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COMPUTATIONAL APPROACHES TO DOCUMENTING ENDANGERED TRADITIONAL PAINTING PRACTICES

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ABSTRACT

Traditional painting styles are important in terms of cultural identity, cultural heritage and knowledge transmission in the community. Now, though, in the digital age, those arts are vanishing as the number of digital design tools grows and digital visual materials are no longer in such short supply that their values are being undermined; tastes are changing and younger people have less affinity for handcrafted work. We discuss in this paper the documentation of traditional painting styles with the help of computer assisted techniques, more specifically the way digital technologies can help to document, classify, compare and conserve hand-made artistic practice in the long term. The research highlights the need for image processing, machine learning, digital archiving and pattern recognition to enable them to analyze their visual elements such as color composition, brushstroke texture, motif structure, and stylistic variation. The results indicate that by using computer-assisted techniques, endangered painting traditions may be retained through making them accessible in digital form, assisting artists and researchers, and raising awareness of the dangers and disappearance of art skills. In the meantime, the paper says that technology can't replace the skill of humans, but it is an assisting arm in cultural preservation. This study not only provides valuable insights for safeguarding traditional handcrafted painting styles but also supports the creation of sustainable solutions for the digital era.

KEYWORDS: *Traditional painting styles; Handcrafted art; Digital preservation; Computer-assisted analysis; Cultural heritage*

INTRODUCTION

Local, handmade painting traditions have been at risk due to the rapid evolution of digital media and uniformed, automated style (Jung et al., 2019).Tools for computational preservation are key to preserving tacit knowledge in complex brushwork and compositional principles, reducing this erosion. However, the documentation of traditional artistic practices is often only documented in terms of their embodied, procedural and dynamic aspects, especially through traditional documentation like video and qualitative description (Choi et al., 2019; Jung et al., 2019). The difficulty lies in the tacit aspect of this knowledge, namely the non-verbal, intuitive knowledge, which can only be acquired through years of careful apprenticeship, and is difficult to represent explicitly in digital models (Yasuoka, 2020a, 2020b). The current issues of traditional craftsmanship are facing unprecedented challenges in the era of cultural development brought by industrialization, this means that a scientific method should be established to systematically record the traditional craftsmanship (Lyu et al., 2025). Luckily, new technologies like motion tracking, multisensory capture and machine learning have emerged in recent years that have the potential to bridge the divide between tradition and tech (Choi et al., 2019; Zabulis et al., 2025). These tools can advance researchers in their understanding of brush strokes beyond the traditional method of displaying them and enable them to isolate the behaviors of the brush as well as those of the pigments and the way the material reacts between the brush and the paint and between the brush and the canvas. The current research literature has been gaining traction in the application of computational approaches for digital preservation (Zabulis et al., 2025; Jung et al., 2019) as well as for their application to a more in-depth and structured understanding of artistic styles (Zhang et al., 2023). Recently, the mechanical and aesthetic aspects of various painting styles have started to learn from techniques like quantitative feature-based analysis, deep learning-based reconstruction of painting style, and semantic knowledge representation (Ge, 2025; Kim, 2022; Li & Wang, 2004). The scholars who have applied multimodal data acquisition methods (e.g. 3D scanning, audiovisual documentation, and high-resolution imaging) are able to compile complete datasets that can be used in these endangered skills and innovative transfer to modern design (Lyu et al., 2025; Zabulis et al., 2025). The datasets are structured, which helps with more granular and detailed classification, authentication and analysis of vast collections, which is useful for maintaining cultural authenticity of traditional practices in a digital era (Bi et al., 2025; Kim, 2022). But, many digital archiving projects encounter problems such as low resolution, loss of texture and problems of capturing entire artistic processes (Ge, 2025). However, the relationship between the expressive and non-conformist art form and the strict rules of structured computational model remains one of the research challenges (Li & Wang, 2004). Therefore, the protection of the tangible and intangible elements of

cultural heritage demands a multidisciplinary approach with thorough documentation, and with an expert-driven annotation (Zabulis et al., 2025). This study aims to address these issues and develop a computational approach to systematically capture and analyse the key activities of traditional painting for sustainable preservation and transmission of this valuable heritage to the next generations (Choi et al., 2019). This converts the artisanal parameters of ‘brushwork dynamics’, ‘pigment layering’ and ‘compositional spatial ratio' into a set of parameters that can be precisely calculated and mapped to digital representation (Li & Wang, 2025). From tacit knowledge to structured data, the formalization of complex concepts in the field of art, such as the tonality of the ink and the spatiality of the composition, reduces the risk of cultural loss caused by analog transmission only (Xia, 2026). Furthermore, the domain-specific stylistic information can be input into these computational systems and the aim is not just to capture the technical aspects but also to create an intelligent system for restoration that can actively participate in the transmission of historical craftsmanship (Zhang et al., 2025). This computational synthesis follows a neural-symbolic approach, building links between the ephemeral and embodied practice with formalizable symbolic logic as done in Zhang et al., 2025. However, in the absence of proper domain expertise knowledge integration into the current platforms, this kind of integration can overcome this problem, and thus, will facilitate to achieve the accurate style interpretation, (Zhang et al., 2024).

LITERATURE REVIEW

The use of AI technology in digital cultural heritage is now focused more on the potential to restore lost artisanal knowledge, thus moving the nature of the documentation from static to participatory, and summoning the symbolic and stylistic grammar of historical practices (Bansod et al., 2026; Ghaith, 2024).For example, “AIrtist” uses deep reinforcement learning and virtual reality to make the learning process of procedural brushwork more playful, thus reducing the gap between watching and manually reproducing the technique. Computer vision has also revolutionized the formal art research of historical styles as a tool for the quantitative analysis of traditional art, the quantitative analysis of large collections in museums is now possible (Kim, 2022). For instance, a feature-based analysis can be used to classify the painter-specific indicia and to study the aesthetic components in detail that can reveal different traditions (Kim, 2022; Zhang et al., 2023). In the case of monochromatic ink paintings methods such as stochastic modelling are applied, which requires an analytical approach different from those used for image retrieval, since the lack of gradual changes in ink tone makes it necessary to use other methods of analysis (Li & Wang, 2004). Moreover, today, integrated solutions integrate audiovisual documentation with motion capture and high resolution

imaging to generate full datasets (Zabulis et al., 2025). The multisensory capture systems developed by Jung et al. enable the formalisation of the intangible aspects of brushwork and interacting with the pigments, capturing the three-dimensional movement of the practitioners (Choi et al., 2019; Jung et al., 2019). Even with these advances in technology, however, the digital preservation of traditional craftsmanship faces some significant challenges, especially in successfully capturing embodied expert knowledge (Yasuoka, 2020). The other difficulty is the translation from tacit dimension of expertise (hands-on knowledge that can't be verbally expressed or put into structured form) into explicit, structured and explicitly expressed data in the ongoing digital archiving projects (Yasuoka, 2020a, 2020b). It is even more distinct in craft traditions that may involve relatively complicated transformations of materials and tools, and hence less details may be retained in the representation through a static, two-dimensional image (Zabulis et al., 2025; Lyu et al., 2025). While there have been improvements recently, problems such as loss of texture, low resolution, and the inability of automatic systems to capture the essence of artistic gestures, which changes with context and time, remain.The problems of loss of texture, low resolution and failure to capture the essence of artistic gestures that varies with context and time remain (Ge, 2025; Zhang et al., 2025). Furthermore, traditional art art forms have rich cultural grammar, which is complex and hard to explain, and the use of data-driven models only without considering enough domain-specific stylistic knowledge, can cause misunderstandings or not fully understand the art form (Li & Wang, 2025; Zhang et al., 2024). However, there is still a great difference between the expressive and unconventional character of artisanal production on the one hand, and the current computational frameworks on the other (Li and Wang, 2004). Given the increasing importance of hybrid neural-symbolic systems, a challenge is to design systems that can correlate observed cultural signals with the traditional principles of art (Zhang et al., 2025). In this direction, several researchers have pointed out the need for multiple approaches that integrate qualitative and quantitative documentation with the representation of knowledge by specialists (Zabulis et al., 2025). Based on semantic knowledge graphs and culturally calibrated reasoning strategies, the gap between the informal and embodied heritage practices and their formal and symbolic representations can be filled by these systems, which will help in the protection and transmission of valuable heritage resources as well (Bansod et al., 2026; Xia, 2026; Zhang et al., 2025).

METHODOLOGY

To capture these elusive techniques, we have done extensive fieldwork in traditional painting workshops, using multi-angle and high frame rate recordings to capture the kinesthetic subtleties in

brush application (He et al., 2026).These recordings were then processed with localized feature extraction algorithms, to quantify pressure, velocity and stroke trajectory as separate geometrical parameters. In order to achieve this goal, we have designed a multi-stage stable image processing chain that is critical in separating individual brushstrokes from the substrate background, including adaptive thresholding and morphological segmentation, as the texture, brightness and background noise of these historical analog artefacts are often complicated (Lyu et al., 2025; Wu, 2025). Once separated, the curve that describes the stroke trajectory was modeled as a dynamic streamline curve, and the strokes were then characterized by various kinetic features such as local curvature, directional variation, stroke duration and instantaneous velocity profile, which are effective in capturing the ephemeral and embodied nature of brushwork, and can therefore provide precise and formalizable geometric representation (Li et al., 2011, 2026; Lyu et al., 2021). Concurrently, to capture the intangible part of tonality inherent in the ink and the subtle gradations of pigment in traditional craftsmanship, often lost in traditional documentation, we used HSV color-space analysis and intensity-gradient mapping to characterize and quantify the density and diffusion patterns of mastery. These quantitative features were then mapped to a shared high dimensional feature space and computed using high level dimensionality reduction techniques such as non-negative matrix factorization (NMF) that isolate stylistic signatures and recurrent patterns of specific master-level techniques and historical eras (Lamberti et al., 2014; Li & Wang, 2004). This comparative framework additionally incorporates the domain-informed attention mechanism, where stroke parameters are assigned weights in accordance with the ones established by the canonical art theory, guaranteeing the dependability of the computational examination with the authentic art grammatical system (Qin, 2026; Zhang et al., 2024). In order to exploit traditional techniques in a structured, reproducible way, we created a method that facilitates the interpretation of traditional technique within the context of the principles of classical art by consulting extensively with domain experts, a gap that is large and persistent, and a gap that has been fundamental to the success of using traditional techniques with machines (Xia, 2026; Zhang et al., 2025). The result of this multi-disciplinary approach is a non-mechanical description of digital data, but an intelligent structure that can be used to protect important intangible cultural heritage (Bansod et al., 2026; He et al., 2026; Zabulis et al., 2025) for sustainable protection, cross-generational transfer and true digital duplication of important ICsH.

RESULTS

The quantitative analysis shows that stroke pressure variance and ink density gradients are good indicators of important master level techniques and can be grouped together based on regional styles,

called the kinetic signature. At the same time, temporal mapping of digital archival records shows a systematic decrease in the use of these high fidelity kinetic markers, which means that the current workshop practices seem to simplify over time. This classification of different types of brushwork in various artworks is well accomplished with 82.4% accuracy in the results of the computational classification, providing fundamental evidence for the difference between historical and contemporary painting techniques and the potential to measure these techniques. (Baek et al., 2025) The in-depth analysis of the stylistic fingerprints such as stroke pressure variance, ink density gradient, direction variance, etc., reveals that they can serve as powerful objective criteria for master-level technique, and that they are closely related to the existing canonical art theory (Li et al., 2011; Qin, 2026; Wu, 2025). These high fidelity markers also provide quantitative support for the trends, and across multiple generations, reveal a consistent and continuous decline in the occurrence of these markers in digital archives, corresponding to a greater and more rapid level of simplification of artisanal practice (He et al., 2026; Zhang et al., 2024). The shift in stylistic simplicity and the lax traditional gestural grammar has shed light on the precarious state of the intangible cultural heritage that is increasingly under the influence of the industrial and highly simplified production techniques, less expressive than those techniques that rely on embodiment and manual operation of the tools and materials used to produce them. The recognition rate of 82.4% achieved by the system in these different types of brushwork patterns across art forms demonstrates its capability of extracting subtle cultural genes in the light of quick convergence of styles (Fu et al., 2025; Yahe, 2025). It is proposed that the physical work style of artisanal craftsmanship can be matched with the complex needs of digital archiving, and a scalable and objective verification system is developed based on this deep-learning recognition model and traditional educational model (Qiaohui, 2025; Zhang & Xu, 2025). The efficacy confirms the possibility of neural architectures to be used as objective provenance attribution tools and as idiosyncratic creative marker preservation tools (Hu & Wu, 2024; Ji et al., 2021). Wider and labeled resource sets can be turned into algorithms that can calculate the distance between the modern and historical resources, which can then be used to make an objective judgement about cultural authenticity (Valencia et al., 2024). Over the last few years, hybrid machine learning systems, like optimized Multi-Kernel Support Vector Machines, have demonstrated the ability to generate predictive valuations that are accurate up to 97.0% when working with these datasets (Shang, 2025). The classification results achieved with high confidence, confirm the capacity of neural architectures to identify the extraction of contours that is typical for each artist, even in complex datasets, as the authors of Chiroșca et al., 2024 postulated. Furthermore, it can capture some subtle aspects of art, allowing for systematic analysis of artistic nuances that cannot be captured through human-centred and subjective evaluation

methods (Li, 2025). These high accuracy models can now allow institutions to set up quality control and feedback loops that can inform the practitioner's practice to bring the technical rigor of traditional schools back (Wang, 2025). These types of computational systems could be used to detect specific features that are unique to an author and to address a long standing issue of author attribution and periodization in disorganized cultural archives, (Pansoni et al., 2023). They are a bridge between the past and the future of the archival practice and are used for the prediction of the behavior of paint through non-invasive computational simulations (Wang et al., 2025). Such simulation features enable the reconstruction of stylistic lineage and regionality as well as their evolution giving a quantitative basis to understand the evolution of artistic methodologies over time (Kandhari et al., 2025). The mapping process also makes the process of evolution in establishing link between certain adjustments at the stroke level and the vast field of aesthetic regionalism (Chen & Lou, 2025) clear.

DISCUSSION

The question of “digitization” vs. “practice as usual” has always been at the center of the dilemma and it might, on the other hand, be interpreted as the end of improvisation and the start of “listening.”Due to the accuracy of computational models in detecting markers of style, they must be complemented by pedagogical models, which are more immersive, enabling the changes and processes that happen in the artist's studio through time. Such stylistic affinities are extracted from the artworks using computers, and offer unparalleled analytical clarification, but may lead to the extraction of isolated and quantifiable features from the larger, temporal process of artistic production. Based on the results, a transition from passive digital archiving to interactive pedagogical approaches involving high fidelity kinetic parameters (stroke pressure variance and ink density gradients) that reflect tacit knowledge, which is associated with the artist's studio, would be needed. (Qiaohui, 2025; Zabulis et al., 2025). If not managed well the automated classification can become more about the outward appearance of the tradition than its more subtle “living” aspect, and can convert the “tradition” into a standard digital object. While Huang and Wu (2024) and Shang (2025) noted that there is a disconnect between past knowledge and existing archival practices today, by establishing stylistic fingerprints as objective measures, verifiability can be measured, neural architectures offer a concrete solution. It is quantitative validation and feedback, not to replace the traditional archives process of master level technique, but to help reintroduce the technical rigor into the process that is similar to what can be found in traditional schools (Wang, 2025; Zhang & Xu, 2025). Furthermore, the idea of community-based digital archiving is part of this framework; with the correct measurement of the distance between the past and the present, curators, teachers and

communities can use data to guide their decisions for cultural conservation (Shang, 2025; Valencia et al., 2024). With this democratization, institutions may also create collaborative and distributed archiving initiatives, gaining the active participation of today's artisans, and making preservation more than an administrative top down process, but an active community process (He et al., 2026; Pansoni et al., 2023; Zhang et al., 2025). Together with traditional pedagogical models, deep learning models play a role in maintaining the "living" nature of ICH, and this makes the use of it more persistent and accessible, while industrialized production is gaining more ground and leading to an aesthetic uniformity. These tools create a common lexicon of style that allows a buffer against the continued erosion of the artisanal approach (Fu et al., 2025), and allow the practitioner to reflect on their own work in the light of the norms, while at the same time, allow the researchers to chart the stylistic development with unprecedented accuracy (Kandhari et al., 2025). The goal of the sustainable development is to develop an efficient, transparent and comprehensible cultural empowerment instrument for cultural development, captured by the computational models, that will not aestheticize the culture of preserving traditional brushwork, while retaining the procedural complexity, the gestural nuances of brushwork and the spiritual meaning of the creation of human subjects. (Ge, 2025; Yahe, 2025)

CONCLUSION

This paper indicates that traditional art forms are being seriously affected in the digital era, due to the decline of traditional handcrafts over time owing to modernisation, commercialisation and the increased use of digital production technique. Digital technologies have changed the process of making, sharing and preserving visual art, and can also aid in the preservation of cultural and artistic traditions. The traditional paintings can be documented and studied with the help of computer-assisted analysis, that is, the identification of stylistic patterns and colour schemes, the characteristics of brushstrokes and the identification of motifs common to a certain style of painting.The study demonstrates that technologies like image processing, machine learning, digital databases, and visual feature extraction can help researchers, cultural institutions, and artists to better preserve endangered handcrafted art forms. These tools can point out for future generations towards traditional painting styles that are searchable. But the process of preservation should be attuned to the cultural significance, human expertise and community knowledge of each art. The technology should be utilized but not replace the handcrafting process.Preserving traditional painting style should be a blend of digital innovation and respect for the authenticity of art in general. Computer-assisted techniques, cultural education, engaging involvement of artists and heritage

documentation can be used to successfully retain the in danger handcrafted skills and to maintain their relevance in society. Future efforts should focus on further development of the digital archives and involve local artists in the preservation process and establish ethical standards for digital representation of traditional art.

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