From Tangible to Phygital: Creative Methodologies and Physical–Digital Integration in Contemporary Post-Digital Art

Do Tangível ao Figital: Integração Físico-Digital e Metodologia Criativa na Arte Pós-Digital Contemporânea

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This study aims to present the articulation between a proposed *phygital* taxonomy and the a/r/cographic methodology, thereby offering an integrated methodological framework for analysing and guiding contemporary hybrid artistic practices. In recent years, contemporary artistic creation has been characterised by the fusion of the tangible and the virtual — a phenomenon referred to as "phygital". This concept describes the interconnection between physical and digital elements, which is redefining processes of production, appreciation, and interaction with art. The *phygital* taxonomy presented here enables the mapping of new hybrid territories. It facilitates a detailed evaluation of the symbiosis between the material dimension, including technological devices, and the virtual or digital dimension, resulting from the execution of code or the reproduction of digital media. The a/r/cographic methodology, in turn, structures the creative process around three essential axes: aesthetics (the cognition, emotions, and sensations elicited by the work), aptitude (the technical and conceptual skills demonstrated), and function (the socio-cultural and communicative impact of the work). The artwork *Texel2048Loom*, developed by the first author of this study, illustrates the proposed approach. This text also underscores the need for further refinement, particularly in ethical, cultural, and multisensory dimensions, offering clear contributions to future research and practice in post-digital art.

Keywords: *phygital*, taxonomy, a/r/cography, Portalegre tapestries

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Este estudo visa apresentar a articulação entre uma proposta de taxonomia figital com a metodologia a/r/cográfica, oferecendo assim um quadro metodológico integrado para analisar e orientar práticas artísticas híbridas contemporâneas. Nos últimos anos, a criação artística contemporânea tem sido marcada pela fusão entre o tangível e o virtual, fenómeno designado por "figital". Este conceito descreve como elementos físicos e digitais se interligam, redefinindo processos de produção, fruição e interação com a arte. A taxonomia figital, ora apresentada, permite mapear novos territórios híbridos e avaliar detalhadamente a simbiose entre o plano material, incluindo os aparatos tecnológicos, e o plano virtual ou digital, resultante da execução de código ou reprodução de média digitais. Por sua vez, a metodologia a/r/cográfica estrutura o processo criativo em três eixos essenciais: estética (cognição, emoções e sensações despertadas pela obra), aptidão (competências técnicas e concetuais evidenciadas) e função (impacto sociocultural e comunicativo da obra). A obra Texel2048Loom, desenvolvida neste âmbito pelo primeiro autor deste estudo, permite ilustrar a abordagem aqui proposta. Este texto evidencia ainda a necessidade de ajustes adicionais, particularmente nas dimensões éticas, culturais e multissensoriais, oferecendo contribuições claras para futuras investigações e práticas na arte pós-digital.

Palavras-chave: *figital, taxonomia figital, a/r/cografia, tapeçarias de Portalegre*

Introduction/Context

The integration of physical and digital domains has profoundly transformed contemporary artistic practices, influencing the creation, production, and appreciation of art. This phenomenon is encapsulated by the concept of "phygital", which refers to the collaborative fusion of material and digital elements. Originally applied in marketing to describe hybrid experiences (Del Vecchio et al., 2023), the term has been rapidly adopted in the visual arts, where it has assumed a central role in redefining artistic creation (Fadeeva & Staruseva-Persheeva, 2023).

The *phygital* has emerged as a hybrid approach that combines traditional materiality with technological innovation, thereby expanding the scope of creative expression. It transcends the mere coexistence of the tangible and the virtual, fostering a symbiotic interaction between the two. In *Thresholds* (2021), by Mat Collishaw, augmented reality is utilised to recreate a historical exhibition, providing an immersive experience that bridges the body, history, and virtual space (Dokholova, 2023). In *Machine Hallucinations* (2022), Refik Anadol transforms visual data into abstract landscapes, repositioning the audience as a physical–digital mediator and challenging conventional notions of interactivity (Weiler et al., 2022).

These works reformulate artistic appreciation and the relationship between the public and the artwork (Grau, 2002). *Virtual Dioramas* (2023), by Alexandra Ginsberg, simulates ecosystems in augmented reality, examining the interaction between humans and the environment through immersive experiences. These practices, characterised by human-machine collaboration, challenge the notion of sole authorship, proposing a distributed approach to creativity and reflecting the interdependence between technology and art.

The concept of "phygital" differs from others, such as "post-digital" and "new media". The former emphasises the seamless integration of digital elements into contemporary culture (Cox, 2015), while the latter focuses on the transformation of traditional media by digital technology, such as through interactive and multiplatform narratives (Manovich, 2001). The *phygital*, however, is characterised by the inseparable fusion of the physical and the digital, generating hybrid and interdependent experiences.

Quantum Memories (2022), by Refik Anadol, utilises artificial intelligence (AI) to create dynamic landscapes in physical spaces, highlighting the convergence of the material and the virtual. *Neural Street Art* (2019) combines robotics and neural networks to recreate Roman mosaics, facilitating a creative dialogue among humans, machines, and space. These practices redefine the boundaries between physical and digital domains, fostering interactions among technology, aesthetics, and audiences (Fadeeva & Staruseva-Persheeva, 2023). Technologies such as AI, augmented reality (AR), and virtual reality (VR) are propelling this evolution: in *Machine Hallucinations*, neural networks transform data into sensory landscapes, positioning AI as a co-creator (Dokholova, 2023); The *Infinite*

Library (2021), by Mika Johnson, uses AR and VR to make libraries interactive, offering personalised experiences.

Despite the growing impact of *phygital* practices in contemporary art, their consolidation as an autonomous field of research faces both theoretical and methodological challenges. The complexity of integrating physical, digital, and sensory elements requires a methodology that coherently combines theory, practice, and evaluation. Interdisciplinary models, such as *Sensoria* by Jewitt et al. (2021), are essential for a deeper and more contextualised understanding of sensory and multimodal experiences. However, the intrinsic fusion of material components, digital technologies, and sensory stimuli continues to hinder the full consolidation of *phygital* practices.

This study proposes a connection between the *phygital* taxonomy currently being developed by the author as part of his doctoral thesis, entitled *Tapeçarias de Portalegre: Tecendo o Figital* (Portalegre Tapestries: Weaving the *Phygital*), and the a/r/cographic methodology (Veiga, 2021), which structures the creative process around the axes of aesthetics, aptitude, and function. By aligning the six taxonomic dimensions — physical-digital integration, sensory experience, cognitive experience, appreciation, interactivity, and bodily engagement — with these three axes, the specific objective is to create an integrated methodological framework for analysing and guiding contemporary hybrid — *phygital* — artistic practices. This framework aims to contribute to addressing current gaps in the analysis and evaluation of such practices and works. The relevance of this study lies in the need to develop and refine methods capable of addressing the increasing complexity of the physical–digital fusion in contemporary art, thereby offering meaningful contributions to future theoretical and practical developments.

Phygital Taxonomy

The *phygital* taxonomy presented here is grounded in the integration and critical synthesis of theoretical contributions from various authors, notably Lev Manovich (2001), Oliver Grau (2002), Jewitt et al. (2021), Kiousis (2002), Hansen (2003), Munster (2011), and Dewey (1934), as well as recent approaches to the concept of *phygital* proposed by Del Vecchio et al. (2023) and Fadeeva and Staruseva-Persheeva (2023). The framework developed in this study is classified into six dimensions: (a) physical-digital integration, (b) sensory experience, (c) cognitive experience, (d) appreciation, (e) interactivity, and (f) bodily engagement — all of which are essential to understanding both the physical–digital relationship within the artefact itself and the interaction between the artefact and its audience. These dimensions inform artistic and cultural practices, serving as reference points for artists, curators, and researchers in the creation and analysis of hybrid artefacts. For evaluators, they offer objective criteria that support contextualised critique, which is particularly valuable for this form of contemporary art.

This *phygital* taxonomy employs a 10-level numerical scale to quantify each of

the six dimensions, thereby facilitating the production of detailed analyses. The quantitative scale, ranging from zero to 10, is also aligned with a qualitative classification structured into four or five levels, depending on the dimension, with each level directly corresponding to a segment of the numerical scale. For example, on a four-level qualitative scale (numbered sequentially from one to four), each level n corresponds to the numerical interval between (n-1)*10/4 e (n-1)*10/4+10/4).

Accordingly, a qualitative classification is proposed for each dimension at specific levels. These levels are mapped to the 10-point scale using the formula above, allowing for more nuanced characterisations of *phygital* practices and avoiding simplifications that could compromise an understanding of the diversity and expressive richness of hybrid phenomena.

For the *phygital* integration dimension, it is proposed that the lowest value on the scale reflects both purely digital and purely physical states, indicating an absence of significant integration between the two. A value of 10 symbolises the ideal combination in which physical and digital elements are balanced in a coherent and integrated representation of their symbiosis. This definition clarifies the extremes of the scale and supports the assessment of the intensity and quality of physical–digital articulation.

This proposal underscores the transformative impact of the fusion between physical and digital domains, demonstrating how this integration contributes to the creation and analysis of aesthetic and cognitive experiences. By suggesting specific fields of study, it expands both creative and critical possibilities, establishing itself as a relevant model for exploring the frontiers of contemporary art and culture. The six proposed dimensions are presented below (Figure 1).
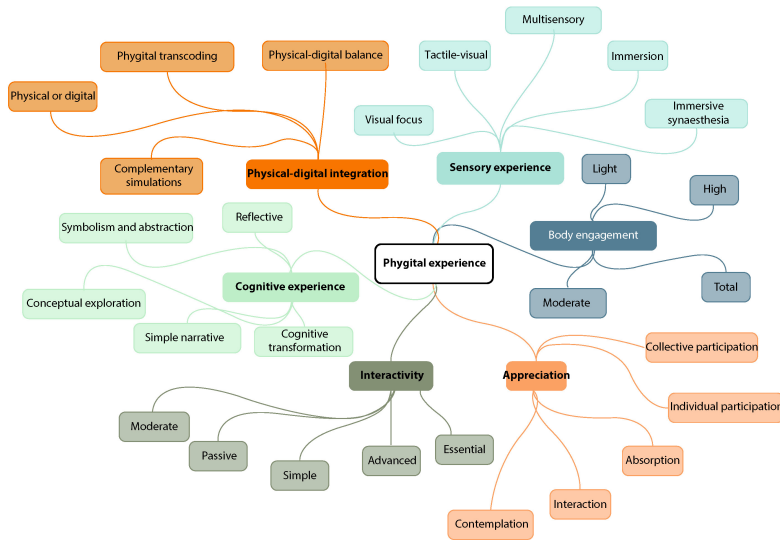
Figure 1: *Mind map of the phygital experience*

Physical–Digital Integration

Phygital art integrates the physical and the digital, challenging the boundaries between the tangible and the virtual. Lev Manovich (2001) defines "transcoding" as the mutual conversion between the cultural and computational layers of digital media, occurring in a symbiotic relationship. Within the *phygital* taxonomy, purely physical and purely digital states represent the most elementary levels. These are followed by complementary simulacra, in which one dimension — physical or digital — dominates while the other serves merely as an accessory. A subsequent level is characterised by the balanced coexistence of both components, demonstrating collaborative interaction without achieving full fusion. *Phygital transcoding* becomes apparent in works that promote continuous and dynamic transformation, where the physical and digital evolve in tandem, continuously reconfiguring the aesthetic and conceptual experience. This integrated relationship signifies an ideal fusion of the two elements, with each influencing the other to generate new expressive, sensory, and conceptual possibilities.

Cognitive Experience

The cognitive experience examines the narrative and symbolic complexity of artworks, considering how interpretations may challenge the audience to explore deeper meanings. Alacovska et al. (2020) highlight the role of digital art in questioning social norms, fostering empathy, and transforming thought, while Dewey (1934) emphasises aesthetic interaction as an active intellectual dialogue.

Within this framework, the qualitative levels are defined as follows: a simple narrative is characterised by clear and accessible communication, reflecting an absence of narrative complexity and conveying straightforward, direct, and immediate messages.

Conceptual exploration negotiates a balance between accessibility and critical reflection. Symbolism and abstraction emerge as elements that complicate simple interpretations, offering multiple layers of meaning and encouraging the audience to decipher messages beyond the obvious, thereby requiring it to decode complex ideas. Reflexivity further implies the elicitation of empathetic and reflective analyses from the audience. Finally, cognitive transformation represents the pinnacle of this dimension, involving critical reinterpretations that challenge and reshape established cultural and social values, profoundly impacting the audience's perceptions and stimulating debate.

Appreciation

The dimension of appreciation addresses the audience's experience, focusing on the sensory and intellectual engagement that the artwork evokes. Dewey (1934) argues that appreciation transcends passive observation, constituting a dynamic process that transforms both perception and the work itself. On the other hand, Grau (2002) emphasises multisensory immersion as a factor that intensifies the connection between the spectator and the work.

Contemplative appreciation is characterised by passive observation, in which the audience refrains from direct intervention and limits itself to a detached engagement, typically resulting in a restricted emotional impact. In contrast, interactive appreciation involves active, though moderate, participation by the audience, allowing its choices or actions to influence the experience without radically altering the work.

Absorption is characterised by intense multisensory involvement, simultaneously engaging the senses of sight, hearing, and touch. This leads to a rich and immersive experience that often causes the audience to become disengaged from the physical space and temporal context of the artwork, relegating these aspects to a secondary role. Singular participatory appreciation reflects individual co-creation, wherein an audience member actively transforms the work, deepening their unique connection to it. Collective participation, by contrast, entails simultaneous engagement by multiple audience members, each exerting a specific influence on the work.

Sensory Experience

The sensory experience evaluates audience engagement through multisensory stimuli, establishing emotional and physical connections that extend beyond the visual. Grau (2002) highlights "total immersion" as a factor that intensifies interaction, while Yu and Yao (2023) observe that immersive environments

transform the observer into an active participant. A focused visual experience is confined to visual stimuli, with minimal impact on additional sensory channels. The tactile-visual experience combines sight and touch, enriching interaction though falling short of full immersion. The multisensory experience activates several senses, albeit to a limited extent. Sensory immersion involves the intense engagement of all senses, producing a profound and lasting emotional and aesthetic effect. Furthermore, immersive synaesthesia provokes interdependent and interconnected sensations across multiple senses.

Interactivity

Interactivity reconfigures the relationship between the audience and the artwork, transforming the spectator into an active participant or co-creator. Kiousis (2002) distinguishes various levels of interactivity, ranging from automatic responses to complete control. Passive interactivity is limited to a contemplative role, exerting no influence on the work itself. Simple interactivity permits basic choices, moderately increasing audience involvement. Moderate interactivity allows decisions that affect the work, but without granting full control over it. Advanced interactivity provides total control, enabling the audience to co-create and shape the artistic experience in a significant way. Essential interactivity builds upon this, making interactivity crucial to the experience or even the very existence of the work.

Bodily Engagement

Bodily engagement considers the audience's body as an active mediator in the aesthetic experience, emphasising physicality in engagement with the work. Hansen (2003) and Munster (2011) stress somatic interaction in digital environments, integrating the body into the artistic process to foster immersion. Light bodily engagement is limited to subtle gestures and minimal physicality. Moderate involvement entails broader movements, characterised by increased physical participation without full expressiveness. High involvement features intense bodily expressiveness, positioning the body as the central element of the experience. Total interaction fully integrates the body into the essence of the work, making it indispensable to the artistic experience.

A/r/cography

A/r/cography, developed by Veiga (2019, 2021), is presented as a creative research methodology that systematically integrates the dimensions of art, research, and communication. Inspired by Springgay et al.'s (2008) a/r/tography, this approach expands and reconfigures the original concepts, proposing a more comprehensive framework suited to the specificities and challenges inherent in digital media art.

The a/r/cographic methodology defines a three-dimensional space for the (self-)evaluation of created artefacts, structured around three fundamental axes:

aesthetics, aptitude (or technique), and function (or impact). This conceptual space is illustrated in Figure 2.
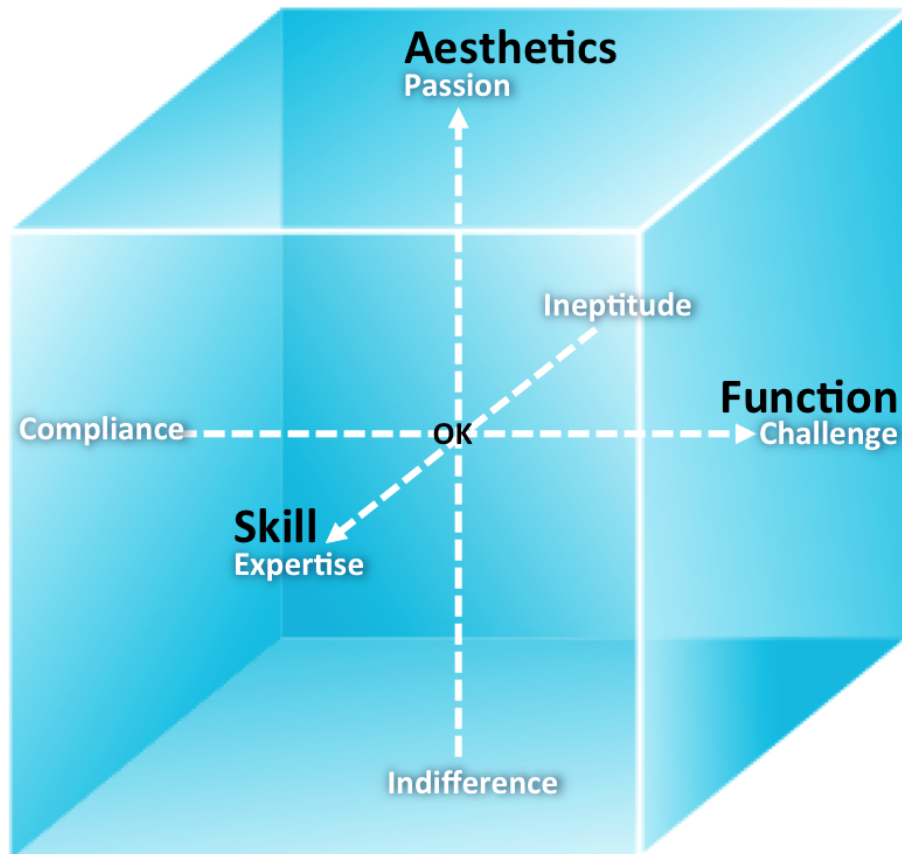

Figure 2: *Representation of the three-dimensional space of a/r/cography*
Source. From "Método e Registo: Uma Proposta de Utilização da A/r/cografia e dos Diários Digitais de Bordo Para a Investigação Centrada em Criação e Prática Artística em Média-Arte Digital" by P. A. da Veiga, 2021, *Rotura – Revista de Comunicação, Cultura e Artes,* (2), p. 22. (https://doi.org/10.34623/y2yd-0x57)

The aesthetic axis evaluates the work's capacity to elicit cognitive, emotional, and sensory responses from the audience, from strong acceptance/rejection to apathy, while aiming to foster a meaningful connection that deepens the spectator's engagement. The aptitude axis assesses the creator's ability to express their vision innovatively and coherently, utilising available artistic and technological resources effectively. Finally, the function axis considers the social, cultural, and communicative impact of the work, including its potential to transform perceptions and stimulate new forms of interaction and dialogue (Veiga, 2021).

The term a/r/cography carries symbolic weight, representing, through the metaphor of the arc, the non-linear trajectory of artistic creation. This path is defined by an eccentric approach that favours connections between different moments of the creative process rather than adhering to a rigid or sequential model. In contrast to linear methodologies, a/r/cography encourages an exploratory yet precise form of creative development. This dynamic flexibility is manifested in the rhizomatic structure of the method, which allows for the continual revisiting and reconfiguration of each stage of the process. It promotes an iterative and adaptable practice, reflecting the interdependence of creativity, context, and research (Veiga, 2021).

The a/r/cographic method comprises seven iterative stages — *inspiration*, *trigger*, *intention*, *conceptualisation*, *prototyping*, *testing*, and *intervention*. These stages do not follow a fixed sequence, allowing continuous adaptation to both the creator and the work. Inspiration arises from internal or external stimuli, while the trigger catalyses initial explorations, setting creativity in motion. Intention guides the conceptual development of ideas, which are then given provisional form in prototyping. Testing allows for controlled validation of the project, leading to intervention, the final stage in which the work is completed and presented to the public.

This entire process is documented systematically through digital logbooks, which record inspirations, (in)decisions, and reflections. They facilitate critical and reflective analysis, serving as a record of the creative journey. The iterative nature of a/r/cography promotes flexibility and responsiveness, encouraging continuous revisiting of all stages and ensuring alignment with the creator's evolving intentions (Veiga, 2021).

A/r/cography transcends artistic production to function as a methodology for the generation and communication of knowledge. It integrates aesthetic, technical, and functional/relational dimensions, seeking both artistic and technological innovation, as well as a broader socio-cultural impact. Promoting dialogue between creator, audience, and society, it stands apart from a/r/tography through its defined structure and its emphasis on communication. These features make it particularly well suited to digital media art, where it articulates creation, research, and communication in a reflective and iterative practice grounded in the contemporary world.

Articulation of *Phygital* Taxonomy with A/r/cography

The integration of *phygital* taxonomy with a/r/cography aims to establish a rigorous methodological approach for creating and analysing digital media artworks. The *phygital* taxonomy, comprising six dimensions — physical-digital integration, cognitive experience, appreciation, sensory experience, interactivity, and bodily engagement — enables the evaluation of the hybrid dynamics between tangible and virtual elements and their impact on the spectator. A/r/cography,

as proposed by Veiga (2021), structures the creative process around the axes of aesthetics, aptitude, and function. This articulation combines the systematic analysis provided by the *phygital* taxonomy with the structural orientation of a/r/cography, supporting artists in the design of artefacts while offering researchers a robust framework for interpreting the aesthetic and cultural implications of digital media art. An abstract representation of this articulation is presented in Figure 3.
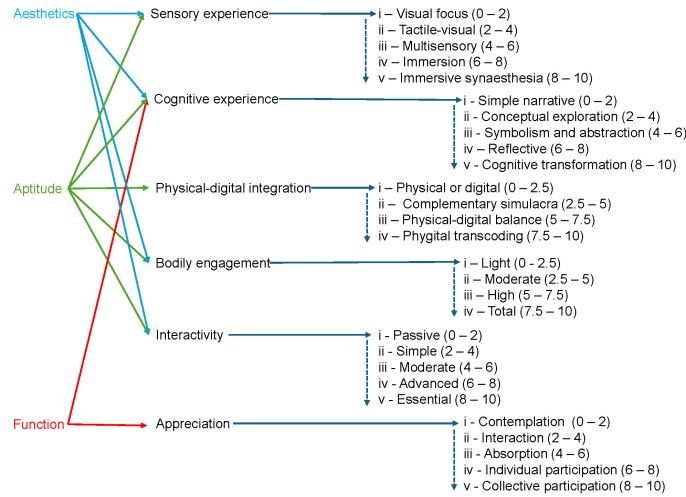

Figure 3: *Overview table of the proposed integration between the phygital taxonomy and a/r/cography*

Aesthetics — Articulation With Sensory Experience, Cognitive Experience, Interactivity, and Bodily Engagement

The aesthetics axis examines the capacity of a work to elicit meaningful emotional and sensory responses from the audience, identifying experiences that resonate simultaneously on emotional and intellectual levels. This axis is intrinsically linked to the dimensions of sensory experience, cognitive experience, bodily engagement, and interactivity within the *phygital* taxonomy. The subcategories of these dimensions offer a detailed analytical framework for evaluating and designing the aesthetic effectiveness of *phygital* creations.

The subcategories within the *phygital* taxonomy enable a comprehensive framing of sensory experiences that extend beyond isolated stimuli. *Atmospheric Memory* (2023) by Rafael Lozano-Hemmer exemplifies this through the use of digital projections, tactile surfaces, and spatialised sound to transform atmospheric vibrations into immersive interactions. By rendering words in vapour and layering evocative soundscapes, the work forges emotional connections between

the audience and the environment, highlighting the transformative potential of the *phygital*.

The exhibition *Black Ancient Futures* (2024) at the Museum of Art, Architecture and Technology in Lisbon further illustrates these dimensions, featuring sculptures, video art, and multisensory installations. Addressing themes such as racism, mysticism, and the African diaspora, it incorporates symbolism and conceptual transformation, enriching the audience's experience. The exhibition negotiates a balance between political and aesthetic reflection, demonstrating how cognitive experience can make art both critical and engaging.

Interactivity transforms the audience into active co-creators of the work. In physical interactivity — as exemplified by *2Poetic AI* (2021) by TeamLab — gestures and movements generate personalised digital projections, resulting in unique scenarios. Cognitive interactivity builds upon this by combining bodily movement with intellectual engagement, inviting interpretation and meaning-making. This physical-mental integration, aligned with the co-creative ethos of a/r/cography, fosters a collaborative artistic experience between the artwork and the audience.

Bodily engagement underscores the importance of physical interaction with the artwork, integrating the human body into both physical and digital environments. In *We Live in an Ocean of Air* (2018–2019) by Marshmallow Laser Feast, the audience actively participates in shaping the final result. The work employs virtual reality, touch, and smell to create an immersive ecosystem wherein participants' movements interact with digital elements, articulating the interdependence between humans and the environment and uniting physical, sensory, and virtual dimensions.

The integration of these dimensions into the aesthetic axis of a/r/cography enables the articulation of a symbiotic relationship that enhances the artistic experience.

This interdisciplinary approach defines the aesthetics axis as a space where technological innovation, sensory expression, and critical reflection converge. It reconfigures *phygital* practice into a field that combines immersive sensory engagement with cognitive experience. Through the taxonomy's subcategories, the aesthetic axis becomes a crucial element for the critical creation and analysis of works that connect audiences in multidimensional ways, fostering interactions among technology, aesthetics, and culture and inviting new forms of emotional and intellectual engagement with contemporary art.

Aptitude — Articulation With Physical-Digital Integration, Sensory Experience, Cognitive Experience, Interactivity, and Bodily Engagement

The aptitude axis of a/r/cography constitutes the fundamental basis for analysing the capacity for research, design, and execution of artworks, integrating pro-

cesses, materials, and technologies that enable their realisation. This axis transcends mere operational function by articulating key dimensions — namely, physical-digital integration alongside sensory experience, cognitive experience, interactivity, and bodily engagement. These categories provide a systematic and comprehensive framework from the perspective of technical and artistic aptitude, allowing contemporary creative practice to be redefined through the alignment of sensory and intellectual experiences with technological mediation.

Physical-digital integration emerges as a central dimension, facilitating the harmonious fusion of tangible and virtual elements and establishing a sensory continuum that offers the audience novel modes of interaction.

By synthesising these dimensions and their subdivisions, the aptitude axis reconfigures *phygital* practice as a domain of technical innovation with significant aesthetic and conceptual impact. The interplay between contemplative appreciation, physical and cognitive interactivity, and full participation establishes a broad framework for expanding the artistic experience and engaging audiences on sensory and intellectual levels. Consequently, the technical axis not only analyses the creative process but also redefines paradigms of the art-technology-corporeality relationship, reinforcing its contemporary relevance.

The convergence of these dimensions culminates in impactful artistic experiences. A notable example is the exhibition *AI: More Than Human* (2019), which fully embodies the articulation of physical-digital integration, interactivity, and bodily engagement. This exhibition presents hybrid installations that explore the relationship between artificial intelligence and humanity, utilising interactive projections, spatialised sound, and real-time visualisations to create an environment that connects audiences with contemporary themes in a reflective and emotionally compelling manner.

Function — Articulation With Appreciation and Cognitive Experience

The function or relationship axis frames the social, cultural, and communicative impact of artworks, exploring how they transcend their aesthetic qualities to act as agents of cultural, social, and experiential transformation. This axis establishes meaningful connections with the audience and the context in which the work is situated, intrinsically articulating with the *phygital* taxonomy dimensions of appreciation and cognitive experience.

Function relates closely to two key taxonomic dimensions: appreciation and cognitive experience. The dimension of appreciation is exemplified by Refik Anadol's *The Infinity Room* (2019), an installation combining digital projections and infinite mirrors to create an immersive environment that transcends the physical confines of space, offering a hybrid experience. When integrated with interactivity, this approach enables dynamic responses to audience gestures and movements, transforming the artistic experience into something tangible and immediate, thereby intensifying sensory engagement.

Participatory appreciation plays a central role by inviting the audience to actively and often co-creatively engage, allowing spectators to directly influence the work's outcome. This dimension is significant within the function/relationship axis, as it transforms the artwork into a space for co-creation and shared meaning. A paradigmatic example is *Me+You* by Es Devlin (2021), which invites visitors to record personal messages that are incorporated into an interactive installation in real-time. Such interaction fosters an emotional and reflective bond between the audience and the artwork, emphasising the spectator's role as co-creator and amplifying the relational impact of the artistic experience.

The cognitive experience, central to the function/relationship axis, evaluates how the narratives and symbolism within artworks validate or challenge cultural and social paradigms. Art can thus reinforce prevailing contexts or catalyse change by questioning established norms. Olafur Eliasson's *Earth Speakr* (2020) exemplifies this by incorporating simple narratives and symbolism into an application that gives voice to objects, connecting audiences to environmental and cultural issues in an accessible yet profound manner. By combining cognitive experience and participatory appreciation, the work creates transformative experiences.

Similarly, Refik Anadol's *The Anticipation of the Night* (2023), which transforms climate data into dynamic visualisations, exemplifies the fusion of participatory appreciation and conceptual transformation, engaging audiences in both individual and collective critical dialogues on environmental change.

Case Study: *Texel2048Loom*

Texel2048Loom developed as part of this research, merges artificial intelligence with textile tradition, highlighting the visual DNA of Portalegre tapestries — their visual and symbolic identity, which, like biological DNA, encodes information adaptable to new technological contexts.

Created by the author, T*exel2048Loom* integrates the *phygital* taxonomy and a/r/cography, serving simultaneously as an aesthetic exercise, a technical exploration, and an ethical inquiry into the recoding of cultural heritage within digital environments.

The project combines innovative visual aesthetics with critical reflection on the ethical challenges inherent in the technological mediation of cultural memory preservation. This ethical dimension, integral to the a/r/cographically documented creative process, reveals tensions and choices embedded in every technical and conceptual decision.

As both creator and theorist, the author addresses issues of authenticity, representation, and legitimacy in the transformation of heritage. The valorisation of "computational error", rather than realistic mimesis, expresses an ethical stance that acknowledges algorithmic limitations, rejects technological neutrality, and embraces the interpretative nature of digital recoding.

Legitimacy was rigorously examined through a/r/cography, scrutinising the

relationship with the Portalegre tapestries. The author proposed a dialogical recontextualisation, respecting tradition while reimagining it through algorithmic processes. The tripartite structure of the work evokes the phases of weaving — warping, interlacing, and finishing — translated into a contemporary visual grammar that preserves the memory of the original gestures.

The paradox between technical specialisation and democratisation was resolved through interfaces that, while maintaining complexity, enable public participation in heritage reinterpretation regardless of digital literacy. In doing so, the work distributes meaning-making across the author, the system, and the audience.

The sustainability of cultural memory is ensured through a detailed a/r/cographic record, creating a meta-archive that guarantees the persistence of knowledge beyond media obsolescence. This integration of *phygital* taxonomy and a/r/cography presents both an ethical and practical model for digital preservation, focused on the dynamic continuity of cultural processes within hybrid environments.

A machine learning model trained on images of Portalegre tapestries was employed to capture colours and textures, prioritising computational error over photorealism (Figure 4).
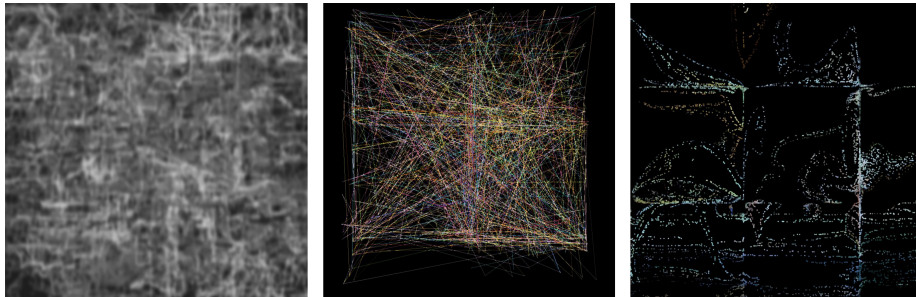

Figure 4: *The three screens of the artwork* Texel2048Loom

After generating several synthetic images, structural lines were extracted using the OpenCV library (Python)[1], serving as the compositional foundation. The work is organised across three interactive screens, inspired by the metaphor of the loom: the first displays diffuse black-and-white lines derived from the synthetic images, suggesting the initial stages of weaving; the second presents defined lines extracted from both original tapestries and generated images, which respond to audience movement, symbolising cultural plasticity; the third transforms these lines into particles manipulable by gestures captured via Mediapipe[2], enabling real-time

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[1]OpenCV is an open-source library (Apache 2.0) for real-time computer vision, providing image and video processing capabilities alongside cross-platform integration with deep learning frameworks (C++, Python, Java).

[2]Google's open-source framework enables the creation of on-device machine learning

interaction and referencing manual manipulation of the loom. The cyclical animation of the lines links artisanal craft with digital technology, dynamically preserving cultural DNA. Thus, *Texel2048Loom* reinterprets tradition through technology, emphasising the potential of cultural heritage to generate novel aesthetic and communicative experiences.

The development of *Texel2048Loom* by the author constitutes a distinctive methodological laboratory wherein the theoretical frameworks of *phygital* taxonomy and a/r/cography were simultaneously applied and refined. This work serves as a practical manifestation of this methodological articulation and the synergistic integration of the physical and virtual realms. It exemplifies practice-based research, characterised by a recursive feedback process between theory and creation, as advocated by a/r/cography.

The project's methodological uniqueness lies in its generative nature. Throughout development, guided by the a/r/cographic principles of iterative experimentation and critical reflection, the necessity of exploring the *phygital* dimensions of the experience became evident. This methodological convergence transformed *Texel2048Loom* into a paradigmatic example of embedded methodology, where the creative process also serves as a space for research and theoretical reformulation. The exhaustive documentation of the entire process — a central pillar of a/r/cography — not only facilitated the creation of the work but also supported concurrent theorisation about methodological integration. In this way, *Texel2048Loom* asserts itself both as an artistic object and as a methodological manifesto.

Application of A/r/cographic Analysis to Development

The application of a/r/cography in the *Texel2048Loom* project is distinguished by its integration of textile tradition with artificial intelligence, establishing a continuous "arc" between the physical and digital realms. This methodology transcends a mere conceptual union, fostering a dynamic flow of interaction, transformation, and documentation that links tradition with contemporary technologies. The process employs three neural network algorithms:

- *Variational autoencoder* (VAE)*: probabilistic generative models that compress each image into a continuous, regularised latent space, capturing the essential visual patterns of the tapestries. This enables sampling and controlled reconstruction for analysis or stylistic reinterpretation (Kingma & Welling, 2013).

- *Residual Network* (ResNet): a deep convolutional network featuring residual connections that mitigate the vanishing gradient problem, refers to a

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pipelines, offering pre-built solutions — such as face, hand, and pose detection — for real-time video applications, with support across Android, iOS, web, and desktop platforms.

phenomenon in deep neural networks where the gradients used to update the weights of the previous layers during training decrease exponentially as they propagate backwards in the network. This means that the initial layers of the network receive very small gradients, which results in negligible updating of the weights and, consequently, slow or even zero learning; this architecture extracts and hierarchises contours, textures, and other structural elements, producing robust representations of the motifs present in the works (He et al., 2016).

- *LightGAN*: a lighter variant of generative adversarial networks consisting of a generator and a discriminator optimised for efficient training. It learns the "visual DNA" of the Portalegre tapestries and synthesises compositions that preserve the colour palette, style, and formal grammar with high realism but at a reduced computational cost (Liu et al., 2021)

Texel2048Loom invites the audience to interact, thereby influencing the reinterpretation of textile heritage through algorithms. This human-technological dialogue generates new symbolic layers, revitalising tradition within a digital ecosystem through feedback cycles.

- Documentation as a living archive: each stage — tapestry analysis, image creation, and line extraction via OpenCV — is systematically recorded, forming an evolving archive that encompasses visual data, creative decisions, and interactions. This documentation, integral to the a/r/cographic process, preserves iterations and 'errors' for subsequent analysis of the journey, bridging past and emergent expressions.

- Bridging tradition and digital innovation: The VAE reinterprets patterns, ResNet identifies structural elements, and *LightGAN* creates hybrid compositions, combining the essence of craftsmanship with innovation. The visual transition from black and white to colour symbolises the fusion of digital technology with the richness of textile tradition, extending its expressive range.

- Gesture and cycle: the animated lines, extracted from the compositions, emulate the rhythm of weaving, imparting an ancestral cadence to the digital medium. The continuous documentation highlights successive "arches" that sustain and prolong cultural memory.

In *Texel2048Loom*, a/r/cography fuses interaction, technology, and tradition into a living process, rewriting textile history in dialogue with the future while remaining firmly rooted in its origins.

Evaluation of the Work *Texel2048Loom*

Through A/r/cography

Veiga's (2021) analysis of *Texel2048Loom* through a/r/cography identifies three fundamental axes — aesthetics, aptitude, and function — offering a comprehen-

sive overview of the creative process, from conceptualisation and prototyping to final intervention.

On the aesthetic axis, the appropriation of the visual language of Portalegre tapestries by AI algorithms (VAE, ResNet, *LightGAN*) generates a reflective visual experience. Through abstract compositions and nuanced variations in colour and form, the work engages the audience while poetically evoking cultural heritage within a *phygital* framework.

Regarding aptitude, the piece utilises computer vision systems to detect and translate audience movements into dynamic visual transformations, demonstrating a high degree of technical rigour. Iteratively documented in digital logbooks, this approach exemplifies the rhizomatic flexibility of a/r/cography, which fosters continuous adjustments until a dynamic interaction between human gesture and algorithmic response is achieved.

Finally, in terms of function, *Texel2048Loom* transcends aesthetic concerns by revitalising tradition within a technological and *phygital* context, encouraging active audience participation. This reinforces the relational dimension of the a/r/cographic methodology, creating space for heritage reinterpretation, co-authorship reflection, and the redefinition of art's social role in the *phygital* era.

Through *Phygital* Taxonomy

To rigorously assess the degree of physical–digital hybridisation and the aesthetic–cognitive impact of *Texel2048Loom*, this study applied the *phygital* taxonomy developed as part of the research. This analytical grid quantifies six core dimensions on a continuous scale from zero to 10, then translates them into standardised qualitative levels. The numerical overview presented in Table 1, complemented by the radar chart, provides a detailed and comparative analysis of the work's performance, highlighting its strengths and identifying areas where further development is possible.

Overview Table of the Evaluation of the *Work Texel2048Loom*

Dimension	Value (0–10)	Qualitative level
Physical–digital integration	9	Full fusion
Sensory experience	3	Minimal tactile-visual
Cognitive experience	8	Cognitive transformation
Appreciation	7	Singular participatory
Interactivity	7	Advanced
Bodily engagement	6	High engagement

Physical-digital integration — 9: real-time gesture capture feeds generative algorithms that project immediate visual responses on the three physical screens,

forming a dynamic body-code-space circuit (see Figure 5). The lack of tactile feedback/actuators prevents the maximum value.
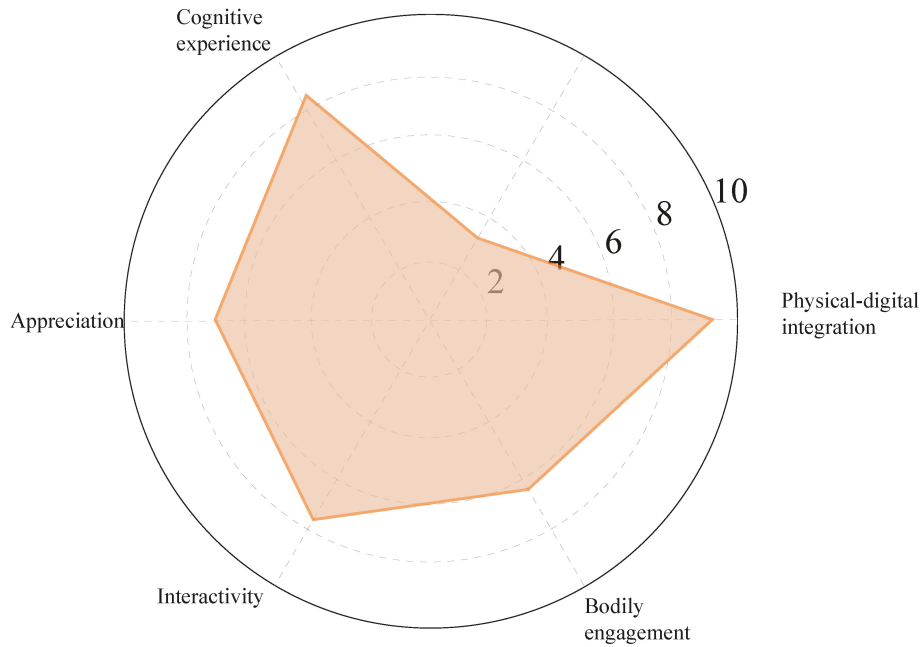

Figure 5: *Radar chart of the phygital profile of the work* Texel2048Loom

Sensory Experience — 3: the work opts for restrained sensory stimulation, confining itself almost exclusively to the visual field. It does not explore sound, tactile, or olfactory components, producing a subtle and deliberately minimalist experience.

Cognitive experience — 8: the work questions the algorithmic recoding of the Portalegre tapestries, addressing cultural memory, authenticity, and technology, leading to a strong "cognitive transformation" (see Figure 6).
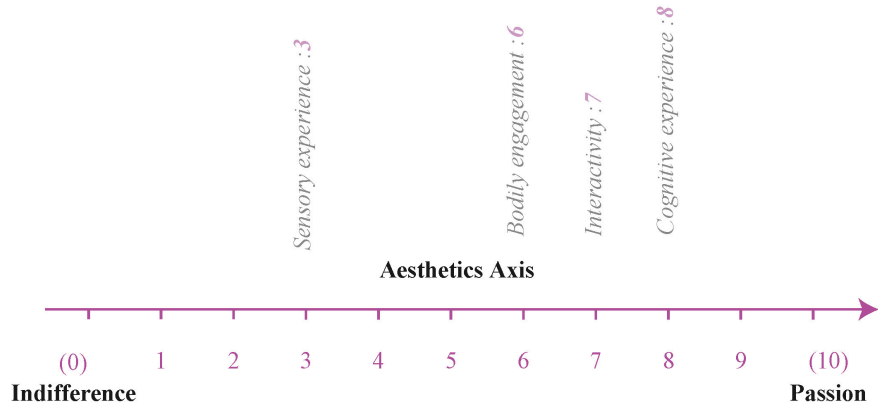
Figure 6: *Graphical representation of the aesthetics axis with the coupling of the phygital taxonomy*

Interactivity — 7: the immediate response implies effective co-authorship; each action contributes to the configuration of the composition, respecting previously defined algorithmic limits and positioning itself at the "advanced" level.

Bodily engagement — 6: the body acts as an essential trigger, but participation remains predominantly gestural; there is room for greater performativity or two-way feedback (see Figure 7).
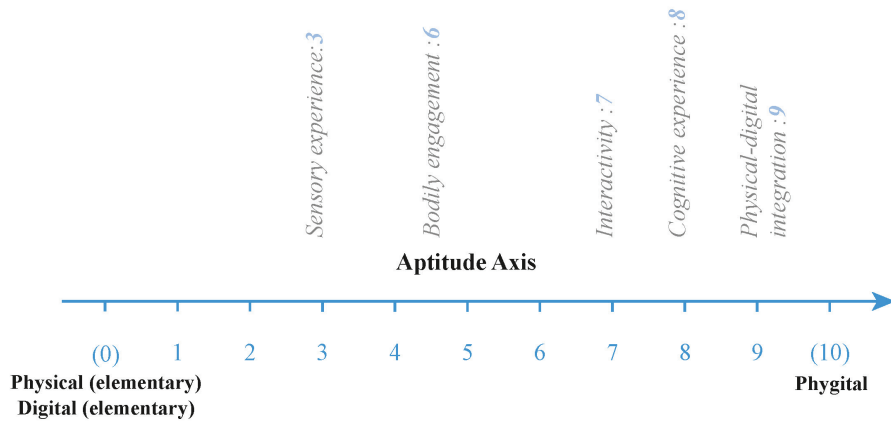
Figure 7: *Graphical representation of the aptitude axis with the coupling of the phygital taxonomy*

Appreciation — 7: chromatic-formal metamorphoses combined with an intuitive interface provide an engaging experience where the audience enjoys the mutations while actively participating in their genesis (see Figure 8).
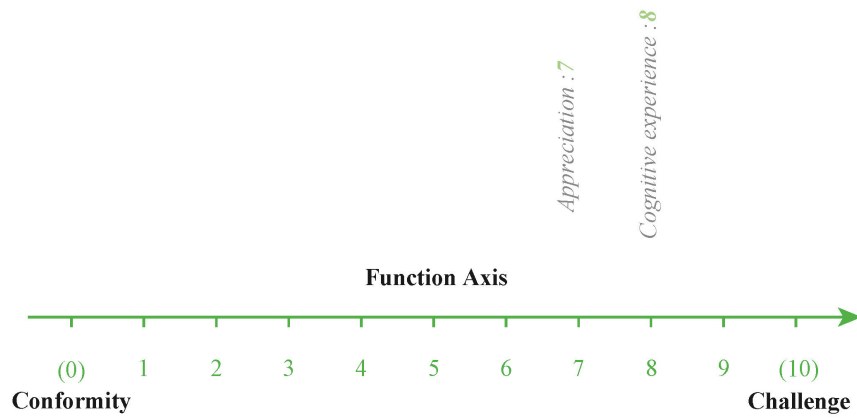

Figure 8: *Graphical representation of the function axis with the coupling of the phygital taxonomy*

Applicability of the Model in Different *Phygital* Artistic Contexts

The methodological integration between the *phygital* taxonomy and a/r/cography, developed within the *Texel2048Loom* project, reveals a high potential for transferability to various contexts of *phygital* artistic practice. This approach combines a robust analytical structure with flexible, practical application, allowing it to be adapted to multiple areas of artistic and cultural intervention.

In the field of heritage-based interactive installations, the proposed methodology serves as a tool for critical analysis and a procedural guide. Its ability to mediate between historical artefacts and digital technologies facilitates the creation of immersive experiences that respect the cultural integrity of objects while promoting innovative interaction with the public.

In the field of dance and technologically mediated performances, the methodology stands out for its approach to capturing and translating human gestures into algorithmic responses. This process offers significant contributions to the articulation between body movement and digital mediation, systematising the interaction between bodily expression and technological responses, with the *phygital* taxonomy allowing the effectiveness of this integration to be evaluated.

In generative art and bioart, the methodology is an effective model for documenting and analysing dynamic and evolving systems. Its analytical structure, provided by a/r/cography, supports the exploration of emerging behaviours, while the *phygital* taxonomy offers a tool for assessing the complexity and impact of these systems.

In the field of interactive public art and digital urban interventions, the methodology offers a conceptual framework that addresses the technical, logistical, and social complexities inherent in these projects. The development of systems that react to the movement of the public serves as a basis for their adaptation to urban environments, with *phygital* taxonomy being an instrument that supports the analysis of audience participation and engagement.

In hybrid museum contexts, the integration of *phygital* taxonomy and a/r/cography offers a structured approach to addressing the challenges posed by the intersection of heritage conservation and digital innovation. The methodology contributes to the documentation and monitoring of digital mediation strategies, utilising *phygital* taxonomy as a means of analysing the effectiveness of the implemented solutions.

The practical implementation, as demonstrated in the *Texel2048Loom* project, reveals that the link between *phygital* taxonomy and a/r/cography forms a solid and adaptable methodological framework capable of guiding all stages of the creative process. This integrated approach presents itself as a versatile resource that can be applied in various artistic practices and research contexts, fostering critical analysis and innovative practice in the field of *phygital* art.

Application of A/r/c ographic Analysis to Development

The physical-digital convergence achieved through the articulation between a/r/cography and *phygital* taxonomy enables a holistic interpretation of *Texel2048Loom*. By intersecting the procedural and relational vectors of a/r/cography with the quantitative dimensions of the *phygital* taxonomy, a coherent view of the work emerges across its multiple layers: material, virtual, and symbolic. The low score for sensory experience (3) contrasts with the high cognitive score (8), emphasising that the device favours metaphorical thinking and the conceptual layer over synaesthetic immersion. Even so, the scores for bodily engagement (6) and interactivity (7) show audience participation that, although already significant, could benefit from an amplification of the physical-digital component — for example, by introducing haptic or sound stimuli that reinforce the continuity between the tangible space and the virtual environment. Finally, the balance between appreciation (7) and cognitive depth (8) confirms an experience that is both accessible and intellectually dense, capable of evoking both emotion and critical reflection in the spectator.

From the perspective of the creative process, a/r/cography illustrates how each fundamental axis — aesthetics, aptitude, and function — was explored throughout the various stages of the work's development, underscoring its iterative and experimental character. The *phygital* taxonomy underlines the hybrid nature of *Texel2048Loom*, quantifying interactivity and bodily engagement and highlighting technological co-authorship. This integrated approach highlights the conceptual cohesion of the work, which, focused on visual stimuli, reflects on the preservation and reinvention of heritage. Thus, it links textile tradition and computer vision algorithms, validating mixed methodologies that evaluate the creative process and interactive quality of *phygital* art.

Level of *Phygital* Achieved

The analysis of the three axes of a/r/cography, combined with the assigned values, indicates that *Texel2048Loom* achieves an advanced level of *phygitality*. The work goes beyond the mere coexistence of the physical and digital domains, establishing a symbiosis that connects them in a natural and enriching way.

The articulation between algorithms and human gestures makes this work a model of the potential of *phygitality* to revitalise cultural heritage, making it dynamic, inclusive, and participatory. At the same time, by involving the public in the creative process and converting complex concepts into emotionally accessible experiences, the work demonstrates the effectiveness of its methodology. In this way, *Texel2048Loom* positions itself not only as a contemporary artistic creation but also as evidence of a/r/cography as an innovative resource in current artistic production.

Advantages and Limitations of Integrating *Phygital* Taxonomy With A/r/cography

The integration of *phygital* taxonomy with a/r/cography has emerged as a robust methodological framework for both analysing and creating artistic practices that merge physical and digital dimensions. While this combination offers significant advantages, it also presents theoretical, methodological, and empirical limitations, as evidenced in the *Texel2048Loom* case study. This section outlines the key strengths and constraints identified, distinguishing between those inherent to the models themselves and those encountered in their practical application.

Advantages

The integration of the *phygital* taxonomy with a/r/cography offers a coherent methodological framework that bridges analytical and creative dimensions in *phygital* artistic practice. While the taxonomy provides a conceptual structure for evaluating the hybridisation of physical and digital components, a/r/cography supports an iterative process of creation, reflection, and documentation.

The *phygital* taxonomy enables the mapping of physical-digital convergence, classifying interactivity, bodily engagement, and cognitive depth. In parallel, a/r/cography organises the creative process across seven iterative stages — from conceptualisation to experimentation and evaluation — fostering a continuous dialogue between theory and practice. Together, they encourage participatory engagement, recognising the audience as co-creators. While the taxonomy highlights the role of interactivity and bodily engagement, a/r/cography supports aesthetic and emotional responsiveness, allowing for adaptive adjustments informed by feedback.

This integration also promotes experimentation with *phygital* configurations by incorporating technologies such as computer vision alongside cultural heritage elements, thus challenging the boundaries between analogue and digital domains. Its adaptability across contexts stems from the balance between the analytical precision of the taxonomy and the practical structure of a/r/cography, making it applicable to a wide range of hybrid artistic practices.

The *Texel2048Loom* project exemplifies these advantages. By combining computer vision, gesture recognition, and the reinterpretation of Portalegre tapestry motifs, the work demonstrates how the taxonomy supports the assessment of interactivity and conceptual complexity while a/r/cography documents and critically reflects on the creative process.

Limitations

Despite its advantages, the combination of *phygital* taxonomy with a/r/cography presents certain limitations, which can be divided into two main categories: theoretical-methodological, linked to the characteristics of the models themselves,

and case-specific, relating to the practical application in the *Texel2048Loom* project. The *phygital* taxonomy, conceived to analyse the interaction between physical and digital dimensions, is less applicable to purely digital or entirely physical projects, thus being limited to hybrid contexts. Although it addresses sensory stimulation, it lacks detailed guidelines for multisensory experiences — such as sound, touch, or smell — beyond the visual, which may necessitate complementary frameworks in broader projects.

Moreover, the taxonomy does not incorporate specific categories to address ethical and cultural concerns, such as digital authorship or socio-cultural impact. This limits the scope of analysis, even though a/r/cography encourages critical reflection in these areas. The integration of both models — *phygital* taxonomy, focused on hybrid dimensions, and a/r/cography, on creation and reflection — may also lead to overlaps or consistency issues in the absence of unified evaluative tools.

In the case of *Texel2048Loom*, bodily interaction was captured through computer vision and projected visually, but lacked material physicality. This imbalance between physical and digital elements affected the *phygital* equilibrium of the work. Furthermore, its primary visual focus highlighted practical limitations in the absence of other sensory dimensions, such as sound, smell, or texture.

Conclusion

This study assessed the integration between *phygital* taxonomy and a/r/cography as methodological tools for *phygital* artistic practices, evaluating their theoretical foundations, practical implications, limitations, and potential refinements. The application of these approaches to a hybrid artefact such as *Texel2048Loom* demonstrated their efficacy in structuring and guiding the creative process, underscoring their innovative potential.

The combination of *phygital* taxonomy and a/r/cography proved to be a cohesive methodological model, uniting the physical and digital dimensions of artistic creation. While *phygital* taxonomy enables a detailed analysis of hybrid interactions, a/r/cography complements it by structuring the creative process around its three conceptual axes: aesthetics, aptitude, and function. This integration enhances the internal coherence of artworks and their capacity to engage with audiences and cultural contexts.

This study explored the integration of *phygital* taxonomy and a/r/cography as methodological approaches to *phygital* artistic practices, assessing their theoretical and practical impact, as well as identifying limitations and potential refinements. Applied to *Texel2048Loom*, these approaches proved effective in structuring the creative process, highlighting its innovative potential.

The combination of these two methodologies forms a coherent model that seamlessly integrates the physical and digital dimensions. The *phygital* taxonomy

provides a detailed framework for analysing hybrid interactions. At the same time, a/r/cography organises the creative process along the axes of aesthetics, aptitude, and function, fostering coherence and meaningful engagement with both the audience and the cultural context.

Texel2048Loom, the central *phygital* artefact in this study, exemplifies this integration by merging physical and digital elements in both its conception and experience. Although predominantly digital, its materiality and interactivity reinforce its *phygital* character, showcasing the methodologies' capacity to address ambiguities and fluid boundaries in contemporary art, as well as their adaptability to diverse forms of analysis.

Advancing this work requires further validation of the methodology through additional case studies and exploring varied hybrid art practices to uncover new insights or identify gaps. Moreover, the development of digital tools to support this methodology could democratise *phygital* practices and enhance their practical application.

The integration of *phygital* taxonomy and a/r/cography constitutes a valuable model for post-digital media art, structuring the creative process and expanding the scope of contemporary artistic practice. By envisioning a productive coexistence of tradition and technology, this study emphasises the potential of *phygital* arts as a dynamic domain of experimentation, critical reflection, and cultural transformation.

Future Refinements, Review, and Expansion

The *Texel2048Loom* case study demonstrated the value of integrating *phygital* taxonomy and a/r/cography, both as an analytical tool and as an operational basis for hybrid practices. However, empirical application identified gaps that must be addressed before this model can be expanded to other artistic contexts.

Analysis of the creations revealed that the predominance of the visual vector is insufficient to encompass the complexity of *phygital* experiences, making it necessary to expand the taxonomy with subcategories that integrate sound, tactile, kinaesthetic, and olfactory contributions, enabling multisensory evaluation. At the same time, it is essential to formalise ethical and cultural indicators that allow for the assessment of socio-cultural impacts, algorithmic authorship, accessibility, environmental sustainability, and social responsibility. In addition, the creation of an autonomous axis dedicated to symbolic reinterpretation and memory is proposed, aimed at examining how identity and collective heritage are transformed by algorithms, ensuring their legitimacy. For predominantly virtual works, it is crucial to establish specific analytical intervals that ensure consistency when physical materiality is reduced, as well as criteria that clarify areas of complex intersection where multiple dimensions overlap, preventing interpretative gaps.

The consolidation of this revised taxonomy should be based on a programme

of incremental prototypes, testing specific variables — such as the progressive introduction of haptic feedback — before their final integration. It is also necessary to replicate this approach in diverse socio-cultural contexts, including regional museums, community initiatives, and urban public spaces, to assess the model's sensitivity to local values and the expectations of heterogeneous audiences. Longitudinal collection mechanisms should complement this process to evaluate the persistence of impact and the evolution of user perceptions over time.

Given the rapid technological evolution, particularly in areas such as artificial intelligence, augmented reality, and virtual reality, the taxonomy should be conceived as a dynamic repository, subject to periodic updates. This process should be supported by transdisciplinary communities of practice and a version control system that ensures the traceability of changes and retrospective compatibility between successive versions.

With the integration of these multisensory, ethical-cultural, and symbolic extensions — and preserving the robustness already demonstrated by a/r/cography — the revised model becomes a holistic framework capable of keeping pace with the complexity of post-digital artistic practices, promoting inclusive, sustainable, and culturally responsible approaches.

Machine Translation Post-Editing: Anabela Delgado

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