

Interactive Motion Tracking for the Digital Preservation of Traditional Malay Kelarai Motifs

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ABSTRACT

This study explores the use of interactive motion tracking technology for the digital preservation of Traditional Malay Kelarai motifs, a form of geometric weaving with significant cultural and artistic value. As urbanisation and modern lifestyles threaten the continuity of traditional crafts, innovative preservation methods have become crucial. This research investigates how motion tracking can enhance the documentation and presentation of twelve selected Kelarai motifs, incorporating elements inspired by flora, fauna, abstract designs, and human names. The study utilises motion tracking to allow users to engage with the motifs through bodily movements, creating dynamic and immersive digital experiences. The findings show that the system successfully detects human movements and behavioural patterns, offering both non-contact and reaction-based interaction methods, while indoor-controlled environments ensure high-quality visual presentations. This research demonstrates the potential of integrating interactive technologies in cultural preservation, offering a modern approach to engaging younger audiences and ensuring the continued relevance of Kelarai motifs in the digital age.



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1 INTRODUCTION

Traditional Malay kelarai motifs are emblematic of cultural identity, craftsmanship, and heritage, frequently observed in woven mats, baskets, and other decorative objects within Malay communities. These geometric patterns are not only visually significant but also carry symbolic meanings, reflecting core values, rituals, and local stories (Kraftangan Malaysia, 2023). However, with the rapid pace of urbanisation and modernisation, these motifs face the risk of fading from cultural memory, particularly among younger generations, presenting a significant challenge in preserving this vital aspect of cultural heritage (Salleh, 2020). To address this issue, innovative approaches are urgently needed to preserve and revitalise these traditional motifs in a manner that resonates with today's digitally native audience.

Digital preservation plays a critical role in this context, utilising modern digital tools to document, protect, and present cultural heritage, ensuring its continued accessibility and relevance across time (Conway, 2010). This study adopts a digital preservation framework specifically designed for Malay kelarai motifs, with the objective of not only safeguarding these motifs from cultural erosion but also making them more accessible in digital formats for educational and cultural engagement.

A key innovative element of this research is the use of interactive motion tracking technology, which harnesses real time user motion to create a dynamic and engaging learning experience. This technology has been demonstrated to enhance cultural engagement through immersive experiences, such as augmented reality (Zhao, 2019). The integration of motion tracking technology enables users to interact with kelarai motifs in an intuitive manner, facilitating both understanding and appreciation through digital media. (Nordin & Che Din, 2025)

Despite its cultural and artistic significance, the craft of kelarai weaving is in decline, primarily due to an aging artisan population and a lack of interest among younger generations (Hassan, 2019). Traditional methods of documentation, such as photographs and static museum displays, have proven ineffective in engaging digital-native audiences (Salleh, 2020). Research in digital heritage preservation underscores the importance of interactive and immersive technologies in capturing and conveying cultural expressions to a wider, younger audience (Ismail & Tan, 2021). However, there remains a notable gap in the application of motion tracking technology for the digital preservation of traditional Malay weaving patterns, which this study seeks to address.

By applying interactive motion tracking to document and present twelve selected kelarai motifs, this study explores how motion-based presentations can enhance cultural awareness and engagement. The goal is to demonstrate how modern digital technologies can play a crucial role in preserving traditional heritage while offering new opportunities for cultural engagement and educational outreach. This approach not only contributes to the field of cultural heritage preservation but also supports artisans, educators, designers, and youth communities by fostering a deeper connection to their cultural roots in a format that is both digitally accessible and engaging (UNESCO, 2020).

1.1 Research Objective

The objective of this study is to digitally preserve traditional Malay Kelarai motifs, focusing on twelve selected designs inspired by flora, fauna, abstract motifs, and human names. The study also aims to enhance the accessibility and appreciation of these motifs among younger generations through interactive motion tracking technology. By creating dynamic digital versions of these motifs, the study assesses the effectiveness of interactive engagement in preserving the cultural heritage of Kelarai and ensuring its continued relevance. Additionally, the research proposes strategies to integrate motion tracking as a tool for safeguarding traditional Malay crafts and promoting their legacy for future generations.

1.1.1 Problem Statement

Traditional Malay kelarai motifs are increasingly at risk due to an aging artisan population, limited intergenerational skill transfer, and insufficient systematic documentation (Hassan, 2019; Salleh, 2020; Ismail & Tan, 2021). While previous studies have highlighted the challenges of preserving traditional weaving practices, no research has applied interactive motion tracking for the digital preservation of these motifs. Therefore, this study aims to document and digitally preserve twelve traditional kelarai designs using interactive motion tracking, contributing to cultural sustainability, providing educational resources, and fostering engagement among younger generations in traditional Malay arts.

2 Literature Review

2.1 Introduction

The preservation of cultural heritage has become increasingly urgent as traditional practices face continuous decline in the digital era. Traditional Malay Kelarai motifs represent a long-standing weaving tradition embedded with cultural symbolism, structural systems and inherited craftsmanship. Previous studies have documented the visual characteristics, symbolic meanings and technical aspects

of Kelarai motifs, yet there remains limited integration of these motifs into contemporary digital platforms. Therefore, this review examines three key areas relevant to this study: interactive motion tracking, digital preservation, and the cultural foundations of Kelarai motifs, including the role of Adiguru in sustaining traditional knowledge.

2.1.1 Interactive Motion Tracking

Interactive motion tracking allows users to engage with digital visuals through real-time bodily movement, creating immersive and responsive experiences suitable for cultural applications. (Shin & Yoo, 2015) identify four essential components in building an effective motion-tracking system: object, content, interaction and environment. The object refers to hardware elements such as sensors and display units responsible for capturing user input. Content represents the digital visuals being presented, whereas interaction involves the behavioural response triggered by user movement. The environment includes the spatial and lighting conditions that optimise system performance. These components can be applied to Kelarai motifs to create dynamic visual experiences, supporting cultural dissemination through interactive technologies.

2.1.2 Digital Preservation

Digital preservation plays a critical role in safeguarding Kelarai motifs, particularly as many traditional designs face gradual disappearance. ("Innovatively Preserving the Kelarai Weave Pattern Design through Photographic Documentation," 2023) report that several Kelarai patterns have been forgotten or simplified over time due to limited knowledge transfer and the decreasing number of skilled weavers. Their findings show that photographic documentation serves as an accessible and effective method for accurately recording Kelarai designs, enabling comparison across regions and ensuring long-term cultural retention. This method allows motifs to be archived visually and preserved beyond physical practice, contributing to the continuity of Kelarai heritage for future generations.

2.1.3 Traditional Malay Kelarai Motifs

Traditional Malay Kelarai motifs are characterised by systematic geometric structures formed through interlacing techniques, often inspired by flora, fauna, and natural elements that reflect cultural identity and symbolic meaning (Idris & Ibrahim, 2023). Common motifs include *mata bilis*, *tapak harimau*, and *bunga cina*, composed through symmetrical grids, diagonal arrangements, and modular repetition. The continuity of these motifs is maintained by master practitioners, particularly Adiguru, who preserve traditional motif structures, colour arrangements, and weaving techniques. One notable Adiguru, Hajah Kelsom binti Abdullah (Kak Ani) from Terengganu, continues to produce complex Kelarai designs while teaching these techniques to the community, ensuring the preservation of technical accuracy, cultural values, and supporting contemporary digital documentation.

3 METHODOLOGY

3.1 Research Design

This study adopts a qualitative content analysis approach as part of its overall research design to explore how interactive motion tracking supports the digital preservation of Traditional Malay Kelarai motifs. The analysis is structured around four main components which are object, content, interaction, and environment as proposed by Hyora et al. (2013). Ten motion tracking installations including gesture-based artworks, touchless museum displays, and real-time interactive visual installations were selected as case samples to examine the contribution of motion-based features toward user engagement and cultural interaction. Data were analysed using the principles of qualitative content analysis outlined by Krippendorff (2013), which involve systematic interpretation and pattern identification within specific contexts. The analytical framework was further supported by Bengtsson

(2016), who emphasised structured qualitative interpretation in digital media research. Visual data were analysed to identify patterns in interactivity, responsiveness, and digital representation relevant to Kelarai motif preservation to ensure that each system component contributes meaningfully to digital heritage engagement and cultural preservation objectives.

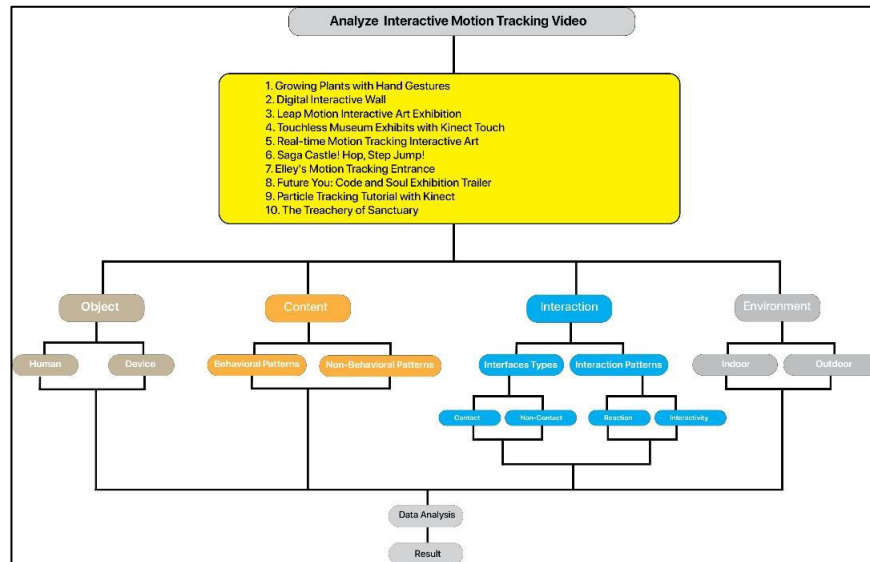


Figure 1 Framework of Study
(Source: Hyora et al. (2013).

3.2 Research Diagram

This study employs a qualitative research design and uses content analysis to explore interactive motion tracking as a creative medium for cultural preservation. The aim of this study is to explore the application of interactive motion tracking technology to digitally preserve and present traditional Malay Kelarai motifs, focusing on twelve selected motifs that are inspired by flora, fauna, abstract motifs, and human names. The study analyses four key components of interactive motion tracking, object, content, interaction, and environment adapted from YouTube videos published between 2011 and 2025 (Hyora et al., 2013).

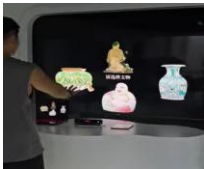
This study analyses four components of interactive motion tracking object, content, interaction, and environment adapted from YouTube videos published between 2011 and 2025.

4 SAMPLE OF INTERACTIVE MOTION TRACKING

4.1 The interactive motion tracking works were selected

The interactive motion tracking works were selected based on their availability on the YouTube platform. These videos showcase how motion tracking technology incorporates interactive elements to engage viewers. The selection includes works from 2011 to 2025, focusing on those that demonstrate the use of interactive motion tracking in digital presentations.

Table 1 Selection Sample of Interactive Motion Tracking Based on video Themed that available on the YouTube Platform.

No	Code	Interactive Motion Tracking	Production	Year & Place	Theme	Platform
1	IMT 1	Growing Plants with Hand Gestures 	@final_animal	2024, Los Angeles, USA	Culture & Heritage	YouTube
2	IMT 2	Digital interactive Wall 	Buro Achter April	2011, Berlin Metro Station, Berlin, Germany	Digital Interaction	YouTube
3	IMT 3	Leap Motion Interactive Art Exhibition 	HD Interactive	2014, Gasparilla Arts Festival, Tampa Museum of Art, Tampa, USA	Culture & Heritage	YouTube
4	IMT 4	Touchless Museum Exhibits with Kinect Touch 	Kleader Multimedia	2025, London, UK	Culture & Heritage	YouTube
5	IMT 5	Real-time Motion Tracking Interactive Art 	VJ Mamiko Kushida	2024, New York, USA	Digital Interaction	YouTube
6	IMT 6	Saga Castle! Hop, Step Jump! 	teamLab	2013, Saga Castle History Museum, Saga, Japan	Culture & Heritage	YouTube
7	IMT 7	Elleys' Motion Tracking Entrance 	Studio Ocupus	2023, Acetech Expo, Mumbai, India	Digital Interaction	YouTube
8	IMT 8	Future You: Code and Soul Exhibition Trailer 	Universal Everything	2025, 798CUBE, Beijing, China	Digital Interaction	YouTube
9	IMT 9	Particle Tracking Tutorial with Kinect 	Kaiho Nishimura	2022, Tokyo, Japan	Digital Interaction	YouTube
10	IMT 10	The Treachery of Sanctuary 	Chris Milk	2014, The Barbican, London, UK	Digital Interaction	YouTube

5 DATA ANALYSIS

Table 2 Analysis of Components of Interactive Motion Tracking

Code	Object		Content		Interaction		
	Human	Device	Behavioural Patterns	Non-Behavioural Patterns	Interface Types	Interaction Patterns	Interaction
				Contact	Non-Contact	Reaction	Indoor/Outdoor
IMT 1	/		(Hand gesture tracking)		((Motion tracking)	(Visuals change based on user movement)	/
IMT 2	/		/		(Motion detection)	/	/
			(gesture tracking)			(Visual response based on motion)	
IMT 3	/		/		(Motion detection via gestures)	/	/
			(Gesture based interaction)			(Visuals change dynamically based on movement)	
IMT 4	/		/		/	/	/
IMT 5	/		/		(Physical hand movement close to the screen)	/	/
			(Gesture based interaction with screen)			(Objects are selected or manipulated based on gestures)	
IMT 6	/		/		(Motion detection via gestures)	/	/
			(Hand gesture interaction with projected visuals)			(Visuals react to user's hand movement)	
IMT 7	/		/		(Motion detection via hand and body movements)	/	/
			Gestural interaction with multi-panel display)			(Visuals react to user's motion)	
IMT 8	/		/		(Motion detection via hand movements)	/	/
			(Gestural interaction with 3D visual object)			(User manipulates the visual object through gestures)	
IMT 9	/		/		(Motion detection via hand gestures)	/	/
			(Hand gesture tracking)			(Particles react to the fist movement)	
IMT 10	/		/		(gesture tracking)	/	/
			(Hand gesture interaction with projection)			(Birds appear based on the user's gestures)	
			/			/	

6 RESULTS

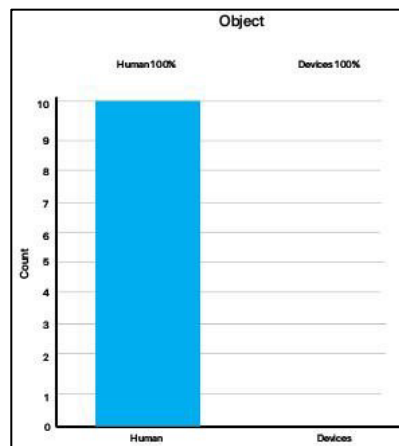


Figure 2 Results of Object in Interactive Motion Tracking

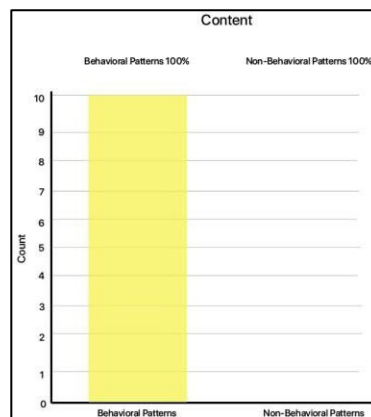


Figure 3 Results of Content in Interactive Motion Tracking

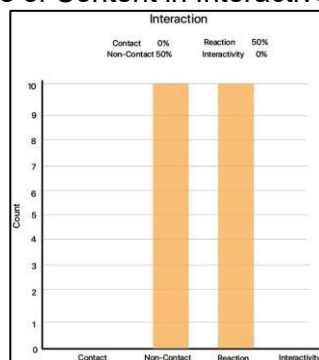


Figure 4 Results of Interaction in Interactive Motion Tracking

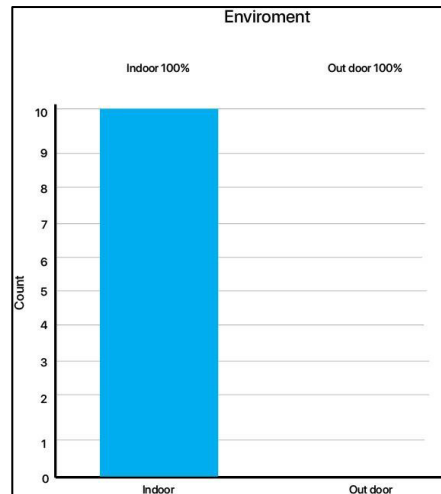


Figure 5 Results of Environment in Interactive Motion Tracking

7 FINDINGS

Based on the analysis of 10 videos, Figures 2 to 5 show the interaction results from the interactive motion tracking system used for the digital preservation of Traditional Malay Kelarai Motifs. The analysis revealed that 100% of the detected objects were Humans (Figure 2), with no Devices detected. In terms of content, all detections (100%) were associated with "Behavioural Patterns" (Figure 3), with no Non-Behavioural Patterns" identified.

For interaction methods, 50% of the interactions were based on non-contact techniques, such as motion detection, while the remaining 50% utilised reaction-based methods, where the system provided visual feedback in response to the user's movements (Figure 4). All interactions occurred in an Indoor environment, with no outdoor interactions recorded, ensuring that the projections were clearer and more vivid (Figure 5).

These findings indicate that the system is highly effective in detecting human movement and focusing on behavioural patterns. It also shows that non-contact interaction methods in indoor environments enhance the digital preservation and presentation of Traditional Malay Kelarai Motifs.

CONCLUSIONS

In conclusion, the interactive motion tracking system proves to be a highly effective tool for the digital preservation of Traditional Malay Kelarai Motifs. The findings highlight the system's ability to accurately detect human movement and behavioural patterns, which are essential for presenting the motifs in a dynamic and engaging way. The analysis of the data shows that the motion tracking system successfully detects user interaction, enhancing the visual presentation of the motifs. The use of non-contact interaction methods and the controlled indoor environment ensure clear, vivid projections, further enhancing the user experience. This study demonstrates that combining interactive technologies with cultural heritage preservation can help bridge the gap between traditional art forms and contemporary digital expectations. The research also emphasises the importance of integrating motion tracking to enhance user engagement, providing a meaningful and accessible way to preserve and promote cultural identity for future generations. Future recommendations include exploring the scalability of this technology for other forms of traditional art and assessing its long-term impact on cultural preservation. Future research could investigate the scalability of interactive motion tracking technology across other traditional art forms to assess its potential for widespread cultural preservation. Additionally, exploring user interaction over extended periods will help to evaluate the long-term effectiveness of this preservation method.

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AUTHOR CONTRIBUTIONS

All authors played equal contributions towards the production of this paper.

CONFLICT OF INTEREST

There is no conflict of interest.

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