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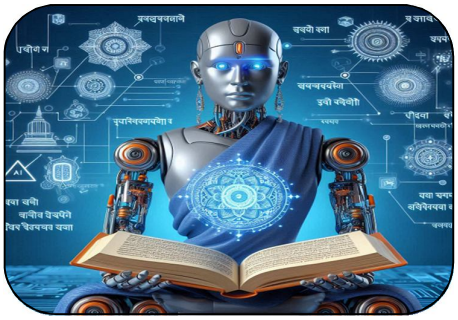
HUMAN-CENTRED AND ETHICAL ARTIFICIAL INTELLIGENCE FOR THE PRESERVATION AND DEMOCRATISATION OF ANCIENT SANSKRIT KNOWLEDGE: CHALLENGES AND OPPORTUNITIES



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ABSTRACT

Ancient Sanskrit literature represents one of the richest intellectual traditions in the world, preserving invaluable knowledge on philosophy, medicine, mathematics, astronomy, governance, linguistics, architecture, and spirituality. Despite its immense cultural and academic significance, a substantial portion of Sanskrit manuscripts remains inaccessible due to physical deterioration, inadequate digitisation, language barriers, and limited public awareness. The emergence of Artificial Intelligence (AI) has created new opportunities for preserving and disseminating this knowledge through Optical Character Recognition (OCR), Natural Language Processing (NLP), Machine Learning (ML), and Large Language Models (LLMs). However, technological advancement alone cannot ensure the authentic preservation of cultural heritage. Ethical concerns such as algorithmic bias, inaccurate translation, transparency, intellectual property rights, and cultural sensitivity require equal attention. This descriptive study examines the role of Human-Centred and Ethical Artificial Intelligence in preserving and democratising ancient Sanskrit knowledge. It discusses the application of AI technologies, highlights major ethical and technological challenges, and explores opportunities for expanding public access to Sanskrit literature.

KEYWORDS: *Human-Centred Artificial Intelligence, Ethical AI, Sanskrit Knowledge, Indian Knowledge Systems, Digital Preservation, Artificial Intelligence, Cultural Heritage.*

INTRODUCTION

India possesses one of the oldest and most diverse knowledge traditions in the world. Sanskrit, often referred to as the language of classical Indian knowledge, has served as the medium for preserving centuries of intellectual achievements in philosophy, literature, Ayurveda, astronomy, mathematics, architecture, music, jurisprudence, and governance. Classical texts such as the Vedas, Upanishads, Puranas, the Mahabharata, the Ramayana, Charaka Samhita, Sushruta Samhita, Arthashastra, Yoga Sutras, and Panini's *Ashtadhyayi* continue to influence contemporary scholarship across multiple disciplines.

The National Mission for Manuscripts estimates that India possesses millions of manuscripts, of which a significant proportion are written in Sanskrit. These manuscripts are preserved in temples, monasteries, universities, libraries, museums, and private collections. Unfortunately, many are vulnerable to deterioration due to climatic conditions, inadequate conservation facilities, insect

damage, and ageing materials. Even manuscripts that have been digitised often remain inaccessible because they lack searchable text, standard metadata, or reliable translations.

Recent advances in Artificial Intelligence have opened new possibilities for addressing these challenges. AI technologies are increasingly being used in cultural heritage preservation to restore damaged manuscripts, recognise historical scripts, generate metadata, perform language analysis, and improve digital accessibility. Optical Character Recognition enables printed and handwritten Sanskrit manuscripts to be converted into machine-readable text. Natural Language Processing supports morphological analysis, semantic indexing, and machine-assisted translation, while machine learning algorithms improve document classification and information retrieval.

However, technological innovation alone cannot guarantee meaningful preservation. Sanskrit texts often contain complex grammatical structures, philosophical interpretations, and culturally embedded meanings that require expert understanding. AI systems trained on insufficient or biased datasets may misinterpret these nuances, resulting in inaccurate translations or misleading interpretations. Consequently, ethical considerations have become central to discussions on AI-enabled cultural preservation.

Human-Centred Artificial Intelligence provides an appropriate framework by placing human expertise, transparency, accountability, inclusiveness, and cultural values at the centre of technological development. Rather than replacing scholars, Human-Centred AI seeks to strengthen collaboration between artificial intelligence systems and domain experts. Such an approach aligns closely with the objectives of the National Education Policy (2020), which emphasises the integration of Indian Knowledge Systems with emerging technologies while promoting multidisciplinary education and digital innovation.

The present study adopts a descriptive approach to examine how Human-Centred and Ethical AI can contribute to the preservation and democratisation of ancient Sanskrit knowledge. It also highlights the importance of responsible governance and collaborative participation among researchers, librarians, Sanskrit scholars, policymakers, and technology developers.

Human-Centred and Ethical Artificial Intelligence in Sanskrit Knowledge Preservation

Artificial Intelligence has evolved from being a computational tool to becoming an important partner in knowledge creation and management. Human-Centred Artificial Intelligence emphasises that AI systems should be designed to enhance human capabilities rather than replace human judgement. According to Shneiderman (2022), Human-Centred AI combines technological innovation with human values such as transparency, accountability, fairness, safety, and collaboration. These principles are particularly relevant when dealing with culturally significant knowledge systems such as Sanskrit.

Unlike modern digital documents, Sanskrit manuscripts present unique computational challenges. Many manuscripts are handwritten and exhibit considerable variation in scripts, including Devanagari, Grantha, Sharada, Nandinagari, Bengali, Telugu, Malayalam, and Tamil scripts. In addition, Sanskrit grammar is characterised by extensive inflection, compound words (*samāsa*), and context-dependent meanings, making automated processing difficult.

AI technologies can nevertheless support preservation in several ways. OCR systems based on deep learning improve the recognition of historical scripts and convert manuscript images into editable text. Image restoration algorithms can reconstruct faded or damaged portions of manuscripts. Natural Language Processing techniques facilitate word segmentation, morphological analysis, syntactic parsing, semantic indexing, and multilingual translation. Knowledge graphs further enhance research by connecting authors, concepts, historical periods, and philosophical schools, allowing users to discover relationships across extensive textual collections.

Despite these technological capabilities, ethical considerations remain indispensable. AI-generated translations or interpretations should never be accepted without scholarly validation. Many Sanskrit terms possess philosophical meanings that vary according to context, tradition, and historical

period. For example, concepts such as *Dharma*, *Yoga*, *Brahman*, or *Atman* cannot be translated accurately through literal word substitution alone. Human expertise therefore remains essential for preserving authenticity.

Ethical AI complements Human-Centred AI by promoting principles such as fairness, explainability, accountability, privacy, inclusiveness, and respect for cultural diversity. UNESCO's Recommendation on the Ethics of Artificial Intelligence (2021) highlights that AI systems should protect cultural heritage while respecting human rights and social values. These principles are equally relevant to Sanskrit preservation, where digitisation initiatives must avoid cultural misrepresentation, algorithmic bias, or commercial exploitation of traditional knowledge.

India has already undertaken several initiatives that illustrate this approach. The National Mission for Manuscripts, the Indira Gandhi National Centre for the Arts (IGNCA), Rashtriya Sanskrit Sansthan (now Central Sanskrit University), IITs, IIIT Hyderabad, and other research institutions have contributed to manuscript digitisation, computational linguistics, and digital archives. These initiatives demonstrate that effective preservation requires collaboration between computer scientists, Sanskrit scholars, archivists, linguists, librarians, and policymakers.

Thus, Human-Centred and Ethical AI should be viewed not merely as a technological innovation but as a multidisciplinary framework that integrates computational efficiency with cultural responsibility. Such an approach ensures that ancient Sanskrit knowledge is preserved authentically, interpreted responsibly, and made accessible to present and future generations.

Challenges in AI-Driven Preservation of Ancient Sanskrit Knowledge

Artificial Intelligence has significantly transformed digital preservation practices; however, applying AI to ancient Sanskrit literature presents several technological, linguistic, ethical, and institutional challenges. These challenges should be carefully addressed.

1. Linguistic Complexity of Sanskrit

Sanskrit is regarded as one of the most systematic languages due to the grammatical framework developed by Panini in the *Ashtadhyayi*. Although its rule-based structure is advantageous for computational analysis, the language poses considerable challenges for AI applications. Sanskrit texts contain complex grammatical forms, extensive inflections, sandhi (euphonic combinations), samasa (compound words), and context-dependent meanings. A single word may have multiple interpretations depending on the philosophical or literary context.

Most AI models are trained primarily on modern languages such as English and Hindi, with comparatively limited high-quality Sanskrit datasets. Consequently, automated translation, semantic analysis, and text summarisation often produce inaccurate or incomplete results. Human expertise therefore remains essential for validating AI-generated outputs.

2. Diversity of Manuscripts and Scripts

India possesses millions of manuscripts written not only in Devanagari but also in scripts such as Grantha, Sharada, Nandinagari, Telugu, Malayalam, Bengali, and Tamil. Many manuscripts have deteriorated because of age, humidity, insects, and improper storage conditions. Faded ink, damaged pages, irregular handwriting, and script variations significantly reduce the accuracy of OCR systems.

Although deep learning has improved manuscript recognition, no single AI model currently performs consistently across all historical scripts. Considerable research is still required to develop multilingual and multiscript OCR systems specifically designed for Indian manuscripts.

3. Limited Digital Resources

Another major challenge is the scarcity of annotated digital corpora. Machine learning algorithms require extensive, high-quality training datasets to achieve reliable performance. However, a large proportion of Sanskrit manuscripts remain uncatalogued or available only as scanned images without machine-readable text.

Many institutions preserve manuscripts using different metadata standards, resulting in fragmented digital collections. The absence of interoperable repositories limits information sharing among libraries, universities, and research organisations. Standardisation of metadata and digitisation practices is therefore essential for building sustainable AI applications.

4. Ethical and Cultural Concerns

Ethical issues are central to AI-enabled preservation of cultural heritage. Sanskrit literature is not merely historical documentation; it represents living traditions associated with philosophy, religion, medicine, performing arts, and indigenous knowledge systems. AI systems trained without cultural understanding may oversimplify or misinterpret important concepts.

For example, philosophical terms such as *Dharma*, *Moksha*, *Atman*, or *Rta* possess layered meanings that cannot always be translated literally. Inaccurate AI-generated interpretations may influence public understanding and academic research negatively.

Another ethical concern relates to ownership of traditional knowledge. Many manuscripts belong to temples, monasteries, families, and indigenous communities. Digitisation initiatives should therefore respect intellectual property rights, cultural protocols, and community participation. Ethical AI requires transparency regarding how digital data are collected, processed, stored, and shared.

5. Shortage of Interdisciplinary Expertise

Effective AI implementation requires collaboration among computer scientists, Sanskrit scholars, librarians, archivists, historians, linguists, and policymakers. Unfortunately, interdisciplinary expertise remains limited. Many AI researchers possess limited knowledge of Sanskrit philology, while traditional scholars may have limited exposure to emerging AI technologies. Bridging this gap through interdisciplinary education and collaborative research is essential for achieving reliable outcomes.

Opportunities for the Democratisation of Sanskrit Knowledge

Despite these challenges, Artificial Intelligence offers unprecedented opportunities for preserving and democratising India's intellectual heritage. Responsible integration of Human-Centred AI can transform Sanskrit knowledge from a specialised academic resource into an accessible public asset.

Large-Scale Digitisation

AI-supported digitisation enables libraries and archives to process thousands of manuscripts more efficiently than conventional manual methods. Image enhancement, automated metadata generation, and OCR technologies reduce the time required for cataloguing and preservation. Institutions such as the National Mission for Manuscripts and the Indira Gandhi National Centre for the Arts have already demonstrated the importance of systematic manuscript digitisation.

Digitised collections reduce dependence on fragile physical manuscripts while ensuring long-term preservation through secure digital repositories.

Enhanced Accessibility

One of the greatest advantages of AI is its ability to improve public access to Sanskrit literature. Intelligent search systems allow users to locate concepts, verses, authors, or themes without reading

entire manuscripts. AI-assisted translation can support learners who are unfamiliar with Sanskrit, while speech technologies can assist visually impaired users.

Such innovations promote educational inclusion and encourage wider engagement with Indian Knowledge Systems among students, researchers, and the general public.

Strengthening Indian Knowledge Systems

The National Education Policy (2020) emphasises integrating Indian Knowledge Systems into higher education and research. AI can support this objective by creating digital learning platforms that connect classical Sanskrit texts with modern disciplines such as medicine, environmental science, astronomy, architecture, ethics, and public policy.

Knowledge graphs and semantic networks can reveal relationships among concepts across different classical texts, encouraging interdisciplinary research and innovation.

Global Research Collaboration

Digital repositories supported by AI enable scholars worldwide to access Sanskrit manuscripts irrespective of geographical location. Collaborative annotation platforms allow researchers from different disciplines to contribute translations, interpretations, and metadata. Such international collaboration strengthens both preservation and academic quality while increasing global recognition of India's intellectual heritage.

Human-Centred AI for Inclusive Preservation

Human-Centred AI ensures that technology remains accountable to human values. Instead of replacing scholars, AI serves as an intelligent assistant that accelerates repetitive tasks such as transcription, indexing, and document restoration. Final scholarly interpretation continues to depend on domain experts.

This collaborative model also encourages participation by librarians, archivists, local communities, and traditional knowledge holders. Their involvement ensures that digitisation efforts remain culturally authentic, ethically responsible, and socially inclusive.

CONCLUSION

Ancient Sanskrit literature represents one of humanity's most valuable intellectual resources, preserving knowledge that continues to influence philosophy, science, medicine, linguistics, mathematics, governance, and cultural studies. However, the preservation of this heritage requires innovative approaches capable of addressing physical deterioration, limited accessibility, and increasing demands for digital scholarship.

Artificial Intelligence has emerged as a transformative technology capable of enhancing manuscript digitisation, script recognition, semantic analysis, translation, and information retrieval. Nevertheless, technological advancement should never replace human scholarly expertise. Human-Centred Artificial Intelligence provides a balanced framework in which AI augments rather than substitutes the knowledge of Sanskrit scholars, librarians, archivists, and cultural experts.

Ethical AI further strengthens this framework by promoting transparency, accountability, fairness, explainability, inclusiveness, and cultural sensitivity. These principles ensure that AI applications preserve the authenticity of Sanskrit knowledge while respecting traditional knowledge systems and community values.

India's ongoing initiatives through the National Education Policy 2020, the National Mission for Manuscripts, the Indira Gandhi National Centre for the Arts, and Indian Knowledge Systems programmes demonstrate significant progress towards integrating digital technologies with cultural

preservation. Continued collaboration among academic institutions, government agencies, technology developers, and traditional knowledge communities will further enhance these efforts.

In conclusion, Human-Centred and Ethical Artificial Intelligence offers a sustainable pathway for preserving and democratising ancient Sanskrit knowledge. By combining technological innovation with ethical governance and scholarly participation, AI can ensure that India's rich intellectual heritage remains accessible, authentic, and relevant for future generations.

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