The Procrustean Body: A Theoretical Analysis of Motion Capture from Critical Disability, Somaesthetic, and Posthuman Perspectives

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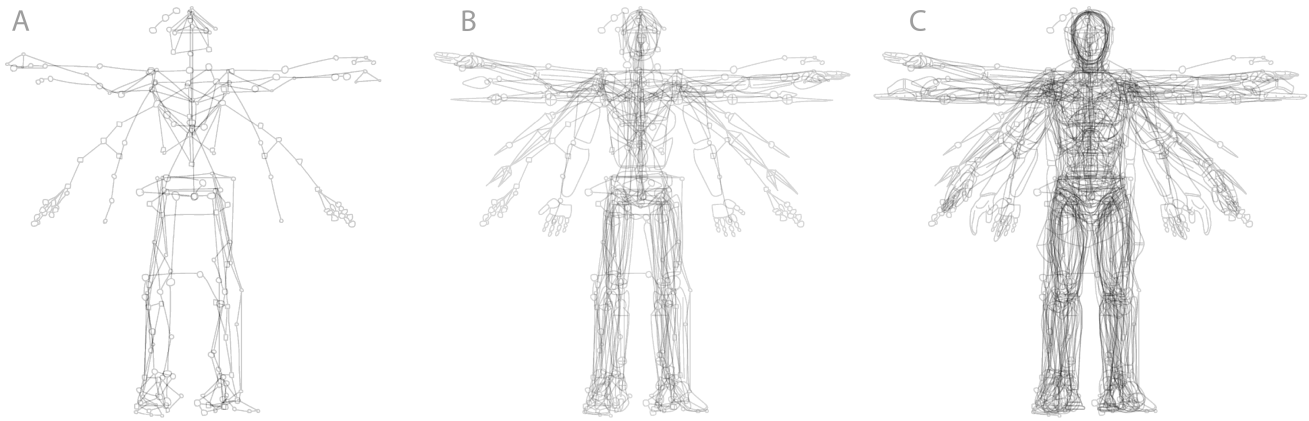


Figure 1: Conformity in motion capture systems: *The construction of the Procrustean Body.* A compilation of 21 sketches taken from visualisations in modern mocap systems. A) Bodies are reduced to a set of marker and node clusters, tracked points on the body. B) This is then assembled into standardised skeletal parameters and body segments, derived from normative biomechanical models. C) A default avatar mesh is then often imposed, aligning the captured body with predefined representational standards.

Abstract

Motion capture (mocap) systems underpin media production and medical science, yet are built on normative assumptions of an 'ideal', non-disabled body. This paper presents a theory-led analysis of

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mocap through critical disability studies, extending prior socio-technical and historical analyses of the technology. We draw on three vignettes from disabled artists and practitioners, and analyse experiences of mocap using three complementary theoretical lenses: Minority Body theory, somaesthetics, and posthumanism. Our findings identify eight interrelated themes demonstrating how normative assumptions permeate the mocap pipeline, from materials and calibration to representational models and data protocols. We introduce the concept of the 'Procrustean body' to describe how mocap systems co-construct bodies to fit normative standards rather than neutrally capturing them. Building on this analysis, we articulate key challenges and propose a research agenda for designing more inclusive, accessible motion capture systems that can centre disabled embodiments.

CCS Concepts

• **Human-centered computing** → **Accessibility theory, concepts and paradigms**; *Accessibility design and evaluation methods*; **Interaction design theory, concepts and paradigms**; **HCI theory, concepts and models**; *Empirical studies in accessibility*.

Keywords

Critical Disability, Accessibility, Motion Capture, Posthuman, Posthumanism, Minority Body, Somaesthetics, Soma Design, Human Computer Interaction

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1 Introduction

Motion capture (mocap) is a process for digitally sampling, measuring and representing the translation and rotation of physical objects in 3D. The vast majority of contemporary mocap systems are designed to capture the motion of human bodies using cameras (in optical systems) and inertial measurement units (in wearable systems) [111, 148, 182]. These systems enable the virtual representation of bodies in a variety of contexts, including animation, film, and gaming [148, 175]; immersive experiences [22, 93]; manufacturing [112]; sports science [93, 157]; and biomechanics and rehabilitation [10, 55, 60, 89, 95, 142, 170, 187]. Particularly in the creative industries, mocap has become a genuinely expressive medium. However, to infer dynamic representations of the body from streams of sensor or visual data, existing mocap systems rely on assumptions about the topology and mechanics of both the skeletal and non-skeletal elements of the human body [68]. As is the case for many body-centric technologies, mocap systems do not consider accessibility for physically disabled people—those with minority bodies compared to the general population [14].

As Harvey et al. [68] describe, "*motion capture rests on normative assumptions about who should be measured to understand the human body: those who are male, white, 'able-bodied,' and of unremarkable weight*". These assumptions have their origins in early studies dismembering and measuring white male cadavers [23, 37], which provided a basis for biomechanical and anthropological research [27, 45, 65, 69, 184] and early work on human factors [43, 162]. Harvey et al. [68] further elaborate three successive eras in mocap's development (*Foundation* 1930–79, *Standardisation* 1980–2000, and *Innovation* 2000–present), showing how, through practices of *measurement and validation*, these assumptions become established and entrenched in modern systems. As a result, at every point in the mocap pipeline — from materials and calibration, through kinematic models, data structures, protocols, and end applications—a 'corporeal standard' of an 'ideal' bounded and non-disabled human body [51, 54] is enforced. Mocap, therefore, plays a role in constructing bodies and raises critical concerns about access, representation, and the kinds of virtual embodiments that are permissible.

The prior work of Harvey et al. [68] probes the historical and socio-technical foundations of mocap, but stops short of fully engaging with a critical disability perspective, calling for future work to use disability as a "*key lens...to interrogate [mocap's] assumptions*". Importantly, critical disability perspectives are informed by theoretical models that frame how bodies, difference, and access are understood [105], for which there are three predominant models:

- The *medical model* views disability as an individual deficit requiring treatment, rehabilitation, or cure [161], positioning impaired bodies and minds as deviations from a 'normative' or 'corporeal standard' [21]. This model remains prevalent in clinical contexts, particularly in rehabilitation and assistive technology [105], but has been criticised as reductive and dehumanising, framing disability as a "*diminished state of being human*"[21].
- The *social model* views disability as arising from social, environmental, and attitudinal barriers rather than individual impairment[122, 123, 161]. While central to disability rights advocacy, the social model has been critiqued for underemphasising the lived, embodied, and intersectional dimensions of impairment [29, 31, 147].
- The *affirmative model* builds on and extends the social model by foregrounding non-tragic, positive understandings of disability [19, 158]. It emphasises disability as a valued aspect of identity and lived experience, reclaiming both disability and impairment as embodied and meaningful.

In this work, we draw on the affirmative model, alongside insights from the social model, to foreground disability as lived, embodied, and generative—moving beyond deficit-based framings to examine how systems such as mocap shape which bodies are represented, valued, and made visible.

Despite the importance of critical disability engagement, mocap already intersects with disability in significant ways, predominantly within medical and rehabilitative contexts [11, 49, 60, 97, 187], where disabled bodies are framed as deviations from normative standards, and mocap is used to measure and correct movement. While some work addresses specific accessibility challenges, such as accommodating mobility aids [78, 87, 94] or limb differences [183], these efforts largely operate within existing paradigms that retain normative assumptions about bodies and movement. For example,

all three works model the body as distinct from mobility aids or prosthetics. In doing so, they overlook the integrated nature of disabled embodiment, where mobility aids form part of movement and the lived body itself [178]. At the same time, broader developments within HCI are beginning to challenge such normative paradigms, with increasing attention to disability not as a technical problem but as a site of theoretical, political, and creative inquiry [54, 63, 64, 176]. In line with this shift, Harvey et al. [68] explicitly calls for approaches grounded in the lived experience of disabled people, recognising that such perspectives cannot be substituted through assistive design alone.

In this paper, we address this gap through a theory-led analysis, grounded in a critical disability perspective, examining mocap as a socio-technical assemblage. Drawing on three vignettes from disabled artists and practitioners, we analyse these experiences of mocap through three complementary lenses: (i) Minority Body theory [14] to highlight the barriers ('local bads') that arise for physically disabled people, (ii) somaesthetics [74] to articulate the qualia and felt experience of using mocap, and (iii) posthumanism [1, 18] to reformulate the assumptions underlying mocap and present alternative designs. These three frameworks are not themselves critical disability theories, but they offer powerful analytical tools for examining the structural, experiential, and relational dimensions of socio-technical systems. We adopt them here from an explicit critical disability perspective, grounded in the affirmative model, to ensure that disability remains centred as a valued and generative standpoint rather than a deficit to be accommodated. We elaborate on this methodological positioning in section 3.

In our analysis, we identify eight themes that describe how normative assumptions permeate the mocap pipeline in interrelated ways. These assumptions are inscribed at every stage. They appear in the *materials*, through standardised equipment such as premade bodysuits and fixed marker placement; in the *procedures*, through calibration and range-of-motion routines that assume an 'ideal' body; in the *models*, which exclude or misconfigure disabled embodiment, such as decoupling mobility aids from the body they move with [178]; and in the *data infrastructures*, which propagate downstream into game engines and animation software.

We argue that mocap imposes a *Procrustean body*. In Greek mythology, Procrustes was a bandit who invited travellers to spend the night in his iron bed, then made each guest fit it exactly: stretching those who were too short, and amputating the limbs of those who were too tall. Only bodies were adjusted, never the bed. The 'Procrustean bed' has since become a byword for any framework that forces its contents into conformity [9], and our analysis leads us to the same figure in mocap: *rather than a neutral observation of physical bodies, mocap reshapes them to fit a pre-existing and idealised design*. We conclude by outlining a set of grand challenges for the design of accessible motion capture, derived from our analysis.

1.1 Contribution

This paper makes the following contributions:

- **A critical disability re-reading of motion capture:** Building directly on prior socio-technical analyses of mocap, we take an explicit critical disability perspective, called for but not yet realised in existing work.
- **A theory-led analysis:** Through three vignettes of disabled artists analysed via Minority Body theory, somaesthetics, and posthumanism, surfacing structural, relational, and experiential tensions which are often overlooked in mocap research.
- **The conceptualisation of the Procrustean body in mocap:** We introduce the notion of the *Procrustean body* to articulate how mocap does not simply represent bodies, but actively constructs new bodies that are designed to fit normative models, offering a new critical lens for analysing embodied capture systems.
- **A research and design agenda for equitable motion capture:** Building on our analysis, we articulate grand challenges for rethinking mocap systems that centre disabled embodiment and address how bodies are modelled, captured, and represented at the fundamental level.

2 Background

2.1 Conceptions of the Body in HCI

Interaction design is always underpinned by assumptions about the bodies and minds of anticipated users. Historically, HCI conceptualised users as abstract information processors, prioritising efficiency and usability in workplace contexts [77, 120]. However, the field has increasingly recognised that interaction is fundamentally embodied [74]. This shift, often described as the "somatic turn", foregrounds the body as central to perception, action, and experience [41, 76, 98, 113]. Rather than separating mind and body, this perspective understands cognition as situated [67] and mediated through the body [41]. Approaches such as somaesthetic design [76] further emphasise attention to internal bodily sensations and lived experience, drawing on practices such as dance, yoga, and performance.

Recent work has extended this view by recognising that there is no singular, universal body. Instead, HCI has begun to engage with *plural and situated bodies*, acknowledging variation across individuals and contexts. Concepts such as *datafied bodies* highlight how technologies measure and represent bodily signals, often in ways that privilege certain forms of embodiment over others [74]. Similarly, *intersectional bodies* recognise that the facets of identity, including disability, gender, race, and age, intersect to shape experiences of technology [74]. Alongside this pluralisation, posthuman perspectives *de-centre* humans, to highlight the "co-constitutive role[...] of more-than-human objects and entities such as things, spaces, people, and materials" [74]. The resulting entanglement theory considers assistive devices, sensing technologies, and material environments to be integral to the formation and experience of the body. Entanglement has been used to design systems such as menstrual cycle tracking [75] and glucose monitoring [48], and even rethink personal fabrication [38].Where systems must represent bodies, *ambiguity* offers a design resource rather than a defect [53]: rather than imposing a prescribed meaning, representations that resist fixed interpretation invite users to ascribe their own. Turmo Vidal and Duval [163] demonstrate this in the context of

bodily data, where deliberately ambiguous representations support plural readings of the same body.

These developments highlight that interactive systems do not simply respond to pre-existing bodies. Rather, they participate in shaping what bodies are, how they are experienced, and what forms of embodiment are recognised as valid. This raises critical questions about how mocap specifically encodes assumptions about bodies, and whose bodies those assumptions serve.

2.2 Motion Capture Technology

Motion capture (mocap) refers to systems that combine sensing technologies and processes that translate physical movement into structured data [85, 112, 121, 177]. Typically, this involves the translation of optical or inertial motion data onto a digital representation, such as a skeletal model, avatar, or virtual object [111]. While the vast majority of interactive devices sense human motion, the term "motion capture" is often reserved for systems that claim to capture the "full" [26, 28, 33, 104, 107, 129, 139, 173] or "whole" body [30, 47, 127, 135, 171].

Optical mocap systems use cameras to track people, animals, or objects. Marker-based systems remain the gold standard for tracking precision [25, 165], with commercial examples including OptiTrack [117], Vicon [101, 102], and Qualisys [2]. However, these systems require controlled environments and bodysuits with specific marker arrangements [168]. Some systems support customised marker configurations [167], but this process is labour-intensive and constrained by predefined kinematic models (e.g., plug-in gait [169]). Increasingly, "markerless" systems are being developed; however, they currently lack the precision and fidelity of marker-based systems and are embedded with assumptions about the expected topology and motion of bodies because they are trained on datasets [186] that overwhelmingly consist of non-disabled participant data (e.g. Human3.6M [82]). Examples include Theia3D [106], Qualisys Miqus (hybrid) [131, 132], VICON Vulcan [100], ART CAPTA [84], and Optitrack Duplex [118].

Inertial systems estimate body pose using networks of inertial measurement units (IMUs) that are attached to the body via bodysuits or straps. Because they are portable, affordable and do not require external infrastructure or controlled environments, inertial systems are widely used in gaming, Virtual Reality (VR), and streaming contexts. One drawback of inertial systems is their use of magnetometers [153], making them susceptible to interference from ferrous metals in the environment. Examples include XSens [20, 80, 81], Rokoko [140, 141], MOxi V100/S100 [114, 115], Perception Neuron 3 [159], and YostLabs PrioVR [88]. Although such systems are individually calibrated and often framed as personal—capturing *your* body in *your* space—individualisation does not necessarily equate to freedom from normativity. Calibration fits a normative skeletal model to a particular body rather than deriving a model from it, and the same holds in consumer VR, where body tracking is estimated against normative assumptions about proportion, limb count, and posture [54].

Optical and inertial systems depend on calibration processes that require users to perform range-of-motion procedures and/or predefined poses, such as the T-pose or A-pose. These poses are used as they are easy to reliably perform for those with normative bodies as well as providing a mechanism for fitting a biomechanical skeletal model to individual body segment measurements.

Across these different mocap systems, models typically represent the body as a set of rigid segments connected by joints, with predefined constraints on movement [68]. While such abstractions aid computational measurement, they also impose limits on what forms of movement and bodily configuration can be represented. These assumptions are often invisible to users, yet they shape both access to mocap systems and the forms of embodiment they represent.

2.3 Motion Capture and Disability

Despite the widespread use of mocap across media production, biomechanics, and healthcare, relatively little work has critically examined its relationship to disability. One notable exception, by Harvey et al. [68], traces the non-innocent history of mocap and its reliance on "normative assumptions". Specifically, the work surveys the historical inception and subsequent socio-technical practices of mocap, describing how assumptions about which bodies are legible and valid become entrenched as a consequence of practices of "measurement and validation". In their discussion, Harvey et al. [68] identify disability as a "key lens" through which mocap systems can and should be interrogated, an approach that remains underexplored in the wider literature.

The vast majority of mocap and disability research has taken place within assistive, clinical, and rehabilitation contexts [5, 89, 187], where movement is evaluated against normative standards. Some examples address barriers to mocap in rehabilitation settings [95], while others support self-directed therapy at home [6, 49]. This reflects technoableism often seen across technology design, a term coined by Shew [149, 150] where non-disabled technologists' aim is to support or empower disabled people; however, the technology reinforces ableist ideas about what body-minds are or should be. As noted by Strobel and Gerling [155], activities such as sport are often reinterpreted as rehabilitation/therapy, displacing other meanings such as play, creativity, and expression. Within mocap, disabled bodies are typically understood in relation to deviation from an assumed norm, enforcing ableist ideals, with mocap deployed to measure, correct, or rehabilitate movement or bodies.

Recent efforts have sought to adapt mocap systems to accommodate disabled users by extending pose estimation to account for limb differences [44, 183] and by incorporating mobility aids into kinematic models [78, 94]. However, these approaches model mobility aids as separate from the body: the aid is treated as a rigid object tracked *alongside* the skeleton, its own coordinate frame appended to a 'human' model, rather than as a segment of the kinematic model itself. The wheelchair is an object within which the body sits, not a part of how the body moves, despite the integrated nature of some disabled embodiments [178]. They also remain limited in practice, for example, in Li et al. [94], only 2 out of 14 participants included in the training set were genuine wheelchair users. More recent speculative systems, such as Hilton et al. [72], have begun to question mocap's accessibility, calling for alternative approaches that make fewer assumptions about users' bodies.

Alternative perspectives are more evident in artistic contexts. For example, *MotionDisabled* [109, 110], has been described as one of the "first non-medical motion capture studies", foregrounding

disabled performers' movement practices. This work highlights disabled people's "*lived engineering experience and learnt movements of alterity*." Similarly, work on wheelchair dance [179, 180] emphasises the entanglement of bodies and assistive technologies, aligning with posthuman perspectives in which wheelchairs are integral to embodied experience rather than external aids.

These examples demonstrate the potential for mocap to support diverse and non-normative bodies, yet these bodies are framed as exceptions. Most systems continue to rely on standardised models of bodies and movement, constraining who can be captured and how movement is represented. While mocap technologies continue to evolve, their underlying assumptions remain largely unexamined, particularly from a critical disability studies perspective. Addressing this gap requires moving beyond technical inclusion toward analysing how mocap systems construct, constrain, and normalise embodied difference. This motivates our theory-led approach, which brings together minority-body theory, posthumanism, and somaesthetics to examine how mocap produces what we term the *Procrustean body*.

3 Theory-led Methodology

Theory-led analysis is well established in HCI as a method for interpreting empirical data and lived experience through theoretical lenses that guide what is foregrounded and how findings are discussed [137]. It is particularly prominent in qualitative and critical HCI, where researchers move beyond usability metrics toward reflective and explanatory accounts of technology [13, 73, 176]. In disability HCI, such approaches have shifted attention away from assistive framings toward the social, cultural, and political assumptions embedded in systems [24, 63, 154, 156]. For example, Gerling and Spiel [54] use theory-led analysis to examine how virtual reality systems presume particular bodies and interactions.

We adopt a similar approach, drawing on three complementary lenses: **Minority body** theory to analyse structural barriers; **somaesthetics** to foreground embodied, sensory experience; and **posthumanism** to explore relational and non-anthropocentric perspectives on design.

3.1 Supporting Theories

3.1.1 The Minority Body. Minority body theory [14] describes a value-neutral model of physical disability, framing it as "*simply another way of being a minority — something that makes you **different** but not something worse off*" [14]. This positions disability amongst other individual factors that may make a person a minority, such as race, gender, and sexuality. Disability, in this view, produces context-dependent *local goods and bads*, shaped by social, environmental, and economic structures.

This contrasts with dominant assumptions that disability is always a disadvantage (a "global bad"). Instead, experiences of disability vary depending on context and intersectional factors such as class, race, and environment. As a crude example, a wheelchair user may encounter a lack of step-free access (a *local bad*) within an otherwise fulfilling life.

In HCI, this framework has been used to identify structural barriers in technologies such as VR, where Gerling and Spiel [54] describe how the "occurrence of local goods and bads can be a helpful tool" to describe the existence of structural barriers. We extend this approach to motion capture, focusing specifically on how tools and processes produce recurring *local bads* for marginalised users.

3.1.2 Somaesthetics and Soma Design. Coined by Shusterman [152], somaesthetics offers a conceptual framework for critiquing and designing technology that foregrounds embodied, sensory experience as central to epistemic and aesthetic understanding. This is particularly relevant to systems that directly measure and mediate bodily movement, such as motion capture.

Building on Shusterman's concept of *somatic connoisseurship*, Schiphorst [145] treats the body as an instrument of knowledge production, arguing for careful attention to proprioception, kinaesthesia, tactile sensation, balance, and movement, to develop a sensitivity to the felt experience of our interactions with technology [46, 76, 79]. While somaesthetics has been criticised for assuming normative bodies, recent work by Das and Ventura [34] has integrated disability studies perspectives to argue for "inclusive design, grounded in diverse bodily experiences".

Our approach builds on this foundation by centring disabled and neurodivergent embodiment without prescribing normative forms. This resonates with Hamraie et al. [64]'s framing of crip technoscience, which foregrounds the practice of *hacking systems* and attending to the embodied knowledge of disabled people.

3.1.3 Posthumanism and the Body. Posthumanism draws on the work of feminist and continental philosophers, as well as indigenous knowledge [42], to reject anthropocentrism and socially constructed dualisms such as human/technology, nature/culture, and mind/body [39, 66, 92, 124]. Instead, it is acknowledged that we coexist within complex, relational (and rhizomatic [36]) networks or *intra-actions* between people, animals, technologies, environments, and other entities [12, 35]. References to the body appear throughout the posthumanist literature where boundaries between the body and technology are blurred, as represented by Haraway's cyborg [66] and Hayles's notion of the "original prosthesis" Katherine [1]:

> *...the posthuman view thinks of the body as the original prosthesis we all learn to manipulate, so that extending or replacing the body with other prostheses becomes a continuation of a process that began before we were born.*

The posthuman body extends outwards into its environment and is understood to be situated within social, cultural, and ecological contexts [67]. This conceptualisation accommodates variation and nuance, in contrast with *humanism*, where differences from an imagined norm are considered inferior, giving rise to a hierarchy of otherness. Posthumanism also asks why the body is considered to "*end at the skin*" [66]? Through the *visceral prosthesis*, Shildrick [151] argues that the body is pluralised and prosthetic beneath the skin. For example, the microbiome comprises 'non-human' life, without which we could not survive. Prostheses and assistive technologies do not restore a lost corporeal 'whole'; 'wholeness' itself is, and has always been, an illusion.

This posthuman perspective resonates with critical disability studies, which makes no hierarchical distinction between bodies

and emphasises the co-constitution of bodies and their environments [59, 119]. Disabled people, as Weise [174]'s "common cyborg" suggests, are already deeply entangled within sociotechnical systems, generating cripistemologies, or situated ways of knowing that emerge from lived experiences of disability [176]. Braidotti [17] takes disability studies as emblematic of the posthuman predicament: what a medical model reads as dependency, a posthuman lens reads as "*a privileged bond with multiple others*". The affirmative model's claim that disability is generative is therefore not consolatory but revelatory: it is what becomes visible once the bounded human subject of posthumanist critique is set aside.

3.2 Combination of Three Theories

We analyse mocap through the combined lenses of Minority Body theory, somaesthetics, and posthumanism to produce a multi-layered account of mocap as a socio-technical practice.

- **Minority Body** theory grounds the analysis in material conditions, centring structural barriers experienced by marginalised users and ensuring attention to lived realities.
- **Somaesthetics** contributes an experiential perspective, attending to how interaction with mocap systems is felt, perceived, and embodied.
- **Posthumanism** conceptualises embodiment as relational and distributed, revealing how bodily assumptions become embedded within human–technology assemblages.

Together, these lenses address three complementary dimensions: structural barriers (Minority Body), embodied experience (somaesthetics), and socio-technical relations (posthumanism).

3.3 Methodology and Positionality

Consistent with third-wave HCI [16, 108], we treat lived experience and author positionality as valid sources of knowledge, interpreted through our theoretical lenses. Disabled and neurodiverse perspectives are represented amongst the authors, as well as intersecting expertise in critical disability, HCI, mocap engineering, somatic practice, and artistic research. Several authors, including the vignette authors, identify as disabled and have direct experience with mocap. Our approach is inspired by the likes of Gerling and Spiel [54] and directly answers the call to action made by Harvey et al. [68], using disability as a "*key lens through which to interrogate [mocap's] assumptions.*"

We also acknowledge the limits of this positionality. All authors reside in one country, and thus in one context of disability policy and access provision, and engage mocap through academic, commercial, and artistic practice rather than clinical practice, for example. Disability is heterogeneous, and our accounts do not stand in for all disabled experiences. Following the long-standing traditions in qualitative methods of inquiry [96], we offer context so that readers may judge these claims' *transferability* to their own settings. Accordingly, our aim is not generalisation from a sample to a population (such as in statistics), but *analytic* generalisation [128]: the movement from situated accounts to conceptual claims, in this case grand challenges of accessible mocap described in section 6.

3.3.1 Vignette Development. Our analysis focuses on three vignettes (**Kris**, **Kat**, and **Annie**) written by or about disabled artists, who are also co-authors. Vignettes are widely used in HCI to surface situated and experiential aspects of interaction [83, 90]. Each vignette was developed either autobiographically or collaboratively and includes contextual biographical detail. The three vignettes differ in form by design, where vignette authors were invited to engage on their own terms to preserve their voices and the authenticity of the lived (and often messy) experience, rather than imposing a single process, which is encouraged to make qualitative research inclusive [172].

Kris's vignette was independently authored in response to the prompt: "*please provide a 3 to 4 paragraph account of your experience with any form of motion capture*", and iteratively refined by Kris himself across several rounds of prompts and written feedback from multiple co-authors. It recounts his encounters with inertial mocap in university and industry research settings.

Annie's vignette was developed from recorded discussions with another co-author, which were transcribed. Annie preferred to recount her experience orally and then edit a co-author's written rendering of it, rather than draft from scratch. Annie's transcripts were shaped into prose, and the draft vignette was then reviewed by Annie, alongside original transcripts, to ensure they accurately reflected the experiences.

Kat was a key collaborator and co-author who passed away during the preparation of this paper[1]. **Kat's vignette** has been constructed from archival recordings of their work with mocap, combining events that occurred within two separate workshops, developed by a close and long-term collaborator (Clarice Hilton) who was present for both. Clarice Hilton worked with Kat for over three years, and both workshops were attended by co-authors. The two encounters are presented as one account for narrative flow, but all events, sensations, and utterances are kept distinct in the settings in which they occurred.

This research was approved by UWE's College of Arts, Technology and Environment research ethics committee (application ID #13451585). All vignette authors provided informed consent for their vignettes to be included and published. For Kat's vignette, consent was obtained from their next of kin.

3.3.2 Analysis Method. Our analysis draws on and is informed by interpretative phenomenological analysis (IPA) and micro-phenomenology [57, 71]. From IPA, we adopt an interpretative orientation that treats vignettes as meaningful accounts requiring active interpretation rather than surface-level coding. From micro-phenomenology, we attend to granular, moment-to-moment experiential detail; the microscopic events and sensations that constitute embodied interaction with mocap systems.

Three of the lead authors independently reviewed all vignettes, identifying excerpts of analytical interest using the three theoretical lenses: Minority body, Somaesthetics, and Posthumanism. These excerpts were then reviewed for overlap and collaboratively clustered into four broad deductive themes using Miro, which were iteratively refined and developed through reflexive discussion among the authorship team into eight inductive themes, corresponding to barriers (or *local bads*), presented in section 5. Figure 2 summarises this process. Importantly, the authors leading the analysis

[1] In line with the ACM Policy on Authorship and Kat's significant contribution to the work, Kat's next of kin has granted permission for them to be included as an author.

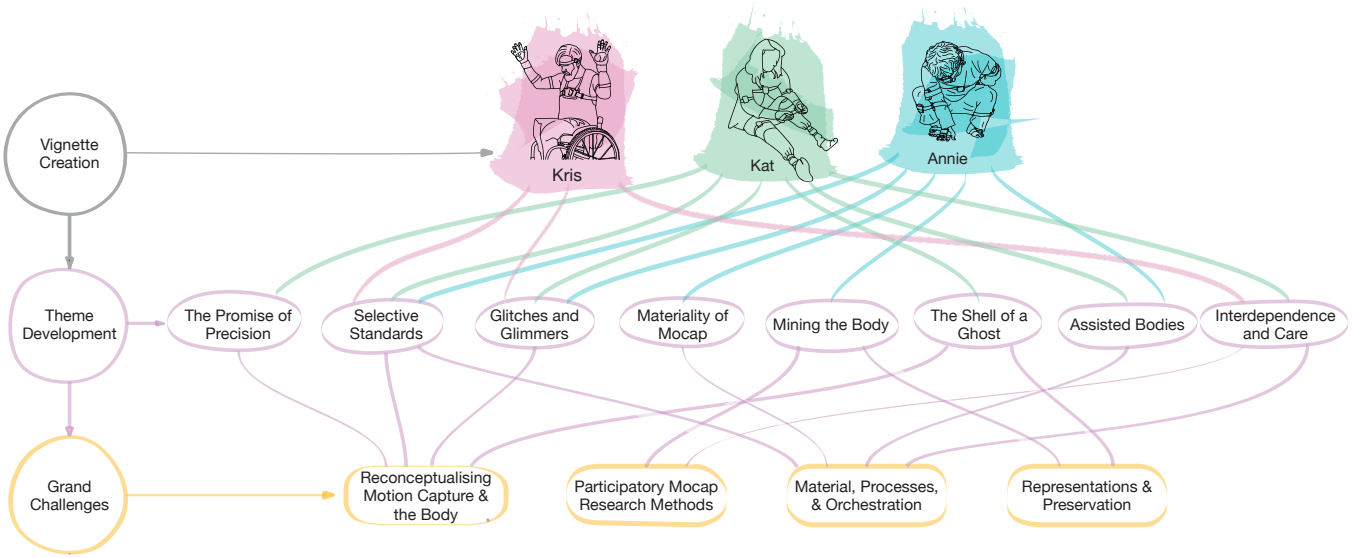


Figure 2: Stages of the methodological process, from vignette creation through theme development to the grand challenges.

have well-established working and personal relationships with the vignette authors spanning many years to over a decade.

Because the accounts are deliberately rich and singular, some of the eight themes developed in section 5 are necessarily led by a single voice. As stated above, we do not treat theme prevalence as a proxy for significance: a theme carried by one vignette is not thereby weaker, and likewise, a theme developed from three vignettes does not equate to a more broadly generalisable claim. Each theme instead earns its place analytically, by i) highlighting a tension in mocap that our theoretical lenses make legible and by ii) contributing to the grand challenges described in section 6, moving from a situated account to a conceptual claim.

4 Vignettes

4.1 Kris

My name is Kris (he/him); I am a musical artist and Disabled person, working in the space of gesture and motion capture as a means to express myself musically, but also to overcome Disabled barriers to traditional instruments. I'm known for my work with the MiMu Gloves, a glove-based form of musical motion capture. I have over a decade of experience using gestural musical interfaces.

I was invited to try out an inertial motion capture suit for music making. I was excited, as it offered a chance to explore two clear questions that have arisen from my artistic journey. Since my earliest performances with the Gloves, audiences have posed the question of what a "full body" version of the gloves would be like. The second question is more phenomenological, around my relationship with my Disabled body-mind and the inherent contradictions in my approach. I believe that gestural technology must extend beyond the minimum boundaries required to digitally trigger a musical outcome. There is a layer of emotive performance required that goes beyond simply triggering a sensor. Postures and Gestures must be "bigger" to truly embody the meaning of using one's body to drive musical composition.



Figure 3: Kris

This contrasts very harshly with my experience of Body Dysmorphia through Disabled body-mind experience; my instinct is to be "smaller", to take up less space, through a fear of my own appearance. Motion capture felt like a valuable — if drastic — way to engage with the phobia of my own physicality. During the project workshops, I put on the suit, which involved strapping multiple sensors to my body. I enjoyed the aesthetic experience of wearing the suit greatly; I enjoy cyberpunk, imagined-future fashion, and almost see the suit as a "platform" to expand that aesthetic.

I always had to perform a calibration before the suit could be used. Calibration was one of the most challenging areas of the project. Part of my disabled body-mind experience is that I have difficulty with movement on the right side of my body; I am unable to reliably

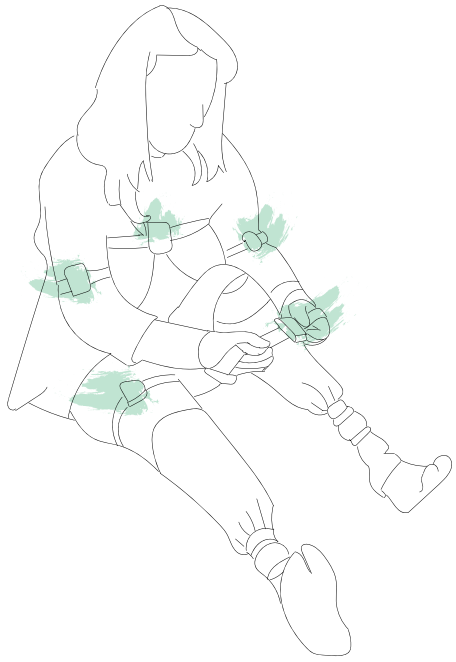


Figure 4: Kat

replicate a pose. This creates some margin for error, which is visibly reflected in the wireframe model. It's interesting to note that this difference between my body and its wireframe equivalent has not impaired musical outcomes so far. It seems reasonable to assume that more complex mappings will expose this discrepancy and create a wider scope for error.

I was very aware of interdependencies across the project and my reliance on others, although I was supported very effectively. I am not hugely experienced with computing beyond music production. Software updates during the project made it easier, as I was less reliant on "under the hood" computing, such as using Terminal. I believe that this poses a wider challenge for accessible tech: there is almost always the need for a tech-savvy — usually non-disabled — person to support. Giving Disabled people autonomy to set up their own creative tools is the next big challenge in the future of accessible tech.

4.2 Kat

Kat (they/them) is a crip artist, movement practitioner, and researcher. Kat is attending a mocap and dance workshop with researchers and dancers, which begins with a demonstration of an IMU-based suit worn by one of the researchers facilitating the workshop. The first visual shown is the default avatar, which is a male, non-physically disabled figure with a muscular physique. Kat remarks "default, man, default, muscular like, there are many other things, yeah, as well as not being impaired". The researchers explain that this is the default representation given by the system, but it could be changed.

The demonstration continues with the team explaining how the sensors track different parts of the body. The head sensor is attached to a hat, and the researcher demonstrates what happens when it is removed. This causes the head of the avatar to jerk around, and Kat recoils while some of the researchers laugh at the avatar's movements. The access support worker checks in with Kat to see if they are happy to carry on or need a break. The group discuss the issues with the visualisation behaving in this way.

Kat asks whether the legs could be removed and at what points. The technical team describe how these joints could be turned off in the mocap software. Kat asks for clarification on how specific the difference could be. One technologist asks what Kat's goal would be, to which Kat responds, "to understand the limitations of the suit". The team discuss the need for measurement, how this has medicalised and disability surveillance connotations, and how it may be an issue for some people. However, Kat accepts this as part of the mocap process.

With the help of a researcher, Kat tries on the suit. Another dancer, who is not a wheelchair user, wears a second suit. There is also a creative technologist setting up the model on a computer. The creative technologist asks Kat what height they would like to be "eermmm... oooooo.... maybe I'll be like 5' 6". The choice is exciting but forces Kat to specify a height, which changes depending on how they are navigating the world. Kat is currently using their wheelchair, the researcher and creative technologist explain that the suit will not track the wheelchair.

They move on to calibrating the system, but none of the calibration poses are suitable for a wheelchair user. They decide together to do the T-pose. After calibration, the visualisation of the body is shown; it has forced Kat's motion data into the form of a male-presenting standing figure, even though Kat is seated: "Okay, so sitting down stood me up". The data is then streamed into Unity (a game engine) and used to animate an avatar. Unlike the other dancer's avatar, Kat's movements through the physical space are not matched by their avatar. "You moved quite fast... but I don't move". Kat explores this mismatch further: "What did it do to my body?" There is a disconnect between Kat's physical movement and the digital expression; however, the non-disabled dancer's movements are represented more accurately.

Afterwards, Kat reflects on the experience: "even though I was moving across space, I felt static, and I felt stuck, and it brought up shame and internalised ableism. I got so jealous with yours... it was fine... Why is mine not doing that?"

4.3 Annie

Annie (she/her) is a freelance dance artist of short stature, working with improvisation and disability informed movement practices.

Annie describes a previous experience with motion capture being used for a project. She was asked to wear an all-in-one suit, which did not fit, "I remember it obviously didn't fit me, and they didn't have any shoes small enough, so they had to like go out and buy some shoes and stick things on it". The other movement artists in the space were "someone who was like, bigger and someone who was really tall, so I think they were having like, different bodies".

During the experience, Annie was not shown how the mocap system was visualising her movements. The computational understanding of her movements was recorded, and she was asked to sign an NDA about what was recorded. She was never told what the mocap was being used for or whether "it even worked in the end." The experience inevitably felt tokenistic and experimental, while the gaps in information formed a sense of exploitation.

On a second encounter with motion capture, Annie is wearing an IMU suit in a workshop with different researchers and another dancer.



Figure 5: Annie

The tracking feels a bit off, so they recalibrate the system again. A lot of time was spent getting the technology right. "It's kind of tracking my body, but it's not quite right". She moves around more, exploring different movements whilst watching the visualisation of the suit. "I think I have to move a particular way to not flick it all off. I don't know if that's because I'm small or it's just Velcro". The suit keeps sliding down on her legs, which impacts the visualisation, and she needs to pull it up again. This reminds Annie of the unique shape of her legs and how ill-fitting clothing impacts her regularly. "I mean, it makes you move very linearly, and I guess like form, not so much from inside sensation, but from the outside."

Annie continues to move with the avatar, exploring different movements, moving to the floor. Annie comments, "because my scoliosis, my shoulder's a bit of an angle... there's a thing about exposing like a skeleton a bit". A couple of minutes after this, Annie decides to swap with another dancer. When reflecting later, Annie describes how that experience changes how she relates to her body: "Seeing yourself represented in a different or certain way can adjust our relationship to our forms, I guess, and like in a disability sense, like expose or reveal, you know, like parts of your physicality. Because in a way it was a little bit like an X-ray, but I've never seen my X-ray move like that or related to it in a non-medical sense".

Moving in the suit felt restricted from a dance perspective as only certain, larger motions would get picked up easily, meaning Annie couldn't move as authentically as she would like to (i.e. slower, smaller gestures). In terms of relating to the suit, although keeping the fit was challenging, it was exciting to see the potential of digital representation and observe the body in this distinct way.

5 Analysis

Here we present eight themes representing common assumptions, barriers, and rationalisations about disability and motion capture. As described in section 3, we derived these themes from excerpts taken from the vignettes in section 4. We first describe each theme, then apply the three theoretical lenses using the excerpts.

5.1 The Promise of Precision

Mocap is framed as producing faithful, precise representations of movement, suggesting that the original motion can be exactly recovered from the captured data. However, from its historical roots in cadaver studies [23, 37] to contemporary socio-technical practices [68], this promise of precision is most readily available to non-disabled embodiments.

Minority Body The assumption of precision produces local bads when it is not met. Kat encounters a stark comparison between the system misbehaving for them and behaving as expected for a non-disabled collaborator — "*you moved quite fast... but I don't move*". Standing uprightness is reinscribed as default, creating a mismatch between Kat and their avatar — "*Okay, so sitting down stood me up.*" Kat's question, "*What did it do to my body?*", reflects how the promise of precision has set the rules and expectations of engagement, where minority bodies are not afforded the same precision.

Somaesthetics Kat experiences a discrepancy between felt and represented movement, particularly speed and posture, qualities that are embodied and bound to effort and balance. Instead, as the system forces motion into the Procrustean Body it produces an unexpected augmentation, highlighting that mocap does not exactly translate, it transforms movement. This mismatch can induce self-surveillance, shame, and comparison, particularly in contexts where disabled bodies are already hypervisible — "*I felt stuck... Why is mine not doing that?*". When systems claim precision but present something contradicting *felt* experience, they risk eroding trust in embodied knowledge.

Posthumanism The promise of precision fragments in moments like "*What did it do to my body?*", an admission that the system has participated in shaping embodiment. Here, the body is not pre-existing data; Kat's virtual body is produced through an assemblage of sensors, kinematic assumptions, a gendered avatar, calibration models, and expectations of being upright. "*Sitting down stood me up*" exposes the 'baseline', normative human that the system expects. Kat's experience not only reveals the entangled co-production of a new body — the *intra-action* — but also betrays a process that is neither transparent nor neutral.

5.2 Selective Standards

The vignettes reveal precision to be selectively enforced. What counts as precise, or worth correcting, is shaped by facilitators, system constraints, and intended outcomes.

Minority Body In Annie's vignette, recalibration is repeatedly pursued whilst slipping sensors persist, shifting the burden of precision onto Annie: "*I think I have to move a particular way to not flick it all off.*" In Kris's vignette, visible discrepancies are tolerated when they do not "*impair musical outcomes*", revealing that standards of precision are selectively enforced depending on the application context. In Kat's vignette, a fixed height is demanded at the point

of abstraction: "*maybe I'll be like 5' 6*", even though Kat's height depends on whether they are using a prosthetic or a wheelchair. When Kat asks whether "*these joints could be turned off*", further justification is requested: "*what would your goal be?*".

Somaesthetics This uneven enforcement produces conflicting embodied demands, requiring users to define their bodies in ways that contradict lived experience: fixing a height or conforming to an inaccessible calibration pose. Elsewhere, imprecision and unpredictability shift attention from felt embodiment towards the system itself. Annie describes how inconsistencies cause her to move "*very linearly... not so much from inside sensation, but from the outside*". Expressive movements are also considered secondary to "*getting the technology right*".

Posthumanism Precision emerges as a property of the socio-technical assemblage, dependent on rigid mitigation processes that demand a bounded, fully specified body. However, the vignettes suggest these standards are neither consistently achieved nor necessary, as Kris's practice demonstrates: meaningful interaction (and intra-actions) can occur despite imprecision. Precision becomes one possible outcome among many.

5.3 Glitches and Glimmers

Related to precision is the unexpected or undesirable behaviour of wireframe models in mocap systems: *glitches*.

Minority Body Glitches appear in all vignettes: "*causes the head of the avatar to jerk around...*" (Kat), and "*It's kind of tracking my body, but it's not quite right.*" (Annie). Kris reflects on the inaccessibility of calibration to iron out glitches as "*one of the most challenging areas*". Typically, these glitches highlight inconsistencies between the physical movement being captured and its virtual representation. While glitches are inherent to complex systems, mitigation processes, such as calibration and algorithmic adjustments assume non-disabled users, producing a local bad of disproportionate instability for minority bodies.

Somaesthetics Glitches create dissonance between the felt and represented movement, whilst producing social dynamics linking non-normative bodies with 'problems' to be 'solved'. Garrett et al. [52] similarly note how robotic breakdowns are framed as failures, even within projects aiming to challenge ableist assumptions. In the vignettes, these moments of glitch direct attention inward: "*difficulty with movement on the right side of my body*" (Kris), "*because my scoliosis...*" and "*expose or reveal parts of your physicality*" (Annie). Crucially, impairment is not the glitch; rather, system breakdowns heighten awareness of embodied difference, shaped by mocap's historical alignment with medicalised, 'Körper' views of the body [125].

Posthumanism These glitches are tied to mocap's longstanding emphasis on measurement and validation [68]. As long as mocap is framed as a measurement tool, glitches will be treated as failures. A posthuman perspective reframes instability as inherent. Entering the apparatus of a capture volume or suit becomes an entangled extension of the body, rather than a process of accurate replication. Rather than errors to be eliminated, glitches then become epistemic opportunities: *glimmers* that reveal the system's assumptions and limits.

5.4 Materiality of Mocap

Many systems require pre-made bodysuits, designed to standardise a wearer's body surface, act as a substrate for retroreflective marker arrangements [168], or to ensure the consistent placement of sensors. Suits, marker/sensor arrangements, and skeletal models assume a normative body type. Where possible, accommodating limb differences requires custom arrangements and measurements [167], lengthy work that mirrors the qualities of medicalisation [134] and 'disability surveillance' [143]: the collection, documentation, and monitoring of data relating to embodied characteristics and attributes of impairment.

Minority Body While assumed to be neutral, the standardised body suit is a materialisation of the assumptions on which mocap systems have been designed, privileging the majority body and minoritising other body types. Annie's experience with a marker-based mocap suit illustrates a *local bad* that manifests from this limitation: an ill-fitting suit "*...it obviously didn't fit me, and they didn't have any shoes small enough, so they had to go out and buy some shoes and stick things on it*".

Somaesthetics From the design of bodysuits to the requirements of upstream data protocols, body differences and mobility aids result in material issues that reveal further assumptions. Dependence on standardised suits and skeletal models requires bodies to conform to a normative template rather than meeting bodies as they arrive. The inability to adapt to differences frequently invokes comparisons with the unassisted, standardised body, which can lead to a dissociation between felt body and the system's representation: a sense of somaesthetic alienation.

Posthumanism Posthumanism rejects the notion of a bounded, separate human body that pre-exists its technological entanglements. Bodies and mocap systems co-constitute each other, and the resulting Procrustean body imposes a fiction of the autonomous human form. From this perspective, there is no corporeal standard, only a human-technology configuration. The body-suit-marker-technology assemblage is normative by design and encodes an anthropocentric form that assumes the boundaries of the body to be self-evident and stable, denying how disabled people experience agency within a network incorporating the body, technology and environment.

5.5 Mining the Body

Mocap emerges not only as a representational technology but as an extractive process, where bodies are configured as data sources to be captured, processed, and repurposed. Bodies become raw material to be mined. By *extraction* we mean the harvesting of bodily data together with the removal of its originators' agency over how it is interpreted, governed, and reused—including, but not limited to, reuse for capital accumulation. Material discomfort appears here,

rather than only in subsection 5.4, because it is where extraction is felt: capture is prioritised over the actor's embodied experience.

Minority Body Annie's vignette explicitly positions the body as a site of data collection and describes how the suit "*obviously didn't fit me*", alongside contrasting bodies ("*someone... bigger and someone... really tall*"), suggesting a specific demographic sampling of difference. She is excluded from the interpretation and governance of the resulting data: "*I didn't even see the technology... I didn't know what they were using it for*". This is indicative of broader mocap practices. Extractive research involving disabled people is well-documented [32, 58], and mocap intensifies this through *hypervisibility* [130], where bodies can be abstracted and repurposed without participant involvement.

Somaesthetics Poor-fitting equipment for disabled users interacts with extraction, dictating how attention is directed within the body. The ill-fitting suit matters here not as a usability failure, but as the point at which the priority of capture over experience becomes sensed. Annie describes how the instability of the suit requires constant adjustment: "*I think I have to move a particular way to not flick it all off*". Movement is reoriented towards sustaining capture rather than internal sensation and expression, positioning the body as both source of data and labourer in its own extraction. Mocap also produces new forms of bodily awareness. Annie compares the experience to "*an x-ray... but I've never seen my x-ray move like that*", highlighting an anatomical visibility that renders the body inspectable and segmented, echoing medical imaging without equivalent consent structures. This creates an ambiguous experience in which the body is both objectified and re-encountered through its extracted form.

Posthumanism Extraction is part of a broader system in which bodies are deconstructed into data and reconstituted elsewhere. The Procrustean body is used to produce usable data, and once captured, that data can be detached from the actor and circulated within academic or commercial contexts. Here, a double standard emerges: The data is treated as Annie's body, yet she is not afforded agency or governance over its use. The body is simultaneously claimed and disowned, recognised as a source of value while detached from control. Annie's account of signing an NDA and never seeing the outcomes highlights how embodied interaction is converted into value that moves independently from the body that produced it. For disabled users, additional labour is required to conform to the Procrustean body, while control over interpretation and outcomes is retained elsewhere.

5.6 The Shell of a Ghost

Mocap systems have a rigid understanding of what counts as a "full body", and what body is represented as default.

Minority Body Most mocap systems enforce a limited standard with minimal customisation for disabled bodies. This produces local bads where users cannot see themselves represented. In Kat's vignette, the default avatar is described as "*default, man, default, muscular... as well as not being impaired*", reflecting an ableist, sizeist and gendered expectation presenting itself as neutral. Such defaults risk becoming global bads by reinforcing normative bodily standards. These assumptions extend to tracking: Kat's wheelchair cannot be captured, and their data is forced into a "*standing figure, even though Kat is seated*". The resulting avatar reflects not the user, but the historical bodies underpinning mocap: the "ghosts" of idealised forms [68], where minor customisations (e.g., disabling joints) are considered deviations from a presumed norm.

Somaesthetics This enforced misrepresentation produces embodied dissonance. Controlling an unrepresentative avatar invites comparison with idealised bodies, generating discomfort or shame. Technologies that promise embodiment intensify these effects, as experiences linger at the level of the body [76]. Excluding mobility aids further fragments embodiment, such aids are often integral to bodily experience: "much a part of the body as the skin, blood, and organs" [178]. Their absence limits both representation and control, reducing the user's sense of a "full" body within the system.

Posthumanism This rigid shell, the Procrustean body, encodes a humanist ideal of the body that has its origins in early 20th century cadaver studies [68]. A posthumanist perspective understands that bodies are inseparable from technologies and environments. Alaimo's concept of transcorporeality emphasises that human corporeality is entangled with the material world [4]. Mocap visualisations are not representations of a singular body, but assemblages involving performer, hardware, software, and design processes. Forcing this assemblage into a standardised figure obscures these entanglements. The Procrustean body could be reformulated as an *emergent body*, one that has an undefined start or end, coalesces throughout time during interaction with a system, moving beyond ableist, gendered, and normative constraints.

5.7 Assisted Bodies

Mocap rests on the assumption that bodies move independently and make no provision for mobility aids. Consequently, mobility aids incorporating ferrous metals (such as wheelchairs or crutches) can "interfere" with the magnetic fields sensed by IMU-based systems or reflect infra-red light that is required by many optical systems. Furthermore, the assumption that bodies move unassisted is deeply embedded into the underpinning infrastructure and data protocols (such as MVN [136]).

Minority Body The tracking issues that mobility aids can introduce for both inertial and optical mocap systems extend beyond technical limitations and reveal deeper structural issues that minoritise people whose movement relies on mobility aids. The lack of mobility aid support manifests as glitches (as discussed in section 5.3) that cast mobility aids as "problems", positioning disabled bodies as secondary to an expected independent body.

Somaesthetics For disabled people, mobility aids are often experienced as somatically integrated into their body schema [56]. By separating the body from mobility aids, mocap becomes

a barrier to somaesthetic expression rather than a tool for it. Encouraging participants to perform a version of embodiment that the system accepts promotes a form of somatic inauthenticity. For example, in Annie's vignette: "*Moving in the suit felt restricted from a dance perspective as only certain, larger motions would get picked up easily, meaning Annie couldn't move as authentically as she would like to (i.e. slower, smaller gestures)*". The influence that the technology has on Kris's movements is perceived positively: "*my instinct is to be "smaller" to take up less space, through a fear of my own appearance. Motion capture felt like a valuable - if drastic - way to engage with the phobia of my own physicality*"

Posthumanism Haraway's notion of the cyborg dissolves the boundaries between nature and technology, questioning "[w]hy should our bodies end at the skin"[66]? The assumption that mobility aids are separate from the body is an example of human exceptionalism: the notion that humans are fundamentally different from, and superior to, technology. Mobility aids are a component of a cyborgian assemblage that mocap systems fail to acknowledge. From a posthuman perspective, metal wheelchairs and magnetic/optical sensors intra-act to produce a particular phenomena and "errors" emerge because the unassisted body-sensor assemblage is privileged above the assisted body-aid-sensor assemblage, which is regarded as different from and therefore less than.

5.8 Interdependence and Care

Mocap's dependence on collaboration between technicians and movement practitioners reflects Kittay's critique of autonomous individualism [86] that we are never truly independent meaning-makers. However, mocap instantiates this interdependence hierarchically, positioning expert technicians above 'dependent' performers. For disabled performers, these imbalances are intensified when embodied knowledge must be translated through normative technical frameworks.

Minority Body Kris's vignette highlights this collaborative requirement: "*I was very aware of interdependencies [...] and my reliance on others*"; noting the technical barriers that all artists face: "*there is almost always the need for a tech savvy — usually non-disabled — person to support*". Kris names this reliance as common to all performers: the technician–performer hierarchy is a general condition of mocap and is not disability-specific. What differs is its frequency and interpretation in the context of disability. Repeated engagement with ableist systems necessitates a reliance on others for access, resulting in an uneven experience of interdependence. The non-disabled experience is considered ordinary collaboration; however, the glitches highlighted earlier mark this reliance as a deviation from the norm, read as a deficit of the body rather than the system, demonstrating that collaborative structures can become sites of minoritisation.

Somaesthetics Interdependency in mocap requires placing one's body in others' hands, literally and figuratively, creating a condition of somatic exposure: your body becomes available to others' perception and manipulation. This shapes how glitches are perceived: "*... this causes the head of the avatar to jerk around. Kat recoils while some of the researchers laugh at the avatar's movements.*" These reactions are connected to individuals' relationship with the technology: technicians view the avatar as a data abstraction and find its limitations a source of amusement, but for Kat, the visualisation represents an embodied figure and its distorted movements evoke a traumatising somatic experience.

Posthumanism Disabled performers bring embodied knowledge, while facilitators engage with technical systems that interpret bodies as data. Posthumanism frames interdependence as negotiation between situated knowledges, without elevating any single perspective [67], and reframes a "reliance on others" as an example of distributed agency. However, mocap environments typically privilege technical over embodied perspectives. Crip technoscience further challenges this division by recognising disabled people not only as subjects of capture but as technical experts and "hackers" who actively rework systems [64]. Reconsidering mocap design could therefore redistribute agency more equitably, enabling performers to shape calibration, interpretation, and failure states. Centring non-normative bodies and positioning their users as co-designers opens the possibility for systems to fail gracefully and with care.

6 Grand Challenges of Accessible Motion Capture

Building on our analysis, we present four grand challenges as critical directions for research at the intersection of disability and mocap. By addressing these challenges, mocap can be transformed and reimagined as a more accessible technology, accommodating a wider range of bodies and practices.

6.1 I Reconceptualising Motion Capture & the body

Motion capture is consistently framed as a technology of precise measurement, providing a transparent representation of the 'full body'. However, '*The Promise of Precision*', '*Selective Standards*', and '*Shell of a Ghost*' demonstrate that claims of precision are fallacious and conceptually misleading. In reality, *motion capture is the business of making bodies*: it produces new bodies representing entanglements of mocap's non-innocent history, design assumptions, kinematic models, physical materials, sensing apparatus and algorithmic 'belts and braces', in combination with the physical movement of the 'subject'. *Selective Standards* and *Glitches and Glimmers* reveal that precision in mocap is negotiated and unevenly realised. For disabled users, body differences and mobility aids expose mocap's limitations, which manifest as instability and misrepresentation. This leads to the first grand challenge:

> *To reconceptualise motion capture as a process of embodiment construction, rather than measurement.*

Historically, mocap has been shaped through methods of measurement and validation [68] in which the so-called "ground truth" body, rooted in cadaver studies [23, 37] and anthropometric standardisation [43, 162], permeates into contemporary models. This

legacy persists as a Procrustean body: a default body that is presented as neutral, yet encodes ableist assumptions about body topography, form, movement, and interdependence.

One way to reconceptualise mocap is to look to puppetry rather than measurement. Measurement implies that a body exists independently from the system. By contrast, puppetry begins with the premise that movement is always mediated, constructed, and shaped through an assemblage of bodies and mechanisms. There is no single default puppet body: from marionettes to shadows and tabletop figures, forms vary widely. Puppetry can even pluralise bodies [8], consolidating the movements of many to control a single figure.

This matters because mocap already operates in this way. Captured movement does not pass directly from person to representation, it is shaped by networks of people, sensors and algorithms. While traces of plurality and reconfiguration exist in downstream practices such as avatar retargeting [3, 70], and digital puppetry [91, 116, 146], the foundational motion model remains fixed, individualised, and normative.

Rather than imposing normativity, improved mocap systems would accommodate variation and reduce embodied misalignment. They would be transparent about the process as a partial co-construction of movement, rather than a comprehensive and precise representation of the body.

Addressing this challenge requires:

- Moving beyond fixed, individual, and Procrustean skeletal models (e.g. the fixed joint hierarchies assumed by formats such as BVH) toward modular, reconfigurable primitives that can be pluralised.
- Supporting non-normative kinematics (e.g., wheels) as fundamental primitives that enable the integration of non-human material into a fundamental motion model, rather than just 'props'.
- Decoupling *precision* from *usability* and unpicking precision as the de facto goal.
- Designing socio-technical arrangements that treat glitch as expected, rather than deviations from a norm.

6.2 II Participatory Mocap Research Methods

"*Mining the body*" reveals mocap as an extractive practice, where bodies are data sources and disabled participants are frequently excluded from interpretation, ownership, and outcomes. "*Interdependence & Care*" highlights that disabled practitioners often rely on technical experts within unequal power structures. These dynamics are further reinforced by mocap's alignment with a medicalised, *Körper* gaze [125], where bodies are measured and evaluated against normative standards. This leads to the second grand challenge:

> *Develop participatory, disability-centred approaches to motion capture research, practice, and design to avoid extraction.*

Current mocap practices often mirror disability surveillance [143] through the hypervisibility of bodies [130] that are captured, abstracted, and circulated. Data governance typically rests with researchers, institutions, or commercial organisations. Mocapped bodies are hypervisible and attributed to the actor, yet actors retain no meaningful control over their data. This challenge becomes more prevalent with the emergence of markerless systems, capable of capturing 'human' motion in everyday settings [40, 133, 138, 144, 164]. In this context, exclusion is no longer confined to specialist studios but pervades into wider infrastructure.

Crip technoscience offers a critical direction for rethinking these practices. As Williams et al. [176] argue, design should "*generatively integrate the plurality of cripistemologies... in the practice of forging new sociotechnical futures.*" Disabled people, understood as the "common cyborg" [174], are already deeply entangled within sociotechnical systems, and bring situated expertise in navigating, adapting, and reworking them.

This perspective reframes disabled practitioners as co-designers and technical experts. Participation is not simply about inclusion but intervention. Central to this is *reciprocity*: a commitment that those whose bodies constitute the data receive tangible return from it—access to their own capture, authorship over its interpretation, and a share in the outcomes it enables—rather than the one-way flow that "*Mining the Body*" describes. Rather than asking how to better extract or model bodily data, future mocap research must ask: *who or what* participates in constructing these systems, and what bodies, movements, and knowledges are allowed to shape their design? Improved methods would shift focus from ownership to *relationality*, rethinking consent, authorship, and responsibility as distributed across the socio-technical mocap system.

Addressing this challenge requires:

- Embedding disabled practitioners as codesigners, not just as subjects for capture, in the ground-up redesign of accessible mocap systems.
- Rethinking consent as ongoing and relational, particularly if data is reused and/or repurposed.
- Creating systems that support modification, adaptation, and "hacking" by users, rather than enforcing fixed workflows.
- Elevating embodied knowledge as equal in value to technical expertise.
- Establishing reciprocity as a baseline: returning captured data, representations, and outcomes to those who produced them, in forms they can use.

6.3 III Material, Processes, & Orchestration

'*Materiality of Mocap*', '*Assisted Bodies*', and '*Selective Standards*', demonstrate that accessibility barriers permeate into its physical material and procedures. Bodysuits, standard marker/sensor placement, and calibration procedures all embed assumptions about bodies and how they move. For disabled practitioners, this produces ill-fitting equipment, inaccessible poses, and unstable tracking. When using mocap, everyone is forced into the Procrustean body; disabled embodiments just make this more apparent. This leads to the third grand challenge:

> *Redesign the material, procedural, and organisational conditions of mocap to support disabled embodiments and enable more equitable forms of interdependence.*

Interdependence and Care indicates the collective procedures of mocap that require coordination between performers, technicians, and systems. However, when errors arise, which occurs disproportionately for disabled people, additional labour is required to adjust and recalibrate. In these moments, control typically passes to, often

non-disabled, technicians. What emerges is a constrained form of interdependence, where disabled practitioners become dependent on technical authority. As Bennett et al. [15] argues, interdependence does not guarantee access, and mocap exemplifies this tension: while it depends on collective coordination, it often fails to recognise or equitably distribute labour and agency.

Mocap requires processes through which aspects of independence can be supported, and access negotiated. This includes rethinking the assumption of a singular, precisely represented 'full-body' as the default outcome. It also requires that the mechanisms for achieving an illusion of precision, often available to non-disabled users, are not withheld, but open to configuration and authorship by disabled participants. Addressing this challenge requires:

- Designing modular material interfaces that accommodate diverse bodies and mobility aids.
- Redesigning calibration and setup procedures, allowing for the authoring of alternative poses, postures, and range-of-motion procedures.
- Enabling participants to negotiate and intervene in capture outcomes and technical control, including how bodies are modelled, represented and interpreted.
- Supporting forms of interdependence that recognise mutual cooperation instead of hierarchical dependency.

6.4 IV Representations & Preservation

The Shell of a Ghost reveals that mocap systems generate movement data through preconfigured normative models. These models lead to 'default avatars', non-disabled, anatomically standardised representations that reinforce a narrow conception of a "full" body. Such representations are not neutral visualisations, but continuations of the Procrustean body identified in our analysis. Mocap representations do not simply reflect bodies, but help shape what kinds of bodies are considered valid and desirable. This leads to the fourth grand challenge:

> *Rethink how motion capture data is represented, standardised, and preserved, to support plural, non-normative embodiments beyond the point of capture.*

These limitations extend beyond capture systems into downstream applications. Motion data is structured through standardised protocols (e.g. MVN [181]), producing skeletal hierarchies, naming conventions, and animation pipelines that are compatible with a range of environments (e.g. game engines). Even if capture systems change, the connecting data formats continue to enforce normativity: the Procrustean body persists across the wider infrastructure.

Work within HCI, VR, and games research has explored more inclusive and diverse avatar representations, including designs that centre disabled embodiment [7, 61, 62, 103, 126, 185]. While these are important works that challenge dominant representational norms, they are primarily in the field of VR, remaining bounded by predefined avatar frameworks, where embodiment is selected or configured from a fixed set of possibilities. In this sense, they extend rather than depart from the underlying representational mechanisms of mocap systems that also constitute VR: that bodies must be bounded and predefined in advance.

However, if mocap is understood as constructing bodies, then predefined representations, common in mocap software and game engines [50, 160, 166], become unnecessary. Instead, systems could start from ambiguous or partial representations that become more specific through interaction. Such *emergent representations* would allow embodiment to develop over time, rather than being defined from the outset.

Finally, *Mining the Body* describes how motion data is detached from the actor and circulated independently. Yet, as Loukissas [99] argues, *all data are local* and never truly context-free: even when abstracted into datasets, they remain shaped by specific "data settings," including the technical, cultural, and institutional conditions of their capture and reuse, which in turn structure how certain movements are valued or excluded. For disabled practitioners, this digital afterlife is consequential, as non-normative movements may be corrected or removed, diminishing embodied difference. Post-processing and 'touch-ups' thus become sites where bodies are reinterpreted and re-authored, raising questions about whose values shape these transformations and the ownership of this entangled, relational body [1, 12]. Addressing this challenge requires:

- Rethinking 'default' representations to support diverse, non-normative, and pluralised embodiments.
- Developing flexible data structures and protocols beyond the boundaries of the Procrustean body, which BVH and MVN formats currently encode and downstream engines inherit.
- Designing representations that emerge over time through interaction, rather than being predefined.
- Critically examining the digital afterlife of mocapped bodies, making explicit how movement is transformed and valued, while maintaining relational links between bodies, systems, and context.

7 Conclusion

In this paper, we argued that motion capture systems are not neutral tools for recording movement, but rather socio-technical assemblages that actively construct an ableist "Procrustean body". We foregrounded the lived experience of disabled artists and practitioners through three vignettes, highlighting mocap's unspoken promise of precision, interdependencies, and extractive practices that unevenly distribute access and agency. Through our theory-led analysis, which combines minority body theory, somaesthetics, and posthumanism, we demonstrate how assumptions permeate the entire mocap pipeline, shaping materials, calibration practices, representations, and data protocols. Across the mocap pipeline, disabled bodies are excluded, reshaped, misrepresented, or rendered incompatible, as a consequence of recurring structural and experiential barriers. However, the encounters described also present opportunities to rethink mocap towards more relational, pluralised, and emergent understandings of embodiment. Through a set of grand challenges, we establish a strong avenue for future mocap research and design, one that centres disability and treats embodiments as co-constructed rather than predefined. Addressing these challenges is a matter of accessibility, but also a fundamental expansion of what bodies motion capture can represent.

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