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Art Biomechanics of Joget Serampang Laut: A Motion Capture-Based Approach for Cultural Preservation

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Abstract

As traditional performance traditions are threatened by modernisation and the constraints of conventional recordkeeping, it has become more important than ever to protect intangible cultural heritage. Joget Serampang Laut, a Malay dance originating from Melaka and reflecting Islamic ideals, Adat, and Adab, is especially vulnerable to superficial depictions that fail to acknowledge its profound symbolism. This work tackles the issue by employing an innovative hybrid methodology that combines motion capture technology with art biomechanics, providing both accurate documentation and interpretative interpretation of the dance as a cultural artefact. A male and a female dancer, both full-time students at Institut Warisan Melaka (INSWA) who trained under Adiguru Noriah Ahmad, executed a whole 216-second routine. Cortex Motion Analysis software was used to capture and evaluate movement data from eight Osprey cameras and 21 retroreflective markers. The results showed that the male dancer used big, angular gestures to show strength and leadership, while the female dancer used small, circular motions to show humility and elegance. There was also a functional split, with the lower body responsible for movement and orientation in space and the upper body responsible for transmitting meaning and emotion. Motion trajectories recreated cultural floor patterns like circles, squares, and diamonds that fit with Malay cosmology and ethics. These patterns are typically hard to see in regular film. In conclusion, the study validates that the amalgamation of motion capture and biomechanics offers an innovative framework for scholarly examination and cultural preservation, enriching pedagogy while protecting intangible heritage.

Keywords: Art biomechanics, dynamic motion, *Joget Serampang Laut*, motion capture technology, traditional dance preservation

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Biomekanik Seni Joget Serampang Laut Melalui Pendekatan Tangkapan Pergerakan untuk Pemeliharaan Budaya

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Abstrak

Seiring dengan ancaman pemodenan dan keterbatasan kaedah dokumentasi konvensional terhadap tradisi persembahan tradisional, usaha untuk melindungi warisan budaya tidak ketara menjadi semakin penting. Joget Serampang Laut, sebuah tarian Melayu yang berasal dari Melaka dan berteraskan nilai islam, adat, dan adab amat terdedah kepada gambaran luaran yang cetek serta gagal mengangkat simbolisme mendalam yang terkandung di dalamnya. Kajian ini menangani isu tersebut dengan menggunakan pendekatan hibrid yang inovatif, iaitu gabungan teknologi tangkapan pergerakan (motion capture) dengan biomekanik seni, bagi menghasilkan dokumentasi yang tepat serta tafsiran interpretatif terhadap tarian ini sebagai sebuah artefak budaya. Seorang penari lelaki dan seorang penari wanita, kedua-duanya pelajar sepenuh masa di Institut Warisan Melaka (INSWA) yang mendapat latihan daripada Adiguru Noriah Ahmad, telah mempersembahkan keseluruhan rutin berdurasi 216 saat. Data pergerakan direkod dan dianalisis menggunakan lapan kamera Osprey serta 21 penanda pasif reflektif menerusi perisian Cortex Motion Analysis. Hasil kajian menunjukkan penari lelaki mempersembahkan gerakan besar dan bersudut bagi melambangkan kekuatan serta kepimpinan, manakala penari wanita memperlihatkan gerakan kecil berbentuk bulatan yang menzahirkan sifat rendah diri dan keanggunan. Turut dikenal pasti ialah pembahagian fungsi, di mana bahagian bawah badan berperanan dalam pergerakan serta orientasi ruang, manakala bahagian atas badan menyampaikan makna dan emosi. Trajektori pergerakan turut membentuk semula pola lantai budaya seperti bulatan, segi empat dan berlian yang sejajar dengan kosmologi dan etika Melayu, yang lazimnya sukar dilihat melalui rakaman video biasa. Kesimpulannya, kajian ini membuktikan bahawa gabungan teknologi tangkapan pergerakan dan biomekanik menyediakan kerangka inovatif bagi penyelidikan akademik serta pemeliharaan budaya, sekali gus memperkayakan pedagogi dan melindungi warisan tidak ketara.

Kata Kunci: *Biomekanik seni, dinamik gerakan, Joget Serampang Laut, tangkapan pergerakan, pemeliharaan tarian tradisional*

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1.0 Introduction

The preservation of intangible cultural heritage has become a global concern, especially in the face of rapid technological advancement and cultural homogenisation (UNESCO, 2003). Traditional dance, in particular, holds profound cultural and philosophical value but is highly vulnerable because of its ephemeral nature. Each performance exists only in the moment it is enacted, and without systematic preservation, valuable knowledge encoded in movement risks disappearing with the passing of practitioners. For communities where oral tradition and embodied teaching remain central, the challenge of sustaining such heritage has become increasingly urgent in the digital age.

Videography and photography, while accessible, do not effectively capture the intricacies of dance. These methods focus on surface-level visuals and ignore biomechanical factors like joint articulation, speed, and spatial trajectories, which are very important for choreographic design (Kico et al., 2018). They also don't reveal what the dancer is trying to do or what the moves represent in a deeper, more abstract sense. Younger individuals lacking an understanding of cultural context may misconstrue, oversimplify, or trivialise embodied knowledge as mere entertainment. These constraints show how important it is to use more advanced documentation methods that capture both technical accuracy and cultural essence.

Traditional Malay dances like Joget Serampang Laut have not been able to endure because there is not enough information about them. Digital technology has enhanced several areas; yet, the majority of studies is either visual or descriptive, lacking biomechanical specificity. Motion capture technology, originally developed for animation, medicine, and sports science, is extensively utilised in intangible heritage research for its capacity to track skeletal structures and physiological movements in three-dimensional space (Parent et al., 2009; Shan et al., 2010). Motion capture has been utilised to digitise Zapin (Mustaffa & Idris, 2017, 2020), Cypriot traditional dances on interactive 3D platforms (Stavrakis et al., 2012), and Taiwan's Ba Jia Jiang ceremonial performance (Syu et al., 2018). These studies show that motion capture can be used to record and analyse the structure, pace, and cultural meaning of movement.

Yet, nonetheless these advancements, Joget Serampang Laut has not been thoroughly analysed through an integrated framework of motion capture and art biomechanics. The dance is especially important because it uses symbolic gestures, gendered vocabulary, and floor patterns to express Malay philosophical principles like Islam, Adat (custom), and Adab (etiquette) (Mohd Herrow & Azraai, 2023). Zapin has been examined for its choreographic patterns, but Joget Serampang Laut has not been investigated enough to see how its motions show cosmological and moral ideas. The absence of biomechanical analysis constrains both academic comprehension and practical implementations in education, digital preservation, and cultural pedagogy. This gap highlights the necessity of employing a more stringent, data-driven methodology that can simultaneously elucidate the technical and symbolic dimensions of the dance.

The objective of this study is therefore twofold. First, it seeks to investigate the biomechanics of *Joget Serampang Laut* in order to reveal its physical structure, expressive dynamics, and symbolic floor formations. Second, it aims to demonstrate the role of motion capture technology in providing both a documentary and analytical framework for preserving traditional dance as a multidimensional heritage

form. By combining empirical motion data with cultural interpretation, this research positions *Joget Serampang Laut* not merely as a performance but as a living manuscript of Malay identity. The integration of art biomechanics with motion capture offers a scalable model for documenting traditional dance, ensuring that its embodied values are safeguarded for future generations while also contributing to the broader academic discourse on digital heritage preservation (Musa et al., 2020).

2.0 Literature Review

2.1 Art Biomechanics

Art biomechanics is concerned with how the body moves and how forces shape that movement. In dance, it offers a way to look closely at the technical side of performance. Researchers often divide it into two areas. The first is kinematic analysis, which describes motion itself. The second is kinetic analysis, which studies the forces that cause motion (Wilson & Kwon, 2008). Both are useful because they show not only what the body does, but also how and why the movement happens.

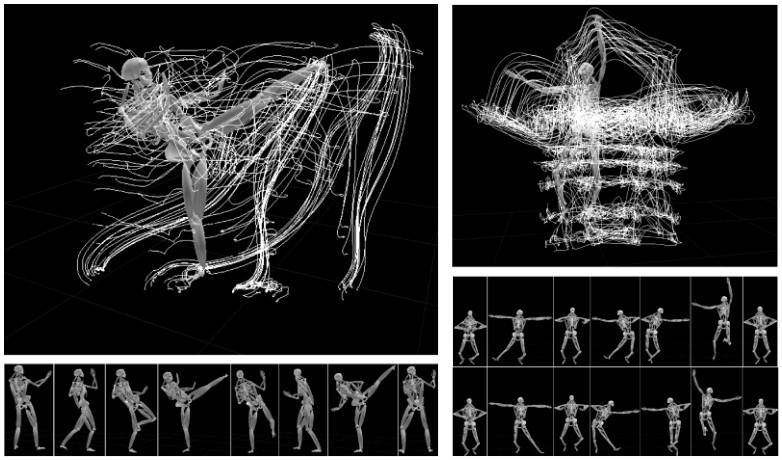

Figure 1: Sample of human movement in sports and performing arts
(Source: Shan et al., 2010)

Figure 1 illustrates examples of human movement in sports and performing arts that are commonly analysed through biomechanical principles. These movements demonstrate how body segments, joint articulation, and spatial trajectories contribute to the efficiency and expressiveness of physical motion. In the context of dance research, such biomechanical observation provides a systematic way to analyse how controlled body mechanics produce aesthetic movement patterns. This perspective forms the foundation of art biomechanics, which enables the study of dance movement not only as artistic expression but also as measurable physical dynamics.

In cultural dance, biomechanics adds another layer. Movements are rarely neutral. They often carry artistic and philosophical meaning. Shan et al. (2010) described biomechanics in the arts as a way to visualise and interpret aesthetic and expressive qualities. This is especially relevant in Malay traditions. Gestures in *Silat* or *Senaman Tua*, for example,

do not only train the body but also express spiritual ideas (Azraai et al., 2018; Md Isa et al., 2020).

Mustaffa and Idris (2020) showed this clearly in their work on *Zapin Lenga*. Their study found that the lower body provided range and direction, while the upper body was more controlled and symbolic. Laban Movement Analysis has also been used as a framework to interpret body, effort, space, and shape (Newlove, 1993; Davies, 2006). Together these approaches demonstrate that biomechanics is more than a technical description. It is also a tool to keep intangible cultural meaning alive.

2.2 Motion Capture in Traditional Dance Preservation

Motion capture technology goes beyond video or photography. By tracking markers on the body, it reconstructs movement in three-dimensional space. This allows researchers to study not only the steps but also the precision of timing, angles, and trajectories (Parent et al., 2009; Syu et al., 2018).

Other cultures have already experimented with this. In Taiwan, Syu et al. (2018) recorded the Ba Jia Jiang ritual dance. They created virtual avatars, making it possible to preserve the performance for the future. In Cyprus, Stavrakis et al. (2012) digitised folk dances and even designed an interactive platform for learners. These examples show that motion capture is not just an archival tool. It can also support education and cultural engagement.

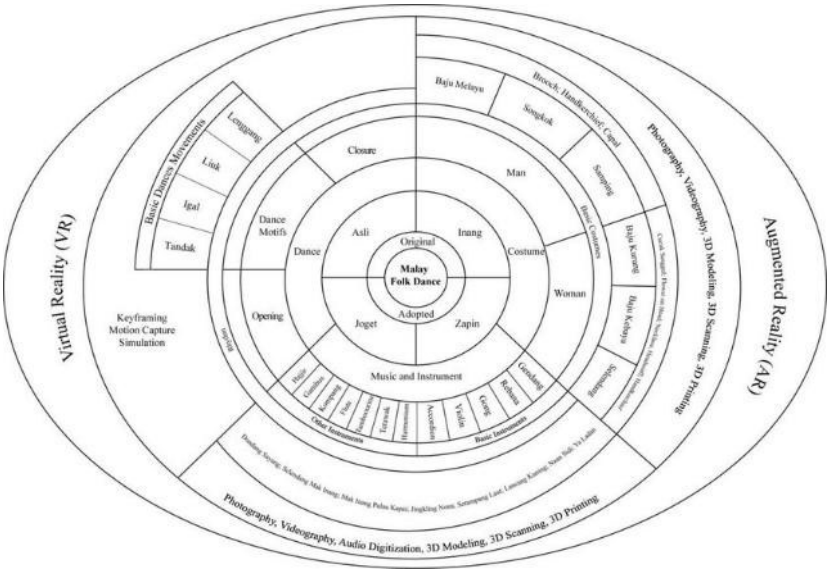

Figure 2: Principal components of the digitalisation of Malay folk dance (Source: Idris et al., 2017)

Figure 2 illustrates a conceptual framework for the digitalisation of Malay folk dance by integrating cultural philosophy, choreographic structure, and digital technologies. At the core of the framework are the cultural values of Islam, Adat, and Adab, which shape the

ethical and aesthetic foundations of Malay dance traditions. The surrounding layers represent key choreographic components such as body movement, gesture, rhythm, spatial patterns, costume, and musical accompaniment that collectively define the structure of dance performance. The outer layer highlights digital preservation technologies including motion capture, virtual reality (VR), augmented reality (AR), photography, and 3D modelling. Together, these components demonstrate how traditional dance knowledge can be systematically translated into digital formats for documentation, analysis, and long-term cultural preservation.

In Malaysia, studies on *Zapin* have demonstrated the same value. Mustaffa and Idris (2017) captured the structural elements of *Zapin* steps and compared traditional teachings with biomechanical data. Musa et al. (2020) expanded this approach in their study of *Mak Yong*, combining motion capture with Laban theory to create a broader framework for preservation.

Technical issues remain a challenge. Marker occlusion, calibration, and environmental factors can interrupt recording (Mustaffa & Idris, 2017; Syu et al., 2018). However, these are usually manageable with careful studio setups and software adjustments. Despite these limitations, motion capture continues to be one of the most reliable ways to preserve traditional dance in fine detail.

2.3 *Joget Serampang Laut*

Malay folk dance Joget Serampang Laut has a quick rhythm, harmonic floor patterns, and a focus on propriety and male-female contact. The dance incorporates Malay philosophical concepts such as Islam, Adat, and Adab into expressive gestures and coordinated movements, according to Mohd Herrow and Azraai (2023). Traditional pair dances teach synchronisation, humility, and cultural respect.

Joget Serampang Laut has traditionally been performed in Melaka Malay community celebrations, weddings, and social events. Adiguru (master practitioners) preserve style, philosophy, and pedagogy, assuring ethical and spiritual qualities in each movement. Adiguru Noriah Ahmad, 75, has been acknowledged for her lifelong preservation and transmission of the tradition. As a cultural guardian and instructor at Institut Warisan Melaka (INSWA), she educates young dancers and promotes traditional Malay performing traditions. Adigurus like Noriah Ahmad highlight Joget Serampang Laut's dual status as a performance art and a Malay identity document.

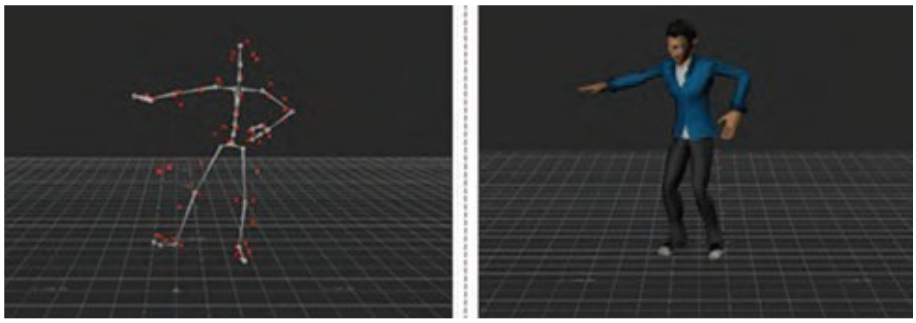

Figure 3: Motion analysis of *Zapin Lenga* in motion capture
(Source: Mustaffa and Idris, 2020)

Figure 3 presents an example of motion capture analysis applied to Malay traditional dance through the visualisation of movement trajectories in Zapin Lenga. The reconstructed skeletal model and motion pathways demonstrate how motion capture technology can reveal spatial patterns, joint articulation, and dynamic body coordination during dance performance. Such visualisation allows researchers to observe movement structures that may not be clearly visible through conventional video documentation. This example highlights the potential of motion capture as an analytical tool for examining the biomechanical characteristics of traditional dance, which informs the present study on Joget Serampang Laut. Studies on other Malay dances, such as Zapin, provide useful points of comparison. Mustaffa and Idris (2020) identified six recurring patterns in Zapin Lenga, paying close attention to how the feet trace lines across the floor, how balance is maintained, and how angles shape the body's flow. They also showed that curved and diagonal pathways carry symbolic weight. In a similar way, the present study applies motion capture to Joget Serampang Laut, examining how its use of squares, arcs, and circular designs reflects broader cultural ideas of unity, order, and collective organisation.

This dance makes a clear difference between masculine and female roles. Women often keep their arms close to their bodies, which is a show of humility and grace. Men, on the other hand, stretch their arms out to show that they are strong and responsible. When these disparities were tracked via motion capture, they became even clearer. The technique recorded the angles of the joints, the paths of the limbs, and the space between bodies in great detail, showing small details that could have been missed otherwise. It becomes clear that Joget Serampang Laut is not just a performance; it's also a cultural text that is written directly via the body.

The study used eight Osprey cameras and twenty-one reflective markers placed at the body's key joints to get such detailed information. Cortex Motion Analysis processed the recorded movements and made visual outputs including line drawings, angular transitions, and dynamic sequences. This digital record keeps the dance from disappearing, but it also gives us new ways to look at it. The examination goes beyond just paperwork to show how cultural values are built into biomechanics and how technology can be utilised to not only store tradition but also make its implications clearer.

3.0 Methodology

This study used a quantitative design supported by motion capture to document and analyse the biomechanics of *Joget Serampang Laut*. The workflow followed four linked stages. First, the capture system was prepared and calibrated. Second, alternative equipment was developed to meet budget and fit needs. Third, the full performance was recorded in controlled conditions. Fourth, the data was processed and analysed using biomechanical indicators and trajectory visualisation.

3.1 Dancer Profile

Two professional dancers took part in the study: a 25-year-old male and a 24-year-old female, both Malaysian nationals and full-time performers with Institut Warisan Melaka (INSWA). Their training came directly under Adiguru Noriah Ahmad, which gave them not only technical mastery but also deep familiarity with the stylistic and philosophical dimensions of Joget Serampang Laut. This background ensured that the movements recorded in the study represented authentic practice as well as cultural intent. For biomechanical reference, additional physical data were noted. The male dancer stood 172 cm tall and weighed 60 kg, while the female measured 167 cm and weighed 58 kg.

3.2 Data Trails

The full Joget Serampang Laut sequence, lasting 216 seconds, was performed and recorded by both dancers. To maintain reliability, the entire routine was captured three times under controlled laboratory conditions. Repetition made it possible to observe natural variation in performance while also reducing the effect of technical challenges such as marker loss or incomplete data. For analysis, the average results from the three trials were used, giving a more stable picture of the biomechanical patterns across the dance. Any irregularities that appeared in individual recordings were cross-checked against the repeated trials and corrected during post-processing in Cortex Motion Analysis.

3.3 Motion Capture System Setup and Observation

The motion capture process was conducted in the Motion Capture Laboratory at the School of Arts, Universiti Sains Malaysia. An optical motion capture system consisting of eight Osprey digital cameras was used to record the dancers' movements. Each camera was calibrated and configured to operate at 245 frames per second with a resolution of 640 × 480 pixels. The high frame rate enabled subtle transitions between joint movements to be captured clearly, allowing the temporal continuity of each ragam sequence to be observed.

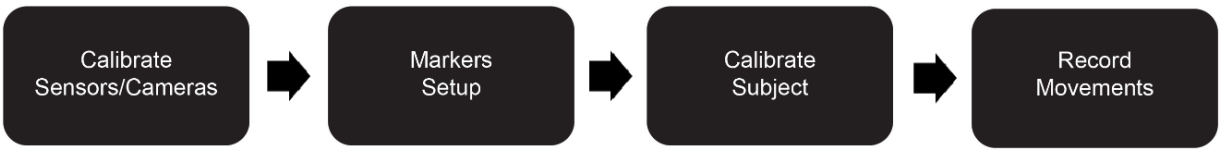

Figure 4: Motion capture pipeline

Retroreflective passive markers were attached to key anatomical joints of the dancers, including the head, shoulders, elbows, wrists, hips, knees, and ankles. These markers reflected infrared signals emitted by the cameras, enabling the system to track the spatial movement of each joint and reconstruct the dancer's skeletal structure in three-dimensional space. The workflow of the motion capture process used in this study is illustrated in Figure 4, which outlines the stages of calibration, marker placement, movement recording, and digital reconstruction of skeletal motion. This process demonstrates how traditional dance movements can be systematically translated into digital motion data for further analysis.

Figure 5: Biomechanics points in *Joget Serampang Laut*

The placement of the retroreflective markers on the dancer's body is shown in Figure 5, where the markers function as tracking points that allow the motion capture system to follow joint movements during performance. Through this configuration, the system records the spatial trajectories and temporal progression of body segments as the dancer performs each ragam sequence. The system-generated data therefore provide visual information about how movement unfolds through space and time.

Although the motion capture system produced motion information such as joint trajectories, frame-based movement sequences, and relative joint movement speed, this study did not aim to construct a fully numerical biomechanical model. Instead, these outputs were interpreted primarily as visual-temporal indicators to observe the continuity,

rhythm, and spatial organisation of movements within Joget Serampang Laut. This approach allows the motion capture data to support visual analysis of dance patterns while maintaining the cultural and interpretive orientation of the research.

3.4 Development of Alternative Equipment

Figure 6: Alternative retroreflective passive markers

Custom components were introduced to keep the setup affordable without losing precision. Retroreflective markers were designed in Autodesk SolidWorks and produced with a Creality Ender 5 S1 printer. Each marker measured 22 millimetres in diameter. After printing, parts were sanded, assembled, and coated with high-grade reflective stickers. Mounting used Velcro and rubber bases to reduce wobble during dynamic phrases. Figure 6 presents the alternative retroreflective markers developed for this study as part of the motion capture setup. The locally adapted design demonstrates how customised components can be used to support motion tracking when specialised equipment is limited. This approach ensures that the movement data can still be recorded effectively while maintaining the accuracy required for biomechanical analysis.

Figure 7: Alternative motion capture suit

An alternative capture suit was also produced. Fleece micro fabric was selected because it is comfortable and holds Velcro securely. The build followed six steps that included material selection, pattern drafting, cutting, sewing, fitting, and finishing. Each suit was

tailored to the dancer to minimise marker drift and to maintain alignment across repeated takes. These adaptations show that locally fabricated tools can support high quality motion capture for heritage work. Figure 7 illustrates the alternative motion capture suit used during the recording session. The suit is designed to securely position the retroreflective markers on the dancer's body while allowing sufficient flexibility for natural movement. This configuration ensures that the markers remain stable during performance, enabling consistent tracking of body motion throughout the capture process.

3.5 Calibration and Data Recording

System calibration preceded every session to define the capture volume and to correct lens distortion. Cameras were aligned and synchronised, then checked against known marker configurations. Dancers completed warm up movements to stabilise posture and to reduce early take errors.

The full choreography of *Joget Serampang Laut* was recorded in several passes. Individual *ragam* were captured for close analysis, and a continuous take documented overall flow and partnering. Multiple takes ensured clean sequences when occlusion or inadvertent marker loss occurred. Artistic supervision by a senior practitioner, Noriah Ahmad, maintained stylistic accuracy and cultural integrity throughout the sessions.

3.6 Motion Data Processing

After the recording session, the captured motion data were imported into Cortex Motion Analysis software for post-processing. The initial stage involved marker labelling, gap filling, and noise reduction to ensure the continuity of the recorded motion sequences. A smoothing filter was applied to reduce minor recording inconsistencies while preserving the natural movement characteristics of the dance performance.

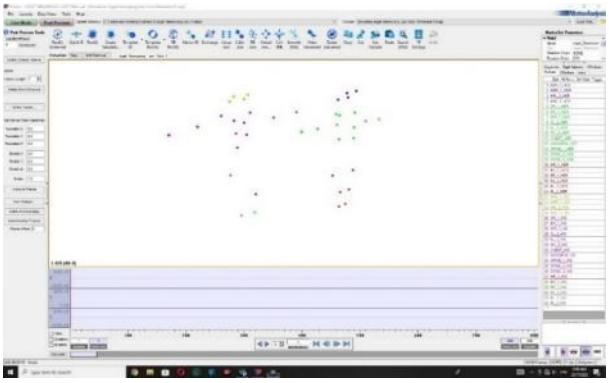

Figure 8: Maker data display in the Cortex Motion Analysis interface

The Cortex system then generated a digital skeletal reconstruction of the dancer's body movement. The interface used for this analysis is shown in Figure 8, where the motion capture software visualises marker trajectories and reconstructs a skeletal representation of the dancer. Through this interface, researchers were able to observe how different

body joints moved in coordination throughout the performance, providing insight into the biomechanical structure of the dance.

The reconstructed skeletal model allowed the spatial trajectories of individual joints to be visualised frame by frame. Although the system was capable of generating kinematic information such as relative movement speed and temporal progression, the present study employed these outputs mainly as visual analytical tools rather than numerical biomechanical measurements. By observing the trajectories and timing relationships between body segments, the motion capture data revealed patterns of movement continuity, directional change, and rhythmic pacing within the choreography.

This analytical approach enabled the movement patterns of Joget Serampang Laut to be interpreted through the interaction of spatial trajectories, temporal flow, and coordinated joint motion, providing a clearer understanding of how traditional dance movements are structured and performed.

4.0 Data Analysis

The motion capture recordings generated detailed spatial and biomechanical datasets that revealed structural characteristics of Joget Serampang Laut movement. Unlike conventional video documentation, the reconstructed trajectories and skeletal models made it possible to observe subtle joint articulations, spatial transitions, and timing relationships between body segments. These visualisations demonstrate how the choreography is organised through coordinated interactions between different parts of the body, where micro-movements such as wrist rotations, ankle pivots, and shoulder adjustments contribute to the continuity of each ragam sequence. When analysed collectively, these biomechanical patterns show that Joget Serampang Laut is structured through a layered system of movement control, where technical precision and expressive intent operate simultaneously.

4.1 Interpretive Insight from the Motion Capture Process

The sessions recorded more than steps. They revealed how the dance thinks through the body. The system picked up the small things that ordinary video usually misses. Wrist rotations that settle a phrase. Ankle pivots that prepare a turn. Shoulder angles that change the tone of a gesture. Seen together, these details link one motif to the next so the choreography reads as a continuous idea rather than a list of moves.

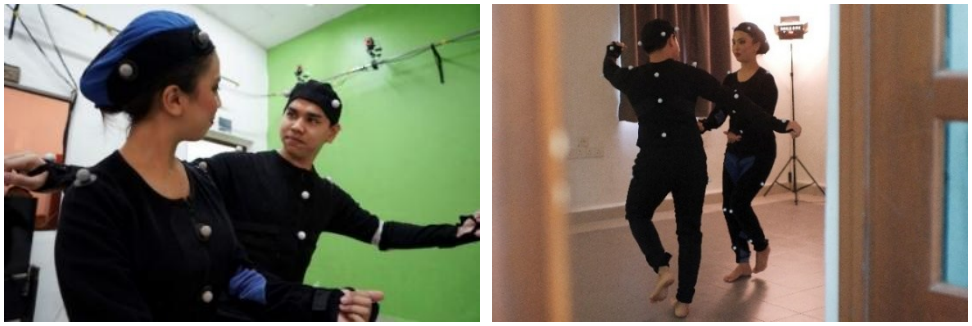

Figure 9: Recording session in motion capture laboratory

Figure 9 shows the motion capture recording session conducted in the laboratory environment during the data collection process. The dancer performs the Joget Serampang Laut movements within the calibrated capture space while multiple cameras track the retroreflective markers placed on the body. This recording setup ensures that the dancer's movements can be accurately captured from multiple angles, enabling the reconstruction of precise three-dimensional motion data for further biomechanical analysis.

Layering across the body became clearer once the traces were visualised. The lower body managed weight, balance, and travel. The upper body held the expressive line and the symbolic message. A regular sequence appeared in many phrases. The head oriented first, then the shoulders and with the limbs following in measured delay. Three-dimensional trajectories also clarified spacing in the duet. Timing matched closely, and distance remained steady, which echoes values of respect and coordinated partnership that teachers emphasise in Malay dance practice.

4.2 Analysis of Digital Skeleton and Joint Movement Trends

After cleaning and labelling, skeletal reconstructions showed stable patterns that matched the identity of the dance. Certain joints did the heavy lifting for expression. Wrists and elbows shaped the visible line. Knees and ankles set the rhythm and guided direction. In the female performance, wrist paths were circular and elbows curved inward. The effect was contained and elegant. In the male performance, shoulders and elbows travelled through broader arcs that read as open and confident.

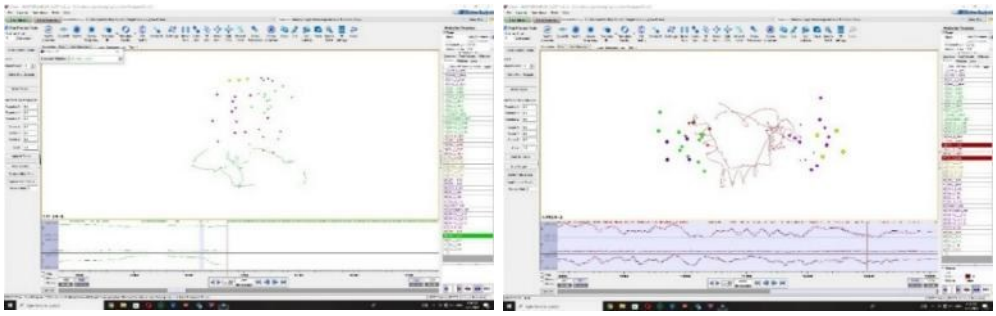

Figure 10: Motion analysis using the Motion Analysis Cortex application

Figure 10 presents the reconstructed skeletal model generated from the motion capture data using the Cortex Motion Analysis system. The digital skeleton visualises the movement of body segments and joint articulation throughout the dance performance. This reconstruction enables researchers to observe the structural coordination of the dancer's body and analyse the biomechanical characteristics that shape the movement dynamics of Joget Serampang Laut.

Velocity and angle plots pointed to deliberate phrasing. Many segments rose in speed and then settled smoothly, which supported transitions between *ragam*. Foot paths looped and crossed in ways that echoed ideas of cycle and return that are familiar within Malay cosmology. One more trend stood out. The lower body determined travel and turn. The upper body moved in a narrower range yet carried symbolic responsibility. In practice, this created a dual system where physical effort and cultural meaning worked side by side.

4.3 Dynamic Motion in *Joget Serampang Laut* through Spiritual and Sublime Elements

Two dimensions shaped dynamic motion. The first is a spiritual dynamic. This refers to internal engagement with rhythm, lyrics, and the value system behind the choreography. It gives intent to the phrase. The second is a sublime dynamic. This is the outward clarity of form. It involves timing, control, and a clean line in space.

When both dimensions align, the performance feels complete. Meaning is grounded inside the dancer and the form projects that meaning to the audience. Figures in the analysis make the connection visible, but the core idea is simple. The strongest moments carry intent and technique at the same time. That union is a signature of Joget Serampang Laut.

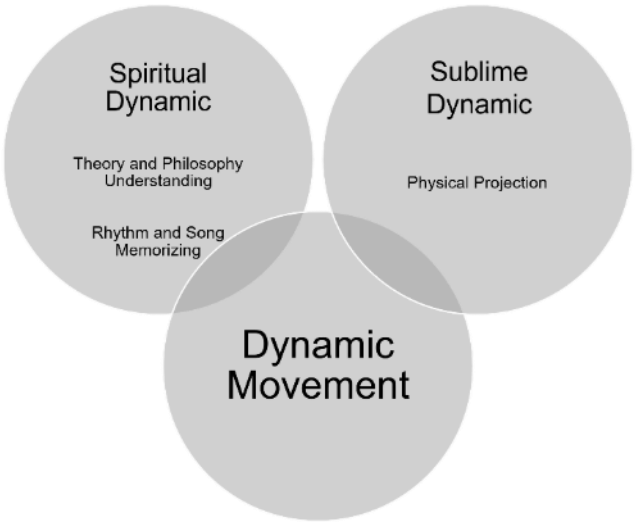

Figure 11: Components of dynamic movement

Figure 11 illustrates the conceptual relationship between spiritual understanding and physical projection in generating dynamic movement within Joget Serampang Laut. The spiritual dimension represents the internal knowledge possessed by the dancer, including the understanding of dance philosophy, theoretical principles, and the memorisation of rhythm and song that guide the choreography. This internal awareness provides the cultural and interpretive foundation that shapes how movements are performed. In contrast, the sublime dynamic refers to the outward physical projection of movement, where body posture, gesture clarity, and spatial control translate internal knowledge into visible performance. The intersection of these two dimensions produces dynamic movement, where biomechanical precision and expressive interpretation operate simultaneously. This relationship highlights that the effectiveness of traditional Malay dance performance depends not only on technical body movement but also on the integration of cultural understanding and physical execution.

4.4 Art Biomechanics of Upper and Lower Body

Findings confirmed a consistent division of labour between upper and lower body. The lower body produced propulsion, balance, and directional change. The upper body carried expressive and symbolic content that speaks to cultural values. Table 1 summarises the biomechanical roles of upper and lower body movements in the performance of Joget Serampang Laut by male and female dancers. The comparison highlights how different body segments contribute to the expressive and structural qualities of the dance. Male dancers tend to emphasise broader and more energetic upper-body movements, while female dancers demonstrate more controlled and refined motion patterns. These distinctions reflect the gendered movement aesthetics embedded within the choreography and illustrate how biomechanical analysis can reveal structural characteristics of traditional dance performance.

Table 1: Biomechanics roles of upper and lower body movement in Joget Serampang Laut

Body Region	Joint Focus	Male Dancer	Female Dancer
Upper Body	Head	Leads orientation with assertive gaze and upright posture, signifying leadership and control	Follows the line of movement with gentle head turns, expressing grace and attentiveness
	Shoulder	Broad articulation with expansive arcs, symbolising strength and leadership	Controlled shoulder rotation and minimal outward extension, conveying humility and poise
	Elbow	Wide angular displacement with assertive energy expression	Tight, inward elbow movements that reflect restraint and cultural grace
	Wrist	Strong directional gestures, often outward and bold in expression	Circular, curved wrist motions indicating elegance, modesty, and inner refinement
Lower Body	Knee	Strong knee flexion and propulsion, supporting forward drive and spatial clarity	Gentle and rhythmic flexion, assisting smooth transitions and spatial containment
	Ankle	Grounded ankle rotation, assisting in balance and directional turning	Controlled ankle pivots with a soft dynamic, symbolising stability and composed rhythm

For the upper body in the male performance, the head stayed upright and the gaze was steady. The shoulders travelled through expansive arcs. The elbows opened and closed with clear amplitude. The wrists directed gestures outward. Together these choices communicated leadership and protective strength without excess. For the female performance, the head followed the flow with gentle turns. Shoulders rotated in a

contained way. Elbows folded inward and wrists traced small circles. The result was modesty, poise, and inner refinement.

For the lower body, both performers relied on knees and ankles to organise rhythm and space, yet the qualities differed. The male performer used deeper knee flexion and grounded ankle rotation, which supported broad directional changes and visual weight. The female performer used lighter flexion and smooth ankle pivots, which produced even steps, balanced symmetry, and a composed rhythm. Travel set the phrase in motion while the upper body wrote the sentence of meaning. Figure 12 visualises the reconstructed movement trajectories generated from motion capture recordings across several ragam sequences in Joget Serampang Laut, including Ragam 2, Ragam 4, Ragam 6, Ragam 7, and Ragam 12. The overlapping trajectories illustrate the spatial pathways formed by the dancer's body during each movement sequence, revealing distinct movement formations and directional flows. Each ragam produces a different spatial configuration, indicating variations in rotational, looping, and directional movement structures within the choreography. The coloured lines represent different tracked joints to assist movement identification, allowing the spatial dynamics of the dance to be observed more clearly. Through this visualisation, the motion capture data highlights how Joget Serampang Laut movements are organised within the performance space.

4.5 Symbolic Trajectories and Geometric Floor Patterns

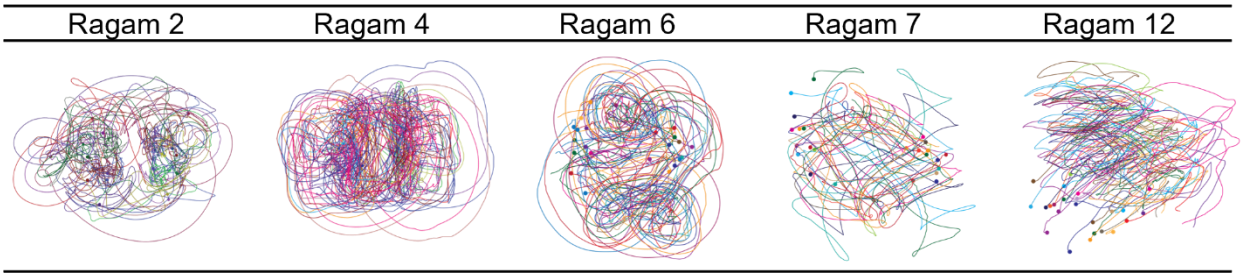

Figure 12: Symbolic floor patterns in *Joget Serampang Laut*

The reconstructed pathways reveal geometric formations such as circles, squares, and diamonds that correspond to specific ragam structures within the choreography. These spatial formations demonstrate how movement patterns function not only as technical choreography but also as visual representations of Malay cultural philosophy and spatial harmony. Tracking of ankle and foot markers allowed precise reconstruction of floor designs for each *ragam*. The reconstructions showed circles, squares, diamonds, and gently waved lines that repeat with intention. Each shape carried a cultural reading. Circle suggested unity and continuity and often appeared near musical or emotional peaks. Square stood for balance and order and echoed architectural and spiritual references in the Malay world. Diamond signalled status and careful arrangement within a pair. Waved lines moved horizontally and suggested the flow of daily life, where rhythm links one action to the next.

These shapes were not decoration. They grew from the logic of the steps. Smooth footwork produced curves that formed a circle. Measured diagonal travel with right-angle turns formed a square. Alternating side steps and forward glides aligned to produce a diamond. Sideward glides with continuous turns produced the waved line. Motion capture made these designs unambiguous. It provided concrete evidence that floor geometry is a carrier of meaning and not only a matter of style.

4.6 Gender-specific Kinematic Characteristic

Trajectory images made the gendered contrast easy to read. The male performer produced expansive and multidirectional lines. Arcs were bold and angles were sharp where needed. Looping paths extended from both arms and legs. These paths layered neatly during turns and shifts, which created a strong sense of structure and command of space. Forward momentum held steady, and balance stayed secure. Figure 13 presents a comparison of reconstructed movement trajectories between male and female dancers across several ragam sequences in Joget Serampang Laut, including Ragam 2, Ragam 5, Ragam 7, Ragam 11, and Ragam 13. The visual trajectories illustrate how the dancers' bodies move through space during each movement sequence, revealing differences in spatial formation and movement intensity. Male dancers generally demonstrate broader and more expansive trajectories, while female dancers produce more compact and controlled spatial patterns. These variations reflect the contrasting movement qualities embedded in the choreography, where masculine and feminine characteristics are expressed through different spatial dynamics. The visualisation highlights how motion capture analysis can reveal subtle structural differences in dance performance that are difficult to observe through conventional documentation.

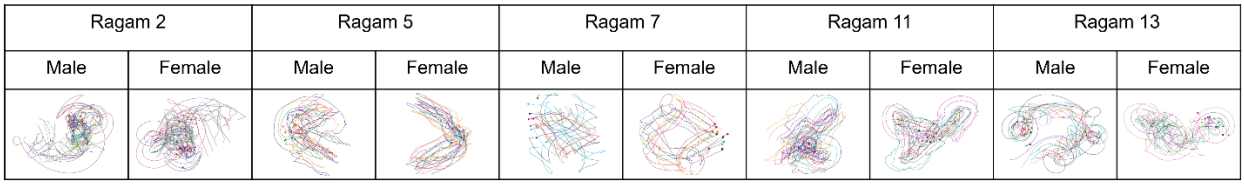

Figure 13: Motion capture floor patterns by gender

The female performer generated compact and symmetrical forms. Lines curled into repeated spirals and soft loops within a moderate range. The arms mirrored one another, and the feet often returned to earlier points in space with measured precision. The overall pattern looked gentle from a distance, yet it was technically exact. In duet passages, circular symmetry from the female performer complemented the wider lines of the male performer. The result was not opposition. It was a planned partnership and visual balance.

5.0 Discussion

Joget Serampang Laut's motion capture research looked closely at movements that are often left out of traditional documentation. The recordings indicated in a subtle way how energy moves from one step to the next. For instance, the way the wrist tilts to be ready for a hand gesture or the way the ankle helps retain balance before a turn. These small alterations show that the dance isn't just a set of moves that don't fit together. Rhythm and memory create a flow of movement.

Patterns on both the upper and lower body reveal how Malay dance balances form and function. The knees and ankles push the body forward, while the upper body translates these rhythms into meaningful motions. When female dancers use their arms in controlled circles, it shows that they are humble and graceful. Men who dance, on the other hand, flex their shoulders and elbows in a wider range of motion, which forms broader arcs that suggest strength and confidence. This divergence is a sign of a bigger cultural idea that argues that harmony comes from finding a balance between being open and being closed.

The utilisation of walkways and spatial architecture was another thing that stood out. The ragam didn't just repeat in a straight line; it also moved in diagonal, curved, and circular paths. These designs support the idea that dancing is a physical philosophy, where movement shows how Malays think about respect, humility, and harmony in a group. The approach enhances cultural interpretation by mapping these trajectories through motion capture, offering a preservation tool for both scholars and practitioners.

The research also demonstrated that ragam might be interpreted as a mechanism for the transmission of knowledge. Each variety encodes values: some stress etiquette in welcomes, others highlight tenderness balanced with restraint, while some, inspired by nature, teach perseverance and courage. In this way, the body becomes a living archive that keeps Islamic ideas, Adat, and Adab alive through gesture. This reinforces the idea that Joget Serampang Laut is both a performance and a philosophy, a cultural text that is still important for Malay identity.

6.0 Conclusion

This study investigated Joget Serampang Laut utilising motion capture and art biomechanics to elucidate the intersection of movement, meaning, and cultural philosophy. The investigation verified that the fourteen *ragam* serve a purpose beyond mere entertainment. They represent Malay principles of respect, modesty, resilience, and peace, making choreography a cultural text that passes on knowledge from one generation to the next.

The findings indicate that dancing should not be taught solely as a sequence of steps. When viewed as both a technique and a philosophy, pupils learn more than just how to do things physically. They also learn about being polite, finding balance, and being conscious of their spiritual side. This makes training a sort of cultural literacy where body and meaning are strongly linked.

From a heritage point of view, the semiotic interpretation of ragam is a methodical technique to keep traditions alive that can't be seen or touched. Using digital tools to record gestures and their symbolic meanings guarantees that the dance may still be understood and enjoyed in the future. This method also makes the archive stronger by recording information about pathways, rhythms, and micro-movements that would otherwise be lost.

For academic purposes, the integration of semiotics with Malay philosophy provides a framework that may be used to understand various traditional dances within the Malay realm and Southeast Asia. This approach promotes comparative analysis of performance, identity, and continuity, while expanding multidisciplinary dialogues around the preservation of culture through embodied practice.

In conclusion, Joget Serampang Laut stands out as not simply a performance to be enjoyed, but also as a live record of memory and belief. The dance may keep guiding how Malay history is understood, protected, and recreated for generations to come by acknowledging its dual role as art and philosophy.

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