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Moving Cinematic History: Filmic Analysis through Performative Research

Jenny Oyallon-Koloski <joyallon_at_illinois_dot_edu>, University of Illinois at Urbana–Champaign
Dora Valkanova <valkano2_at_illinois_dot_edu>, University of Illinois at Urbana–Champaign
Michael J. Junokas <junokasm_at_gmail_dot_com>, University of Illinois at Urbana–Champaign
Kayt MacMaster <ccm6_at_illinois_dot_edu>, University of Illinois at Urbana–Champaign
Sarah Marks Mininsohn <sarahmm4_at_illinois_dot_edu>, University of Illinois at Urbana–Champaign

Abstract

In this paper, we argue for the value of motion capture-driven research that moves audiovisual analysis in a performative direction to integrate the dancer/researcher into the cinematic space. Like the work of videographic practitioners who communicate their findings through the audiovisual medium, rather than the written medium, this work seeks to engage with what Catherine Grant and Brad Haseman have called performative research by applying a practice-led approach to moving image analysis. Through a physical and virtual embodiment of film and dance form, we seek to better understand the formal implications of dance's integration into cinematic space and the material conditions that affected filmmakers' narrative and stylistic choices. The Movement Visualization Tool (mv tool) is a virtual research environment that generates live feedback of multiple agents' movement. Accessible motion capture technology renders an abstracted skeleton of the moving agents, providing information about movement pathways through space using color-based and historical traceform filters. The tool can also replicate a mobile frame aesthetic, allowing for a constructed mover and a virtually constructed camera to engage in performative dialogue. We use the mv tool and videographic methods to recreate and disseminate two cases: movement scales from Laban/Bartenieff Movement Studies and dance sequences from narrative cinema. Rather than working from existing audiovisual content, we posit that the act of recreating the movement phrases leads to a deeper understanding of the choreography and, in the case of the filmic examples, of the formal practices that led to their creation.

Introduction

1 The human body is a staggeringly intricate instrument. Filmmakers have developed meaningful, complex ways of staging figure movement on screen for storytelling purposes, both aided and impeded by the industrial, technological, and cultural changes that affect the conventions of film form. Despite significant developments in the digital humanities, the infinite variability and historical specificity of the body and cinematic space defy any single tool or method's attempts to offer an automated, comprehensive categorization of figure movement in film. Much of the work in the field prioritizes quantitative and qualitative methods for observing and communicating research findings. What knowledge could we gain by integrating the researcher into a cinematic space, using digital tools to recreate the craft of dance and film form?

2 We argue for the value of motion capture-driven research that affords us such integration and moves audiovisual analysis in a performative direction. The *Movement Visualization Tool* (mv tool), a virtual research environment that generates live feedback of multiple agents' movement, makes these lines of inquiry possible. Inexpensive, lightweight motion capture technology renders an abstracted skeleton of the moving agent, providing information about movement patterns and pathways through space using color-based and historical traceform filters. The tool also allows a virtually constructed mover and camera to interact through manual or algorithmic manipulation, replicating a mobile frame effect to study patterns of camera and figure movement. Researching in such a space is therefore inherently hands-on, interactive, and driven by the creation of new audiovisual content. Like the work of videographic practitioners who study

and communicate their findings through the audiovisual medium, rather than in written form, this work applies performative research methods [Haseman, 2006] [Grant, 2016] to a study of movement on screen. We posit that through a practice-led embodiment of film and dance form we can better understand the formal implications of dance's integration into cinematic space and the material conditions that affected filmmakers' narrative and stylistic choices. By visualizing movement patterns with the mv tool and disseminating that video data as an essential part of our research output, we hope to offer alternative modes of scholarly dissemination that enriches humanistic observation of cinematic movement.

Two audiovisual case studies allow us to test the methodological value of this approach and deepen our understanding of moving image form. The first explores patterns from Laban/Bartenieff Movement Studies (subsequently LBMS) to observe the compatibility of this system's expansive taxonomy of human movement with computerized analytical methods. By recording and manipulating LBMS' Axis and Girdle movement scales, we can better perceive how those forms are rendered in a cinematic, rather than live, space. The second builds on this foundation and involves the recreation of dance sequences from two films, *Top Hat* (1935, Marc Sandrich) and *Beau travail* (1999, Claire Denis). By isolating the body and camera from their cinematic surroundings, we can recreate core staging and figure movement elements and can generate alternative camera and figure relationships. The result is a better understanding of these film sequences' functions and the motivations that drove the filmmakers' choices. A performative method combined with digital capture tools sharpens formal analysis, when studying figure movement on screen in particular. This approach enhances our ability to rigorously articulate the complexities of the human body in motion and deepens our understanding of cinematic production histories. 3

Mapping Performative Research in the Digital Humanities

Approaching our subject from a performative research paradigm helps us to further understand the stylistic and material components of dance in narrative filmmaking. Catherine Grant draws upon Brad Haseman in describing performative research as an approach in which symbolic data and material forms of practice "work as utterances that accomplish, by their very enunciation, an action that generates effects" [Haseman, 2006, 102] [Grant, 2016, 14]. Practice is thus a critical aspect of performative research with the performative act serving as the data. 4

Scholars in a number of disciplines have engaged with methodologies of performative or practice-led research in order to approach their subject from a more dynamic perspective [Haseman, 2006], formulate new research questions in audio-visual analysis [Grant, 2016] [Mittell, 2019] [Keathley and Mittell, 2016] [Hagedoorn and Sauer, 2018], illuminate hidden or implicit characteristics of audiovisual texts [Cox and Tilton, 2019] [Arnold et al., 2019], and develop new pedagogical tools [Proctor, 2019]. We mobilize the methodological advantages of a practice-led approach through embodied, analytical recreations of figure movement in cinematic space and through an engagement with the material constraints of cinematic form. 5

Studying movement in motion

Film and digital humanities scholars have created theoretical and historical models that expand our understanding of how bodies can manifest on screen [Brannigan, 2011] [Bordwell, 2005] [Genné, 2018] [Keating, 2019] [McLean, 2008], while others have built digital tools that enable productive methods of study through the application of computerized methods [Arnold et al., 2019] [Acland and Hoyt, 2016] [Flueckiger and Halter, 2018]. Substantial research outside of a cinematic context has explored the value of quantifying aspects of LBMS's movement frameworks [Bernardet et al., 2019] [LaViers and Egerstedt, 2012] [Tsachor and Shafir, 2019] [Woolford, 2017] and of using computerized methods to study figure movement [Assaf et al., 2019] [Alemi et al., 2014] [Cuan et al., 2019] [Slaney et al., 2018]. However, this work rarely includes its movement data as part of the published output, reducing the reader's ability to directly engage with the object of study's dynamic nature or to evaluate the data generated by a performative research paradigm. 6

Our research method perceives the object of study as one in motion as well as in stasis, engaging with what Henri Bergson has called an "intuitive" knowledge of movement [Bergson, 2007] to better understand choreographic patterns and the myriad choices filmmakers make in staging the body for the camera. Carol-Lynne Moore sees close ties 7 between Bergson's categorizations of intellectual and intuitive perception and Rudolf Laban's theories of Space from LBMS, which describes where the body moves in its environment. Whereas intellectual knowledge perceives movement as snapshots in time, an intuitive understanding perceives movement as a "flowing continuity fluctuating endlessly" [Moore, 2009, 84]. This approach to perception has phenomenological implications as well. Our ability to study past traceforms of movement through the mv tool's historical traceform filter evokes the sort of "thickness" that Maurice Merleau-Ponty theorizes in his evocation of the accumulation of perceptual content [Merleau-Ponty, 2002, 321]. Embodying the movement is a key part of our analytical process; the videographic content presented in this article serves both as a record of the movement recreations and as a component of the research output.

It can further be argued that intuitive understanding is also an implicit aspect of videographic criticism, which allows practitioners to "enter into" their object of study [Bergson, 2007, 130], in this case an audiovisual or filmic form. As Grant elaborates, in videographic criticism the researcher engages with the logic of the medium on its own terms in a way that encourages experimentation and play [Grant, 2016]. Jason Mittell similarly points to the transformative value of entering moving images through nonlinear editing, arguing, "Even if you don't make something new with the sounds and images imported into the editing platform, you can still discover something new by exploring a film via this new interface" [Mittell, 2019, 226]. Rather than working from existing audiovisual content, we posit that the act of recreating the movement phrases leads to a deeper understanding of movement patterns and, in the case of the filmic examples, of the formal practices that led to their creation. 8

Performing constraints

Haseman positions this kind of practice-led approach as central to a performative paradigm, but he does not discuss the potential of considering choices and constraints as a part of such an approach. All creative practices are affected by constraints or obstacles of various kinds at both the macro and micro level of production: a director makes storytelling and aesthetic choices based on the budget available to them; a cinematographer chooses how to place and move the camera based on available technology; a choreographer can only work in a particular dance style (jazz, for example) if the surrounding cultural conditions have encouraged professional dancers to also train in that form. Filmmakers are constantly using craft practices, existing models and experience, and trial and error to guide their decision-making. As a result, stylistic history can benefit from what David Bordwell calls a problem-solution model of understanding the choices filmmakers make by envisioning stylistic history as a "network of problems and solutions" [Bordwell, 1997, 149]. 9

A practice-led approach, through the physical and intellectual act of recreation, encourages the analyst to engage with a similar level of material specificity. Indeed, as Bordwell argues, adopting a problem-solution model to understanding film history has recreation of practical details as an inherent aspect of its approach; the task "is one of reconstruction. On the basis of surviving films and other documents, the historian reconstructs a choice situation" [Bordwell, 1997, 156]. Through a performative approach, the act is one of recreation rather than reconstruction. By directly engaging with the process, we end up with a tangible creation, informed by careful study of the original, that was subject to its own series of problems and solutions. The video and motion-capture recreations of LBMS scales and dance numbers published here, in turn, communicate research findings that complement our written analysis of those same movement examples. For example, in "No Strings (Reprise)" from *Top Hat* there is a movement where Fred Astaire shifts his weight into a chair and ostensibly falls asleep. In practicing the sequence for recreation with our dancers, we discovered that using a chair for the ending led to a more constrained and cautious movement quality, due to the light chair creating an unstable situation as the movers shifted weight onto it. Choreographing a graceful final posture for Astaire's number resulted in a series of choices, perhaps an adjustment to the choreography, a change of furniture so that a lower armchair would permit Astaire to better counterbalance into it, or the addition of the carpet which mitigates most of the instability. We similarly needed to find solutions to the problem, but in our case, different furniture or securing the chair to the floor was not an option (i.e. the obvious solution of nailing the chair in place would certainly have infuriated the building owner and prevented our ability to continue working in the studio). Since our greatest priority was maintaining the spinning choreography, the feeling of lightness, and the increasing drowsiness of Astaire's character, we chose to have the dancers shift into a final resting pose on the floor instead, which allowed us to more effectively maintain the movement qualities and the long line of the body seen in the final pose. 10

Methodologically, by conducting research in an audiovisual medium, our work will lead us to make choices and confront obstacles in parallel to the films we were recreating.[1] Catherine Grant touches on this issue in referencing concerns from the art-scholar Barbara Bolt, articulating that "following Haseman, the problem for the 'performative' (or creative) academic researcher can lie in recognising and mapping the effects or 'transformations' that have occurred in their practice-research" [Grant, 2016, 14]. In our work, we choose to approach this problem as an opportunity. Incorporating an acknowledgment and understanding of constraints and choices into the performative research method leads to a more rigorous process and, as we found with our case studies, to new and valuable insights. It also helped us refine our understanding of the Kinect's technological advantages and limitations in motion capture. 11

Our results were affected by the resources and technology available to us, and we made deliberate, informed decisions based on those practical constraints. In choosing to work primarily with motion-capture data over video, however, we are able to move beyond the gravitational and physical constraints of reality, and our research tool is specifically designed to modify the rendering of the captured data, allowing for experimentation with the relationship between figure and frame. 12

Technical Description of the Movement Visualization Tool

The *Movement Visualization Tool* (mv tool) is a modular system for figure movement data capture that facilitates a variety of processes. The modular nature of the system's components allows for a dynamic architecture. We can extract or add modules as needed to achieve tasks concurrently or independently. Users can visualize the abstracted skeleton generated by the mv tool with the addition of various forms of visual and sonic feedback to better perceive the body's movement through space. The users' interaction with the skeleton and the visual/sonic filters can occur in a real-time (live) environment or can be recorded and manipulated for post-collection analysis. For the purposes of this research, the system can be broken down into three modules: data collection, data analysis and preprocessing, and visualization. 13

Data Collection

The *data collection* module is a motion capture application that utilizes remote sensors to extract abstract movement data from users. Movement data is captured using the Microsoft Kinect V2, which we chose for its relative robustness-to-cost ratio, its portability, and its lightweight network protocol coupling capability, principally with Open Sound Control (OSC). The Kinect uses infrared cameras to generate depth maps, which are then internally transformed into a variety of different generalized representations, including a 25-joint skeleton frame. Using custom developed software applications [Junokas et al., 2018], users can access the Kinect's application programming interface and construct a 3-by-25 *skeleton sensor array* for each body captured by the Kinect (i.e. the three spatial dimensions along horizontal/x, vertical/y, and sagittal/z planes for each of the 25 joints). 14

To increase resolution and/or range, multiple Kinect data collection stations can be added to the system, generating independent skeleton sensor arrays using the same module articulated above but in multiple instances. These arrays are then sent to the next module for data analysis and preprocessing (Figure 1). 15

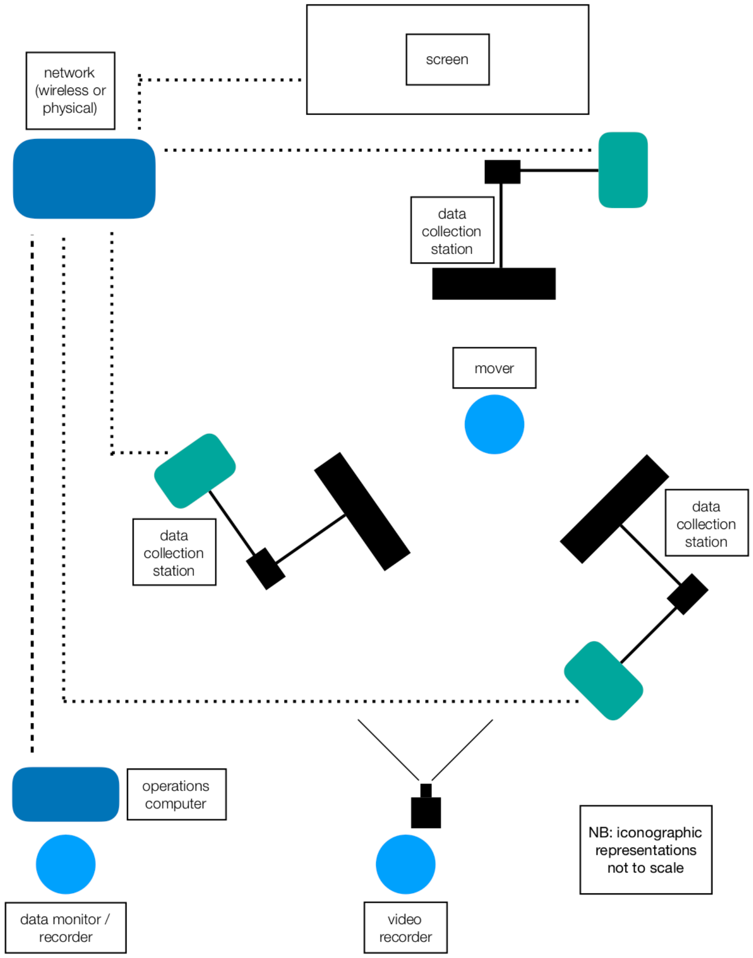


Figure 1. Movement visualization tool infrastructure.

Data Analysis and Preprocessing

The skeleton sensor arrays are sent from the data collection module into the *data analysis and preprocessing* module, where they are prepared for the next series of modules within the system. The analysis and preprocessing is done with Max/MSP/Jitter [Puckette, 2018], which we chose due to its signal-processing based computational design, native support for real-time interaction, compatibility with the chosen protocol (i.e. OSC), and the ability to easily create object oriented visualization filters. 16

The multiple skeleton sensor arrays from the Kinects can be synced at a constant frame rate, combining the multiple data streams into one representative *skeleton frame,* transforming them to generate the highest resolution and largest sensor capture range possible from the input skeleton sensor arrays. For this research, while three Kinects were used, comparable resolutions were achieved using the data from one Kinect. This was largely due to the asynchronous frame rate of data capture across the three Kinects, leading to a non-unified temporal dataset that could not simply be made into a higher resolution (e.g. a frame missing from one Kinect would not necessarily be at the same frame as the other Kinects, making corrective interpolation or substitution substantially more difficult). Due to this, the ultimate skeleton frame was composed from a singular sensor's data capture. 17

The skeleton frame is then parsed into respective body arrays for individual, positional mover analysis, taking the first and second derivative of the skeleton joint positions, generating an approximate measure of *velocity* and *acceleration*. The magnitude of these derivatives is calculated, generating an approximate measure of *speed* and the *magnitude of acceleration.* Using these physical representations, kinematic limitations can be placed on the skeleton frame, setting 18 programmatic bounds modeled on physically possible human movement. This reduces jitter and discontinuity errors between frames, making a more realistic physical representation for the digital data stream.

From these bounded positions, kinematic measures and relative positions are measured and collected, providing an extension to the sensor's positioning. These relative positions measure the dimensional difference of each joint from every other joint. On top of these physically limited relative positions, infinite impulse response filters (with dynamic coefficients that can be user defined) can be applied, weighting the current frame's position by the previous frame's position, creating a type of smoothing on the positions, which dampens jerky frame-to-frame movements, resulting in the *preprocessed skeleton array,* the main source of data for the rest of the system (Figure 2). In this research, the mv tool uses the preprocessed skeleton array to drive the visualization of mover and the relative camera position. 19

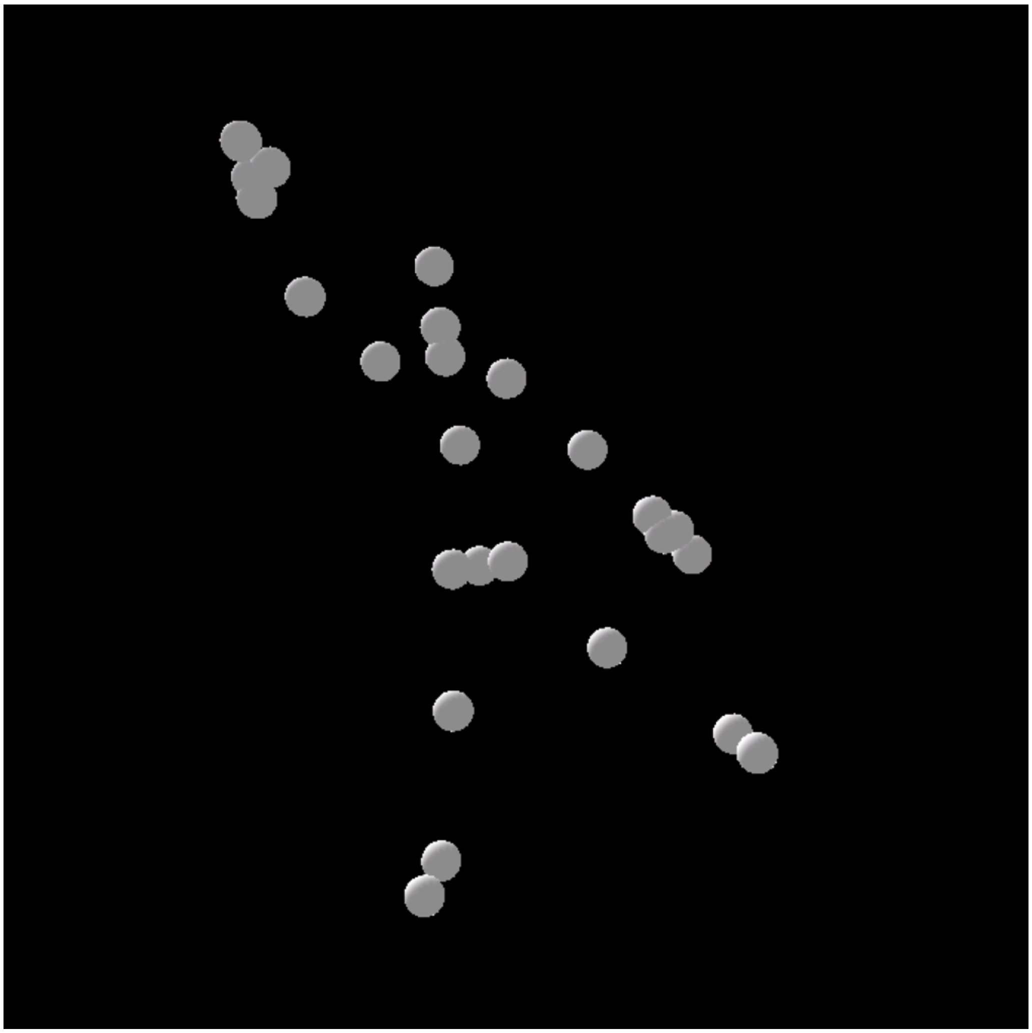


Figure 2. The preprocessed skeleton array.

Visualization

The mv tool visualization principally serves as an abstract joint skeleton representation that shows the subject's movement in relationship to a virtual camera position. Purposefully eliminating other environmental contexts, this abstracted view focuses on what is being captured by the system, ultimately informing the direction of our research. Additionally, the mv tool allows for visual filters to be placed on the abstract skeleton, highlighting several opportunities for further analysis and understanding. For the purposes of this work, we apply three filters to provoke deeper research: dynamic camera positioning based on joint movement, historical joint traceforms, and spatial color maps. 20

The mv tool has the capability to dynamically change the position of the virtual camera in the digital space, operating independently or coupled with the subject it is "filming." While users can manually control the three-dimensional digital 21 camera position in the digital space, the camera movement can be tied to track a specific joint of the subject, moving in relation to the subject figure's movement. For example, the camera can track the pelvic joints of the subject, moving in *parallel* or in *counterpoint* to the joint, allowing the subject's pelvis to control the position of the camera as it moves (Figure 3).

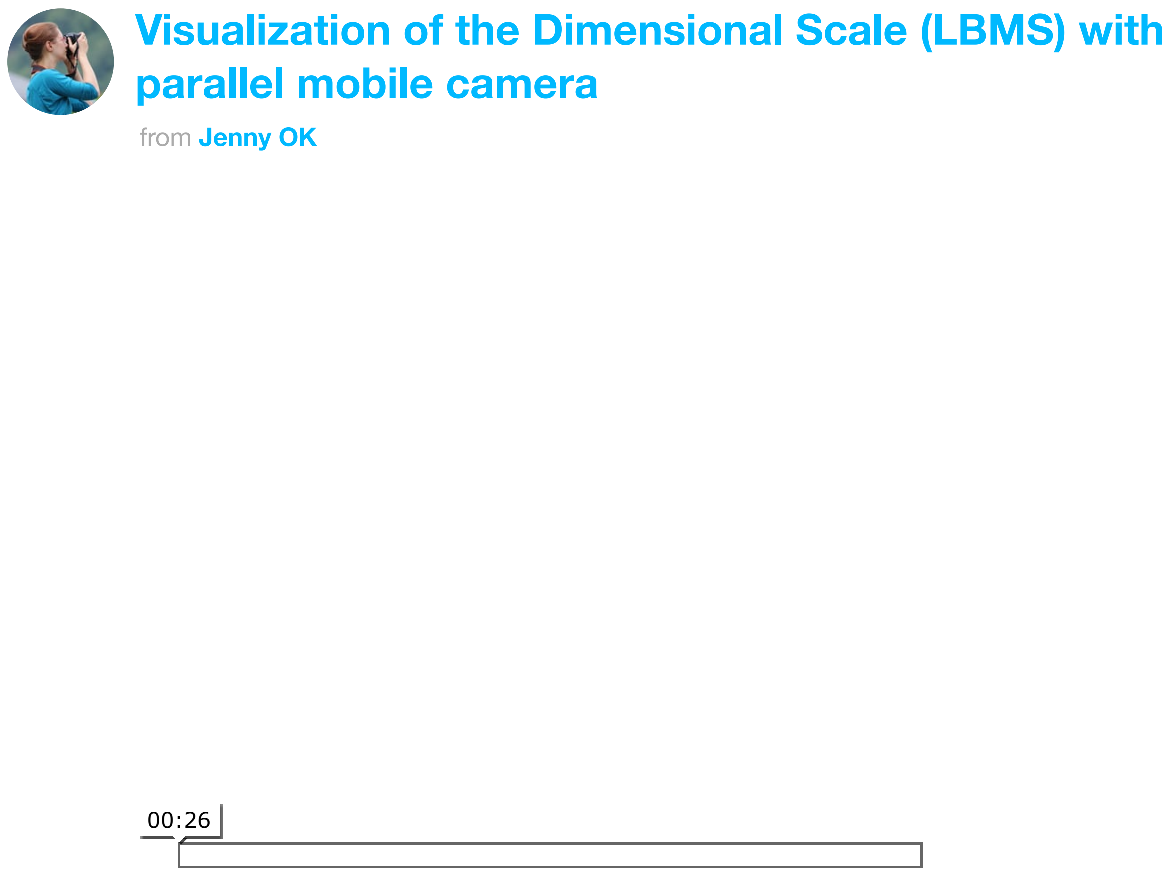


Figure 3. LBMS dimensional scale demonstrating parallel pelvic movement.

A historical joint trail filter can also be applied to the skeleton figure, leaving a dynamic history of the subject's movement in the scene. The persistence of the traceforms in the scene can be manipulated by the user, ranging from no historical traceforms to the entire temporal record of the captured movement. This provides the user with a visual "history," giving better insight into the paths and patterns of their movement (Figure 4).

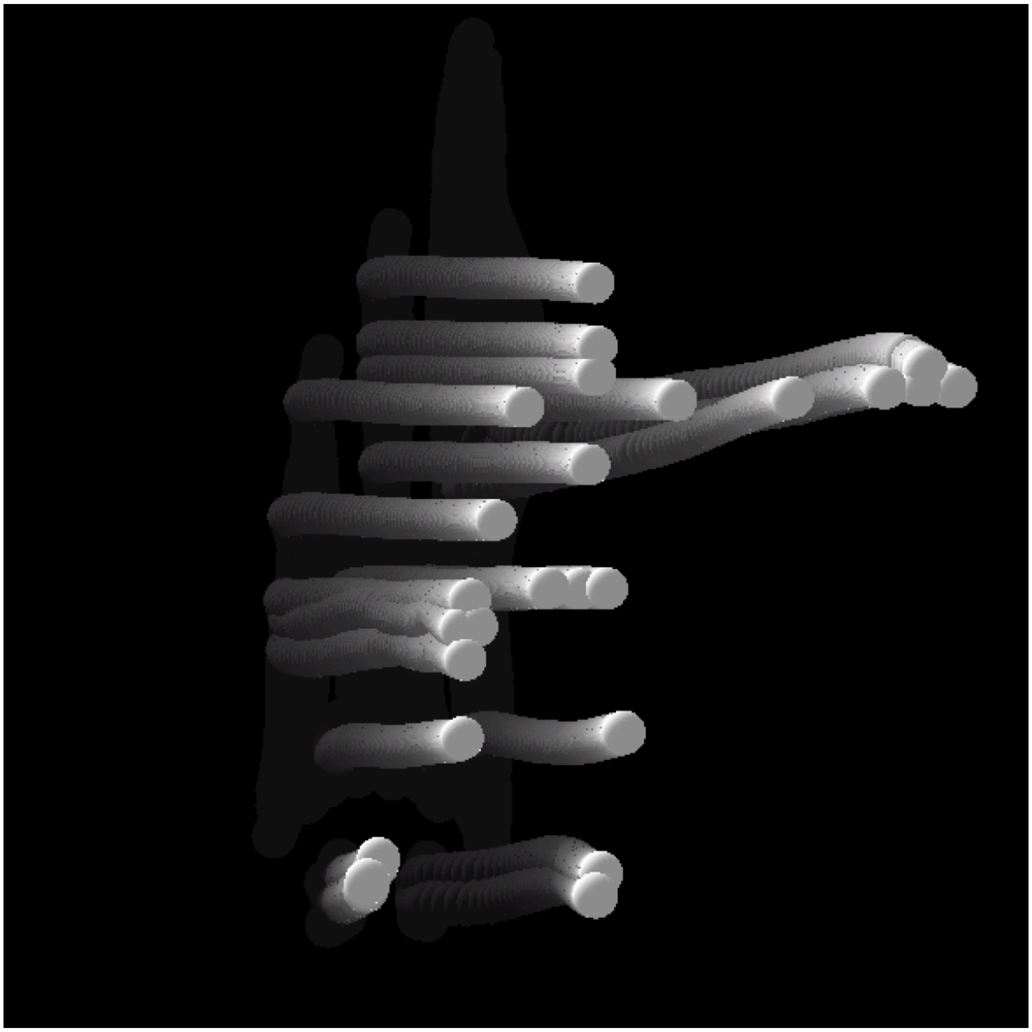


Figure 4. The mv tool's historical joint trail filter.

Spatial color maps can also be added to the skeleton joints, providing insight into the trajectory of a given joint's movement from an anchored point (Figure 5). For example, the trajectory of the right wrist from the spine mid can be colored in relation to its proximity to a three dimensional unit projection from the spine mid, providing the mover with a color map relating which of twenty-seven unit projections their movement aligns closest with (i.e. the complete set of permutation that can be made using only 1 and 0 in 3D). 23

Figure 5. The mv tool's spatial color maps.

The ability to manipulate recorded movement data in these ways allows the analyst to draw attention to different aspects of the body's movement in space. These adjustments create a "poeticized quantification" of data that resembles videographic deformation methods articulated by Jason Mittell, which he argues can help scholars formulate new observations about an art object's form [Mittell, 2019]. By algorithmically changing our visualizations of human movement, we can amplify certain observable patterns, posit hypothetical alternatives (in the relationship between camera and figure, especially), or simply marvel at the expansive complexities of the human body. 24

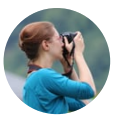
Case study: Laban/Bartenieff Movement Studies (Axis and Girdle Scales)

Laban/Bartenieff Movement Studies offers a detailed taxonomy to describe, analyze, and categorize forms of human movement and encourages the analyst to take a performative approach to their workflow by both observing and embodying movement patterns. Our first case study comes from the Space category of LBMS, which seeks to understand where the body moves to in its environment. This exploration considers in a more quantitative manner the changing shape of the Kinesphere, or "the space within the reach of the body" [Laban, 2011a, 10].[2] Rudolf Laban theorized a series of movement scales designed to increase the body's range of motion and encourage the exploration of movement through particular pathways. Like musical scales, they are designed with a theoretical rigor, follow a series of guidelines based on the necessary space between each directional pull (frequently referred to in LMBS as Spatial Pulls), and are repeatable. 25

The Space category taxonomizes multiple geometric elements to describe the body's orientation in space [Laban, 2011a, 10–17]: 26

- Directionality, or Spatial Pulls, of movement as articulated along the three dimensions (Vertical, Horizontal, Sagittal)
- The shape of the pathways with which the body moves from point to point (Central, Peripheral, or Transverse)
- The position of movement relative to the body center (Near Reach Space to Far Reach Space)
- The height (Low, Mid-height, High) of the leading movement

Space draws on Laban's research into theories of platonic solids, leading him to argue for twenty-seven dominant 27
Spatial Pulls or directional rays [Laban, 2011a, 10–17]. Six pulls form the basis for axial movement (up, down, forward, back, right, left), rays that when plotted on a graph represent the end points of an octahedron. When sequenced together, these six pulls form the dimensional scale, which isolates each of the three axes (Vertical, Horizontal, Sagittal) and demonstrates the relative stability of this range of motion (Figure 6).



Visualization of the Dimensional Scale (LBMS)

from **Jenny OK**

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Figure 6. A visualization of the Dimensional scale.

Laban theorized that all remaining Spatial Pulls are the result of these six fundamental pulls combining in both unequal 28
and equal combinations. Twelve rays form the basis for planar movement; the three planes — horizontal, vertical, and sagittal — each contains four Spatial Pulls. Laban theorized movement between those twelve rays as existing in an icosahedral space. Combining all three Dimensional Pulls equally leads to highly mobile movement, which Laban saw as moving between the endpoints and diagonals of a cube: Right-Forward-High, Left-Back-Low, Left-Forward-High, Right-Back-Low, Left-Back-High, Right-Forward-Low, Right-Back-High, Left-Forward-Low. To these twenty-six rays or

Spatial Pulls we add Place, Laban’s articulation of a relatively neutral starting and ending position for scales, in which the figure is standing with the arms relaxed by their side and the feet planted in parallel.

29 The two scales we chose to visualize come from movement in an icosahedral space, the Axis scale and the Girdle scale. These forms are paired and complementary; each scale includes six points, none of which are repeated in the other scale’s movement. As a result, the two scales together move the body through all twelve theorized planar directions. Both scales also interact with the Right-Forward-High to Left-Back-Low diagonal of the cube. The Axis scale moves through Transverse pathways that deflect off of the diagonal without ever crossing it. Its Spatial Pulls are as follows (Figure 7):

30 Right-High (vertical), Back-Low (sagittal), Right-Forward (horizontal), Left-Low (vertical), Forward-High (sagittal), Left-Back (horizontal)

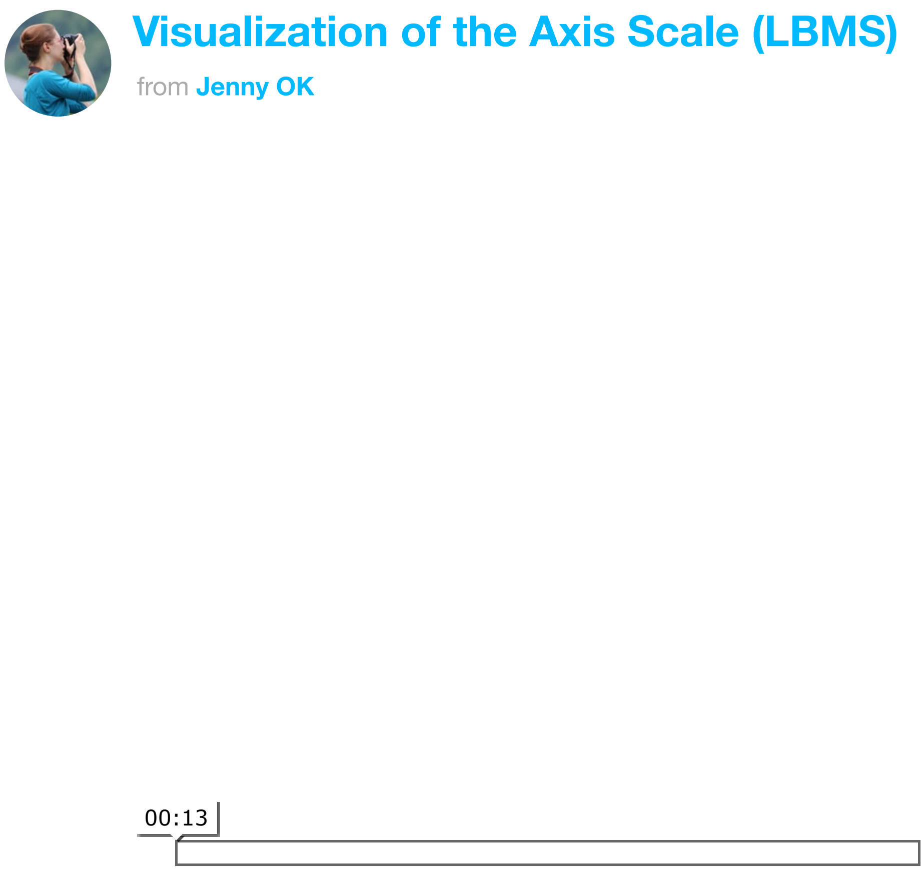

Figure 7. A visualization of the Axis scale.

31 In contrast, the Girdle scale, which Laban calls "a chain of six surface-lines" [Laban, 2011a, 68] moves in a Peripheral pathway that orbits the diagonal, as follows (Figure 8):

32 Left-High (vertical), Back-High (sagittal), Right-Back (horizontal), Right-Low (vertical), Forward-Low (sagittal), Left-Forward (horizontal)

Visualization of the Girdle Scale (LBMS)

from **Jenny OK**

00:33

Figure 8. A visualization of a repeating Girdle scale.

Each scale results in a different gestalt movement quality and progression through pathways. As the Axis scale deflects 33
off of the diagonal, its movement has more of a swinging feel as the body moves back and forth between High and Low, Forward and Back, and Right (open) and Left (closed). The Girdle scale, through its peripheral movement, creates a pathway that maintains a consistent distance from the body center and moves through adjacent icosahedral Spatial Pulls, creating a smoother, circular quality in the body [Laban, 2011a] [Moore, 2009].

Defining twenty-seven possible directions for the body to move is inherently limiting. Laban writes that "innumerable 34
directions radiate from the centre of our body and its kinesphere into infinite space" [Laban, 2011a, 17]. However, these limitations and geometric parallels are beneficial to a computerized visualization of movement, in which we must define each possible zone of movement. This subdivision provided the spatial segmentation for the mv tool’s color filter, in particular, which aligns closely with the maximum number of distinctions our color filter could render (Figure 9).

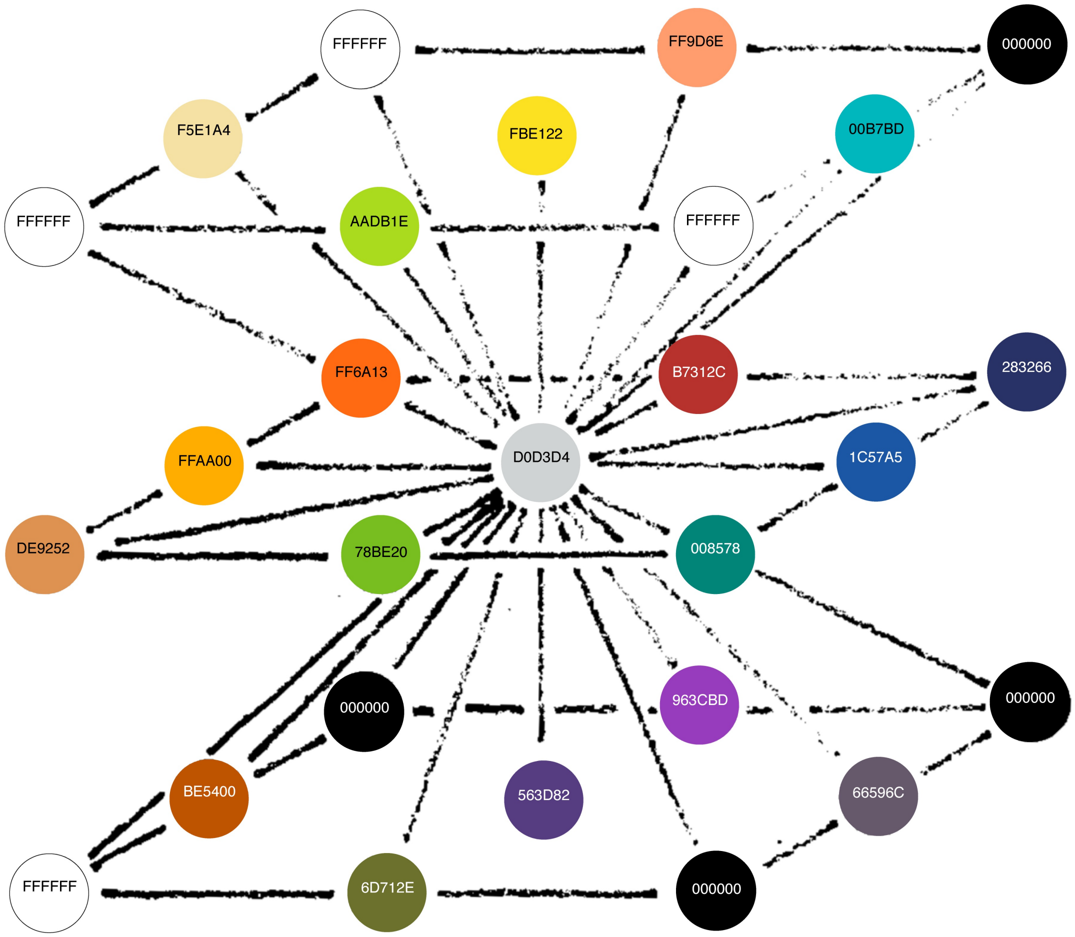

Figure 9. Our chart reference for the mv tool's color filter, annotating Laban's drawing which also posits twenty-seven directional rays [Laban, 2011a, 16].

When moving through a LBMS scale, one body part initiates and leads the movement through the various directional Pulls. Our recordings demonstrate these movement pathways as led by the right hand in a Far-Reach movement pattern for greatest visibility, but one can explore these sequences led from any body part (the right hip, the left big toe, the tongue) and at a bigger or more restrained scale. In all recordings presented in this article (LBMS scales and dance recreations), the color changes are dictated by the spatial position of the right wrist, with the color changes affecting the entire skeleton. Like all the filters built for the mv tool, the body part dictating the color change can be moved to any of the skeleton's twenty-five recorded points. 35

The color filters provide data on the spatial zones that are most activated by a recorded movement phrase, as is visible in the motion-capture data for the Axis and Girdle scales with added color changes (Figure 10 and Figure 11): 36

Visualization of the Axis Scale (LBMS) with color

from **Jenny OK**

Figure 10. A visualization of the Axis scale with color filters.

Visualization of the Girdle scale (LBMS) with color

from **Jenny OK**

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Figure 11. A visualization of the Girdle scale with color filters.

What becomes immediately apparent are the limitations of translating Laban's theorization of twenty-seven Spatial Pulls into a computerized environment, as the color changes are not restricted simply to the six colors corresponding with the scale Spatial Pulls. Instead, the software recognizes any of the twenty-seven zones activated by the movement of the right wrist. Similarly, the starting position of Place, with the arms relaxed at one's sides, renders as the color for Right-Low (a dark orange) rather than Place (grey), given that the wrist is below the body center. In other work, where establishing a place of neutrality is necessary, we adjust the starting point to have the right wrist resting on the sternum. This additional data, however, is valuable. In the color visualization of the Axis scale, we can observe the skeleton activating approximately fourteen color points, whereas the Girdle scale activates approximately eight. This aligns with the complementary pathways of the two scales; while the Girdle scale moves between spatially adjacent points (Peripheral pathways), the Axis scale uses Transverse pathways to slice obliquely through the Kinesphere to get to each subsequent Spatial Pull, activating additional space in the process. This contrast is visible through the addition of historical traceforms filter, in which the greater smoothness of the Girdle pathways is apparent (Figure 12 and Figure 13):

Visualization of the Axis Scale (LBMS) with color and trails

from **Jenny OK**

Figure 12. A visualization of the Axis scale with color and historical trail filters.

Visualization of the Girdle Scale (LBMS) with color trails

from **Jenny OK**

00:35

Figure 13. A visualization of the Girdle scale with color and historical trail filters.

What also becomes apparent from these visualizations is that the recommended technique for performing LBMS scales 38
is ideal for a Kinect-driven motion-capture environment. While the torso, arms, and legs frequently need to twist and reach away from a forward facing position to move through the Spatial Pulls or counterbalance the movement, the pelvis should remain frontal and forward-facing, encouraging mobility of the spine and limbs. As a result, the body center is always facing forward. Some scales, like the Girdle scale, are more easily performed by taking a few steps, but the scales are always fairly spatially contained, and often result in a relatively stationary practice in which weight is shifted between the two feet. Finally, performing LBMS scales rarely requires the mover to lie prone on the ground. All three of these conditions — a consistently forward facing, a limited range of locomotion, and standing movement patterns — are ideal for this technological infrastructure. They facilitate the Kinects' ability to maintain a consistent skeleton rendering, minimizing the quantity of glitching and increasing the accuracy of movement pathways. Determining these conditions helped in the selection process of our cinematic movement examples.

Case study: Dance in narrative cinema

This case study seeks to better understand how filmmakers use figure and camera movement to guide viewer attention 39
and communicate narrative and aesthetic meaning. In selecting examples to analyze, our decision-making process was heavily influenced by technology and infrastructure. We needed to work with solo dancers, as recording multiple performers simultaneously is more difficult with the Kinects, especially if those performers cross paths or touch during the number. In order to more closely recreate the relationship between camera and figure, we chose to work with

sequences that maintained a relatively consistent camera position and that included minimal editing. We also did not have a studio space large enough to capture more expansive dancing, or movement that travelled through a wider space accompanied by a follow shot.

Our data capture approach differed for the LBMS material and the film material. As Oyallon-Koloski is certified in Laban Movement Analysis and familiar with the LBMS movement scales, she performed those phrases herself. The scales are theoretical movement exercises without an existing audiovisual referent, so no filmic comparison was necessary. In contrast, a recreated, close approximation of the choreographed movement from our filmic examples was a central component of our analytical process for studying these dance phrases, for which more specialized dance training and rehearsal time was necessary. As a result, the dance recreations were learned and performed by two Dance MFA students at the University of Illinois, Urbana-Champaign, Catherine MacMaster and Sarah Mininsohn. MacMaster has technical training in ballet, contemporary, and modern dance forms, with a secondary focus in tap dancing, musical theater jazz, West African dance, Afro-Cuban Folkloric Dance, and Tango. Mininsohn has technical training in modern dance, improvisation, and ballet, with a choreographic focus on contemporary and improvisational styles. 40

Because Oyallon-Koloski's broader research interests focus on musical cinema, we chose to include one number that allowed us to study how these stylistic patterns affected the musical number's relationship to the larger narrative. MacMaster and Mininsohn collaborated with Oyallon-Koloski in the selection of appropriate dance phrases given their movement backgrounds. In selecting a number from a Hollywood musical, the most compatible numbers all came from the 1930s, with solo tap dancing numbers emerging as the most logical choice. We chose to work with Fred Astaire's soft-shoe reprise of "No Strings (I'm Fancy Free)" from *Top Hat* (1935), an iconic number that our dancers felt was compatible with their movement training. For our second example, we chose the final dance sequence from Claire Denis' *Beau travail* (1999). Its construction similarly met our criteria — a single dancer (Denis Lavant), a restricted setting, a single camera set-up, and limited editing — but provided us with an example that contrasted *Top Hat*'s technological, industrial, and cultural context. Despite sharing numerous stylistic characteristics — an emphasis on a single performer who in both cases is white and male, a relatively static camera, a longer average shot rate, few overall edits, and long shot framings on the dancers — the choreography and overall function of each number diverge, as do their production histories and choreographic processes. 41

For both sequences, the dancers' focus was on understanding the holistic staging patterns of the choreography, the essential movement qualities (with the language of Effort qualities from LBMS guiding much of our analysis), and the narrative motivation of the dance. One significant revelation from this work was the unusual nature of the form of movement learning; despite their extensive movement training, neither had ever learned choreography before purely from an audiovisual artifact. Choreographic recreations frequently benefit from video recordings of previous performances but are led by movement professionals who have often performed the movement themselves and who re-learn and teach the choreography to the performers. Because such prior knowledge was not available to us, MacMaster and Mininsohn learned the choreography together, in consultation with Oyallon-Koloski, working from a recording of the dance sequence flipped on the horizontal to facilitate the process of learning the steps and pathways on the correct side. Both MacMaster and Mininsohn recorded multiple takes of each movement phrase, improvising or resetting their staging position during the moments when the performer in question (i.e. Fred Astaire and Denis Lavant) was not on screen. In order to allow the dancers to focus on different aspects of narrative, staging, and choreographic detail in each take, during several they performed alongside a playback of the filmic dance, while in others they performed alongside the audio track from the film only. The video recordings, shot on a Canon EOS R, approximate the camera placement but do not fully replicate the camera movement of the originals, as the dance recreations vary somewhat as well, and serve primarily as documentation of the stylistic analysis performed by our dancers. 42

"No Strings (Reprise)" | *Top Hat* (1935)

Top Hat is directed by Marc Sandrich, photographed by David Abel, and choreographed collaboratively by Fred Astaire and Hermes Pan. It was the first film for which Pan served as dance director [Franceschina, 2012, 60]. Pan, not Sandrich, likely worked with Abel on the camerawork for the dance numbers and had decision-making power over the integration of the figure movement into the cinematic space. Constantine, a writer for *Dance Magazine* who interviewed 43

Pan in 1945, suggests that the dance director’s job is to “focus the camera on the most important part of the choreography and swing the camera in rhythm with the dancers” [Franceschina, 2012, 60]. Patrick Keating discusses this relationship with more detail in his discussion of the “No Strings (I’m Fancy Free)” number, in which “the camerawork remains completely subordinate to Jerry’s [Astaire’s] movements. When Jerry dances behind some chairs, the camera dollies in to follow; when Jerry spins to the right, a pan keeps him in frame” [Keating, 2019, 85]. Astaire had a reputation for remaining closely involved in all the stylistic elements of his dances and for wanting the camera to be an "involved but unobtrusive spectator" [Mueller, 1985, 26], a "subservient" form of camerawork that was nonetheless the result of a complex choreographic process [Keating, 2019, 85].

This reprise occurs very soon in the plot after Jerry Mulligan’s (Astaire) "No Strings (I’m Fancy Free)," in which his enthusiastic tap dancing awakens and irritates Gale Tremont (Ginger Rogers). Immediately smitten with Gale, he performs a soft-shoe "sand-man" version of the number to help lull her back to sleep, as Edward Everett Horton’s character (Horace Hardwick) observes him. Jerry’s motivation, therefore, is to perform a soothing number that stylistically contrasts its bombastic predecessor, but his movement quality is also the result of his newly discovered feelings for Gale. In preparing the recreation, we focused on the sense of lift in Astaire’s physicality (Light Weight), particularly in the upper body, paired with a core stability evoking his ballroom training that results in him skimming the surface of the floor. MacMaster and Mininsohn also embody the deliberate weight shifting steps coming from a tap dance vocabulary that move him through both swooping lateral staging changes and circular pathways. In our recreations, MacMaster performed in tap shoes and emphasized the formal steps in her learning process given that she has tap dance training; Mininsohn, drawing on her improvisation training, performed barefoot and prioritized the movement qualities and their relationship to narrative motivations (Figure 14, Figure 15, Figure 16, and Figure 17). 44

“No Strings (reprise)” video documentation performed by Sarah Mininsohn

from **Jenny OK**

01:34

Figure 14. "No Strings (Reprise)" video documentation performed by Sarah Mininsohn, with side-by-side comparison of the original.

"No Strings (reprise)" video documentation performed by Catherine MacMaster

from **Jenny OK**

01:34

Figure 15. "No Strings (Reprise)" video documentation performed by Catherine MacMaster, with side-by-side comparison of the original.

Visualization of “No Strings (reprise)” performed by Sarah Mininsohn

from **Jenny OK**

01:38

Figure 16. Visualization of "No Strings (Reprise)" performed by Sarah Mininsohn.

Visualization of “No Strings (reprise)” performed by Catherine MacMaster

from **Jenny OK**

01:39

Figure 17. Visualization of "No Strings (Reprise)" performed by Catherine MacMaster.

The choreography for this number involves numerous turns and pivots that move the figure away from a frontal facing and an ending weight shift into a chair which, as discussed above, our dancers performed into the ground. Both proved difficult for the Kinect to render properly; the latter results in some glitching rather than a clean line of the body, and the rotations are more difficult to perceive in the abstracted space. This points to the Kinect’s design for home gaming use, which is adapted for standing (or sitting), front-facing postures without much simultaneous movement of the limbs across the midline. However, adding the historical traceforms to Mininsohn’s recorded skeleton allows us to perceive the graceful pathways of Astaire’s movement, the Free Flowing movement that skims the surface, and the choreographic emphasis on repeated pathways and continuous motion (Figure 18).

Visualization of “No Strings (reprise)” with historical trails, performed by Sarah Mininsohn

from **Jenny OK**

01:39

Figure 18. Visualization of "No Strings (Reprise)" with historical traceforms, performed by Sarah Mininsohn.

We also learn from a closer analysis of the "No Strings (Reprise)" number that one of the camera movements during the dancing is the result of Horton’s, as well as Astaire’s, movement. Jerry’s dancing in the beginning of the number moves him repeatedly through the horizontal space of the frame, but it isn’t until Horace walks rightward towards the couch as Jerry also slides right in front of him that the camera pans slightly right to follow, ensuring that Horace remains fully visible as he sits on the couch. The camera remains static until the end of the dance, even though Astaire’s leftward pivot turns in the middle of the dance briefly cause his arms to go out of frame. By adding our mobile frame filter to keep the skeleton centered in the frame, we can visualize what Astaire’s phrase would have looked like had the camera followed all of his lateral shifts; here the body element maintained in the center of the frame is the skeleton’s pelvis (Figure 19). 46

“No Strings (reprise)” with mobile framing, performed by Sarah Mininsohn

from **Jenny OK**

01:39

Figure 19. Visualization of "No Strings (Reprise)" with mobile framing, performed by Sarah Mininsohn.

This goes against the logical assumption that the dancers on-screen would dictate figure-motivated camera movement, 47
as both Constantine and Keating articulate. Yet such a choice on Pan and Abel’s part does not necessarily contradict this rationale. The lack of reframing to the left ensures that Horace remains visible on the right and reinforces that the number is serving a crucial narrative purpose, one that is guiding the filmmakers’ stylistic decisions as much as the impulse to clearly capture Astaire’s artistry on-screen. Having Jerry perform the number is not only for the sake of aesthetic excess (as a demonstration of Astaire’s physical prowess) but also to make amends for disturbing Gale. In the process of the number, Horace also watches the soothing dancing and is lulled to sleep before Jerry succumbs to sleep himself. Keeping Horace in frame during the dancing allows us to see that he is watching Jerry dance, and a later cut to a closer framing of him looking tired cues us to watch the background as Jerry continues to dance, where we can observe Horace put his head down on the couch. Even in the earlier "No Strings" number, the choreographic and cinematographic decisions are made to either keep Astaire dancing close enough to Horton so that the latter remains in frame or have Astaire’s dancing carry him far enough through lateral space that Horton does not awkwardly reappear at unexpected moments in the background. Ultimately, the camera helps to emphasize the most important function of the choreography: narrative comprehension. Recreating and manipulating the movement for the purposes of formal analysis enhances our, and hopefully the reader’s, ability to observe these choreographic and cinematic patterns.

Galoup’s final dance sequence | *Beau travail* (1999)

Beau travail, loosely adapted from Herman Melville’s *Billy Budd*, is directed by Claire Denis and photographed by Denis’ 48 long-time collaborator Agnès Godard. The film’s narrative portrays much choreographed movement in its focus on French Foreign Legion soldiers stationed in Djibouti, and choreographer Bernardo Montet’s creative contributions were essential to the film’s preproduction design [Mayne, 2005, 93]. *Beau travail* includes several dance scenes between local Djibouti women and the Legionnaires but also emphasizes performances of military and domestic exercises, blurring the line between dance, military calisthenics, and pedestrian movement. The film relies little on dialogue or explicit narration, forcing the viewer to read the implicit meaning of the figure movement; Judith Mayne describes the film as a "kind of choreographed ritual" [Mayne, 2005, 93]. The protagonist Galoup’s final solo dance occurs after the character’s presumed suicide, which allows the viewer to read the motivation of that final dance in numerous ways: as a frenetic but ultimately futile attempt at escape [Mayne, 2005, 101], as an example of the post-colonial body [Hayward, 2002], as a marker of queer displacement [Sosa, 2011]. Denis viewed the scene as an attempt at freedom; while initially planning to include the number before the suicide, she changed the plot order to "give the sense that Galoup could escape himself" but also because after filming the number she realized it was the stronger ending [Darke, 2000, 18]. Our close analysis through recreation of the film’s final dance scene is equally revelatory in its emphasis on the explicit diegetic details present and the craft mechanics of the scene.

Montet was closely involved with *Beau travail*’s narrative development in preproduction, but his influence on Galoup’s final dance sequence, performed by Denis Lavant, is unclear. Denis recalls the number’s process in an interview with *Senses of Cinema*: 49

But we never rehearsed the dance scene at the end of *Beau Travail*. I told him [Denis Lavant] it’s the dance between life and death. It was written like that in the script, and he said, 'What do you mean by "the dance between life and death"?’ So, I let him hear that great disco music [*laughs*], and he said, 'This is it.’ So, we didn’t need to rehearse. . . . He said, 'You don’t want us to fix some of it?’ I thought it was better to keep the energy inside, because if we started fixing some stuff then we would have made many takes. And we made one take. But he was exhausted at the end" [Hughes, 2009]. 50

Lavant already had extensive movement training at the time of filming, with a background in circus and pantomime, so it is plausible that he created the number without Montet’s assistance. Denis’ comment about a lack of rehearsal and a single take seems suspect but indicates that an improvised approach to avoid an over-rehearsed look was key to the process. Most accounts of this number describe the dancing as frenetic, but upon closer analysis we can observe that Lavant’s movement is in fact quite graceful, with increasingly controlled and complex movements originating from the body center (the result of core stability and alternating Bound and Free Flow) and reverberating into the limbs. Like Astaire’s movement, much of Lavant’s movement patterns are driven by an upward impulse and a feeling of lift, but with a greater sensation of strength (Strong Weight) in contrast to Astaire’s lightness. Unlike the fluidity and ongoing nature of the "No Strings" number, Lavant frequently starts and stops. The spatial relationship of camera and figure also creates an off-kilter feeling. Rather than film Lavant straight-on, the camera remains to his left (likely to avoid revealing the camera in the mirrored wall). His gaze and facing frequently focuses leftward as well, as if he is intrigued by something off-screen left that the viewer cannot see. In recreating this number, MacMaster and Mininsohn focused on this sense of increasing and halting range of motion, as if in the afterlife Galoup is discovering an ability to fully express himself for the first time. They embodied the specific pathways and gestures Galoup employs in the first half of the number (including his smoking) but chose to improvise the more expansive movement of the second half (Figure 20, Figure 21, Figure 22, and Figure 23). 51

Galoup’s final dance documentation performed by Sarah Mininsohn

from **Jenny OK**

01:24

Figure 20. Galoup's final dance documentation performed by Sarah Mininsohn, with side-by-side comparison of the original. For fair use purposes, an extract and limited audio are included.

Galoup’s final dance documentation performed by Catherine MacMaster

from **Jenny OK**

01:24

Figure 21. Galoup's final dance documentation performed by Catherine MacMaster, with side-by-side comparison of the original. For fair use purposes, an extract and limited audio are included.

Visualization of Galoup’s final dance performed by Sarah Mininsohn

from **Jenny OK**

Figure 22. Visualization of Galoup's final dance performed by Sarah Mininsohn.

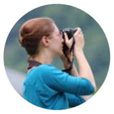
Visualization of Galoup’s final dance performed by Catherine MacMaster

from **Jenny OK**

02:37

Figure 23. Visualization of Galoup's final dance performed by Catherine MacMaster.

Denis’ film does not fall within the confines of the musical genre. But the space of Galoup’s final dance feels more 52
liminal or beyond the limits of the established diegesis the way many musical sequences would, an impression that comes from the disparate stylistic choices of staging, choreography, cinematography, and sound. Unlike the earlier club scenes, where we hear French Creole and Turkish popular music, Galoup here performs to Corona’s Eurodance hit, "Rhythm of the Night." Previously we see Legionnaires and local Djibouti women dancing, but now Galoup is alone (with his mirror self). As the narrative progresses, the camera allows us to see more of the movement by adopting more distant framings. The early disco scene is shot at close proximity, allowing us to see the men and women dancing together in medium close-ups. The second disco scene in which the women dance as Galoup watches shows them in a medium long shot. It is only during Galoup’s final number where we see him dance in a full long shot, and even then we frequently lose his extremities as they extend beyond the edges of the frame. Adding historical traceforms allows us to perceive the increasing expansiveness of Galoup’s movement and release, especially after his leap to the ground (2:08 in Figure 24's video).



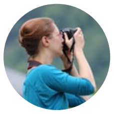
Visualization of Galoup’s final dance with historical trails, performed by Sarah Mininsohn

from **Jenny OK**

02:34

Figure 24. Visualization of Galoup's final dance with historical traceforms, performed by Sarah Mininsohn.

Godard’s camera in *Beau travail*’s final number never dollies through the space, but she frequently pans and tilts to holistically follow Lavant’s movement through the small space of the disco. A visualization of the movement with the addition of a parallel mobile camera (that reframes along the horizontal, sagittal, and vertical planes) takes this follow aesthetic to the extreme (Figure 25). 53



Visualization of Galoup's final dance with mobile framing, performed by Sarah Mininsohn

from **Jenny OK**

02:34

Figure 25. Visualization of Galoup's final dance with mobile framing, performed by Sarah Mininsohn.

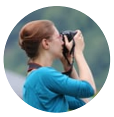
54 A perfectly aligned, parallel camera removes the feeling of spontaneity from the number. While Godard's cinematography calmly and subtly reframes as Lavant moves through the space, parts of Lavant's body occasionally move out of frame, specifically his head during sudden leaps, imbuing him with a sense of freedom and release. If Lavant were always centered, the expansiveness of his movements would potentially be diminished by the parallel movements of the camera, especially as the number progresses. In seeing a perfectly centered version of the dance, we also are reminded that Lavant is not truly alone in the number, as Godard keeps his mirrored image in frame throughout, balancing the space between Lavant and his reflection. Like "No Strings (Reprise)," Galoup's final solo number results in a composition that reminds the viewer of the importance of both figures through deliberate choreography and mobile framing.

In conclusion: What movement should the camera follow?

55 The mobile framing in these dance sequences from *Top Hat* and *Beau travail* are motivated by figure movement. For Keating, mastery of the follow shot requires "timing the camera's movement to coincide with a character's," and he summarizes the spectrum of follow shot aesthetics as residing between "invisible" and flamboyant impulses [2019, 75]. Our ability with the mv tool to manipulate the figure's relationship to the mobile frame raises the question, which part of a character's movement should the camera follow? In many instances of cinematic staging, in which the camera follows a character who is walking with an erect posture, this question may serve little purpose. However, both Astaire and Lavant expand and contract their Kinespheres by moving their limbs towards and away from their body center, and their

choreography pulls them off-vertical into diagonal pathways. The visualizations of mobile framing above, in which the pelvis' position guides the parallel mobile frame, gives an approximation of what a holistic follow shot would look like, if the cameraperson was obsessively accounting for every tiny shift of the body. An examination of the end of Astaire's solo emphasizes the importance of the cinematography in creating an unobtrusive sightline for the viewer through the cinematic space. The camera dollies to follow Astaire as he drowsily dances towards the armchair, yet it does not also retreat in parallel as Astaire's spins briefly move him back towards the right. Instead, the follow shot creates a smooth pathway to end the number with Astaire centered, his straight body line on the diagonal of the frame.

With the mv tool's mobile camera filter and the practice-based impulses of performative research, we can hypothesize 56
what a more flamboyant approach to the follow shot would look like in these films. If the camera focuses on following the right wrist instead of the body center, for example, the mobile framing becomes significantly more obtrusive. Readers who are easily nauseated may choose to skip these visualizations, a warning that on its own can explain why filmmakers have not traditionally chosen this cinematographic approach (Figure 26 and Figure 27).



Visualization of “No Strings (reprise)” with mobile framing tied to the wrist, performed by Sarah Mininsohn

from **Jenny OK**

01:39

Figure 26. Visualization of "No Strings (Reprise)" with mobile framing tied to the wrist, performed by Sarah Mininsohn.

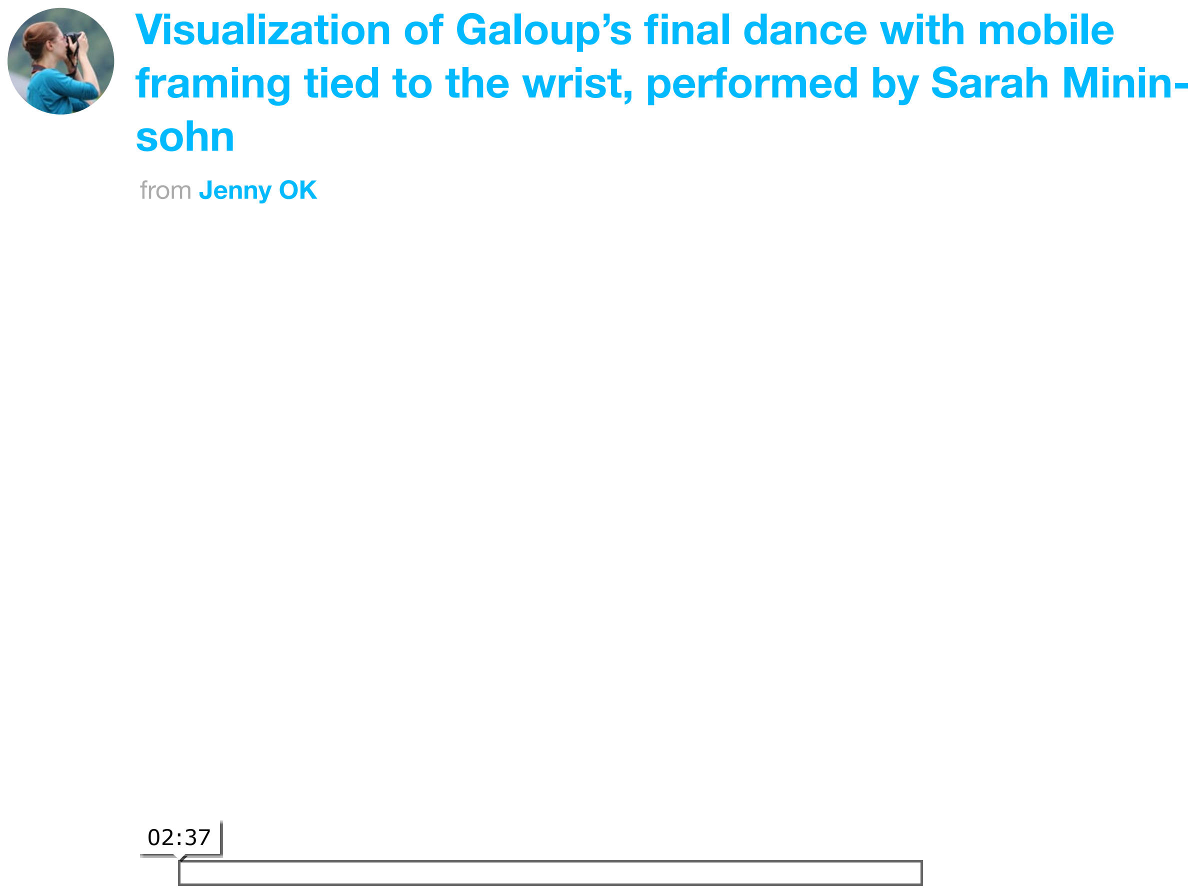


Figure 27. Visualization of Galoup's final dance with mobile framing tied to the wrist, performed by Sarah Mininsohn.

Using digital resources like the mv tool and a performative methodology for stylistic analysis allows us to explore innovative and experimental research questions. The discovery that “No Strings (Reprise)” includes a follow shot motivated by a secondary character points to new lines of inquiry. How common is this occurrence, in Astaire numbers and musical cinema more broadly? With more data, could we articulate a correlation between a norm of camera movement motivated by secondary (non-dancing) characters and an emphasis on drawing viewer attention to narrative details? The flamboyant and extreme camera movements that we can record with the mv tool may not be accessible to filmmakers working in live-action environments due to the limits of camera technology. Yet the ability to change the relationship of the figure to frame initiates questions about how subtle changes to cinematic staging affects a viewer’s perception of the figure movement and can lead us to better understand why filmmakers make the choices they do. For aspiring filmmakers and cinematic choreographers, being able to play in such an environment can empower them to find creative and experimental solutions to the problems inherent in translating an idea to the screen. Performatively engaging with these digital tools provides material insight into audiovisual objects and fosters creative discovery. 57

Notes

[1] While techniques for teaching figure movement or film form is not the focus of this article, this approach also has obvious pedagogical value in its ability to instill a greater awareness of and respect for the complexities of any audiovisual production.

[2] Capitalized terms indicate vocabulary from the LBMS framework. For more on the LBMS work, see [Laban, 2011a] [Laban, 2011b] [Moore,

2009]. For an approach to the work using less technical language, see [Studd and Cox, 2013].

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