

# AVLMA: Laban Movement Analysis as Catalyst for Generative Art in an Experimental Audiovisual Pipeline Using MediaPipe

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## Abstract

This paper investigates the potential of real time movement analysis as a driver for generative audiovisual performance. Premised on a generative logic of movement fueling transformation, we propose an experimental pipeline — AVLMA — that fuses Laban Movement Analysis (LMA) with real time motion capture using MediaPipe. The system extracts spatial and qualitative features of bodily movement to modulate generative sound and visuals in a live performance context. Key components include: particle systems that trace bodily landmarks with expressive variation; a swarm based visual model employing boid dynamics to reflect motion complexity; cellular automata that evolve in response to movement flow characteristics; and a FAUST based audio engine responsive to LMA derived parameters. These layers interconnect through a unified interface developed in Unity3D, forming a reactive, self organizing audiovisual ecosystem. Rather than functioning as background embellishment, the audiovisual system becomes an active agent in the experimental performance—interpreting and responding to the dancer’s evolving gestures. This study expands on the notion of choreography as computation and demonstrates how movement analysis can serve not only as input but as an aesthetic grammar for generative media.

## CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI)**.

## Keywords

Laban Movement Analysis, MediaPipe, generative art, motion capture, audiovisual synthesis, real time performance, swarms, cellular automata.

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## 1 Introduction

If we consider movement to be a driving force that generates new movement, then there are countless digital technologies available

to artists today to integrate and complexify their performances. Among them is motion capture, a technology that has quickly become part of the scenographic repertoire since it reached a certain maturity. There are countless examples that we could give to illustrate this idea, but Bill T. Jones is undoubtedly a pioneer in making this technology a full protagonist [7]. Motion capture means that bodily movement is abstracted from the person performing it. This abstraction makes it possible to record the spatio-temporal trajectories of certain points on this moving body and then reconstruct the gestures and actions on another virtualized body. It is therefore a three way cycle of original movement, recording and archiving, and subsequent reconstruction. In real time, motion capture opens up new possibilities for immersive narratives and dynamic visual presentations of interaction with the performers. In particular, it allows for articulation with other techniques that complexify the visualization of the reconstructed process of this abstraction. This article starts from the idea that movement generates further movement, exploring the fusion of a live dancer’s gestures with generative graphics. To this end, this study investigates the use of various techniques to achieve this interaction, starting with i) Google Mediapipe, which allows movement to be captured in real time with low budget equipment such as a computer’s webcam; followed by ii) LMA - (Laban Movement Analysis [2, 13]), which helps us to understand the quality of the movements performed; iii) the use of Swarm behavior to create a group of particles that follow and accompany the body’s movements; iv) Particle Systems to create a smoky blob of the body, and finally, v) Cellular Automata, which is used to create a dynamic and constantly evolving background, vi) and an audio generation system using FAUST . All these layers are interconnected, with the coordinates and quality of that movement as a starting point, influencing the parameterization of the graphic properties that make up the abstract visualization of the performance in action in real time. The project, entitled AVLMA (an acronym for Audiovisuals and Laban Movement Analysis), extends our previous investigations, in which Laban Movement Analysis was employed to mediate and transform human movement within immersive virtual reality contexts. In those earlier works, we introduced the concept of composite behavioral forces in interactive algorithmic systems — such as swarm and agent based environments, generative audiovisual processes, and the hybridization of human and virtual bodies - thereby expanding the dancer’s kinesphere and triggering emergent behaviors and sound [4, 5, 11].

## 2 Context

The kaleidoscopic experience presented here is set within a framework that presupposes a somewhat nostalgic understanding of Generative Art, with roots in the “Generative Computergraphik”



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exhibition in 1965, and more precisely in Manfred Mohr, who coined the term “generative art” in 1968, in the classic understanding of Margaret Boden [3] and Philip Galanter [6]. Galanter, for example, proposed Generative art as “any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art”. This understanding of the term has been coopted in recent times by generative practices based on deep-learning, which have taken the public perception of the term by storm and are therefore in danger of becoming a *de facto* standard. Boden proposed eleven types of electronic work, in which generative art would provide a general framework for works where “the artwork is generated, at least in part, by some process that is not under the artist’s direct control”. Perhaps it is necessary to reclaim the term now, or on the contrary to suggest that this classic Bodian framework is inadequate, and that a new term is needed to accommodate these new practices supported by Generative AI without making a disregard for the history of Generative art. Tools like Max/MSP, SuperCollider, TouchDesigner, OpenFrameworks, and Kinect have democratized real time generative audiovisual creation in performance. Artists such as Whitley, Troika Ranch, Mondot & Bardainne, and Verstand exemplify digital scenography merging bodily motion and interactive systems. While evolutionary techniques are less common today, echoes remain—for instance, Wayne McGregor’s *Evolutive Pathways* uses genetic algorithms to generate choreographic mutations, while Klaus Obermaier’s *Apparition* evolves visuals in real time based on dancers’ inputs. These works aren’t purely biological nor about relinquishing control. Their public facing nature imposes constraints. In contrast, our work leans toward noise driven experimentalism, challenging spectacle through speculative digital scenography.

### 3 Methodology

The project’s guiding principle is therefore the chaining and interdependence of actions, setting up a pipeline that shapes the movement input through a set of manipulations in a kaleidoscopic process. To do this, we used a set of techniques which initially involved capturing the performer’s movement.

#### 3.1 Motion Capture

We used Google’s mediapipe framework, which allows us to capture a set of key points on the human body, the landmarks, in real time from images taken by a webcam. This is a module built in python and using mediapipe version 0.10.14. This python module sends about 20/30 times per second (depending on the specific rate of CPU/GPU performance, and any potential lag from encoding and network transmission can affect the true rate) and by UTP in a JSON package, the coordinates obtained to a C# module that serves as an input interface within an application developed in Unity3d.

#### 3.2 Movement Quality

In this second phase, we developed a deterministic system for the automatic classification of movements, based on the principles of Laban Movement Analysis (LMA). Laban/Bartenieff Movement Analysis (L/BMA) is one of the most recognized and consistent

systems in dance studies, providing a language and framework for understanding human movement. Created by Rudolf Laban and expanded by Irmgard Bartenieff [2], this system focuses on the interconnected elements of Body, Space, Effort and Shape, which combine, to create unique movement phrases. The Effort component encompasses Weight, Spatial Relationship, Time and Flow. Our implementation was first based on Morita et al [9], which starts from the positions of the landmarks, but then also on Ajili et al [1], which also takes into account the angles formed between the parts. We had to make some adaptations because the key points of the mediapipe landmarks differed from Ajili’s model. For each frame, we began by determining the angles and distances between specific landmarks: i) hands and shoulders, ii) elbows and hips, iii) elbows and shoulders, iv) between the hands, v) nose and left hand vi) nose and right hand, vii) between the hands and the midpoint between the shoulders, and ix) between the feet and the center between the tops of the two legs and finally the angle between the knees. In addition, we calculated the mean, standard deviation, and range for each landmark.

**3.2.1 Shape.** The formulas for calculating the shape parameters are identical to Ajili’s equations, so we’ll avoid reproducing them here by explaining the small and slight differences we’ve made in this implementation. To calculate the “Spreading-Enclosing” feature we analyze how the landmarks around the spine joint (landmark 24 in the mediapipe protocol) move in relation to each other over time, indicating whether they are moving away (spreading) or closer (enclosing), by analyzing the distances between key points, such as the hands, hips or other symmetrical landmarks in relation to the spine, in a sequence of 20 frames (snapshots). To implement the “Rising/Sinking” calculation, we need to calculate the average vertical movement (along the Y axis) of the landmarks in relation to their positions in the initial frame, comparing the positions of each frame with the initial frame of the snapshot. We didn’t implement “Advancing/Retreating” because it is difficult for the mediapipe to realistically determine the degree of depth in the sagittal field since the spatial information is obtained from a single point of view.

**3.2.2 Time.** In order to distinguish between sustained/abrupt movements - the former performed at an almost constant speed and the latter at high speed - Ajili calculates the average, standard deviation and amplitude of the speed of the head-spine-hand junction. Instead, and more in line with Morita, we integrate the reference points of the nose, shoulders, hands, upper limbs and feet. Time(W) and Time(S) calculate the speed of change in weight effort and spatial effort between the initial and final moments of the 25 frame snapshot, respectively.

**3.2.3 Weight.** According to Wahl “Weight effort is about the quality of how you use your mass and invest in relationship to gravity, and how this is manifested in movement. It is about the inner attitude toward one’s mass, not the quantity of one’s mass. Weight can be rarified and delicate, or condensed and powerful.” Wahl [13, p. 95–96]. Within the framework of this methodology, weight is a measure representing the average magnitude (or intensity) of motion vectors across time and space. It helps classify movement within the Light-Strong spectrum, where Light indicates an invariant rhythm with minimal acceleration, while Strong denotes

motion requiring significant force and acceleration. To calculate weight effort, a function must process the last 20 snapshots, each containing all reference points. It calculates the magnitude of movement for each reference point between consecutive frames based on position changes, similar to Morita’s approach with optical flow. By summing these magnitudes across all frames and reference points and averaging the result, the overall weight effort is determined.

**3.2.4 Flow.** To determine whether the movement is free or of a loose type, in the Free - Controlled (Bound) binomial, we will calculate the Yaw and Pitch using the changes in the X, Y and Z coordinates of the nose, left wrist and right wrist over the time of the snapshot. Yaw is the rotation in the X-Z plane. Pitch is the rotation in the Y-Z plane. For free movement, we’ll get a greater range compared to a Bound movement.

**3.2.5 Space.** To distinguish the directness of the movement (direct-indirect) we calculated the Space\_Directness function which takes into account the Straightness Index (S) for the nose, shoulder, leg and hand marks, calculating the ratio between the direct distance (D) from the position of the marks in the first to the last frame and the sum of the distances (L) between successive frames for each mark. This involves following these marks throughout the 25 frames of the snapshots, calculating the direct distance (D) between their positions in the first and last frames and calculating the length of the path (L) by adding up the distances between consecutive frames, where an index close to 1 indicates direct movement and an index close to 0 indicates indirect movement.

### 3.3 Particles

The structural form of the virtual performer is defined by multiple particle systems, each linked to a specific landmark. As a result, each particle system tracks the spatial coordinates of its corresponding landmark. The particles themselves are a blend of light and smoke textures. The emission rate of these particles varies, with the number of emitted particles being adjusted dynamically based on the momentary Space\_Directness of movement, serving as a multiplier (Fig. 1). In turn, the color of the smoke is correlated with the shape of the performer, since the spread-shrink interval is mapped to the 0.255 interval associated with the red component of the color, while the rise-sink is also mapped to green.

### 3.4 Swarm

This section describes the implementation of a swarm of small objects that revolve around the shape of a virtual dancer. Each element in the swarm follows the principles of the Boids algorithm, developed by Craig Reynolds in 1986, which simulates behaviors observed in flocks of birds and schools of fish. The Boids algorithm is based on three main rules that govern the behavior of each individual within the swarm: i) separation from nearby agents, ii) collision avoidance and iii) group cohesion [10]. These rules work together to create what is known as “Composite Behavior”, which will be explained below:

$$F_{\text{composite}}(X_i^t) = \sum_{\text{behaviors}} F_{\text{behavior}}(X_i^t) \cdot w_{\text{behavior}} \quad (1)$$

where  $X_i^t$  represents agent  $i$  at frame  $t$ .



**Figure 1: Smoky particle systems are attached to the motion captured keypoints (landmarks) of the performer’s body**

The composite behavior  $F_{\text{composite}}$  generates a three-dimensional vector, where  $\text{behaviors}$  denotes the list of contributing factors and  $w_{\text{behavior}}$  represents the weight associated with each behavior. At each time step  $t$ , each behavior generates a force vector. This vector is multiplied by its respective weight and combined with the strength vectors of the other behaviors to form a weighted sum. This sum produces a composite force vector that dictates the next movement of the element (Eq. 1).

The available behaviors include: a) cohesion, b) alignment, c) evasion, and d) follow bones.

The composite behavior function combines these behaviors using a weighted average of the intensity of each. The resulting forces depend on the agent’s environment.

In this implementation, each boid is attracted to a specific bone from a list of bones, determined by the remainder of dividing its index by the total number of bones. This cyclical system ensures that the indices return to zero when the maximum number of bones ( $\text{numBones} - 1$ ) is reached:

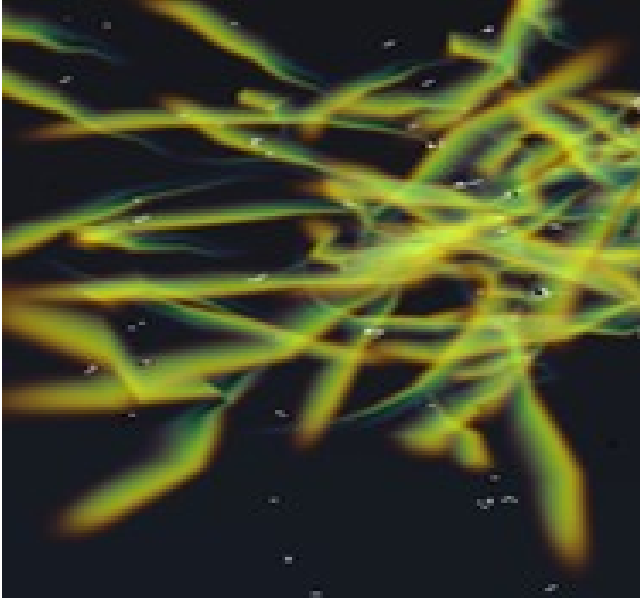
$$r = \text{rank} \bmod \text{numBones} \quad (2)$$

where  $\text{rank}$  is the position or index of the boid in the list,  $\text{numBones}$  is the total number of bones, and  $r$  is the remainder (modulus) when  $\text{rank}$  is divided by  $\text{numBones}$ .

In a second step, the elements of this swarm are joined together to form Bézier curves. Each of these curves is defined by the coordinates of a set of three consecutive elements from the list of constituent elements of the swarm. These are then materialized using a `LineRenderer` with a texture (Fig. 2) in a process that is common to all the lines, which share the same material or texture. However, each of these curved lines is dynamic, shrinking or stretching according to the coordinates that define it.

### 3.5 Cellular Automata

A cellular automata [12] panel acts as a background (Fig. 3). The cellular automata operates on a two dimensional grid of cells with a color state and evolves based on the states of neighboring cells up



**Figure 2: Various Bézier curves formed from the elements of the swarm.**

to a distance that is defined based upon the flow of movement of the performer [controlled-free], in a scale of neighborhood [1, 12] where 1 is controlled and 4 is free. Unlike the traditional binary Game of Life, each cell has a continuous color state, and updates are influenced by the color properties of neighboring cells.

Let  $G \subseteq \mathbb{Z}^2$  represent a finite grid of cells. Each cell  $c \in G$  at position  $(x, y)$  at time  $t$  has a color state vector:

$$S_t(c) = (r_t(c), g_t(c), b_t(c)) \quad (3)$$

where  $r, g, b \in [0, 1]$  represent the red, green, and blue color intensities, respectively.

To calculate the iterative cycle, the neighborhood depth  $d \in \mathbb{Z}^+$  is the distance within which neighboring cells influence  $c$ . A neighborhood  $N_d(c)$  of depth  $d$  for cell  $c$  is the set:

$$N_d(c) = \{ c' \in G \mid 0 < \|c' - c\|_\infty \leq d \} \quad (4)$$

where  $\|\cdot\|_\infty$  denotes the Chebyshev distance (maximum norm). The value of  $d$  is indirectly determined by the flow of movement parameter [free-controlled].

A cell is considered *alive* if its brightness, defined as the average of its RGB components, exceeds a threshold  $B_{th} = 0.5$ :

$$\text{Alive}(c) = \begin{cases} 1, & \text{if } \frac{r_t(c) + g_t(c) + b_t(c)}{3} > B_{th} \\ 0, & \text{otherwise} \end{cases} \quad (5)$$

For each cell  $c$  at each time step  $t$ , define the *Alive Neighbor Count*, which counts the number of alive cells within the neighborhood  $N_d(c)$ :

$$A_t(c) = \sum_{c' \in N_d(c)} \text{Alive}(c') \quad (6)$$

### Update Rules for Cell State:

- **If**  $A_t(c) \geq 2$ : The cell remains alive or “revives” with a vibrant color, chosen probabilistically from its living neighbors. This vibrant color is defined by a random selection among the RGB values of its alive neighbors:

$$S_{t+1}(c) = S_t(c') \quad \text{for a randomly selected } c' \in N_d(c) \text{ such that } \text{Alive}(c') = 1.$$

- **If**  $A_t(c) = 1$ : The cell retains its current color state without change:

$$S_{t+1}(c) = S_t(c) \quad (7)$$

- **If**  $A_t(c) = 0$ : The cell “dies” and fades to a low-intensity “dead” color  $S_{\text{dead}}$ , set to a dark gray:

$$S_{t+1}(c) = (0.1, 0.1, 0.1) \quad (8)$$

This modified cellular automaton rule set combines elements of Conway’s *Game of Life* with probabilistic color continuity, promoting localized persistence of color patterns. The neighborhood depth  $d$  allows for more complex interaction patterns, generating extended formations over time due to the influence of multiple layers of neighbors.

**Boundary Conditions:** For boundary cells, periodic boundary conditions are applied, allowing the edges of the grid to wrap around and connect to form a continuous surface.



**Figure 3: Section of the scene background which is a dynamically composed texture from a Cellular automata.**

### 3.6 Faust

The immersive audiovisual experience is enriched by an audio design that blends multiple sound waves to create a cohesive auditory atmosphere. This process involves mixing audio elements by adjusting their levels, frequencies, and spatial positioning. To manipulate the sound properties of each element, we utilize a FAUST plugin integrated into Unity3D. FAUST is a powerful programming language designed for sound synthesis and processing [8]. We model an audio synthesis and sound manipulation setup where parameters from LMA motion attributes and spatial position data dynamically influence various FAUST audio effects in Unity resulting in dynamic sound modulation. The FAUST code implements vibrato, phaser, reverb, and other audio processing controls, while a Unity script sets these parameters based on real time input data. Here is how this interaction is mathematically represented:

### Panning Control (Stereo Balancing)

$$\text{pan}_L(\text{signal}, x) = \text{signal} \cdot \sin\left(\frac{(x+1)\pi}{4}\right), \quad \text{pan}_R(\text{signal}, x) = \text{signal} \cdot \cos\left(\frac{(x+1)\pi}{4}\right) \quad (9)$$

### Vibrato Effect

$$\text{vibrato}_{\text{applied}}(\text{signal}) = \text{signal} \cdot (1 + \text{vibratoDepth} \cdot \sin(2\pi \cdot \text{vibratoFreq} \cdot t)) \quad (10)$$

### Phaser Effect

$$\text{phaser}_{\text{applied}}(\text{signal}) = \text{signal} + (\text{signal} \cdot \text{depth} \cdot \sin(2\pi \cdot \text{rate} \cdot t)) \quad (11)$$

### Reverb and Filtering

$$\text{filtered}_{(L/R)}(\text{signal}) = \text{moogLadder}(\text{audio}_{(L/R)}, \text{normFreq}, Q) \quad (12)$$

### Flanger Effect (with LFO)

$$\text{flanger}_{\text{audio}}(\text{signal}) = \text{inputAudio} + \text{depth} \cdot \sin(2\pi \cdot \text{lfoRate} \cdot t) \cdot \text{feedback} \quad (13)$$

A control script then sets FAUST audio parameters based on the LMA analysis data and positional data of body landmarks.

### Frequency Control

$$\text{frequency}_{\text{faust}} = 800 + \text{LMA.direct\_indirect} \quad (14)$$

### Phaser Control (Ratio)

$$\text{phaserRatio}_L = |\text{Landmark.RightWrist.x}| \times 10, \quad \text{phaserRatio}_R = |\text{Landmark.RightWrist.y}| \times 0.5 \quad (15)$$

### Reverb Control

$$\text{reverb}_L = |\text{Landmark.LeftWrist.x}| \times 2, \quad \text{reverb}_R = |\text{Landmark.LeftWrist.y}| \times 2 \quad (16)$$

### Vibrato Frequency Control

$$\text{vibratoFreq}_L = |\text{Landmark.Nose.x}| \times 10, \quad \text{vibratoFreq}_R = |\text{Landmark.Nose.y}| \times 10 \quad (17)$$

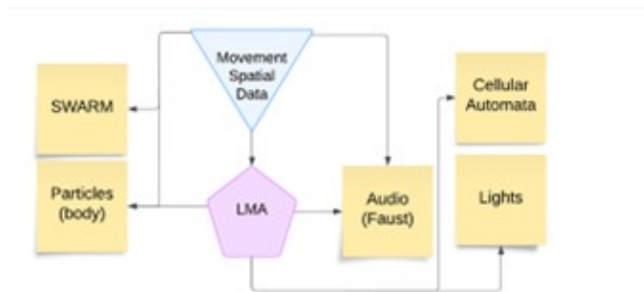


Figure 4: Diagram of the system’s pipeline. The two central modules provide the core functionalities capturing movement spatial data and determining its qualities.

## 4 Discussion

The performative environment described in this work is one of (The per) continuous adaptation – an ecosystem where movement and sound actively shape the space in real time. As the performer moves, the digital landscape responds and transforms, generating a living choreography that evolves through reciprocal engagement between human and machine. Here, aesthetics do not precede interaction – they emerge from it, co-constructed by the body and the algorithm in a continuous loop of action and response.

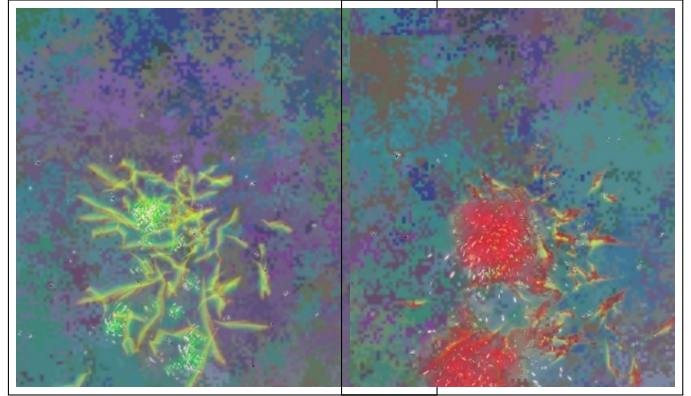


Figure 5: Two snapshots of the visual component captured at different moments during the show.

At the heart of this process is a recursive feedback loop: data flows from the performer to the system and back again, enriching the improvisational space with layers of responsiveness and surprise. Movement no longer functions as a simple trigger for predefined outcomes. Instead, gestures modulate and sculpt the audiovisual environment in real time, acting as primary compositional agents within the system. This transformation is made possible by the integration of real time motion capture via MediaPipe and the Laban Movement Analysis (LMA) interpretive lens. Together, they enable the system to assess not only the spatial coordinates of the body but also the quality of movement - its weight, flow, and time and spatial intent - allowing for a nuanced, semantic encoding of the performer’s presence. These motion qualities then influence variables across multiple visual and sonic dimensions, opening a rich expressive vocabulary for generative modulation. The addition of real time sound synthesis through FAUST further deepens this multimodal feedback. Movement and sound become coextensive: gestures dynamically alter the sonic field, while auditory cues feed back into the performer’s embodied choices. The result is a synesthetic fabric of experience, an interwoven field where motion, sound, and visual (graphic) transformation become interdependent modalities of expression. Simulation techniques such as cellular automata and particle based systems inject another layer of complexity and unpredictability. Microinteractions among visual elements give rise to emergent patterns that are not wholly authored by the performer nor by the algorithm alone. These self-organizing behaviors create space for organic aesthetics to arise—performative gestures are

not overdetermined but instead invite the spontaneous co-creation of form. This stands in stark contrast to rigidly choreographed or static compositions, embracing flux over fixity. The result is a dialogic system in which performer, environment, and sound are not isolated channels but interwoven agents within a greater generative process. Rather than mirroring the human body, the digital system co-evolves with it — reactive yet autonomous, expressive yet unpredictable. In this shared authorship, the stage becomes a space of ongoing negotiation, where performance is never finished, only ever becoming.

## 5 Conclusions

In reimagining performance as a dialogue between body and code, this work suggests that choreography is no longer confined to the dancer's body nor composition to the artist's will. Instead, it emerges from a dynamic interplay — between biological impulse and algorithmic reaction, between intention and emergence, between flesh and technology. AVLMA (Audio Visual and Laban Movement Analysis) does not treat the dancer as an operator of a machine, nor the machine as an invisible tool, but invites both to co-compose a living ecosystem of gesture, sound, and image. In doing so, we shift the paradigm: movement is not merely interpreted by code — it becomes code. The body no longer performs for the system, but with it, producing a space where expression, autonomy, and uncertainty entwine. What results is not a spectacle of control, but a processual aesthetics—one where performance is continually negotiated in real time, and each gesture leaves behind a shimmering trace in the unfolding audiovisual landscape.

Through the use of various technologies, such as Google MediaPipe for capturing movement in real time, Laban Movement Analysis (LMA) for interpreting the quality of movement, swarm behaviors for generating dynamic interactions with particles, Cellular Automata for creating dynamic and constantly evolving backgrounds, generative audio systems in FAUST, and Unity3D to assemble the audiovisual elements together, the work reveals that when gesture becomes code, performance becomes a site of coauthorship between body and system. By replacing control with coevolution, AVLMA transforms choreography into computation, and computation into ephemeral, embodied experience.

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