

THE FUTURE OF MEDIA

Edited by Joanna Zylinska
with Goldsmiths Media



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Contents

Introduction: The Future of Media – *Goldsmiths Media* page 1

HOW TO TALK ABOUT THE FUTURE

- 1 The Future and the 'Poetry of the Past' – *Gholam Khiabany* 7

THE FUTURE OF MEDIA REFORM

- 2 Media Reform and the Politics of Hope – *Natalie Fenton
and Des Freedman* 25

THE FUTURE OF JOURNALISM

- 3 An End to Futility: A Modest Proposal – *James Curran* 45

THE FUTURE OF TRUTH

- 4 Future Faking, Post-Truth and Affective Media – *Lisa Blackman* 59

THE FUTURE OF TELEVISION

- 5 How Will the Future Cope With(out) Television? – *David Morley* 81

THE FUTURE OF MEDIA WORK

- 6 Our Platformised Future – *Clea Bourne* 99

THE FUTURE OF SOCIAL MEDIA

- 7 The Celebrity Selfie: Gender, Race and 'New' Old Ways
of Seeing – *Milly Williamson* 113

THE FUTURE OF 'DIVERSITY' IN MEDIA

- 8 Rethinking 'Diversity' in Publishing – *Anamik Saha and Sandra van Lente* 135

THE FUTURE OF FEMINISM

- 9 Exit Wounds of Feminist Theory – *Sarah Cefai* 157

THE FUTURE OF QUEER MEDIA

- 10 *Queerama*: Re-Imagining Queer Past and Futures – *Daisy Asquith* 177

THE FUTURE OF DANCE

- 11 New Telematic Technology for the Remote Creation and Performance of Choreographic Work – *Daniel Strutt, Andreas Schlegel, Neal Coghlan, Clemence Debaig and Youhong 'Friendred' Peng* 197

THE FUTURE OF AUDIO

- 12 Everywhere in Particular: Some Thoughts on the Practice and Potential of Transpositional Locative Sound Art – *NG Bristow* 225
- 13 If 6 Were 9 (or 2 x 108): A Case Study of the *One Oh Eight* Project – *Richard M. Shannon, NG Bristow and Mathapelo Mofokeng* 239

THE FUTURE OF ACTIVISM

- 14 How Smartphones and Digital Apps are Transforming Activist Movements – *Sue Clayton* 253

THE FUTURE OF DIGITAL HUMANITARIANISM

- 15 Technological Futures as Colonial Debris: 'Tech for Good' as Technocolonialism – *Mirca Madianou* 281

THE FUTURE OF THE CITY

- 16 The Smart City and the Extraction of Hope – *Richard MacDonald* 297

THE FUTURE OF PHOTOGRAPHY

- 17 Does Photography Have a Future? (Does Anything Else?)
– *Joanna Zylinska* 315

THE FUTURE OF 'THE FUTURE'

- 18 Astronoetic Voyaging: Speculation, Media and Futurity – *James Burton* 333
- Afterword: Forward – *Sean Cubitt* 353
- Notes 363
- Contributors 371
- Index 377

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THE FUTURE OF DANCE

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New Telematic Technology for the Remote Creation and Performance of Choreographic Work

Daniel Strutt, Andreas Schlegel, Neal Coghlan, Clemence Debaig and Youhong 'Friendred' Peng

Introduction and Context

At the time of writing, we are in lockdown in the UK due to the Covid-19 virus. While many of us are discussing the possibility of going back to our physical workplaces over the coming months (despite the potential for future lockdowns with a second or third wave of infections), artists and performers are wondering in which *year* they will find themselves again in front of a live audience. This issue, which has clear implications for the financial stability of both individuals and arts companies, is particularly prescient for the dance industry. An article published in *The Guardian* on 5 May 2020, titled 'An Industry in Freefall', asks: 'With tours cancelled and rehearsal rooms closed, what's the future for dance?' (Bakare 2020). In this difficult situation, we have witnessed an extraordinary blossoming of many forms of performance through platforms such as Facebook Live, Zoom and YouTube, with DJs, musicians and singers, drag and performance artists, outdoor performers and actors streaming live video content directly from their homes. There has also been a lively discussion about possibilities for future development of this kind of content, and about the potential forms of revenue and income it can generate, as virtual festivals, digital art, events and interactive media move to the centre of the debate about a 'culture in quarantine.'¹ But how does dance fit into all of this? While actors, DJs and musicians can largely work solo or in safely distanced forms, the discipline of dance is inherently about close bodily contact, on a daily basis, being fundamental to its practices.

In this chapter we aim to offer an interrogation into the future of dance, framed by theoretical questions that have been raised by a collaborative interdisciplinary project that the authors have been engaged in. The project researches the potential application of a new generation of wireless, flexible and studio-less motion capture in the creation, rehearsal, teaching and performance of choreographic dance work. While these relatively recently available technologies (only being on the consumer market since around 2016) could be used to either supplant or augment other existing video-based modes of working or performing remotely, we have found the need to remind ourselves that the problem they address is not primarily one of using technology to *substitute* for live presence. There are already several technologies that aim to do just this, for instance, in VR concerts (e.g., Melody VR) or for corporate conferences (e.g., Musion Eyeliner). In a straightforward way those technologies aim to recreate the perceptual experience of 'being there'. However, the problem as we see it should not simply be about trying to generate a sense of actual live physical presence, but rather about finding in a digital medium such forms of meaningful connection, as well as engaged interest and attention, which can be decisively and qualitatively *different*.

We might even wish to undermine the presumption that live presence is in some way optimal or preferable in all performance contexts, or that we should simply prioritise the translation or adaptation of existing live work for virtual or remote forms of engagement. We can consider the ways in which forms of connection between performer and performer, and between performer and audience – while limited in terms of actual somatic immersion (e.g., the sense of touch, smell, temperature, spatial audio etc.) – can be articulated differently or even enhanced in certain virtual and technologically augmented modes which play to the strengths and affordances of new digital applications and immersive interfaces. In this way, we argue that engaging virtually with dance, as much as with any kind of performance, does not need to be an impoverished copy of the live theatrical experience, but can instead create a new and unique experience altogether. As choreographer Robert Wechsler notes, the idea of technological progress towards a point where media become transparent is not the primary issue for performance. The issue is about applying the existing technology intelligently and creatively: 'The central challenge that this field faces is not one of improving the technology, but rather one of developing an understanding of its implications – The changes in the mindset and sensibility of the artists as they put it to use' (Wechsler 2006, 75).

Technological newness in and of itself is not enough to constitute meaningful aesthetic progress and can easily instead become gimmicky or uncomfortably tagged on to existing disciplinary practices. What is more important, then, is that recent cutting-edge or bleeding-edge technologies are understood within the wider narrative of aesthetic development from the past to the present visions of the future of performance. For this reason, in this chapter we wish to consider the practical potential of recent real-time and generative motion capture applications, specifically those used for remote collaborative practice in the discipline of dance, but within a historical and theoretical problematic of networked or distributed performance (Birringer 2008), and of telepresence, telematics and virtuality in dance practice.

As 'digital choreographer' and theorist Sarah Rubidge already articulated well in 2002, we should not be narrowly considering these potential applications as being only about pragmatic solutions to the problems of physical distancing that choreographers and dancers might continue to face in the immediate future (though, in the first instance, they are this as well). We should rather see them as a new avenue of research and futurist vision – as potentially an altogether new medium for dance. In Rubidge's own words:

Certain forms of digital technology provide a framework for choreography which opens up new modes of practice, and new ways of thinking in and through dance. Amongst these are those forms of digital media which allow for real-time interactivity. These may prove to be a new medium, not merely a new tool, for choreography. This is indicated by the fact that some features of this digital medium raise interesting philosophical questions which have the potential to extend and enhance our understanding of what constitutes the choreographic art.

(Rubidge 2002, 2)

What follows, then, is first a thinking through of some of the concepts, discourses and technologies which contextualise this sphere of digital or 'virtual' dance practice and performance, before a consideration of the potentialities and limitations of several forms of actual 'cutting-edge' software, hardware and platforms that are currently being used in the field. This will lead us to raise both practical and theoretical questions that can frame future research projects, including our own, with the intention of working towards a down-to-earth vision of a virtual choreographic art for the future.

Physicality and Virtuality in Digital Performance

Between the encyclopaedic works of Johannes Birringer (*Performance, Technology, & Science*, 2008) and Steve Dixon (*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation*, 2007), we already have a thoroughly researched historical exemplification and conceptualisation of the many facets of digital performance, since the first experiments and demonstrations in the 1960s through to milestone pieces such as Merce Cunningham's *BIPED* (1999).² Of particular interest for this article are their sections on interactive, networked and telematic work, where digital communication technologies and interfaces are used to bring geographically distant artists into virtual proximity to produce performative events (Pérez 2014). While telematic work has been a feature and form of performance since the 1980s, it has struggled with the inherent technical difficulties of tele-communication, suffering from delay, latency, noise and glitches on the one hand and a palpable frustration at the lack of the genuine aesthetic advancement and emotional connection on the other. The unattained ideal is still felt in 2020–2021, with a desire not only to have a real-time networked performance, but also to achieve it with meaningful affective and emotional connection and communication between performers, and with a sense of immediacy, liveness and embodied presence being produced for both performer and audience. Quoting Steve Dixon, Elena Pérez argues that,

From a theatre and performance perspective, mere juxtaposition does not qualify for telematic performance to be satisfactory. He [Dixon] claims that 'telematic works too commonly suspect that the simple presence of these remote, virtual bodies is considered to be enough, since the magic of technology is there for all to see.' In his view, the juxtapositions need to be meaningful rather than separated and arbitrary.

(Pérez 2014)

To be meaningful, or even 'satisfactory,' is thus a balancing act between the awareness of the technological prowess of the mediating interface, and the sense of direct, almost unmediated communication between performer and performer, and between performer and audience (a balance that Bolter and Grusin, in 1998, captured within the simultaneous impulses towards hypermediacy and immediacy). As discussed above, some exponents of digital performance idealise the total disappearance and transparency of the interface for the direct 'live' and immediate experience of being there. However, given that this disappearance is

still to be achieved in any ideal sense, with ‘imperfect’ hardware still causing too many potential ruptures, we propose that we can instead look to the capacities of different technological interfaces to create sensations of closeness and presence beyond any notions of ‘liveness’ – and in their own unique ways.

To be *virtual* is not simply to be approximate to, and to *simulate* is not to be similar to, as each interface must be considered to have its own emergent properties in terms of possibilities for physical or cognitive engagement. Thus, when we refer here to virtual performance in simulated spaces, we are talking about the creation of a unique set of aesthetic dynamics with affective nuances and capacities for expression that are contextualised by the affordances of specific technologies. In many ways these new forms of technological dynamics between hardware, software, bodies and cognitive processes complexify the more direct and tangible expressivity of a physical dance practice. As media theorist Kris Paulsen describes it: ‘Telepresence and its tactile interventions in and through the screen space complicate the boundaries of our bodies, extend our corporeal agency and influence and blur the distinctions between physicality and virtuality’ (2017, 10).

While it can be noted that each new wave of ICT or telematic technologies does indeed bring a unique and emergent complex of feelings of embodiment, touch, action and agency in new contexts, it’s also important to note that the underlying concepts and ideals of remote connection and interaction to which we bring them have actually remained relatively consistent over the last 50–60 years. These concepts are of virtuality, vitality, presence and telepresence, embodiment and affection. In the 1950s, aesthetic theorist Susanne Langer was already discussing the ‘virtual powers’ of dance as an evocation of force and touch beyond the actual physicality of the dancers themselves. She described how the work of dance *evoked* forces of agency and vitality within the mind of the spectator – what she called ‘vital gesture’ – and that the primary skill of the dancer was their ability to act as a conduit within this process (Langer 1953, 169). Drawing on Langer’s almost 70-year-old concept of virtuality, we can imagine a way in which touch does not always need to be *actual* in dance, since, from the point of view of the audience, the vital sensation of action and touch is already somewhat virtual, in as much as it is *simulated* within our own mental environment. When we experience a physical reaction to dance – say, the hairs raising on our skin – we are, in a way, experiencing this virtual touch.

This feeling can also be said to apply to the interior experience of the dancer, who, while performing choreographed movement in its real physical, spatial

actuality (which Langer defines as elements of ‘place, gravity, body, muscular strength, muscular control’ (Langer 1976, 79)), simultaneously inhabits a virtual interior and imaginary dimension, not just going through the motions mechanistically, but rather channelling imagined actions and intentions that are charged with emotional and affective resonance. Langer’s understanding of this virtual essence of dance practice appeals to the idea of ‘phenomenological space’ put forward by dance theorist and movement therapist Hubert Godard (McHose 2006). For Godard, the space of the dancer should never be defined by the physical dimensions of a real space, or, as he calls it, a ‘topos,’ but should rather be seen as an experiential space imbued with subjective, historical and social context. The space of the dance is thus always virtual, filled with imagination, memory and emotion, with a ‘latent potential’ for action according to these phenomenological frameworks. Godard says: ‘That should be the title of this chapter – “Phenomenological Space” – because I’m in the space and the space is in me. There is not a distinction first between “me” and “the space”’ (McHose 2006, 34).

In other words, within the event of the actual physical performance, both dancer and spectator are having an experience in dual actual (physical) and virtual embodied modes. For Langer, however, it is the virtual dimension in particular that is at the heart of being able to communicate affect and emotion within the discipline of dance. Technological interfaces for digital dance can thus seem an apt means of channelling and exploring these pre-existing capacities for virtual sensation and agency, potentially even opening the way for more immersive, interactive and intense experiences of dance than those afforded by simply looking at a stage space from a seated distance. As researchers Kim Vincs and John McCormick point out, combining dance practice with technological interfaces is an apposite way to investigate virtual experience in general.

Langer’s writings provide a provocative starting place for exploring the idea that dance might encompass virtual, as well as actual, physical, touch. ... Dance might provide a means of exploring ways of reinserting the complexity of whole-bodied agency – the nuance of physical sensation and action – within virtualized digital interfaces.

(2010, 360)

Importantly, these philosophical concepts of virtuality speak first to the phenomenological, interior experiences of the dancer and spectator within the performance event, before speaking to the relative virtuality of digital technological systems. We can therefore see that new hardware and software do not *make* dance

virtual – as it has been virtual all along. Yet these concepts are useful insofar as they guide us towards approaching some actual technologies, with a view to posing the question: How can they extend, augment or evolve the inherent virtual powers, virtual gestures and phenomenological spaces of the choreographic art?

Authorship in ‘Layered’ Real and Virtual Spaces

Dwelling on a similar theme, but dealing with somewhat more practical concerns, dance theorist and choreographer Pauline Brooks draws on her explorations into the digital complexities of telematic dance to articulate a new spatial ‘frontier’ for such work (2010). Influenced by the telematic work of Paul Sermon from the 1990s through which he articulated a concept of a ‘third space’ for performance (see Sermon 2019, Figure 11.1), Brooks discusses her own considerations around the occasionally problematic multiplicity of experiential spaces that emerges in the layering of real and technologically-mediated zones of performance. She has found that the dancers, already invested in the conceptual goals of a project, creatively played with their awareness of the camera’s capture of the dance and thus of an imagined hypothetical zone of representation, creating a third space of ‘virtual interplay’ between actual and imagined ‘territories of performance space’ (Figure 11.2). As Brooks puts it,

We have a new space for performance, a global space linked by the Internet and identified through the projector screen and a local space defined by the physicality of the studio theatre stage. ... The challenge for the performers is to be able to embody the artistic theme and to stay connected to all performers (live and digitized) as well as to visible and invisible audiences.

(Brooks 2010, 53)

Brooks explains that this complexity of space also generated new reactions in the spectators. While some appreciated the blending of live dance and the projected screen images, others didn’t enjoy having to choose themselves where to pay attention at any given moment. Brooks concludes that, just as the dancers develop their awareness of the different ‘territories’ in which the work is happening, the audience also need to be guided or trained in the skills of reading or decoding the ‘dance information’ of the work, and thus also in its overall symbolic or aesthetic meaning. What this seems to suggest is that, while a distribution of attention across live and mediated spaces and surfaces can be a superficially



Figure 11.1 Video still from line-out footage of composited image of separate participants sitting and interacting together in *Telematic Vision* for the 'ZKM Multimediale III' exhibition.

Screengrab by Paul Sermon, October 1993.

interesting technical feature of some works, there is clearly a decisively different type of presence, attention and engagement demanded of the spectator within layered spaces. These new imperatives for Brooks either draw us more intimately



Figure 11.2 The telematic dance work of Pauline Brooks.

Photo: Noel Jones. See www.paulinebrooks-dance.com.

and actively into the dancers' actual and virtual space(s), or, inversely, can leave us distracted and disengaged, with the technology perhaps even getting in the way of our appreciation of the virtual powers of the dance.

In *Digital Performance* Steve Dixon speaks to these new dynamics of engagement by boldly stating that 'presence is about interest and command of attention, not space or liveness' (2007, 132). He states that the effectiveness of telematic performance is not simply about generating the feeling of having two distant things happening at once in the same space, but rather that the two together generate a convincing or poetic sense of coordinated, virtual co-presence – not as a tug of war for our attention, but as a single, albeit multiplanar, emotive object of communication (2007, 132). Dixon thus seems to suggest, contra Brooks, that this is a question of good authorial intention, 'command' and design, rather than one of having to educate an audience in how to read a piece properly.

The tension that emerges between Dixon and Brooks concerns the notions of choice and control as much as it does the concepts of the actual and the virtual. Questions arise around whether the 'virtuality' of the dance should be managed and guided – such that we should know what is aesthetically important, where to look and how to read the piece. Or should the layering of the actual and virtual spaces be curated but not determined, with the audience simply instructed

in how to productively interact with the work? Does the former approach actually foreclose virtuality, making the work actualised, linear and fixed? Or does the latter style too easily dissipate into an ungrounded technological gimmick without the guiding hand of an author? In other words, we can simply ask again: Which approach could be said to best enhance or augment the inherent virtual powers of dance?

In traditional live theatrical dance performance, and in the dance discipline as a whole, authorial control seems to be more straightforward than in telematic work. It is enacted by a singular space (or stage), and often by a single author/choreographer, towards which the audience's attention is wholly directed. However, even this mode of performance can be rarely said to be singular or linear, with our embodied cognition already in a synaesthetic flux between the physical and the virtual.³ In this sense, the task of the analogue choreographer already involved the curation of a field of physical, kinetic and gestural points of attention, and the more virtual allusions and evocations that those same movements generate. While digital, virtual or telematic performance work can offer us a potential actualisation (or visualisation) of some of these more allusive elements in abstract graphic forms, it also offers added complexity of dimensions, spaces, surfaces and bodies, and quite often multiple authors – in as much as the choreographer is rarely also the programmer or digital visual artist, while the technology itself often exerts a kind of non-human agency. For Sarah Rubidge, this means that the choreographic work or 'dance event' in this technological context should perhaps rather be described as a 'performative, choreographic open installation' – which only exists when activated by the spectator or 'user' of the work (2002, 2). The choreographic installation can in fact begin to seem more like an interactive, nonlinear game space than like a stage space, and the choreographer/author here becomes instead a kind of digital dramaturge, curating a set of actual and virtual connections and interactions, and working between dancers, digital artists, technological apparatuses, performance institutions and audiences.

This state of events poses an obvious challenge to the traditional creator of the choreographed work. Due to the digital nature of the engagement, a certain level of nonlinearity, interaction and improvisation is almost demanded, otherwise we simply get a linear recording. How, then, can connections be woven such that attention can flow between the real and the virtual in meaningful, intended ways? How can it enable the aesthetic meaning of the work to be adequately

expressed when both performer and audience must effectively guide their own awareness and perceptual choice? This is an issue not only of training the audience (as per Brooks' advice), but also of possibly requiring a new craft and a more complex and interactive approach to narrative and aesthetics. Furthermore, if images, bodies and spaces are to be effectively layered and connected in ways that draw the spectator away from a superficial fixation on the technical interface, they need to juxtapose in meaningful ways through aesthetic continuities and contrasts that speak to narrative suggestion, even if not in a conventional linear storytelling mode. At all times the virtual powers of dance, the nonverbal expressivity which is after all its essence, should be preserved – that is, the ability to allude to evoke emotions, sensations and forces beyond what is literally being represented.

Accessibility, Affordability, Useability

Alongside these somewhat abstract concepts and questions of presence, immediacy and attention, we should consider the rather more pragmatic concerns of access, affordability and useability when framing contemporary digital and telematic dance performance. All the factors raised above pivot on the affordances and limitations of certain (and very material) technological apparatuses. These apparatuses play against each other within each specific assemblage. And thus, for example, the spatial realism of one type of screen interface might come at the cost of affective nuance due to issues of scale and distance from the image. With another, despite the high aesthetic cohesiveness of the screen image, emotional connection might be lost due to issues of delay or latency. The 'perfect' solution to most of these issues is usually extremely costly, requiring the kind of capital investment that arts companies simply will never have access to. The imperfect solution, then, is always a considered compromise, creatively building technological limitations into the production.

Elena Pérez summarises this point through a critique of high-tech telematics performances, which, as she notes, are only accessible to 'scientists' in research institutions, and which function primarily as technological spectacle, often lacking aesthetic value (2014, 4). Because of this, she looks instead at the relative strengths of low-tech telematics options, using widely accessible webcams, video-conferencing apps and live screen montage apps UpStage and Mosaika.



Figure 11.3 *ANGRY 1*, 121212 UpStage Festival of Cyberperformance, 12 December 2012. Live node: Kawenga Montpellier. Photo: David Lavaysse.

tv (e.g., in the performance work of Annie Abrahams – Figure 11.3) in her case studies. While expensive and technologically advanced options might be a futuristic ‘vision of what performance can be,’ Pérez notes that they are not truly representative of the actual ‘state of the art’ in performance (2014). The reality of the production of meaningful connections in telematic performance arts involves the struggle to find relatively simple, reliable, glitch-free, widely accessible and well-supported technology. In 2020–2021 for many performers these continue to be platforms such as Skype and Zoom.

However, in the 10–12 years since Dixon’s and Birringer’s major publications there have been incremental technological advances that have improved the fine balance of factors in an enhanced telematic or networked performance experience. It is within this situation, and with being observant of the enduring underlying theoretical questions of immediacy, interactivity, aesthetics and narrative – and of the phenomenologies of meaningful connection and presence – that we are aiming to frame a specific set of new motion capture technology. In our own research we have suggested that, as evidenced by the widespread take-up of the Microsoft Kinect camera in performance arts since 2010, the next step in accessible tools for telematic performance should be a more refined and accurate, yet affordable and easily useable, motion capture system. To qualify this point, in

the next section we will provide an analysis of some recent interesting examples of the current 'state of the art' in digital, virtual and telematic performance.

The State of the Art in Telematics and Virtual Performance Technologies

Video and TV

Traditional or conventionally 'highbrow' arts performance content such as theatre and dance is still resolutely a stage-based medium, which has, of course, been problematic in the pandemic. There have been some forays into the screen presentation of this content – with limited success, for instance, in the screening of live stage performances in cinema spaces, on TV channel Sky Arts (launched as Artsworld in 2000 before being purchased by Sky) and on streaming platforms such as Marquee TV (launched in 2018 and rolled out globally in 2020). As a 'Netflix for the Arts', and clearly targeted at existing and established audiences, Marquee TV has intended to reach a new and younger demographic for classic performance (Heathman 2018). However, beyond the traditional stage arts and a rather elite set of well-established and establishment national and royal production companies, these TV and content streaming platforms have up until now offered little bandwidth to smaller-scale, future-facing or experimental work.

For small and medium-sized performance companies, the typical go-to during what we could call the 'first phase' of the Covid-19 pandemic was live video streaming, with most artists working under lockdown thorough standard video-conferencing and TV apps such as Skype, Zoom, Houseparty, Google Meet and Twitch.tv. While these platforms have their advantages in certain areas, for many performers, and in particular those that have to move to perform, they offer a fairly limiting and solitary experience. As our project's choreography partner Mavin Khoo has told us, 'the performance should be a dialogue between the performer and the audience', and this sense, for him, is totally lost with only a laptop screen grid view for company. Perhaps because of this, many technological advances in telematic, remote digital work focus not only on distribution to an audience but also on the level of agency the audience member is given in being able to react to, interact with or intervene in a live performance. In video media, however, this is still largely a matter of clicking and commenting within the standard chat functions of any given platform.

Diverging from this pattern, the newcomer smartphone app TikTok (formerly called Music Ally) has swiftly become a highly profitable start-up that exhibits a strong participatory performance element. In March 2020, notable for being the month in which most countries were in their first lockdown, it was the most downloaded non-gaming app (Sensor Tower Blog 2020). One of TikTok's largest areas of viewed video content is dance – from choreographed pieces by professional dancers and performers through to enthusiastic amateurs who disseminate viral dance moves and sequences to be copied and learnt. Alongside its amateur participatory practices, TikTok is also a platform for professional performers to lip-sync, dance and produce comedy skits and magic tricks, directly interacting with audiences to allow them to creatively respond to short viral clips in ways that go far beyond the standard 'like', share and comment types of interaction. TikTok has allowed stars to emerge through music and dance content released on this platform (e.g., Loren Gray, Lucky Dancer, Charli D'Amelio), and then cross over into other mainstream entertainment media. While in the past it was only musical content that had become monetisable for artists on social media platforms, here other forms of performance content such as choreography can also generate revenue, with highly followed artists earning up to \$175,000 per post (Leskin 2020).

What TikTok shows is that there is a clear market for, and interest in, dance performance content on video-based social media platforms, beyond the relatively passive experience of viewing conventional arts content. This does pose a question of how traditional dance companies can think about bringing content into these cultural and commercial networks in ways that remain aesthetically meaningful, and without demeaning the aesthetic quality and integrity of the work.

Microsoft Kinect for Body Tracking Performance

Released in 2010, the Microsoft Kinect camera was initially designed and released as a motion-sensing hardware available as an additional item with the Xbox gaming console, with the Nintendo Wii being a forerunner. However, very soon after its release the body tracking hardware was recognised to have potential for a multitude of alternative applications – and its software was hacked (Loftus 2010). Using both an infrared (IR) projector and camera and an RGB camera, the hardware proved immediately useful for a vast array of computer vision applications

due to its capacities for multi-gesture recognition, depth sensing, 3D reconstruction in any location and its useability in low light. With the only options for motion capture prior to the Kinect being prohibitively expensive professional studios, this cheap and accessible system quickly raised interest in a variety of disciplines outside of gaming: robotics, medicine, security, fashion and, of course, performance (Jamaluddin 2020). Shortly after these unofficial uses started to gain cultural traction, Microsoft opened up the Kinect's code to developers, releasing a non-commercial software development kit (SDK) and separate hardware for PCs.

A good example of the use of Kinect in dance performance is *The Measures Taken* (2014; Figure 11.4), a dance performance made by choreographer Alexander Whitley with digital studio Marshmallow Laser Feast. In this piece, the bodily movements of five dancers were tracked in real time by Kinect to generate graphic visualisations of geometric shapes and abstract volumes to be projected onto several translucent screens.

However, as a camera sensor device, the Kinect came with its own disadvantages and limitations. The first is that, with a detection range from approximately 0.4 to 4.5m, dancers can easily move out of the detectable area, by accident, during a live performance, bringing the digital performance to an abrupt stop. The use of Kinect thus requires a restrictive dance space. Second,

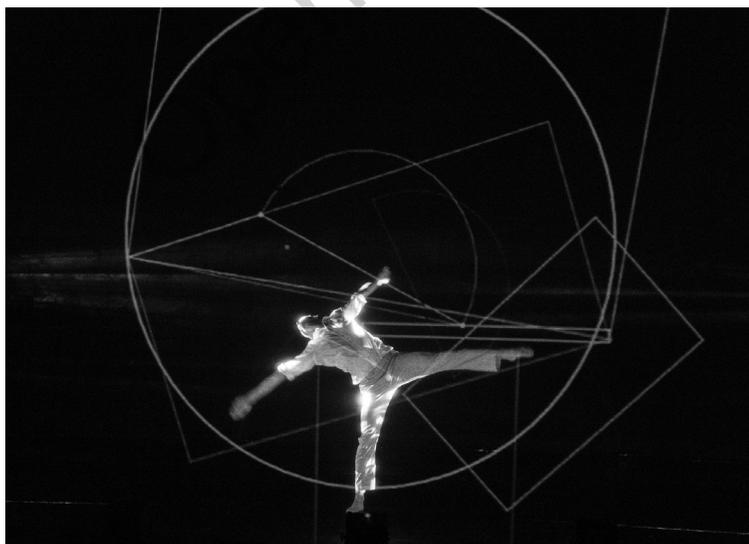


Figure 11.4 Dancer Wayne Parsons in Alexander Whitley's *The Measures Taken*, 2014. Photo: Foteini Christofilopoulou.

both Kinect v1 and v2 have relatively low depth resolution.⁴ In a large-scale project in which multi-skeleton tracking is required, the Kinect simply cannot give the required accuracy. Third, as Kinect is a mono-directional infrared projector and camera sensor device, there are many reported problems with movement tracking and occlusion, where overlapping bodily movements of more than one dancer become impossibly 'noisy' (Iqbal and Sidhu 2017; Kim 2017). If a movement leads a dancer to position themselves at an angle tangential to the camera, there is often a confusion of the skeleton recognition and the model becomes tangled in knots. While initially seen as a liberating tool for choreographic capture, having to accommodate for the Kinect's many errors of gesture recognition can be restrictive, glitchy and distracting for both dancer and spectator. Some groups have effectively worked within these limitations (for instance, patching together multiple Kinect camera inputs for greater reliability), but many of the problems of camera-based motion capture are more simply overcome by the use of some more recent motion capture techniques.

PoseNet and Inertial Motion Sensor Systems

Coming after Kinect, the most recent developments in computer vision technologies, especially those based on machine learning models, have been promising. Machine learning pose-estimation systems such as PoseNet and inertial measurement sensor 'suit' systems such as Perception Neuron, Xsens and Rokoko Smartsuit have their application-specific advantages – the former being characterised by very simple webcam access and the latter by its relative precision and its wireless, mobile functionality. Both allow performers to engage in remote virtual activities such as live performances, training or experimentation. They function as a fast and lightweight form of telematic performance communication which doesn't rely on the streaming of chunky video data via the internet.

Projects such as DensePose and PoseNet offer real-time human pose estimation, whereby skeletal information can be detected, captured and tracked without specialist hardware (as is the case with the Kinect camera), using only a built-in or standard webcam. Since the system runs in an internet browser, it is accessible to a broad audience and has consequently built a strong participatory creative community around it, enabling its members to experiment and explore body movement computationally. 'Friendly' machine learning initiatives such as ml5js or RunwayML provide accessible platforms and guidance via a web browser

not only for developers and programmers but also for amateur artists, creatives and students. All this has made PoseNet a popular candidate for experimenting with poses and movements computationally, finding application in human-computer interface development (HCIs) and providing a platform for computer vision-based explorations in dance and performance. In a good example of such experiments, renowned choreographer Bill T. Jones, together with a team of digital collaborators including Google, created a series of movement experiments using the PoseNet system in the work *Dancing with a Machine* (Figure 11.5) (Mapondera 2019).

However, pose estimation machine learning platforms can require substantial processing power for complete accuracy. Although this might not be so problematic in their more casual and participatory uses on home computers, it can have a detrimental impact on movements that require high accuracy, update frequency and detail – for instance, with complex choreography and in professional performance environments.

Since 2016, a new generation of on-body motion detection sensors has demonstrated comparatively accurate skeletal motion tracking results. This style of motion capture ‘suit’ system involves a series of small interconnected inertial measurement sensors (IMUs) that are attached at fixed points on the body. The IMUs gauge orientation, acceleration and position at a very high speed and resolution with a simple local Wi-Fi network. In contrast to PoseNet, this type of motion tracking solution allows the user to move freely within a physical space

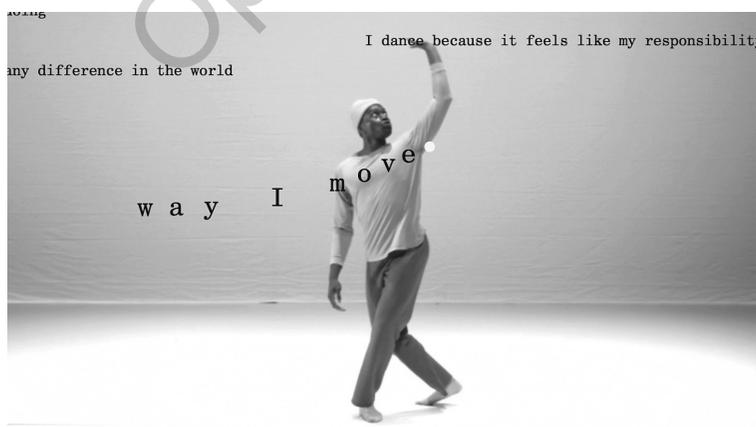


Figure 11.5 Dancer Vinson Fraley, Jr. in Bill T. Jones' *Dancing with a Machine*. Photo: courtesy of Google Creative Lab, © Google LLC.



Figure 11.6 The Perception Neuron motion capture system.

without being eye-tied to a screen. Thanks to a flexible number of sensors, it can provide more complex and accurate data on body movement, with up to 32 skeleton points on the Perception Neuron suit (Figure 11.6), compared to 17 with PoseNet and 20 with Kinect. The lightweight data is wirelessly captured by a nearby computer, where it can be transformed into audio, visual or other outputs in real time, or it can be streamed anywhere in the world for the same purposes – as is the purpose of our own current research project.

Further to its use in performance contexts, the increased richness and accuracy of the movement data yielded by these inertial sensor motion capture systems has practical application in learning and teaching, and in scientific and technical analyses of dance (see Strutt 2021). The capture and rendering of high-quality movement data in real time, and in three dimensions (compared to, for instance, a two-dimensional image from a fixed video-camera angle), can offer unexpected insights into the fine detail and immanent complexity of dance technique, even disrupting accepted cultural grammars of dance. The use of motion capture systems in the dance studio can thus reveal new perspectives for the dancer or choreographer, helping them to develop their art and practice, ‘revealing hidden stories in the movement data that can provoke artistic, aesthetic

and conceptual questions about what dance movement creation is and could be' (Vincs and Barbour 2014, 64).

Augmented/Mixed/Virtual Reality

In the past decade, we have seen a set of quite specialised dance companies and performance artists take up the use of motion capture technologies to create new performance elements and practical creative and learning tools. From mixing realities on stage with the use of projection, to using more immersive virtual reality hardware, digital dance collaborations are creating a new genre of choreographic practice which is slowly exerting an influence on mainstream arts.

Australian dance company Chunky Move, with its piece *Mortal Engine* (2008), took an early lead in researching symbolic expressions of the dancer's body by adding digital projection onto a stage space – steeply raked to double as a screen. In this work the movement of bodies and their position in the space were tracked with depth infrared cameras, with corrective geometry algorithms used to align the projection with the body. The moving bodies affected the virtual environment around them, while their own representation was distorted or enhanced by the superimposition of graphic elements and projected light and shade.

Similarly working within stage spaces, in their work *Hakanai* (2013), artists Adrien M. & Claire B. developed the methods used by Merce Cunningham in *BIPED* to project onto gauze, or scrim, on stage. With enhanced projection technology and with multiple, almost completely transparent, gauzes in many positions on stage, the conventional 'screen' effectively disappears, along with the visibility of the stage itself, such that the dancer appears to our perception to be hovering in an immersive cube of moving textures and light.

This style of virtual, mixed-reality performance has also been used to take dance outside the traditional stage space and into other interior or exterior locations. The 2018 work *0AR* by AΦE (choreographers Aoi Nakamura and Esteban Lecoq), is a collection of short dance pieces that audiences as young as five can interact with in augmented reality (AR). The viewer holds a tablet device through which they can see digital avatars and abstract objects move in the real space before them, and they themselves can move around, or dance with, the three-dimensional images. Similar AR techniques have been used to produce what are essentially digitally augmented dance films, rather than live or interactive performances. In the short film *The Fates* by Zachary Eastwood-Bloom

(2019; Figure 11.7), made in residency with the Scottish Ballet, graphical elements are superimposed on the camera image in post-production to express a virtual spatial and sculptural connection between dancers.

AR's capacity to visually overlay digital dimensions onto video images of dance has led to both enhanced learning experiences and the creation of functional choreographic tools. In 2018 the College of Art and Science at Ohio State University started experimenting with the Microsoft HoloLens AR Headset to create an AR tool called *LabanLens*, a dance-scoring application that virtually assists in Laban-based movement notation and analysis by visualising a set of notational tools in the space in front of the dancer. We have also seen the launch of consumer AR apps such as Dance Reality, an app which make dances learning accessible to a wider amateur audience. This AR technology displays the steps on the real floor space in front of the user and offers a three-dimensional virtual teacher who can demonstrate moves and be mirrored by the user. The EU Horizon 2020 project *WhoLoDance* (2016–2018; Figure 11.8) then combined several of these tools, using motion capture with the Microsoft HoloLens AR system, and alongside AI movement recognition systems, to allow a dancer to choreograph movement alongside a digital virtual avatar, who would respond to them in real time (Wood *et al.* 2017).

From the point of view of contemporary dance audiences, we are only at the beginning of the development of a variety of tools that can see spectators do considerably more with dance work than simply sit and spectate in either a stage space or with a two-dimensional screen. Audiences of all ages for this kind of



Figure 11.7 Zachary Eastwood-Bloom's *The Fates*, Scottish Ballet, 2019.



Figure 11.8 Flamenco dancer (Rosa Cisneros) working with Microsoft HoloLens at the Motek Entertainment studio (Amsterdam). © 2016 WhoLoDance.

Photo: Giulio Bottini.

work clearly do exist – and can be developed. As evidence of this, in September 2019 some 400,000 people joined violinist Lindsey Stirling’s live *Artemis* performance in virtual reality (VR). Using the XSens 3D motion capture suit and Manus VR Gloves, her violin-playing movement and choreographed dance routines were captured, rendered and broadcast to VR systems in real time. While this performance offered a limited scope for interaction, it provided some insight into the potential of AR, VR and XR platforms in creating a future vision of a new kind of immersive virtual space within which audience and dancer could interact in more meaningful ways.

Gaming Platforms

In many ways, at the present moment it is actually gaming technology that offers the most tangible vision for the future, driving forward the cutting edge for performance arts, both in terms of interactive platforms and, as with TikTok, in the potential monetisation of content. Epic Games, with its real-time game engine Unreal and its incredibly popular game *Fortnite*, has amassed a global audience of 350 million registered users (Statista 2020). While Epic is developing this platform with playable gaming as its primary function, it has also started diversifying its content by hosting live music events within the virtual game world – and with

purely online audiences. *Fortnite* is first and foremost a first-person shooter game, but over time it has complexified through the addition of narrative chapters and ten-week seasons, each with exclusive maps, sets of items and storylines. Each of these seasons now ends with an 'exclusive' live music event, with popular artists such as Travis Scott, Marshmello and Diplo performing. These events have a captive player audience that can interactively participate through their own game controllers, and with (purchasable) avatar dance moves called 'emotes'. Emotes do not serve any direct game function and are described by Epic as 'purely aesthetic', yet they have become a point of cultural fascination for a wider internet audience, crossing over into viral mimicry videos found on both YouTube and TikTok under the hashtag #fortnitemoves (Kaufman 2018). Epic Games was in fact recently subject to five lawsuits about copyrighted dance moves used in its games, highlighting how easily choreography can be trademarked and monetised, potentially with royalties paid for each time the dance is used (Robertson 2019).⁵

The massive popularity of *Fortnite* as a game has developed due to several factors, mostly because it is a free-to-play, multiplatform game that is funded by in-game micro-transactions (including the purchase of dance emotes) and through collaborations with commercial properties (e.g., promotional tie-ins with film and TV content such as *Star Wars*, *Avengers: End Game* and *Stranger Things*). However, the ease of access and relatively low cost-to-instant-gratification ratio of this type of gaming platform offers an interesting model of a participatory and interactive virtual space for arts performance. Epic Games has expressed a wish to open the platform up for creative development, with creative sandboxing and the release of its *Fortnite Creative* mode in 2018. Can we thus imagine a future in which gaming platforms such as Unreal and virtual game worlds such as *Fortnite* could offer an opportunity for live arts events, or for motion-captured dance or theatre performance?

Conclusion: Questions Shaping Future Research

It is perhaps no surprise that traditional forms of the arts such as dance and theatre are now losing out to the more 'entertainment'-focused industries, particularly with younger audiences. It is now easier and more accessible, as well as more fully embodied and participatory, for a child or teen to express themselves through dance on a 'virtual battlefield' than it is to do it in a classroom or conventional arts space. How, then, especially in socially distanced times,

can dance practitioners think about engaging with online audiences beyond the narrow scope and abbreviated format of a platform like TikTok? Despite some excursions into augmented reality, motion capture and digital visualisation tools (e.g., with Sadler's Wells' 'Digital Stage' programme of 2020 or Scottish Ballet's 'Digital Season' in 2019), there is still a long way to go for traditional forms of stage-based performance to have the same kind of digital and economic traction as music, gaming and film – forms whose creators benefit from putting their work online through sharing and streaming platforms. While the subscription service Marquee TV is a good example of a step towards more accessible and diverse (including digitally augmented) online arts content, it lacks the meaningful sense of layered spatial presence and attention that live performance can afford, as well as lacking the sense of direct emotional and affective communication that can be experienced by both viewer and performer.

Established dance and theatre audiences are typically slow to catch up, adopting newer technology reluctantly as they age (Snow 2016). This is not to say, however, that younger audiences don't also appreciate the same type of arts content as older generations. It is just that the platforms of delivery, the forms of attention given and the modes of monetisation for creative content are changing, and this, in turn, must force the content to evolve. There is a technological opportunity to capture a new and younger audience that already display an interest in dance and choreographic content. Meanwhile, with almost 62% of people in the UK playing videogames (Waterson 2021), rising to 70% in the USA (Crescente 2018), audiences are already accustomed to the kinds of interactive functionality and participatory experience that are associated with gaming (e.g., they know how to use a controller and a menu or experience an avatar). Online audiences have also proven that they want to be able to have more agency in works, from the live streaming of DJ sets on Boiler Room with live chat through to donation-funded Twitch Esports content.

We believe that future-oriented concepts for platforms, audiences, interactive performances and the monetisation of choreographic content exist in ways that can neatly merge with the currently developing motion capture, immersive and mixed-reality technologies. Framed by developments in motion capture technology from the camera-based systems of Kinect and PoseNet to inertial-sensor systems such as Perception Neuron, Xsens and Rokoko, the future of dance and choreographic content being shared on various AR, VR and XR platforms looks more immersive and more participatory. It is in part the responsibility of dance companies to embrace new technology through the dedication

of time and resources, but collaborative academic research is also needed here, to be coordinated between the humanities, computing technology and design industries. Through interdisciplinary collaborative projects such as ours, dance performers and choreographers can learn to understand ways of sharing and developing new work, while shaping a digital future for traditional performance arts.

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