, fields and continuities as they might be relevant for understanding performance space." [5] Various approaches from topology, such as connectedness, interrelationships, and continuous change, were applied to a range of practices outside of mathematics to explore dynamic transformations and non-hierarchical relationships. Lury refers to topological concepts as being able to

> understand capacities for change as constituted in relations [of ordering, of connectedness and so on] rather than being constituted by some essential properties [e.g. archetypes, values or norms], or perhaps better, to the extent, that it is possible to speak of properties, these are seen to be relative to specific transformations or relations. [6]

Lury discusses how this leads to ways of considering capacities for cultural change across boundaries. Points, sets, and planes may be considered as transformative and movement may become part of the discourse of cultural practice. Topology when applied to new fields may allow for rearranging spaces. Move-
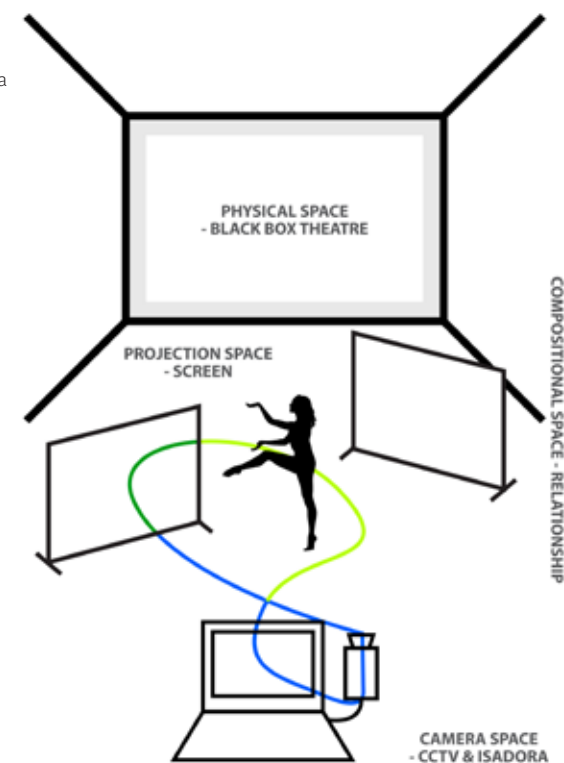
ment, continuity or connectedness, rather than value, amount or other hierarchical approaches to organization may become apparent.

Other ways to consider the relationships within cultural practice include a hierarchy based on classifications of types of space or typology. Within topology, the continuous change means that space cannot be classified unless the movement is stopped and the continuity is stopped. To consider these continuous relationships also means that does not provide a measurable system for the relationships of the spaces and is therefore not topographic. Topography functions in Euclidean space and provides maps and distances between spaces. This charting of movement is static and does not account for the relationship of time and space found in topology.

For this research, "topology characterises dance as a precisely choreographable pattern in space and time." [7] This pattern is not a static form, but a complex interrelation of spaces via movement. In choreographic work there are various properties of space that become complex and allow for topological concepts to be applied. While some have applied topological definitions to gestures, such as Portanova and Piccirillo or Naveda and Leman, [8] others have used these concepts to explore relationships of movements that are articulated throughout the body, such as Sabisch. [9] Topology in dance has also been used to discuss compositions of groups of bodies within a choreography by Rubidge [10] and topology has been used to define parameters of choreography to demonstrate concepts of time and space by Rotman. [11]

While concepts from topology are applicable to this study of choreography with real-time video, it is important to remember that topology is a form of mathematics. This research does not aim to justify dance studies by using theories based upon mathematic

equations. It does find that the concepts from non-Euclidean geometry are useful to explore and discuss choreographic studies. To further these concepts, choreotopology will be discussed as a framework for choreography with real-time video. Here topology is considered alongside concepts from dance studies, such as choreutics.

CHOREOTOPOLOGY

Choreotopology is a framework for choreographic work in which movement is transformed through interrelated frames that are sets and subsets of space. The interrelations are developed through qualitative rhythm to develop a plane of composition. [12] By utilising real-time video systems within live dance performance, spaces that create interrelationships and choreography are apparent.

The concept of choreotopology is based on movement being transformed continuously through space. The spaces in which the transformation of movement occurs are considered frames for movement and these frames do not exist without movement. This means the sets and subsets of space are interdependent because they all contain the same movement that has been transformed continuously. Within point-set topology the open set is contributing to the subsets and an intersection of any sets contains the same movement, transformed. Choreography becomes the interrelation of spaces through the movement, creating a choreographic work, which is dependent on interrelated and spatiotemporal elements being choreographed. This interrelated and interconnectedness is found in the transformation of movement through frames happens via choreological means yet reflects topology.

This diagram aims to illustrate the continuous movement through physical space, camera space, projection space and compositional space. © Kate Sicchio. Used with permission.

PHYSICAL SPACE
- BLACK BOX THEATRE

COMPOSITIONAL SPACE - RELATIONSHIP

PROJECTION SPACE
- SCREEN

CAMERA SPACE
- CCTV & ISADORA

Choreotopology in choreography with real-time video includes four frames for movement. These are identified as physical space, camera space, projection space and compositional space. Each space has a relationship with movement that is creating both the frame and relationship of the frame with the other frames through continuous transformation. Movement in the physical space is transformed by the camera and software, by employing computer vision techniques such as background subtraction. This same movement is transformed in the projection space, which again is dependant on movement for a video to emerge. The compositional frame of the physical movement and the projection frame is relational to the movement that is occurring. The real-time video allows for the temporal aspects of topology to transform movement from space to space and as well as for movement to create space to choreograph an overall composition of space.

FRAMES FOR MOVEMENT

Spaces that are transforming the movement are referred to as frames within this research. The research of this author was performed in a black box theatre space and this essentially becomes the first frame for movement. Other frames include the camera space, projection space and compositional space. But before this can be expanded upon, the frame itself must be discussed.

Grosz sees the frame as a condition for all arts and as part of the construction of a composition.

> The emergence of the 'frame' is the condition of all the arts and is the particular contribution of architecture to the taming of the virtual, the territorialisation of the earth... The frame is thus the first construction, the corners, of the plane of composition. [13]

The frame creates relationships between the composition and what is set apart from "the chaos of earth" [14] and "framing becomes the means by which the plane of composition composes." [15] Framing becomes essential to create the spaces for movement within choreography with real-time video.

Territory, as mentioned in Grosz's definition of frame, borrows from Deleuze and Guattari. Territorialisation is "the act of rhythm that has become expressive, or of milieu components that have become qualitative." [16] This idea of territorialisation help to define the frame as a way to set apart movement of a choreography from movement found elsewhere. By creating frames for relationships through movement, space and time, choreography becomes as act of framing and this is seen in the frames of physical space, camera space, projection space and compositional space.

Physical space for choreography may be discussed space in terms of entrances and exits and filling a void

with movement as discussed by Preston-Dunlop, [17] Blom and Chaplin, [18] Briginshaw. [19] While there are some literal borders such as the walls, the ceiling and anything that encloses the performance area, the frame of physical really becomes defined as the space where the movement occurs from a physical performer (rather than movement detected by a camera). This movement locates the physical boundaries of the space, which is typically the space of the black box theatre space in this research. This movement finding borders happens while the movement is transformed into other frames of movement and also while all the frames relate to each other in the choreography of the space.

Camera space has two components: the camera and software. These elements work together in transforming movement and therefore become one frame for movement in choreotopology. A change in the movement is detected using the camera in conjunction with software, to create a space of transformation. The camera and software work together with the use of computer vision techniques. [20] The two components of camera and software are viewed as one frame within this application of choreotopology. In terms of computer vision the algorithms running the software and the camera lens capturing the image are both part of the same process and are not separate. Within the choreographic process, the movement detected by the camera is deeply effected by how the software settings, such as threshold and difference are programmed. Rather than choreograph the camera, then choreograph the software settings, the two are integrated into one process. They can be considered one space in the choreography because of this process. To further discuss choreography with real-time video by utilising the concept of choreotopology, the integration of the camera in conjunction with software is applied again. Both camera and software working together transforms movement and this joint effort is

considered choreography, rather than separate operations.

Choreographing with camera space means designing movement that is in view of the camera, so the software can then relay that image to the projection. It also means being aware of proximity and distance. For example, when movement is close to the camera certain gestures are enlarged and abstracted, or when movement is far away from the camera and the image created for the projection is made much smaller. Choreographing camera space also uses computer vision processes such as background subtraction or setting thresholds and difference for detection of pixel change within the camera's image. For example, a circle floor pattern in a choreography may be detected as less pixel change when the movement is circling far away from the camera, but detected as more pixel change when the movement is circling towards the camera. Physical limitations of the camera, such as the perspective, the lens of the camera or the lighting, effect how software detect pixel change and the movement within the choreography.

Another space conceptualised in this research is projection space. It is comprised of a surface or screen that occurs in the physical space and the two-dimensional digital video. These elements present video movement on screen in real-time as part of choreography. The meeting of these two elements creates this space for movement, as well as the movement creating these elements. Without movement there would not be a video image to be transformed and projected. Without the projection the movement does not have a relationship with the projection to create a composition through the relationship of these spaces. Attributes such as the location of the projector or a projection surface may determine where video projection is in the compositional space. However, the movement determines the video image that is shown on the

projection surface. Both of these elements are considered in the conceptualising of projection space. This is demonstrated when movement in the projection space is creating the movement that is transformed by the camera space. It is only when the projection space in a specific relationship with the other spaces through movement that all the transformation of the movement becomes visible in the projection space and is able to create a composition.

The video of the projection space again transforms movement but also is determined by the movement itself. There is an incorporation of color, texture or other qualities that creates an emergence of projection space as a qualitative space. There may be blurs and trails that slowly fade, morphing movement over time in a different space from the camera or physical, yet still within the interrelated space of the choreography. The movements of the video also create the borders and boundaries of this frame through their entrances and exits onto the projection surface.

The concept of compositional space refers to the relationship of all of the spaces of choreotopology. It is the movement between and of the physical space, camera space and projection space and how these are composed. These spaces are all related by the movement that is being continuous and this is due to the video technology being real-time. The relationship between the four spaces reflects topology. There is constant transformation and movement between sets or frames of space.

What is key in understanding these spaces for choreography with real-time video is the movement continuously manipulates these spaces. The movement seen in the physical space of the theatre is transformed by the camera space and re-presented in the projection space (which also is located within the physical space). There is also the overall composition of all of these

spaces in relation to each other, which is the compositional space. By utilising the real-time video system, the compositional space could be seen as the movement continuously transforming physical space, camera and projection space. There is interplay between all of these frames and the movement that transforms. Choreographing this interplay through relationships and rhythm is the aim of the movement of compositional space. And by studying the interrelationships being created, one could say this is the choreology of this topology or choreotopology.

INTERRELATED AND CONNECTED

The complex interrelationships of frames formed by the transformation of movement inform the concept of choreotopology. The connectedness of spaces within live choreography with real-time video systems is apparent through movement. The movement does not occur just in the physical space, as it happens in the camera space, projection space and the composition space. This reflects point-set topology in that all the spaces of choreotopology are open sets that are connected. These spaces must all be choreographed with connectedness in mind or the choreography will not reflect concepts from topology and therefore choreotopology.

During the devising process, how the motion within the physical space, how the camera and software work to detect the movement, and how projection appears and moves in the space are all decisions that need to be made together because the movement happens throughout all of these spaces whilst creating an interrelation to form a composition. For example, when a movement is devised in the physical space, how this movement is detected in the camera and projected is also being devised. As a choreographer, knowing what movement creates these transformable

relationships allows for decisions of what movement to devise for different moments in the choreography. At times movement may not be wanted in all frames to create a certain type of relationship. Whatever the chosen relationship, it is not determined by the dimensions of space but continuous transformation of the movement through complex space.

CONTINUITY AND SPATIOTEMPORAL

Continuity is another term used in discussing topological space that applies to choreography with real-time video and is important in defining choreotopology. Continuity is the time aspect of topology. Because the movement from one space to another is continuous and the video system works in real-time, the space of the relationships within the choreography cannot be measured unless time is stopped and the continuity is broken. This means that a key element of considering choreotopology is time. The real-time video creates a time delay so minimal that the movement being transformed by the camera and software is not detected by those viewing the choreography. The movement is therefore continuous in its transformation and results in any point in the movement being in any sub-set of the space at the same time.

Bergson's definition of continuity also considers the spatiotemporal like Massumi.

What is this continuity? That of a flow or passage, but a self-sufficient flow or passage, the flow not implying a thing that flows, and the passing not presupposing states through which we pass; the thing and the state are only artificially taken snapshots of the transition; and this transition, all that is naturally experienced, is duration itself. [21]

Within choreotopology this form of continuity, which lies within movement and space, is broken when one stops the movement in a specific time. As Bergson states, it becomes an "artificially taken snapshot" rather than a moment of transitional movement.

One aspect of the choreography in this research which also effects the continuous element of choreotopology is the use of real-time video. The term real-time is a computer science term and is used to refer to processing that happens with as short of delay as possible. The technical system used in this research, allows for the delay to be short enough that the time delay is not detectable to humans. This real-time aspect allows for the perception of movement in all spaces not only to be simultaneous but to allow for relationships to emerge at the same time as the transformations of movement and space. This is what reflects the continuous aspects of the concept of choreotopology.

Considering the spaces in choreography as continuous and based upon movement is also drawing on topology to create choreotopology. As the space is continuous and dependant on time, the only way that the space can be measurable is to stop the movement. Not only does this stop the continuity as previously discussed, but it also begins to divide the spaces into Euclidean geometric planes, that may become separate rather than interconnected. Therefore, continuity relates to the transformation of movement through space and time. The real-time aspect allows for the movement to transform in complex space in a continuous manner and movement to be choreography of relations in space.

TRANSFORMATIONS

Transformations are apparent in both definitions of topology and the concept of choreotopology. Transformations map points of movement from one space to another. Points transform movement from a physical space, to the movement of pixels within a camera and software, and then within video projections continuously.

Movement is transformed through choreography, not only in the physical space but also in the way the camera and software detect the movement and the way the projection of the movement is created. Choreotopology is about the choreography of movement that changes qualitatively as a result of its movement through space. The transformation is not only of the movement or of the space but the transformation of movement through space and the transformation of space through movement. These transformative functions are continuous and result in a spatiotemporal relationship through choreography.

By considering the movement that happens as a result of real-time video within this work, technology may be choreographed. This refers to detection of movement by the camera and software. Decisions of how movement will be detected, the threshold at which it is detected and the difference level for the detected movement, all begin to resemble choreography. First, the decision of the technique for detecting motion becomes part of the choreography. For example, choosing background subtraction or blob detection. This may be like choosing a method for devising movement such as a structure in which a dancer improvises. "The notion of instructions or rule setting as a way to generate dance material, is similar to rules and instructions, called algorithms." [22] In this set of rules for movement, threshold and difference levels must be set within the programming of the movement detection. This may be compared to choosing dynamics or movement efforts within a dance making process.

The programming process for real-time video systems aims to create relationships between movement in the physical space as well as movement in the projection space. Qualitative changes to this movement may be instigated through code. The programming of a system is not only a technological element of a dance piece, but a choreographed part of the work.

Other decisions such as location and perspective of the camera are also part of choreographing the technology. This is may be similar to floor patterns or locations in the performance space for movement to happen. By considering the technical procedures that are part of the computer vision process, technology may become choreographed and transform movement. Setting the aspects of the software that effect movement such as thresholds and difference, the movement is effected and changed. There is a transformation that has been programmed and creates a relationship with other spaces. This is a choreographic action that is performed through a camera and software.

Transformation of movement within choreotopology is across four frames for movement including physical space, camera space, projection space and compositional space. The interrelationships of these spaces happen through not only the use of a digital camera, but also software that allows for background subtraction and visual effects to be applied to the movement being captured. The camera and software create a space where movement is detected and then transformed. By programming the software, decisions about this movement is made in a similar way to that of a choreographer. This also reflects how the choreography of the technology is considered in the connectedness of choreotopology.

CHOREOTOPOLOGY IN PRACTICE

A practical choreographic study created by the author further demonstrates the concept of choreotopology as applied to choreography with real-time video. This piece was created for a live performance at the Digital Stages Festival in London, UK in 2011. The piece was performed in a black box theatre and featured two mobile sharktooth mesh screens on stage. There was a CCTV camera at the back of the black box theatre that captures the movement on the stage. This video image feeds to a laptop running the software Isadora to detect the movement and perform background subtraction techniques. A projector pointed from the back of the theatre was aimed at the screens. This set up of the technology allowed for the movement to be captured from the physical space of the stage to be transformed to the camera space and the projection space. The relationship of these spaces forms the compositional space.

Within this choreography frames for movement were continuously changing and creating new compositional spaces. This was because of the movement and possible semi-transparency of the screens and the spatial relationships based upon the location of the screens. This new movement and new relationships of spaces contributed significantly to the creation of choreotopological compositions of physical, camera and projection spaces. Because of this, the movement created compositions that were not plottable configurations in physical space but deformations and distributions of movement across spaces. This choreography of topological space can be considered the concept choreotopology.

The movement of the projection space was also in a continuous relationship with the other spaces in the composition in addition to the movement of the visuals within the projection. As the frame moves, the camera picks up its movement and creates a difference image that is then projected. However, the pro-
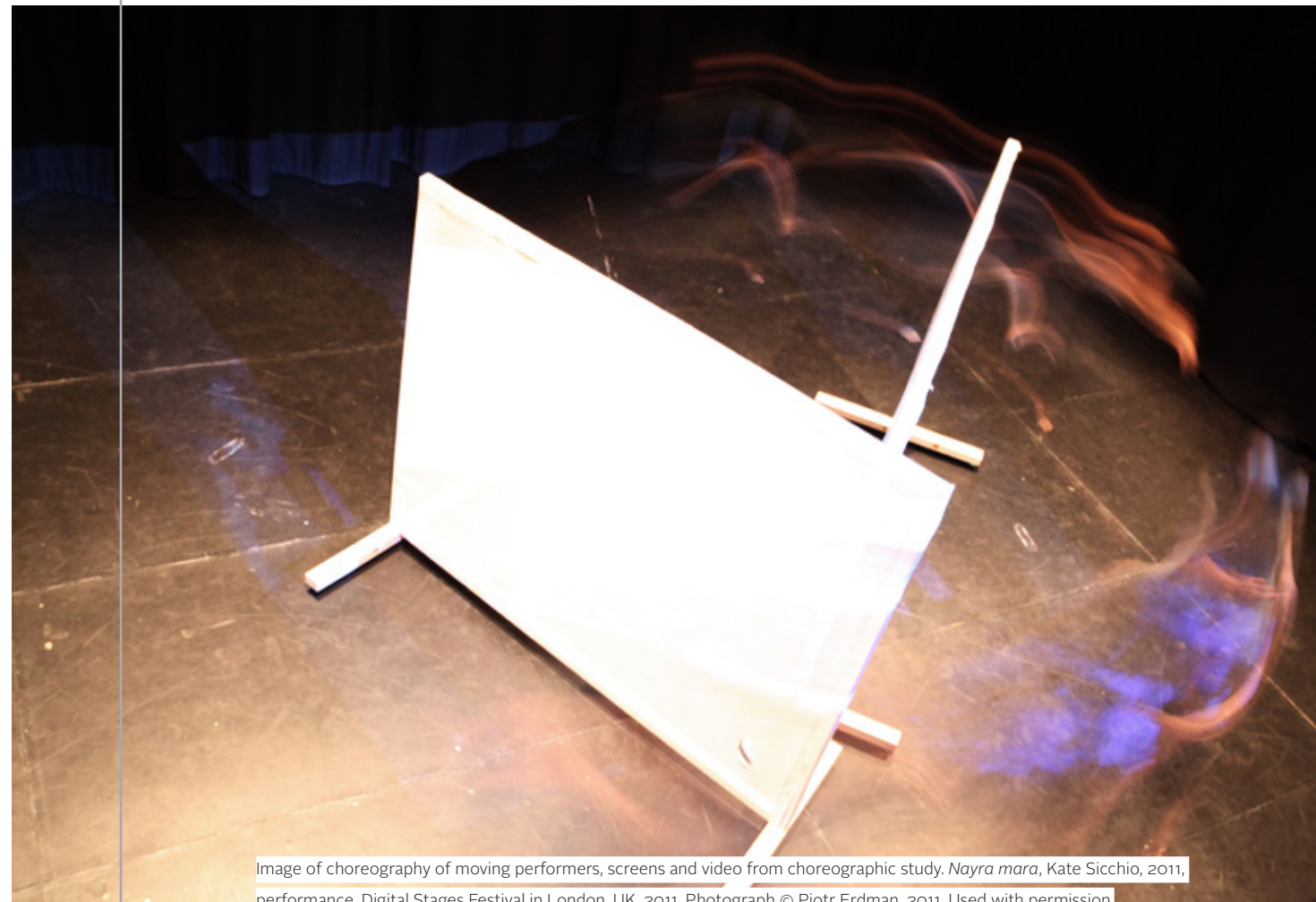

Image of choreography of moving performers, screens and video from choreographic study. *Nayra mara*, Kate Sicchio, 2011, performance. Digital Stages Festival in London, UK, 2011. Photograph © Piotr Erdman, 2011. Used with permission.

jection space in now moving in a circle and the movement from the camera space is only visible when the projection space is moving through a position in which one of its wide sides is in front of the projector. When this happens, the movement of the performer and the screen are visible briefly and then they continue to move and the image is lost from the projection space, until it is repeated moments later. The projection space now depends on time and movement to be part of the composition. This moment in the piece creates a dynamic space and illustrates Massumi's concept of topology as a system for understanding spaces where movement is continuous. If one were to make this moment of the piece static, the movement would not be seen transforming into projection space. Frames for movement in this study are in motion and therefore continuously creating interrelations

All the spaces within this study are connected, interrelated and are composed with the consideration of the plane of composition. In one section of the piece, one performer is located in front of one screen and the second performer is behind the screen. The second screen has been placed perpendicular in the physical space. After the movement sequence is repeated twice by the performer in front of the screen it is then repeated by the dancer behind the screen. The semi-transparency of the screen allows for the camera to see the movement behind the projection space. This is the first time throughout this research that the movement being performed is located behind the projection being generated. The performer then walks around to the front of the screen where the movement that was just performed has been captured and is projected as the performers watch. Because the

Performer behind the screen being captured in choreographic study. Photograph by Piotr Erdman, 2011. *Nayra mara*, Kate Sicchio, 2011, performance. Photograph © Piotr Erdman. Used with permission.
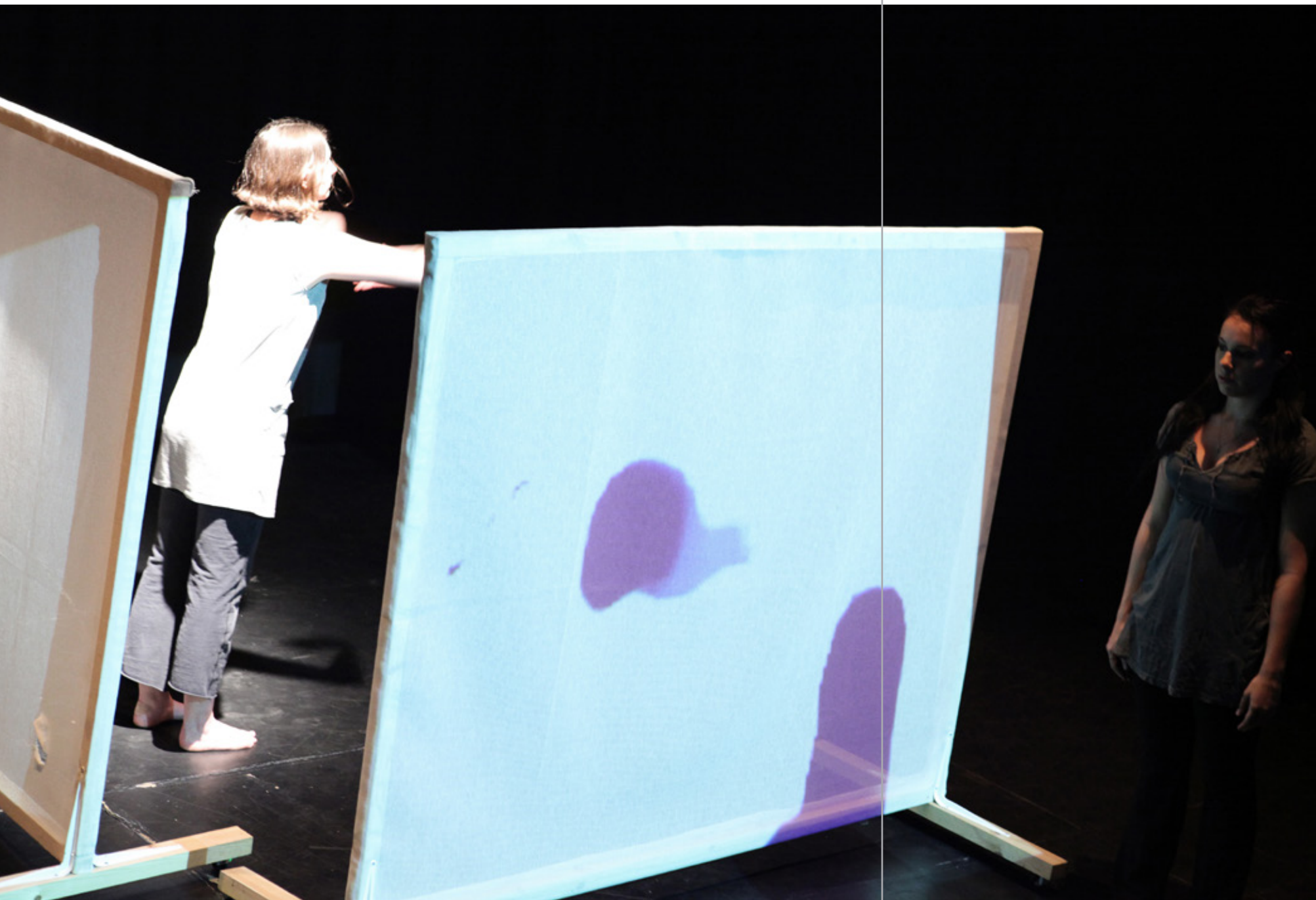
movement can be seen through the screens, the possibility of performers being located behind the projection space is possible and creates new relationships of the physical space, projection space and camera space within the composition.

The interrelational aspect of choreotopology is occurring in this section of the piece. The gesture creates the interrelationships as it happens across spaces. The movement is in the physical space, camera space and projection space. But what is also at play in this section is the compositional space and the relationships in space that are created by movement. Here the movement of the physical space is placed behind the projection space and its movement. This study is the first in this research to create this new compositional relationship.

This interrelationship also reflects Deleuze and Guattari's plane of composition. Rather than the spaces being organised to create a formation of one space behind another, it is actually movement being choreographed to transform from one space to another. The relationship of these spaces relies on movement but also demonstrates the possibility to transform movement from a space from behind another space. It highlights that transformation may occur despite location to create composition. This composition happens continuous to create a spatial-temporal transformation.

The continuous aspect is important in this composition. All of the movement being considered is happening in real-time. This means as little delay as possible is occurring in the video system when a movement is first initiated in the physical space, detected in the camera space, and projected onto the screens. The real-time aspect allows for the movement to be continuously in each space. This results in each point in the movement mapped from space to space and for a continuous interrelationship of space. The spatio-tem-

poral relationship that occurs across the movement is a representation of a topological concept and allows for transformation to happen continuously.

In the middle of the piece, the movement in the physical space begins with a gesture forward with the right arm and repeats this several times, gaining speed and momentum and allowing the left arm to join the gesture and the body to bounce as a result of the force of the movement. The movement is stopped abruptly and both arms are 'caught' behind the live performer, where they struggle to release the hands from behind the body by leaning forward. Eventually they release the arms from this position and rebound and settle back to the original neutral standing position, to being the sequence again. The movement is transformed from the physical space by the camera space and then the projection space to then join the compositional space. The result is a projection that is reflecting the gesture but has been transformed into a blurred form, which slowly increases and decreases in size based on the amount of movement in physical space.

Again, these sections of the study demonstrate not only the transformation of space that reflect choreotopology, but also how this transformation reflects the plane of composition. The movement allows for a composition to emerge because of the continuous nature of the movement and this movement is transformed continuously to form complex interrelationships of space. In the definitions of the plane of composition discussed above, movement creates the composition through transmutation and relations. This also allows for movement in various spaces (such as a live space and a mediated space) to exist with little less tension in the creative process.

SUMMARY

Within this research the use of topology to discuss the relationships of space within choreography with real-time video creates the conceptual framework of choreotopology. This is then further defined by exploring frames for movement that are interrelated through the continuous transformation of movement. Interrelationships are found throughout space in choreotopology and movement both creates and is found in space. The ways in which the frames interact to create choreography reflect Deleuze and Guattari's plane of composition. The frames within choreotopology are transformations of movement through space and are part of this continuous choreography. Within this research, transformations occur with real-time video visuals, and create a process of choreographing technology.

This work provides new insights into the application of topology to cultural works, as well as new forms of choreological investigation. By using this field of geometry to explore space within choreography, more research about the interrelationships of movement and spaces may be explored. This may lead to future developments in various areas of studies, such as choreology, architecture, sound or digital media, and may help in finding new interrelationships and discourse between disciplines. ∎

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