Human-AI Co-Dancing: Evolving Cultural Heritage through Collaborative Choreography with Generative Virtual Characters

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ABSTRACT
This paper presents a novel approach of “human-AI co-dancing” that combines human dancers with virtual dance partners powered by algorithms derived from traditional choreographic knowledge. Specifically, the principles of Thai classical dance “Mae Bot Yai” were translated into computational procedures capable of generating and transforming movements in real-time. A system was developed to allow dancers to explore these traditional vocabularies and principles generatively by improvising alongside the virtual agent. Multiple interaction modalities were devised, including direct voice control, mediated control by a secondary dancer/choreographer, and even audience participation through real-time voting of parameter changes. Preliminary co-creation rehearsals exhibited intriguing artistic results as hybrid movement aesthetics emerged from the synergy and friction between human and machine. This research illustrates promising potentials at the intersection of intangible cultural heritage, intelligent technology, and posthuman choreography, using computation to evolve traditional knowledge into novel forms for the future.

CCS CONCEPTS
• Human-centered computing → Human computer interaction (HCI); Systems and tools for interaction design; Collaborative and social computing systems and tools; • Applied computing → Performing arts; Media arts; Fine arts.

KEYWORDS
Human-AI Interaction, Choreography, Virtual Character, Cultural Heritage

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1 INTRODUCTION
Dancing exists as a living form of cultural heritage [2, 10], with choreographic knowledge being transmitted between bodies across temporal bounds. Tacit encodings of movement vocabularies are
continuously expanded through improvised forms that connect traditional forms with new explorations. Recent developments in motion capture technology have enabled the digitization of traditional dance movements, providing a means to preserve this intangible heritage [9, 11, 20, 21, 27]. While the digitization approach can conserve the visual form of dance, the deeper layers including the tacit knowledge, improvisational skill, and generative lineage remain frozen in time rather than flourishing as living practices.

This research introduces a novel approach to computationally formalize traditional dance knowledge as interactive models [17, 19, 24] beyond the static recording of dance. Specifically, this paper presents the idea of 'Human-AI co-dancing', which involves combining human dancers with virtual dance partners powered by computational principles derived from traditional knowledge. We refer to this as an "artificial intelligence" system because it aims to encode the "choreographic intelligence" of traditional dances into algorithms capable of responding and choreographing with human dancers in real-time. We acknowledge the importance of non-Western cultural knowledge systems that are often overlooked in the colonial understanding of AI [1, 6]. To illustrate this concept, the authors collaborated with Thai choreographers and dancers to convert the principles of the Thai classical dance 'Mae Bot Yai' (also known as the 'Greater Fundamentals') [26] into a functioning system. The system allows the dancer to interrogate the principles by calling upon them, which activates culturally-inspired algorithm that can be applied to any dance movement and executed live through the virtual dancer. This paradigm enables present-day practitioners to creatively and respectfully interact in with computational manifestations of ancestral choreographic knowledge.

Preliminary rehearsals exhibit intriguing artistic synergies between human and machine as both familiar vocabularies and novel aesthetics intersect within an imaginative vision of post-human choreography [3, 8, 13], expanding out from its traditional roots, and advancing the research in computational choreography [5, 16, 17, 22–24]. This paper discusses both conceptual visions and technical developments behind this platform for intangible cultural evolution through human-AI co-dancing. By bridging the creative possibilities of computation with the accumulated wisdom woven into traditional movement vocabularies, this research cultivate a form of dance that unites the past and future, as well as the human and the machine.

### 1.1 Cultural Context

Contemporary dance performances in Southeast Asia have been experiencing growing recognition and appreciation, as evidenced by increasing audience engagement. Choreographers across the region have gained greater visibility due to their diverse artistic forms of expression, informed by rich cultural backgrounds. A distinguishing character of this contemporary scene is that many of its pioneers and practitioners originated their creative development within local traditional dances or folk practices, grafting new extensions from long-standing movement lineages unique to Southeast Asia. This can either come from formal training in arts academies or from informal involvement in social and cultural communal groups[18].

One of the notable choreographers from Southeast Asia who has inspired this paper is Pichet Klunchun. He is a contemporary Thai dancer and choreographer known for his reinterpretation of Thai traditional dance practices into contemporary pieces. Some of his widely recognized works include "I am a demon" (2005), "Pichet Klunchun and Myself" with Jérôme Bel (2006) [4, 7, 14], "Nijinsky Siam" (2010), "Black and White" (2011), and "Dancing with Death" (2015) [18, 25].

In 2017, Klunchun and his dance company embarked on a project titled "No. 60", which sought to encapsulate two decades of Klunchun’s research and artistic praxis within Thailand’s classical dance tradition. The project was centered around Klunchun’s deconstruction of the foundational set of 59 interconnected poses and movements known as "Mae Bot Yai" (the "Greater Fundamentals") or "Theppanom," with the latter term denoting the inaugural posture within the sequence. This repertoire of poses and movements constitutes the foundational core curriculum imparted to all students of Thai classical dance [25].

The mastery of the Theppanom, the first pose in the sequence, and the other Mae Bot Yai fundamentals enables dancers to execute the demanding choreography and movements of Khon [12], a Thai classical court masked dance with a history spanning centuries. Khon performances enact the Ramakien, the Thai rendition of the Ramayana epic. The Mae Bot Yai fundamentals comprise highly stylized and codified gestures and body positions derived from Indian dance traditions as well as Thai culture, including movements with symbolic hand gestures, graceful walking patterns, and varied arm positions. Additionally, Khon features distinctive footwork and lower body movements such as circular stepping patterns, fluid knee movements, and rhythmic stamping actions. Other characteristics are elaborate hand and finger movements like intricate finger curls and stylized finger poses. There is also coordinated isolation and articulation of various body parts, muscles and joints to create flowing, lyrical motions while maintaining firm stances. Dancers employ techniques like shifts in body weight, controlled torso movements, and the integration of arm and leg actions. Fundamental to executing the Mae Bot Yai properly is achieving smooth transitions between poses and an unbroken continuity of movement.

### 1.2 No. 60 Deconstructing Thailand’s Classical dance

In Klunchun’s effort to deconstruct the embodied knowledge within the Mae Bot Yai, the fundamental poses underlying Thai traditional performance, Klunchun created diagrams and annotations analyzing the 59 constituent movements and postures. His goal was to elucidate potential applications of his findings to dance and catalyze a reimagining of classical Thai dance from a novel vantage point.

A salient aim was to furnish an ingress into Thai dance unfettered by mythology or ideology. Through meticulous movement analysis, Klunchun sought to extract choreographic principles from the Mae Bot Yai fundamentals and gain new insight into their possibilities, free from established conventions. His diagrams and notes represent an attempt to break down and reconstruct the components of this traditional vocabulary in order to reassemble them in innovative ways that could reinvigorate the form.

Klunchun has uncovered 6 choreographic principles from Mae Bot Yai through his analysis, which are demonstrated in his recent work "No. 60". This work aims to reimagine a hypothetical 60th
movement, outside of the traditional 59 movements in Mae Bot Yai, through a re-synthesis of the principles. The 6 principles include: Energy, Circles & Curves, Axis Points, Synchronous Limbs, External Body Spaces, and Shifting Relations. Here are explanations for the 6 elements distilled from the analysis of the Mae Bot Yai fundamentals:

- **Energy** - Exploring the dynamic quality and vitality of the movement and dance phrases. Looking at aspects like force, momentum, acceleration/deceleration.
- **Circles & Curves** - Examining the circular pathways, arcs and curved lines that the body makes in space. Analyzing rounded versus linear patterns.
- **Axis Points** - Considering points on joints and segments of the body that serve as axes of rotation and balance. Identifying the key pivot points around which motion occurs.
- **Synchronous Limbs** - Analyzing the coordinated movement between different limbs, sides or parts of the body. Looking at synchronous versus asynchronous body movements.
- **External Body Spaces** - Exploring the spatial patterns, geometry and relationships between the body and environment. Observing the directions, planes and dimensions moved through.
- **Shifting Relations** - Investigating how transitions between movements and poses direct audience attention and focus to different body parts and actions. Analyzing how progressions from one form to another create seamless flow.

This pursuit led Klunchun to view the elements he discovered through his analysis of the Mae Bot Yai as valuable tools for generating improvisational abilities, not only for dancers familiar with the Thai classical tradition but also for those without any experience or knowledge of Thai dance traditions [25].

Figure 2: Left: Photography of Mae Bot Yai demonstration (1924); Right: Pichet Klunchun Dance Company’s Performance of No. 60 Performance (2017)

Figure 3: The 6 conceptual elements distilled from Thai traditional movements include: Energy, Circles & Curves, Axis Points, Synchronous Limbs, External Body Spaces, and Shifting Relations.

1.3 Technical Concept

The aim of this project is to explore how algorithmic approaches can further advance Thai traditional dance movements as a representation for the future exploration of Southeast Asian artistic practice. This project utilizes the 6 choreographic principles from Klunchun’s ‘No. 60’, which deconstructed and analyzed the Mae Bot Yai repertoire of fundamental poses and movements constituting the core vocabulary of Thai classical dance. The project involves devising culturally-inspired algorithmic procedures based on the 6 principles, which can be used to modify and transform movement data and performed in real-time by a virtual character. In a
Figure 4: Technical Pipeline of the Project consists of 4 major processes: 1) Capturing Movement Data, 2) Encoding choreographic intelligence, 3) Developing the Interactive Interface, and 4) Rehearsing Human-AI Co-dancing

sense, this represents a form of “artificial intelligence” - a rule-based system encoding traditional choreographic knowledge from the Mae Bot Yai fundamentals. The result is an interface allowing both dancers and audience to interrogate and explore the movements and the traditional principles embedded within a virtual character that dances alongside human performers.

1.4 Artistic Concept
As Mae Bot Yai embodies the fundamental knowledge for Thai classical dance that portrays the epic of Ramayana, one inspiration for this work was a renowned passage about the demon king Ravana (also known as Thotsakan) grappling with the haunting specters of his dreams. Bibhek, Ravana’s brother and a shaman, interprets these dreams as omens of impending apocalyptic battle that threatens to plunge the demonic realms into oblivion. Enraged by Bibhek’s interpretation, Ravana expels Bibhek from the kingdom, pushing him to become an ally with Prince Rama, which eventually results in Ravana’s demise.

The cautionary tale of heeding a premonition holds significant relevance in our modern era, particularly with the rise of AI. Bibhek’s foretelling of destruction facing the demons resonates deeply as it mirrors the formidable prospect of AI overshadowing human artistic creativity and spirit. Instead of casting aside this complex, perilous vision, this project, proposing an alternate path where human could have a symbiotic relationship with machines cultivating a novel form of contemporary dance. This allows the human and virtual dancer to co-create performances and develop novel choreography together. The development process consists of four major processes:

2 METHODOLOGY
This research presents an approach to formalizing traditional dance knowledge as interactive computational models. It combines human dancers with virtual dancers embodying the intelligence of traditional choreographic knowledge derived from the Thai classical dance, Mae Bot Yai. The goal of this project is to develop an interface that enables a dancer to perform and explore traditional knowledge in a living way through a virtual dancer. This allows the human and virtual dancer to co-create performances and develop novel choreography together. The development process consists of four major processes:

(1) Capturing Movement Data: The creation of a foundational virtual character through motion capture of a human dancer’s movements. This provides the raw input to the culturally-inspired algorithm.

(2) Encoding choreographic intelligence: The development of a culturally-inspired algorithm takes the form of a rule-based system that can apply principles from traditional dance knowledge to manipulate and transform captured movement data. This imbues the virtual character with traditional choreographic intelligence.

(3) Developing the Interactive Interface: The integration of the rule-based system and virtual character into an interactive interface that allows both the dancer and users to control aspects of the system and dance with the virtual agent in real-time through voice control. This enables responsive, improvisational co-creation.

(4) Rehearsing Human-AI Co-dancing: The exploration of collaborative performance exercises using technology develops novel choreography through human-AI interplay. This provides a testbed for future dance developments.
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The rule-based system aims to encode traditional dance principles

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imbues the virtual character with a dynamic generative capability

the system allows new movement possibilities to be generated

Synchronous Limbs, External Body Spaces, and Shifting Relations.

The process of constructing this model involves analyzing the six chore-

additional Thai Classical Dance repertoire and continues with No.60

principle knowledge, choreographed by Thai dancers. This sensor
data is recorded and processed to construct a skeletal model of

human body as the dancer performs 59 signature poses from tra-

Overall, the technical development supports an overarching con-

cceptual goal of fusing tradition and innovation to pioneer new
directions in Southeast Asian performing arts.

2.1 Capturing Movement Data

Creating a virtual character involves capturing a human dancer’s
movements using motion capture technology through Asix Studio
which works as the standalone software and is compatible with
the Perception Neuron suit. This process requires sensors attached
to the dancer’s body which track the position of each joint and
limb in 3D space. The capture includes 17 main axis points on a
human body as the dancer performs 59 signature poses from tra-
ditional Thai Classical Dance repertoire and continues with No.60
principle knowledge, choreographed by Thai dancers. This sensor
data is recorded and processed to construct a skeletal model of
the dancer and recreate the performed movements in a .BVH data file.
This generates a robust library of movements that reflect the detail
and techniques of a skilled human dancer. The captured motions
can then be transferred onto a virtual humanoid character model
or virtual skin by aligning the .BVH data file to the virtual skin
and proportioning it to the human performer in a 3D modeling
software. This technique provides a starting vocabulary of Thai
dance movements.

2.2 Encoding choreographic intelligence

The rule-based system aims to encode traditional dance principles
and techniques into computational algorithms. These can be ap-
plied as adjustable parameters to transform movement data. The
process of constructing this model involves analyzing the six chore-
ographic principles, including Energy, Circles & Curves, Axis Points,
Synchronous Limbs, External Body Spaces, and Shifting Relations.
These principles are extracted from Mae Bot Yai and can be ab-
stracted and translated into procedural rules and parameters. By
providing algorithmic controls over these choreographic attributes,
the system allows new movement possibilities to be generated
while retaining the core essence of the traditional vocabulary. This
imbues the virtual character with a dynamic generative capability
rooted in the principles of Thai classical dance. Here are algorithm-
ic representations of the 6 choreographic elements deconstructed
from Mae Bot Yai:

- **Energy** - This principle represents the dynamic range of
  motion in different parts of the body over time, which is im-
  portant to the aesthetics of Mae Bot Yai, such as the unique
  knee movements and rhythmic stamping actions. To computa-
tionally model energy, the algorithm scales the timing of
  the different groups of the limb’s animation keyframes to
  increase or decrease the velocity of each individual part’s
  movements, resulting in a variation of movement speed across
  the bodies.

- **Circles & Curves** - This principle represents the circular
  and curved movement trajectories with rounded, rather than
  linear pathway transformations, which make the Mae Bot
  Yai dance fluid, graceful, and pleasing to watch. To computa-
tionally model this principle, we apply mathematical equa-
tions to the rotational quaternions of the limb’s animation
keyframes, such as a Gaussian smoothing filter, derivatives,
low-pass and high-pass filters. This results in an increase or
reduction of curvature in the movement.

- **Axis Points** - This principle represents key pivot points
  and body segments, which serve as the reference points
  for hand movement. The hand points towards this reference
  point, creating elaborate hand and finger gestures in Mae Bot
  Yai. To computationally model this principle, the algorithm
  applies inverse kinematics and smooth linear interpolation
to gradually interpolate the position and rotation of arm
and leg limbs towards the core axis points. The original
movement is altered to gravitate towards the core skeletal
axes points.

- **Synchronous Limbs and Shifting Relations** - These two
  principles represent opposing qualities in Mae Bot Yai, where
  synchronous limbs create synchronous bodily movement
  across the body, and shifting relations create asynchronous
  movement that draws the audience’s attention to specific
  body parts. To model these principles, the algorithm applies
timing offsets to the individual limb’s animation keyframe to
de-synchronize the limb movements from the original
movement. While the original movement is often mirrored and
synchronized due to the nature of the dance, the resulting
movement becomes more independent and uncoordinated.

- **External Body Spaces** - This principle represents the nega-
tive geometric shapes outside the body that create beauty in
Mae Bot Yai. In order to computationally model this principle,
the algorithm detects transition signals between sequence
positions to slow down the movement and influence the
audience to see the negative space in the frozen pose. The
algorithm identifies the movement sequences containing
minimal rotational changes, then extends the timing of the
animation keyframe for those sequences to pause the move-
ment. The resulting movement highlights the external spaces
around and within the dancer’s body.

Additionally, outside of the six principles derived from Mae Bot
Yai, we have introduced parameters such as **Joint Rotations**. This
parameter allows the algorithm to manipulate the virtual charac-
ter’s joint angles and orientations. In reality, a dancer’s joint rotation
is restricted by their own physical capability. However, in the realm
of the virtual, such restrictions are obviated. By experimenting with

![Figure 5: Sensor positions on the dancer body](image)
the joint rotations, we can create new, novel body configurations for the virtual character, enabling movements that would ordinarily be impossible in reality. This expansion into possibilities that transcend physical constraints deepens the dance vocabulary of the virtual character and further heightens the creative scope of the system. The algorithmic rules developed function as parameters adjustable by either the dancer or the audience. This adjustability allows a viewing of what occurs to a given movement when a certain principle is applied. All rules are applicable individually or in conjunction. Figure 6 depicts the example outcomes of applying the principles to dance movement. The following section on the interface will discuss how dancers interact with these rules.

2.3 Developing the Interactive Interface

The virtual character and rule-based system are integrated into an interactive interface built using Three.js for 3D rendering, Vue.js for the interactive user interface, and TypeScript for programming the system behaviors. This allows real-time animation of the virtual agent using algorithmically generated motions while exposing controls for modulating the parameters representing the six choreographic principles. When the parameter is set at 0%, it means that the virtual dancer will perform a given dance move without incorporating that principle. If the parameter is increased to 100%, it implies that the virtual character’s movement would be significantly altered by that principle. Voice recognition capabilities enable the issuing of spoken commands to manipulate the character’s movements. The interface presents the choreographic elements as dropdown menus. Users can call up elements such as “Energy”, and the system provides follow-up options to specify details like which body parts to modify, as shown in Figure 8. Slider controls allow for fine-tuned parameter tweaking, while timeline widgets enable sequencing movements and transitions. The human dancer can view the character’s live animated responses, allowing for an improvisational, call-and-response dynamic during the performance. This real-time interactivity facilitates creative experimentation between the human and virtual agent, allowing for the co-development of innovative choreography that blends tradition and technology.

2.4 Rehearsing Human-AI Co-dancing

To explore the creative possibilities of human-AI co-dancing, we invited four dancers/choreographers (2 from Thailand and 2 from other countries) to participate in a one-week workshop. During this workshop, we conducted rehearsal sessions to experiment with and develop novel choreography. The human dancer and virtual characters would improvise together, responding to each other’s movements and modulating the performance using voice commands or
Figure 7: Photographs from Rehearsal with Dancers; Top: Virtual character rendered with scale larger than human body dimensions; Bottom: Virtual character depicted to one-to-one identical scale with human form

Figure 8: The virtual character and rule-based system are integrated into an interactive interface built using Three.js for 3D rendering and JavaScript for programming the system behaviors. This allows real-time animation of the virtual agent using the algorithmically generated motions, while exposing controls for modulating parameters of the rule system.

interface controls. The dancer channeled their traditional vocabulary while the virtual agent exhibited new responses generated algorithmically from the traditional choreographic knowledge of Mae Bot Yai. We devised exercises to stimulate novel performance ideas as shown in figure 7. For instance, various interaction modalities were explored for real-time manipulation of the virtual character: In "Direct Control mode", the dancer could trigger rule changes by verbally calling out principle alterations, allowing for fluid responsive directing during dancing. "Mediated Mode" had a secondary dancer or choreographer modulate rule parameters in real-time instead, which facilitated more complex commands unencumbered by primary dance motions. Most intriguing results emerged from the impromptu "Audience Control mode", where viewers voted mid-performance through buttons to direct autonomous stylistic changes in the virtual dancer, allowing for emergent collective choreographic interventions.

During co-creation exercises, the human dancer was challenged to intentionally resist, embrace, or conceptualize contrasting responses to the virtual agent’s generative dance offerings. Attempts to harmonize with machine-generated interpretations opened spaces of synergy where hybrid vocabularies organically arose from fusions of traditional principles and synthetic outcomes. Alternately, foregrounding moments of rupture, friction, and opposition highlighted the technology’s non-human-centric alterity in striking relief against the dancer’s physicality. This fluid spectrum between resonance and dissonance suggested that multiple performative modes could yield engaging artistic impacts. This emerging choreographic process points to rich potentials for developing future posthuman [3] performances where human and virtual dancers collaborate as creative equals.

The virtual character was also rendered at multiple scales during experimentation to explore its impact. When visualized at an identical one-to-one proportionality with the human dancer, a deeper sense of direct empathy and similarity was reported. Alternately, when enlarging the avatar to heights beyond human scale, it reinforced its digital nature and took on a more towering, transcendent presence during collaboration. The scaled extremes appeared to
affect the perceived role and semantics of the virtual character during co-choreographed performances in intriguing aesthetic directions. Additionally, we delved into simulations involving two virtual characters, each representing different aspects of our experiment. One character maintained an unaltered presentation, offering a baseline for comparison, embodying a traditional dance form in its purest form. On the other hand, the second character represented the altered aspect of movement dynamics, serving as a contrasting variable. This juxtaposition provided us with valuable reference regarding how shifts in movement presentation affect viewer perception and interaction. This experimental approach of having an ‘unaltered’ and ‘altered’ virtual dance character offered a multi-dimensional perspective on the relationship between human dancers and their virtual counterparts. It allowed us to explore how variations in movement, represented visually through the avatars, contribute to the overall interaction dynamics in co-choreographed performances.

3 DISCUSSION

This research introduces a promising new direction for human-machine co-creativity within the evolution of the intangible cultural heritage of dance. By computationally encoding the traditional knowledge of Thai classical dance, the developed Human-AI co-dancing system facilitates emergent choreographic dialogues between the past, the present, and the future [15] [3].

As the human dancer physically challenges, resists, follows, and improvises with the virtual dance partner’s algorithmic interpretations of traditional dance vocabularies, intriguing frictions arise that highlight each intelligence’s distinct perspectives and capabilities. This dynamism suggests rich questions around autonomy, influence, control, and co-dependence as human and artificial agencies entangle through points of resonance and dissonance. Such interplay prompts vital discourses on the essence of the human spirit and freedom when choreographically coupled with non-human outputs operating from cultured datasets.

The rehearsal demonstrated the potential of this system to expand the creative output spaces of both the human dancer and the algorithm through cycles of call-and-response. The influence of the machine on the dancer and the dancer’s influence on the machine, forming a cybernetic loop, prompts the inquiry into the future of human creativity. It provokes the question of how human-machine assemblage could be more than the sum of its parts. What role does technology play in re-animating wisdom from the past?

Ultimately, this research charts an imaginative vision for the future of intangible cultural expressions through fusions of the body, code, and data. We address limitations of static digitization approaches by demonstrating rich interactive synthesis capacities forged across body-data-code substrates. The Human-AI co-dancing paradigm introduced in this research points to the role intelligent systems could play in preserving living knowledge traditions through continuously evolving artistry beyond the bounds of mortal form.

REFERENCES


