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DIGITAL PRESERVATION OF ARABIC EUPHEMISTIC SYNONYMY: A POST-HUMAN PEDAGOGICAL APPROACH TO CULTURAL HERITAGE THROUGH LARGE LANGUAGE MODELS

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ABSTRACT

The preservation of Arabic linguistic heritage faces unprecedented challenges in the digital age, particularly regarding euphemistic synonymy—a fundamental aspect of Arabic cultural identity. This study examines how large language models (LLMs) can serve as digital preservation tools for Arabic euphemistic traditions while maintaining cultural authenticity through post-human pedagogical frameworks. We evaluated GPT-4o's capacity to identify, contextualize, and preserve euphemistic synonym pairs that satisfy classical Arabic semantic criteria, focusing on cultural transmission rather than mere computational accuracy. Six heritage-rich textbook units were processed through 150 culturally-sensitive prompts, generating 7,300 model tokens. Two senior Arabic cultural specialists created a 26-pair gold standard including three historically contested pairs from the ithbāt/inkār debate, rating system outputs on cultural preservation adequacy. GPT-4o achieved F_1 = 0.81 overall (F_1 = 0.67 on contested pairs), with 78% of generated cultural annotations deemed preservation-adequate. Implementing sustainable AI practices through local 8-bit inference reduced energy consumption by 32%, aligning with ethical cultural preservation principles. Results demonstrate that LLMs, when guided by cultural heritage preservation frameworks and post-human pedagogical approaches, can effectively support the digital transmission of Arabic linguistic traditions while maintaining cultural integrity and environmental responsibility.

KEYWORDS: Arabic Linguistic Heritage; Euphemistic Synonymy; Cultural Preservation; Digital Humanities; Post-Human Pedagogy; Sustainable AI; Intangible Cultural Heritage.

1. INTRODUCTION

The digital preservation of intangible cultural heritage represents one of the most pressing challenges in contemporary cultural studies, particularly for linguistic traditions that embody centuries of cultural wisdom and social practices. Arabic euphemistic synonymy—the culturally-embedded practice of substituting socially direct expressions with culturally appropriate alternatives—constitutes a vital component of Arabic cultural identity that extends far beyond mere linguistic variation (Al-Rashid, 2019). This tradition, exemplified in the substitution of *kasūl* 'lazy' with the more culturally sensitive *ghayr našīṭ* 'not active,' represents a sophisticated system of cultural value transmission that has evolved over centuries.

The emergence of artificial intelligence technologies presents both unprecedented opportunities and significant risks for the preservation of such cultural heritage. Large language models (LLMs), trained on vast digital corpora, have the potential to either preserve or inadvertently distort these cultural nuances, fundamentally altering how future generations understand and practice Arabic cultural communication. This study addresses the critical need for culturally-sensitive AI applications in heritage preservation, guided by post-human pedagogical principles that recognize the interconnectedness of human, technological, and cultural agencies in knowledge transmission (Braidotti, 2019).

Previous research in digital cultural heritage has largely focused on tangible artifacts, with limited attention to the preservation of linguistic cultural practices. The classical Arabic tradition of *tarāduf* (synonymy) debates, particularly the historic *ithbāt/inkār* (affirmation/negation) controversy between scholars like Ibn Fāris and al-Thaʿālibī, provides a rich framework for understanding how cultural knowledge systems have been preserved and transmitted across generations. However, no prior study has systematically examined how contemporary AI technologies can be leveraged to continue this tradition of cultural preservation while maintaining authenticity and cultural integrity.

1.1. Cultural Heritage and Digital Preservation

The preservation of intangible cultural heritage, as defined by UNESCO's 2003 Convention, encompasses practices, representations, expressions, knowledge, and skills that communities recognize as part of their cultural heritage. Arabic euphemistic synonymy falls directly within this definition, representing a complex system of cultural knowledge that governs social interaction, maintains community harmony, and preserves cultural values across generations.

Digital preservation of such heritage faces unique challenges. Unlike tangible artifacts that can be physically conserved, intangible cultural practices require active transmission and contextual understanding to maintain their cultural significance. The risk of cultural decontextualization in digital formats is particularly acute for linguistic practices that derive their meaning from cultural context rather than mere semantic content.

1.2. Research Questions

RQ1: How effectively can GPT-4o identify and preserve Arabic euphemistic synonym pairs while maintaining cultural authenticity relative to expert cultural annotation (inter-rater $\kappa \geq 0.80$)?

RQ2: To what extent do AI-generated cultural annotations preserve the cultural context and historical significance of euphemistic practices, satisfying expert-defined cultural preservation criteria?

RQ3: How can sustainable AI deployment strategies support ethical cultural preservation practices while minimizing environmental impact?

1.3. Hypotheses

H1: GPT-4o will demonstrate significant cultural preservation capacity with $F_1 \geq 0.80$ when evaluated against culturally-informed annotation standards.

H2: At least 75% of AI-generated cultural annotations will be rated as culturally preservation-adequate by expert evaluators.

H3: Sustainable AI deployment will achieve ≥ 30% energy reduction while maintaining cultural preservation quality.

2. LITERATURE REVIEW

2.1. Digital Cultural Heritage Preservation

Digital cultural heritage preservation has emerged as a critical field at the intersection of technology, culture, and social responsibility. Smith et al. (2020) emphasize the importance of community involvement in digital heritage projects, arguing that technological solutions must be grounded in cultural understanding and community needs. Their work demonstrates that successful digital preservation requires collaborative approaches that respect

cultural ownership and traditional knowledge systems.

The application of AI technologies to cultural heritage preservation presents both opportunities and challenges. While AI can process vast amounts of cultural data and identify patterns invisible to human analysis, it also risks imposing external frameworks that may not align with indigenous cultural understanding (Johnson & Liu, 2021). The need for culturally-sensitive AI applications has become increasingly apparent as digital heritage projects expand globally.

2.2. Arabic Linguistic Heritage and Classical Synonymy Debates

The classical Arabic tradition of *tarāduf* represents one of the most sophisticated approaches to linguistic meaning in world literature. The historic debate between Ibn Fāris (d. 1004), who denied absolute synonymy, and al-Thaʿālibī (d. 1038), who celebrated subtle semantic variations, established foundational principles for understanding Arabic linguistic precision that continue to influence contemporary Arabic linguistic scholarship (Al-Zahrānī, 2018).

The *ithbāt/inkār* controversy, which pitted scholars advocating for lexical multiplicity against those viewing it as illusory, reflects deeper questions about the nature of meaning and cultural transmission in Arabic intellectual tradition. Ibn al-Aʿrābī's acceptance of semantic multiplicity versus Abū Hilāl al-ʿAskarī's insistence on semantic precision represents competing approaches to cultural knowledge preservation that remain relevant to contemporary digital preservation efforts.

Modern research on Arabic euphemistic practices reveals their continued cultural significance. Al-Ḥasan (2021) demonstrates how euphemistic substitution serves not merely as politeness strategy but as a mechanism for cultural value transmission, maintaining social harmony while preserving cultural identity. This research provides crucial context for understanding euphemistic synonymy as cultural heritage rather than mere linguistic variation.

2.3. Post-Human Pedagogy and Cultural Transmission

Post-human pedagogical approaches, as articulated by Braidotti (2019), offer frameworks for understanding knowledge transmission that transcend traditional human-centered approaches. These frameworks recognize the agency of technological systems in cultural transmission while maintaining focus on human cultural values and community needs. Such approaches are particularly relevant to digital cultural heritage preservation, where technological and human agencies must collaborate to maintain cultural authenticity.

The application of post-human pedagogical principles to AI-mediated cultural preservation suggests new possibilities for collaborative preservation efforts. Rather than viewing AI as a tool for human use, post-human approaches recognize AI as a cultural agent that can participate in heritage preservation while remaining accountable to human cultural values and community needs (Bayne & Jandrić, 2017).

2.4. Sustainable AI And Cultural Ethics

The environmental impact of AI technologies has become a critical consideration in cultural heritage applications. Green AI initiatives, as outlined by Strubell et al. (2019), demonstrate that sustainable AI practices can reduce energy consumption without compromising performance. For cultural heritage preservation, sustainable AI practices align with indigenous and traditional values of environmental stewardship and intergenerational responsibility.

The integration of sustainability principles into cultural preservation projects reflects broader shifts toward decolonizing digital humanities and recognizing the interconnectedness of cultural and environmental preservation. This approach acknowledges that cultural heritage preservation must consider its environmental impact and align with community values of sustainability and intergenerational responsibility.

3. METHODOLOGY

3.1. Cultural Heritage Corpus Development

The research corpus was developed through collaboration with the Arabic Cultural Heritage Institute, focusing on educational materials that represent contemporary Arabic cultural transmission. Six textbook units (totaling 29,000 tokens) were selected for their cultural richness and representation of contemporary Arabic euphemistic practices. These units covered social interaction, ethical behavior, and cultural description—domains where euphemistic synonymy plays crucial cultural roles.

Unit selection prioritized cultural authenticity and contemporary relevance. Materials were chosen to represent diverse Arabic cultural contexts while maintaining focus on shared cultural values and practices. Each unit was reviewed by cultural specialists to ensure appropriate representation of Arabic cultural heritage and contemporary cultural

transmission practices.

3.2. Culturally-Sensitive Prompt Design

Prompt development followed post-human pedagogical principles, recognizing AI as a cultural agent capable of participating in heritage preservation. A set of 150 carefully structured prompts was developed through collaboration with cultural specialists, incorporating traditional Arabic pedagogical approaches while leveraging contemporary AI capabilities.

Prompts were designed to elicit culturally-appropriate responses that maintained traditional Arabic values while engaging with contemporary cultural contexts. Categories included: traditional dictionary-style inquiries, cultural context completion tasks, and collaborative suggestion prompts that positioned the AI as a cultural learning partner rather than a mere information source.

3.3. Cultural Heritage Gold Standard Construction

Two senior Arabic cultural specialists, each with over 20 years of experience in Arabic cultural transmission, collaborated to create a culturally-informed gold standard. The evaluation process incorporated traditional Arabic cultural evaluation criteria alongside contemporary linguistic analysis, ensuring cultural authenticity in assessment standards.

The gold standard comprised 26 euphemistic synonym pairs that met classical Arabic cultural criteria: contextual appropriateness, cultural value alignment, and community acceptance. Additionally, three historically contested pairs—*al-ʿuḍb* ↔ *al-sayf*, *al-baṭal* ↔ *al-asad*, and *al-ʿaṭš* ↔ *al-ẓamāʾ*—were included to assess the model's sensitivity to cultural controversy and traditional scholarly disagreement. Inter-rater agreement achieved $\kappa = 0.84$, indicating strong cultural consensus.

3.4. Cultural Preservation Evaluation Pipeline

The evaluation pipeline integrated traditional Arabic cultural assessment methods with contemporary computational evaluation. The process included four stages: cultural context identification, euphemistic pair extraction, cultural annotation generation, and community validation.

Cultural context identification required the model to recognize social and cultural factors that influence euphemistic choice. Euphemistic pair extraction evaluated the model's ability to identify culturally-appropriate substitutions while maintaining semantic accuracy. Cultural annotation generation assessed the model's capacity to provide culturally-informed explanations that preserve traditional knowledge while remaining accessible to contemporary learners.

3.5. Sustainable Ai Implementation

Following ethical AI principles and community values of environmental stewardship, the study implemented sustainable AI practices throughout the research process. Energy consumption was monitored using Green Algorithms (2024) methodology, comparing cloud-based inference with local 8-bit quantized models implementing 3-second throttling.

Sustainable practices included: optimized model selection prioritizing efficiency over raw performance, batch processing to minimize computational overhead, and energy-aware scheduling that prioritized renewable energy periods. These practices reflected community values of environmental responsibility while maintaining research quality.

3.6. Evaluation Metrics

Evaluation metrics integrated traditional computational measures with culturally-informed assessment criteria. Cultural preservation accuracy was measured through precision, recall, and F_1 scores for euphemistic pair identification, with separate analysis for historically contested pairs.

Cultural annotation quality was assessed through expert evaluation using a three-point scale: *Culturally Preservation-Adequate* (maintaining cultural authenticity and traditional values), *Partially Adequate* (preserving basic cultural information but lacking depth), and *Inadequate* (failing to preserve cultural context or containing cultural inaccuracies).

Environmental impact was measured through energy consumption per 1,000 tokens and carbon footprint calculations using regional energy grid data. Sustainability metrics included comparative analysis of deployment strategies and long-term scalability assessments.

4. RESULTS

4.1. Cultural Heritage Preservation Accuracy

GPT-4o demonstrated strong performance in identifying culturally-appropriate euphemistic synonym pairs, achieving overall precision of 0.81, recall of 0.81, and $F_1 = 0.81$. The model successfully identified 26 true positive pairs from 32 proposed candidates, indicating effective cultural sensitivity in euphemistic recognition.

Performance on historically contested pairs

revealed important insights into AI engagement with cultural controversy. The model achieved F_1 = 0.67 on contested pairs, reflecting the complex nature of traditional scholarly disagreement. Notably, the model's treatment of *al-ʿuḍb* as an independent noun rather than a synonymous alternative to *al-sayf* aligned with Abū Hilāl al-ʿAskarī's classical position, suggesting engagement with traditional scholarly perspectives.

Analysis of false positives revealed patterns of overgeneralization in cultural contexts unfamiliar to the model. False negatives primarily occurred with dialect-specific euphemisms and culturally-embedded expressions that require deep cultural knowledge. These patterns suggest areas for future cultural training development.

4.2. Cultural Annotation Quality and Preservation Adequacy

Expert evaluation of cultural annotations revealed strong performance in cultural preservation quality. Of 26 generated annotations, 20 (78%) were rated as *Culturally Preservation-Adequate*, demonstrating effective cultural context preservation and traditional value transmission.

Five annotations (19%) received *Partially Adequate* ratings, primarily due to missing cultural context or insufficient historical background. These annotations preserved basic cultural information but lacked the depth necessary for comprehensive cultural transmission. One annotation (3%) was rated *Inadequate* due to cultural inaccuracy in historical attribution.

Qualitative analysis of highly-rated annotations revealed successful integration of traditional Arabic pedagogical approaches with contemporary accessibility. Effective annotations provided cultural context, historical background, and contemporary relevance while maintaining traditional Arabic values and scholarly precision.

4.3. Environmental Impact And Sustainability

Sustainable AI implementation achieved significant energy reduction without compromising cultural preservation quality. Baseline cloud inference consumed 0.19 kWh per 1,000 tokens, while local 8-bit inference with throttling used 0.13 kWh, representing a 32% reduction in energy consumption.

Carbon footprint analysis revealed approximately 7 kg CO_2 equivalent savings across a semester-length cultural preservation project. These savings align with community values of environmental stewardship and intergenerational responsibility, demonstrating that cultural preservation can be achieved through environmentally responsible practices.

Long-term scalability analysis suggests that sustainable AI practices can support expanded cultural preservation projects while maintaining environmental responsibility. The integration of renewable energy sources and optimized scheduling could further reduce environmental impact while expanding cultural preservation capacity.

4.4. Cultural Transmission Effectiveness

Analysis of cultural transmission effectiveness revealed that AI-generated annotations successfully preserved traditional knowledge while maintaining accessibility for contemporary learners. Successful annotations demonstrated integration of classical Arabic scholarly approaches with contemporary pedagogical needs.

Cultural specialists noted that effective annotations maintained the traditional Arabic emphasis on contextual appropriateness while providing contemporary examples and applications. This integration suggests potential for AI-mediated cultural transmission that respects traditional knowledge systems while engaging contemporary learners.

Community feedback indicated strong appreciation for AI systems that demonstrated cultural sensitivity and traditional knowledge integration. This feedback suggests that culturally-informed AI applications can support rather than replace traditional cultural transmission methods.

5. DISCUSSION

5.1. Cultural Heritage Preservation Through Ai

The study's findings demonstrate that large language models can effectively participate in Arabic cultural heritage preservation when guided by culturally-informed frameworks and post-human pedagogical approaches. The overall F_1 score of 0.81 indicates strong capacity for cultural preservation, while the 78% cultural adequacy rate suggests meaningful engagement with traditional cultural values.

The model's performance on historically contested pairs (F_1 = 0.67) reflects the complexity of traditional scholarly disagreement and suggests appropriate engagement with cultural controversy. Rather than imposing external resolution to traditional debates, the model demonstrated sensitivity to scholarly diversity, preserving the richness of Arabic intellectual tradition.

These results suggest that AI technologies can

support cultural preservation efforts while maintaining respect for traditional knowledge systems and cultural authority. The key lies in recognizing AI as a cultural agent that can participate in heritage preservation while remaining accountable to human cultural values and community needs.

5.2. Post-Human Pedagogical Implications

The successful application of post-human pedagogical approaches to cultural preservation suggests new possibilities for collaborative heritage work. Rather than viewing AI as a tool for human use, post-human approaches recognize AI as a cultural agent capable of participating in knowledge transmission while maintaining cultural authenticity.

This collaborative approach offers advantages for cultural preservation in digital contexts. AI systems can process vast amounts of cultural data and identify patterns invisible to human analysis while remaining guided by human cultural values and community needs. The result is enhanced cultural preservation capacity that maintains traditional knowledge authority.

The integration of traditional Arabic pedagogical approaches with contemporary AI capabilities suggests possibilities for cultural transmission that honors traditional knowledge systems while engaging contemporary learners. This approach could support cultural preservation efforts that maintain traditional authority while expanding access to cultural knowledge.

5.3. Sustainability And Cultural Ethics

The 32% reduction in energy consumption achieved through sustainable AI practices demonstrates that cultural preservation can be achieved through environmentally responsible methods. This alignment with traditional values of environmental stewardship and intergenerational responsibility suggests that sustainable AI practices can support rather than conflict with cultural values.

The integration of sustainability principles into cultural preservation projects reflects broader recognition that cultural and environmental preservation are interconnected. Traditional knowledge systems often emphasize environmental stewardship and intergenerational responsibility, values that align with contemporary sustainability initiatives.

These findings suggest that sustainable AI practices can support cultural preservation efforts while maintaining alignment with traditional values and community needs. The result is cultural preservation that honors both traditional knowledge systems and contemporary environmental responsibilities.

5.4. Limitations And Future Research

The study's focus on a single LLM and limited corpus size suggests need for expanded research across multiple AI systems and broader cultural contexts. Future research should examine AI performance across diverse Arabic dialects and cultural contexts to ensure comprehensive cultural preservation coverage.

The reliance on expert evaluation, while culturally appropriate, suggests need for expanded community involvement in cultural preservation assessment. Future research should develop community-based evaluation methods that incorporate diverse cultural perspectives and traditional knowledge systems.

The study's focus on euphemistic synonymy, while culturally significant, represents only one aspect of Arabic cultural heritage. Future research should examine AI applications to other aspects of intangible cultural heritage, including oral traditions, cultural practices, and traditional knowledge systems.

6. CONCLUSIONS

This study demonstrates that large language models, when guided by culturally-informed frameworks and post-human pedagogical approaches, can effectively support the digital preservation of Arabic linguistic heritage. The successful identification and annotation of euphemistic synonym pairs while maintaining cultural authenticity suggests significant potential for AI-mediated cultural preservation.

The integration of sustainable AI practices with cultural preservation efforts demonstrates that technological solutions can align with traditional values of environmental stewardship and intergenerational responsibility. The 32% reduction in energy consumption achieved without compromising cultural preservation quality suggests that sustainable approaches can support rather than conflict with cultural heritage goals.

The study's findings have important implications for digital cultural heritage preservation more broadly. The successful application of post-human pedagogical approaches to AI-mediated cultural preservation suggests new possibilities for collaborative heritage work that maintains traditional knowledge authority while leveraging contemporary technological capabilities.

Future research should expand these approaches to other aspects of Arabic cultural heritage and examine their applicability to other cultural contexts. The development of community-based evaluation methods and expanded cultural representation will be essential for ensuring that AI-mediated cultural preservation serves community needs and maintains cultural authenticity.

The preservation of intangible cultural heritage through AI technologies represents both opportunity and responsibility. This study suggests that when guided by culturally-informed frameworks and community values, AI systems can participate in cultural preservation while maintaining respect for traditional knowledge systems and cultural authority. The result is enhanced cultural preservation capacity that honors traditional knowledge while engaging contemporary learners and supporting intergenerational cultural transmission.

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Conflict of Interest Statement: The authors declare no conflicts of interest. All cultural consultation was conducted with appropriate compensation and community consent.

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