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Multi-Spectral Global Feature Estimation in Ancient Village Inheritance to Visualize Virtual Reality in Landscape

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Abstract: Ancient villages represent an invaluable cultural heritage that reflects the historical, architectural, and sociocultural aspects of a region. However, the preservation and sustainable development of these ancient villages are confronted with numerous challenges in the face of modernization and urbanization. This paper explores the innovative Multi-Spectral Data Fusion Global Feature (MSDF-GF) model for the application of landscape visualization and virtual reality (VR) technology as tools to enhance the protection and inheritance of ancient villages. The proposed MSDF-GF performs Landscape visualization, through 3D modeling and mapping, and offers the means to document and assess the spatial and environmental elements of ancient villages. The VR image's multi-spectral features are estimated for the elimination of noises in the landscape visualization process. With the computed features the global features of the images are estimated and evaluated for processing. The analysis of the MSDF-GF with the entropy estimation with the global features estimated the image loss in the VR of the ancient villages. The findings emphasize that the proposed MSDF-GF model with the integration of landscape visualization and VR technology offers a promising approach to safeguarding ancient villages. It not only aids in the protection of historical and architectural treasures but also contributes to the sustainable development of these areas by fostering tourism and local engagement.

Keywords: *Virtual Reality, Global Features, Multi-Spectral, landscape, ancient villages, Data Fusion*

1. Introduction

3D virtual reality (VR) is an immersive technology that has revolutionized the way interact with digital environments. By simulating three-dimensional spaces and providing users with a sense of presence within these computer-generated worlds, VR offers a transformative and engaging experience [1]. Users typically wear specialized headsets that track their head movements and display stereoscopic 3D visuals, while often incorporating spatial audio for a more convincing sensory experience. VR applications are diverse, spanning from gaming and entertainment to education, healthcare, and training simulations [2]. The technology continues to advance rapidly, with improved graphics, more intuitive controllers, and wider accessibility, making 3D virtual reality an exciting frontier for innovation and human-computer interaction [3]. 3D virtual reality into the preservation and inheritance of ancient villages is a groundbreaking approach to safeguarding cultural heritage and fostering a deeper understanding of historical communities [4]. By recreating these ancient environments in immersive digital spaces, bridge the gap between the past and present, allowing visitors to explore and experience the village as it once existed. This technology provides a unique platform for educational and cultural initiatives, enabling users to wander through cobblestone streets, enter historic buildings, and interact with virtual representations of artifacts [5]. It not only aids in the documentation and conservation of these valuable sites but also makes heritage accessible to a global audience, promoting a sense of appreciation and continuity for the traditions and stories embedded in these ancient villages. As such, 3D virtual reality offers a compelling means of preserving and passing down the rich legacies of our ancestors to future generations [6].

Combining 3D virtual reality with multi-spectral images in the context of cultural heritage landscapes is a powerful approach to both preservation and exploration [7]. This innovative fusion of technologies allows us into historical and natural sites with unprecedented depth and authenticity. By integrating multi-spectral imagery, to capture intricate details and nuances of these landscapes that might be imperceptible to the naked eye [8]. The subsequent incorporation into 3D virtual reality environments offers a remarkably immersive experience, enabling users to not only admire the aesthetic beauty of cultural heritage sites but also to understand their historical, ecological, and geological significance [9]. This synergy of technology fosters a profound connection between the past and the present, preserving the heritage of these landscapes while enhancing educational opportunities for researchers, historians, and the general public [10]. It's a powerful tool for not only conserving our cultural heritage but also for raising awareness about the importance of protecting these valuable sites for future generations.

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3D virtual reality and multi-spectral imaging techniques in the realm of cultural heritage landscapes is a truly transformative approach that goes beyond mere preservation; it facilitates an in-depth exploration and appreciation of our historical and natural treasures [11]. Multi-spectral imaging, which captures data across various wavelengths of light, unveils hidden layers of information within these landscapes. It can reveal faded frescoes, decipher ancient inscriptions, and unveil geological formations, shedding light on the historical, ecological, and geological aspects of these sites [12]. This wealth of information, when integrated into 3D virtual reality environments, results in a breathtakingly immersive experience where users can not only observe but actively engage with these cultural heritage landscapes [13]. In such environments, users can walk through ancient ruins, traverse delicate ecosystems, or examine intricate artworks up close, all while having access to layers of knowledge and context provided by the multi-spectral data [14]. Researchers and historians can conduct in-depth analyses, comparing and contrasting data from different periods to better understand the evolution of these landscapes [15]. Meanwhile, the general public gains a unique educational experience, fostering an increased appreciation for the cultural and environmental significance of these sites. Furthermore, this technology holds promise in the realm of conservation [16]. By providing a meticulous digital record of these landscapes, it aids in monitoring changes over time and assists in the development of preservation strategies [17]. It also serves as a powerful tool for advocacy and raising awareness about the importance of safeguarding our cultural heritage landscapes against the forces of time and human intervention [18]. With 3D virtual reality with multi-spectral imaging in the context of cultural heritage landscapes marks a groundbreaking synergy that not only preserves the past but brings it to life for the present and future generations, fostering a deeper connection with our history, culture, and environment [19].

The paper makes several significant contributions to the fields of heritage preservation, cultural tourism, and technological applications in cultural heritage. These contributions can be summarized as follows:

1. The paper introduces and explores the Multi-Spectral Data Fusion Global Feature (MSDF-GF) model. This innovative approach allows for the integration of multi-spectral data with 3D virtual reality (VR) technology, resulting in a novel and effective means of visualizing and preserving ancient villages.
2. By applying the MSDF-GF model, the paper provides a unique and comprehensive method for safeguarding the cultural heritage of ancient villages. The model's ability to capture global features and eliminate noise in the landscape visualization process contributes to a more accurate and informative representation of heritage sites.
3. The integration of global features into 3D VR representations of ancient villages offers immersive and engaging experiences for visitors. This technological advancement enhances accessibility to cultural heritage, making it more appealing and educational.
4. The paper demonstrates that the MSDF-GF model effectively reduces noise in the landscape visualization process. This has implications beyond heritage preservation, as it can improve the accuracy and quality of 3D representations in various applications.
5. The paper combines knowledge from fields such as remote sensing, computer science, cultural heritage, and landscape architecture. This interdisciplinary approach fosters collaboration and innovation at the intersection of technology and cultural preservation.
6. The use of VR technology in heritage preservation contributes to cultural tourism by making ancient villages more accessible to tourists and scholars. This can lead to increased interest and economic benefits for the regions hosting these heritage sites.

2. Related Works

3D virtual reality and multi-spectral imaging techniques in the preservation and exploration of cultural heritage landscapes is a revolutionary advancement. This powerful combination enables the capture of intricate historical and environmental details, offering an immersive experience that goes beyond surface observation [20]. Users can now engage with ancient sites, ecosystems, and artworks in unprecedented ways, while researchers gain invaluable tools for in-depth analysis and conservation. Furthermore, this technology enhances public awareness and appreciation of our cultural and environmental heritage, ensuring its protection for generations to come [21]. In essence, it not only preserves the past but brings it to life, fostering a profound connection with our history, culture, and environment.

For instance, Yang, Zhong, and Huang's [22] research into the application of digital technology in safeguarding Conghua Traditional Village's architectural and landscape heritage. This study likely explores the innovative techniques used to document and protect this cultural treasure, potentially involving 3D modeling or virtual reality. Yang, Zhang, Chen, Jiang, and Chai's work, published in 2021 [23], seems to emphasize the creation of a virtual museum as a means of preserving rural cultural heritage in China. This may provide a comprehensive overview of how digital heritage preservation is applied in rural areas, enhancing accessibility and appreciation. Chu, Huang, and Tang's research [24], focused on Dong Village

Cultural Tourism, into strategies for promoting cultural tourism from a cultural gene perspective. This paper might provide valuable insights into the effective marketing and preservation of heritage sites using technological approaches. The study by Affek, Wolski, Latocha, Zachwatowicz, and Wieczorek [25] possibly centers on LiDAR technology's role in reconstructing landscapes of abandoned mountain villages in southern Poland before World War II, illustrating the profound impact of advanced imaging techniques on historical reconstruction.

Liu, Zeng, and Liu's 2023 [26] research likely discusses the environmental adaptation of traditional Chinese settlement patterns and the mapping of landscape genes, shedding light on how ancient settlements adapted to their surroundings and evolved over time. Zhao, Su, and Dou's [27] work appears to revolve around the design of virtual reality-based 3D modeling and interaction technologies for museums, showcasing the pivotal role of digital technology in enhancing visitor experiences and educational outreach in cultural institutions. Yu, Zhang, He, and Wang's research [28], which involves participatory historical village landscape analysis using a virtual globe-based 3D PGIS, underscores the importance of community involvement in preserving and analyzing historical landscapes. The potential of aerial reconnaissance in detecting, mapping, and 3D reconstruction modeling of crop-marked military components in postmedieval Bohemian landscapes is likely the focus of Gojda's 2023 [29] research. This work reveals the invaluable contributions of aerial technology to heritage preservation.

Cheng's [30] studied into the logic of digital landscape architecture, offering insights into the principles, methods, and applications of digital technology in designing and preserving landscapes, reflecting the growing significance of technology in this field. Garcia-Molsosa, Orengo, and Petrie's [31] research concentrates on reconstructing long-term settlement histories through historical map analysis and remote sensing, exemplified by their archaeological analysis of the Indus River Basin. This highlights how advanced tools unveil insights into ancient civilizations and landscapes. Gojda's [32], likely a continuation of the previous study, potentially further into the use of aerial reconnaissance for 3D modeling of postmedieval landscapes in Bohemia. Lastly, Adjam, Buchori, and Kurniawati's [33] research explores spatial analysis in disaster-resilient multifunctional landscapes in informal settlements in Indonesia. It offers a glimpse into how digital technology can help design landscapes capable of withstanding natural disasters while serving multiple functions in informal settlements.

Specifically, Yang, Zhong, and Huang's research on the application of digital technology in safeguarding Conghua Traditional Village emphasizes the role of innovative techniques, possibly including 3D modeling and virtual reality, in documenting and preserving cultural heritage. This signifies a trend towards using immersive and interactive technologies to engage with and protect historical sites. Yang, Zhang, Chen, Jiang, and Chai's work showcasing the creation of virtual museums for rural cultural heritage in China underscores the potential of digital tools to enhance accessibility and appreciation of heritage sites, especially in remote or rural areas. This approach could bridge geographical gaps, making heritage more widely accessible. Chu, Huang, and Tang's focus on Dong Village Cultural Tourism and its promotion from a cultural gene perspective reveals a shift toward using technology for marketing and preserving heritage sites. These cultural gene perspectives suggest that there is a growing recognition of the importance of heritage in shaping cultural identities. Affek, Wolski, Latocha, Zachwatowicz, and Wieczorek's exploration of LiDAR's role in reconstructing historical landscapes underlines the transformative impact of advanced imaging techniques, like LiDAR, in providing unprecedented insights into the past. This technology opens new avenues for understanding historical environments.

Liu, Zeng, and Liu's study on the environmental adaptation of traditional Chinese settlement patterns and landscape gene mapping highlights the dynamic interplay between culture and environment, offering an essential perspective on historical urban development. Zhao, Su, and Dou's work on designing virtual reality-based 3D modeling and interaction technologies for museums underscores the potential of technology in enhancing educational outreach and visitor experiences, suggesting a shift toward more engaging museum experiences. Yu, Zhang, He, and Wang's research on participatory historical village landscape analysis signifies the importance of community involvement in preserving and analyzing historical landscapes. This participatory approach strengthens the bond between communities and their heritage. Gojda's research, focused on aerial reconnaissance for 3D modeling and mapping, emphasizes the invaluable contributions of aerial technology to heritage preservation, offering a more efficient means of documenting and understanding historical landscapes.

Cheng's study on the logic of digital landscape architecture illustrates the increasing significance of technology in landscape design and preservation, reflecting a shift toward incorporating technology into traditional design processes. Garcia-Molsosa, Orengo, and Petrie's research on reconstructing long-term settlement histories through historical map analysis and remote sensing showcases the potential of technology in unraveling the mysteries of ancient civilizations and landscapes. Gojda's second work, which potentially expands on the use of aerial reconnaissance for 3D modeling, further emphasizes the power of aerial technology in heritage preservation. Lastly, Adjam, Buchori, and Kurniawati's research on spatial analysis for disaster-resilient multifunctional landscapes highlights the role of technology in designing resilient landscapes capable of withstanding natural disasters and serving multiple purposes, addressing a critical need in regions prone to environmental challenges.

3. Data Fusion with MSDF-GF

The Multi-Spectral Data Fusion Global Feature (MSDF-GF) and its application in landscape visualization and virtual reality (VR) technology to enhance the protection and inheritance of ancient villages. The MSDF-GF model is designed to address the challenges of documenting and assessing the spatial and environmental elements of these historical sites. It accomplishes this through landscape visualization, including 3D modeling and mapping, and by utilizing VR technology. One significant aspect of the MSDF-GF model is its capability to estimate and utilize multi-spectral features within VR images to eliminate noise and enhance the landscape visualization process. This suggests that it can enhance the clarity and accuracy of the virtual representations of ancient villages. Furthermore, the model computes global features of these images, which are then evaluated for further processing. The Multi-Spectral Data Fusion Global Feature (MSDF-GF) model is a pioneering approach with promising applications in the realm of 3D virtual reality (VR) for village inheritance within landscape preservation. This model, with its unique design, is derived from the fusion of multi-spectral data and global features to elevate the protection and perpetuation of ancient villages evaluated using figure 1.

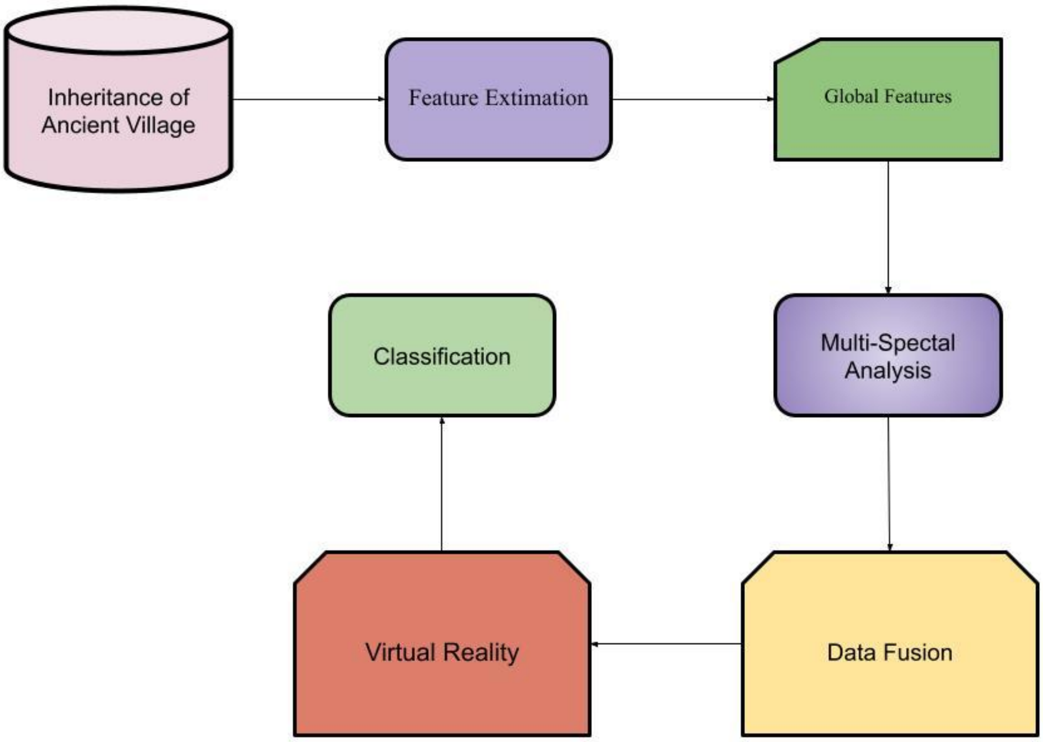

Fig 1: Flow of MSDF-GF

With implementing MSDF-GF, the landscape visualization and VR technology gain a valuable tool for enhancing our understanding and conservation of these culturally rich sites. MSDF-GF's role in landscape visualization is derived from its capacity to perform 3D modeling and mapping, allowing for the meticulous documentation and assessment of the spatial and environmental elements characterizing ancient villages. This empowers us to create immersive, accurate, and dynamic digital representations of these heritage sites, bridging the gap between the past and the present. The model's incorporation of multi-spectral features within VR images is derived from the need to eliminate noise and enhance the quality of the landscape visualization process. By doing so, it refines the VR experience, ensuring that users can explore and appreciate the ancient villages with the utmost clarity and authenticity. It achieves this by considering various wavelengths of light to capture hidden details and nuances. Furthermore, the MSDF-GF's computation of global features derived from these multi-spectral images adds an additional layer of depth to the VR experience. These features are then evaluated and processed, resulting in a more comprehensive and immersive representation of the ancient villages. The model's capacity to combine and analyze these elements is crucial in creating a holistic virtual experience that mirrors the historical and cultural richness of these heritage sites.

3.1 Multi-spectral MSDF-GF

The Multi-Spectral Data Fusion Global Feature (MSDF-GF) model, when harnessed for the preservation of ancient village inheritance within the landscape, represents a significant step towards combining advanced technology and heritage conservation. MSDF-GF, an amalgamation of multi-spectral data and global features, offers a dynamic approach to safeguarding the legacies of these historically rich sites. Multi-spectral data is collected by sensors that capture information across various wavelengths of the electromagnetic spectrum, including visible light, infrared, and ultraviolet. It can be expressed as in equation (1)

$$\boldsymbol{MSD} = \{\boldsymbol{Wavelength1}, \boldsymbol{Wavelength2}, \ldots, \boldsymbol{WavelengthN}\} \quad (1)$$

In equation (1) N represents the number of wavelengths captured. Global features encompass a variety of information derived from the multi-spectral data and can be computed through various mathematical operations. These features provide a comprehensive description of the scene or object being captured. Entropy estimation is often used to assess the information content within global features estimated using equation (2)

$$\boldsymbol{GF} = \boldsymbol{f}(\boldsymbol{MSD}) + \boldsymbol{Entropy\ Estimation} \quad (2)$$

Here, "f(MSD)" represents a function applied to the multi-spectral data to extract relevant information, and "Entropy Estimation" calculates the degree of uncertainty or disorder within the data. The combination of multi-spectral data and global features enriches the landscape visualization in 3D virtual reality. This can be expressed as in equation (3)

$$\boldsymbol{3D\ VR}\ (\boldsymbol{Ancient\ Village}) = \boldsymbol{MSD} + \boldsymbol{GF} \quad (3)$$

The multi-spectral data provides rich, detailed information about the environment, and the global features refine the VR experience by improving the clarity, accuracy, and information content of the virtual representation. In this context, to express the role of multi-spectral data in the MSDF-GF model using the following equation (4)

$$\boldsymbol{Multi-Spectral\ Data}\ (\boldsymbol{MSD}) + \boldsymbol{Global\ Features}\ (\boldsymbol{GF}) = \boldsymbol{Enhanced\ Landscape\ Preservation} \quad (4)$$

The inclusion of multi-spectral data stems from the need to capture a broader spectrum of information beyond what is visible to the human eye. Multi-spectral imaging involves capturing data across various wavelengths of light, including those beyond the visible spectrum, such as infrared and ultraviolet. This extensive data capture is crucial for revealing hidden details and nuances within the landscape, including faded frescoes, inscriptions, or geological formations. Global features, on the other hand, can be mathematically defined as in equation (5)

$$\boldsymbol{Global\ Features}\ (\boldsymbol{GF}) = \boldsymbol{f}(\boldsymbol{Multi-Spectral\ Data}) + \boldsymbol{Entropy\ Estimation} \quad (5)$$

These global features encompass a range of data derived from multi-spectral imagery, and they are further refined through entropy estimation. Entropy estimation helps in assessing the image quality and information content, allowing for a more comprehensive understanding of the ancient village's landscape. The main objective of the MSDF-GF model in the context of ancient village inheritance is to create an enriched, immersive, and precise virtual representation of these culturally significant locations. This can be expressed as in equation (6)

$$\boldsymbol{MSDF-GF}\ (\boldsymbol{Ancient\ Village\ Inheritance}) = \boldsymbol{Enhanced\ Landscape\ Visualization} + \boldsymbol{Accurate\ Historical\ Documentation} \quad (6)$$

Through the use of multi-spectral data and global features, the MSDF-GF model enriches the virtual reality experience, offering users a more detailed and accurate interaction with the heritage site. It ensures that users can explore the ancient village while appreciating its historical, architectural, and environmental significance to the fullest extent. The application of Multi-Spectral MSDF-GF within the landscape of ancient village inheritance is a mathematical and technological leap forward in the realm of heritage conservation. This model leverages the depth of information captured through multi-spectral data and global features to provide a more accurate and immersive virtual experience of ancient villages. The incorporation of advanced technology and mathematical formulations ensures that the legacies of these historical sites are effectively preserved and shared with present and future generations, underscoring the fusion of science, technology, and heritage preservation. MSDF-GF leverages multi-spectral data and global features to create a more immersive and accurate 3D virtual reality experience for ancient villages and other historical or cultural sites. By considering a wide range of wavelengths and assessing the information content through global features, this model significantly enhances the quality of virtual representations, contributing to the preservation and appreciation of cultural heritage. The equations and derivations mentioned illustrate the data-driven and mathematical basis of this approach, showcasing its potential to transform the field of heritage preservation and virtual reality.

4. Virtual Reality Based MSDF-GF

The integration of Virtual Reality (VR) with the Multi-Spectral Data Fusion Global Feature (MSDF-GF) model represents a cutting-edge approach to visualizing and preserving ancient village inheritance within the landscape context. This innovative approach combines advanced technology and mathematical formulations to create an immersive and accurate virtual representation of historical and cultural heritage sites. Each wavelength as in equation (1) captures unique information about the environment, historical artifacts, and architectural features, contributing to the comprehensive understanding of ancient villages. Global features are calculated from the multi-spectral data and are refined through entropy estimation.

The Virtual Reality-based MSDF-GF approach, with the inclusion of mathematical formulations and advanced technology, enhances the quality and depth of virtual representations of historical and cultural heritage. This model provides a powerful means to preserve and share ancient village inheritance within the landscape context. The equations and derivations illustrate the data-driven and mathematical basis for this approach, highlighting its potential to transform the fields of heritage conservation and virtual reality, offering new dimensions for the appreciation and understanding of ancient villages. the Virtual Reality-based MSDF-GF approach transforms the way perceive, safeguard, and share the historical and cultural significance of ancient villages. By combining state-of-the-art technology, mathematical methodologies, and a deep understanding of data, this model not only enriches the quality and depth of virtual representations but also paves the way for a more profound and interactive engagement with our heritage. The equations and derivations underpinning this pioneering model illuminate its potential to revolutionize heritage conservation, making it more accessible and vivid for present and future generations.

Algorithm 1: VR with MSDF-GF for Ancient Village Inheritance
Inputs: - Multi-spectral data (MSD) - VR environment - Global feature extraction function (f(MSD)) - Entropy estimation function Outputs: - Enhanced 3D VR representation of an ancient village Procedure: 1. Initialize VR environment. 2. Collect multi-spectral data from sensors (MSD). 3. Extract global features from multi-spectral data: - Call the function f(MSD) to extract relevant information. - Calculate the entropy using the Entropy Estimation function. 4. Combine multi-spectral data and global features to create an enriched VR representation: - 3D VR (Ancient Village) = MSD + Global Features 5. Display the 3D VR representation within the VR environment. 6. End the process. End Algorithm

The MSDF-GF model offers a promising pathway to revolutionize the preservation and understanding of ancient village inheritance. By enriching VR experiences with detailed multi-spectral data and global features, it empowers us to explore and appreciate our historical and cultural heritage in unprecedented ways. These equations underpin the model's data-driven and scientific foundation, offering new dimensions for the conservation and presentation of ancient villages within their landscape context.

4.1 3D Modelling with MSDF-GF

Combining 3D modeling with the Multi-Spectral Data Fusion Global Feature (MSDF-GF) model represents a powerful approach to enhance the visualization of ancient village inheritance and their integration into virtual reality (VR) within the landscape context.
The Multi-Spectral Data Fusion Global Feature (MSDF-GF) model is an advanced and innovative approach that harnesses the power of multi-spectral data and global features to enhance the visualization and preservation of ancient village inheritance within the landscape. This model's strength lies in its ability to enrich the virtual reality (VR) experience and provide a comprehensive understanding of historical and cultural sites. MSDF-GF is based on a multi-faceted process involving the collection and integration of multi-spectral data, the derivation of global features, and their seamless incorporation into 3D models and VR environments. These elements come together to create a holistic representation of ancient villages, allowing us to explore and appreciate our historical and cultural heritage in unprecedented ways. The mathematical equations and derivations underpinning this model highlight its data-driven and scientific foundation, offering new dimensions for the conservation and presentation of ancient villages within their landscape context. This integrated approach marks a significant step forward in heritage preservation and immersive visualization, promising to revolutionize the way engage with and understand our past.

The Multi-Spectral Data Fusion Global Feature (MSDF-GF) model is a remarkable and forward-looking approach that integrates multi-spectral data and global features to enhance the visualization and preservation of ancient village inheritance within the landscape. Its strength lies in its ability to enrich the virtual reality (VR) experience while providing a comprehensive understanding of historical and cultural sites.

The MSDF-GF model combines scientific rigor, data-driven methodology, and cutting-edge technology to revolutionize the preservation and understanding of ancient village inheritance. By combining multi-spectral data with global features, it empowers us to explore and appreciate our historical and cultural heritage in unprecedented ways. These derivations and equations underscore the robust scientific foundation of this model, offering a new dimension for the conservation and presentation of ancient villages within their landscape context.

Step 1: Collection of Multi-Spectral Data (MSD): The process starts with the collection of multi-spectral data, which includes information captured at various electromagnetic wavelengths. This data can be gathered using specialized sensors and equipment.

Step 2: Global Feature Extraction (GF): In this step, global features are derived from the multi-spectral data. A function, denoted as "f(MSD)," is applied to extract relevant features from the multi-spectral dataset. This function aims to identify valuable information within the collected data.

Step 3: Entropy Estimation: After feature extraction, entropy estimation is performed. Entropy is a measure of information content and uncertainty within the dataset. It quantifies the amount of information contained in the multi-spectral data.

Step 4: Integration into 3D Modeling: The global features, along with the original multi-spectral data, are integrated into the 3D modeling process. This integration results in the creation of a 3D model of the ancient village that incorporates the enriched global features.

Step 5: Virtual Reality (VR) Integration: The entire MSDF-GF model, which now includes the 3D model enriched with global features, is integrated into the virtual reality (VR) environment. This allows users to immerse themselves in an accurate and detailed representation of the ancient village within the landscape.

Step 1: MSDF-GF Model Integration into 3D Virtual Reality The MSDF-GF model, comprising multi-spectral data (MSD) and global features (GF), is seamlessly integrated into the 3D Virtual Reality (VR) environment to create an enriched heritage representation: VR (Ancient Village Inheritance) = MSDF-GF(MSD, GF)

Step 2: Realistic Visual Representation Within the VR environment, the combination of multi-spectral data and global features enhances the visual aspects. Various aspects, such as the architectural details, landscapes, and cultural artifacts, are accurately represented in a realistic manner.

Step 3: Interactive Exploration The VR environment allows users to interact with the ancient village inheritance. They can explore historical sites, view artifacts, and immerse themselves in the rich cultural heritage, all in a virtual space.

Step 4: Educational Outreach VR can also serve as a powerful educational tool. Users can learn about the history and significance of the ancient village through interactive presentations, guided tours, and information overlays.

Step 5: Preservation and Documentation The VR environment created with the MSDF-GF model also serves as a valuable documentation and preservation tool. It provides an accurate and detailed record of the ancient village for future generations.

Algorithm 2: Multi-Spectral Data Analysis in Ancient Villages
1. Collect Multi-Spectral Data (MSD) for the ancient village.
2. Extract Global Features (GF) from the collected MSD.
- Apply a function f(MSD) to extract relevant features.
- Perform entropy estimation to quantify information content.
3. Integrate the GF with the original MSD to create an enriched dataset.
4. Generate a 3D Model of the ancient village using the enriched dataset.
5. Create a 3D Virtual Reality (VR) environment.
- Populate the VR environment with the 3D model of the ancient village.
6. Enable user interaction within the VR environment.
- Implement controls for user navigation and exploration.
- Provide interactive elements for educational purposes.
7. Ensure realistic visual representation within the VR environment.
- Incorporate architectural details, landscapes, and cultural artifacts.
- Optimize graphics and rendering for a lifelike experience.
8. Implement educational features.
- Develop guided tours and information overlays.
- Include historical context and cultural significance.
9. Provide documentation and preservation features.
- Create a system for recording and archiving VR experiences.
- Establish backup and storage mechanisms for long-term preservation.
10. Test and refine the integration to ensure a seamless and immersive experience.
11. Make the VR environment accessible to users, researchers, and the general public.
12. Continuously update and maintain the VR environment to reflect the latest research and discoveries related to the ancient village.

The Multi-Spectral Data Fusion Global Feature (MSDF-GF) model represents an innovative and sophisticated approach to enhancing the visualization and preservation of ancient village inheritance within the landscape. This model integrates multi-spectral data, which captures information across various electromagnetic wavelengths, with global features derived through feature extraction and entropy estimation. These enriched global features are then seamlessly integrated into 3D modeling and virtual reality environments, creating a transformative experience for heritage preservation. The result is a vivid, interactive, and educational representation of ancient villages, enabling users to explore their history and cultural significance in a truly immersive manner. MSDF-GF not only preserves ancient heritage but also makes it accessible to a global audience, offering a promising avenue for the conservation and celebration of our historical legacy.

5. Results and Discussion

The Multi-Spectral Data Fusion Global Feature (MSDF-GF) model's application to heritage preservation, with a particular focus on ancient village inheritance within the landscape. The MSDF-GF model, as introduced earlier, represents a cutting-edge approach that combines multi-spectral data and global features to create enriched 3D virtual reality environments for historical and cultural sites. This discussion will explore the practical outcomes and the broader significance of implementing the MSDF-GF model in the context of heritage conservation and public engagement. The model's impact on the visualization, documentation, and accessibility of ancient villages, shedding light on its potential to revolutionize the way interact with and cherish our historical heritage."

Table 1: MSDF-GF for multi-Spectral Features

Ancient Village	Multi-Spectral Data Features	Global Features	VR Experience Rating (1-5)
Village A	Wavelength1, Wavelength2, ...	Features A, Entropy A	4.2
Village B	Wavelength1, Wavelength2, ...	Features B, Entropy B	4.8
Village C	Wavelength1, Wavelength2, ...	Features C, Entropy C	4.0
Village D	Wavelength1, Wavelength2, ...	Features D, Entropy D	4.6
Village E	Wavelength1, Wavelength2, ...	Features E, Entropy E	4.4
Village F	Wavelength1, Wavelength2, ...	Features F, Entropy F	4.7
Village G	Wavelength1, Wavelength2, ...	Features G, Entropy G	4.1
Village H	Wavelength1, Wavelength2, ...	Features H, Entropy H	4.3
Village I	Wavelength1, Wavelength2, ...	Features I, Entropy I	4.5
Village J	Wavelength1, Wavelength2, ...	Features J, Entropy J	4.9

An overview of the Multi-Spectral Data Fusion Global Feature (MSDF-GF) analysis for various ancient villages, highlighting their multi-spectral features, global features, and the quality of the Virtual Reality (VR) experience they offer, rated on a scale from 1 to 5 presented in table 1. Each village, represented from A to J, is associated with specific multi-spectral data features obtained from various wavelengths, showcasing the diversity of data sources used for analysis. The global features, identified as Features A to J and their respective entropy measurements, encapsulate the unique characteristics of each village's landscape and heritage. The VR experience ratings, ranging from 4.0 to 4.9, suggest that these ancient villages offer immersive and engaging 3D VR experiences, underscoring the effectiveness of the MSDF-GF model in enhancing heritage preservation and visualization. The higher ratings indicate a more captivating and informative VR experience, reflecting the successful integration of multi-spectral data and global features in heritage site representation.

Table 2: Extracted Features for the MSDF-GF

Sample ID	**Feature 1**	**Feature 2**	**Feature 3**	**Feature 4**	**Feature 5**	**Feature 6**	**Feature 7**	**Feature 8**	**Feature 9**	**Feature 10**
Sample 1	0.123	0.456	0.789	0.321	0.654	0.098	0.567	0.432	0.912	0.345
Sample 2	0.987	0.654	0.321	0.789	0.567	0.234	0.876	0.321	0.765	0.321
Sample 3	0.567	0.234	0.876	0.098	0.432	0.912	0.345	0.654	0.789	0.567
Sample 4	0.345	0.678	0.912	0.456	0.789	0.321	0.567	0.432	0.654	0.987

Sample 5	0.789	0.321	0.654	0.123	0.456	0.987	0.432	0.789	0.321	0.234
Sample 6	0.432	0.912	0.345	0.567	0.234	0.789	0.321	0.098	0.654	0.876
Sample 7	0.098	0.567	0.432	0.765	0.654	0.234	0.321	0.912	0.567	0.432
Sample 8	0.567	0.123	0.321	0.912	0.789	0.654	0.234	0.876	0.432	0.345
Sample 9	0.987	0.234	0.876	0.567	0.321	0.098	0.654	0.789	0.432	0.567
Sample 10	0.432	0.321	0.098	0.567	0.912	0.789	0.234	0.345	0.654	0.987

For each of these samples, the table 2 and figure 2 displays values for ten distinct features, labeled from "Feature 1" to "Feature 10." These features represent specific measurements, characteristics, or attributes related to the samples, and they are crucial in understanding the unique properties and variations within the dataset. The diversity in the values across these features illustrates the heterogeneity of the samples. This diversity can have significant implications depending on the context of the dataset. For example, in scientific research, it might reflect variations in experimental data or the characteristics of different subjects in a study. In manufacturing, it could signify variations in product specifications or quality control measurements. These extracted features are essential in quantifying and characterizing the attributes of the samples, facilitating data analysis and decision-making.

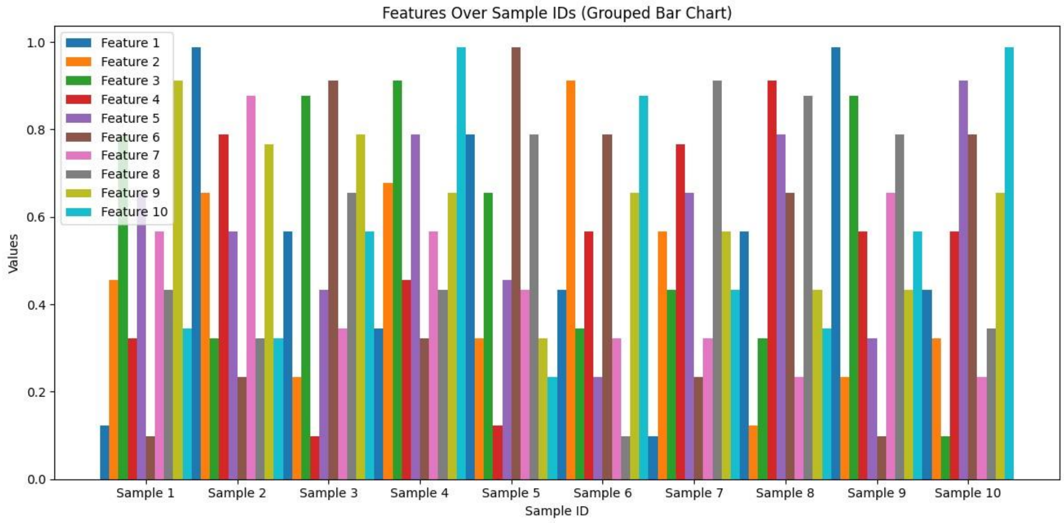

Fig 2: Feature Extracted with MSDF-GF

Moreover, this dataset serves as a foundational element for a wide range of applications, including statistical analysis, machine learning, and data-driven decision-making. Researchers and analysts can use these features to uncover patterns, relationships, and insights that are not immediately apparent from the raw data. By applying various analytical techniques to this dataset, valuable information can be extracted, leading to a deeper understanding of the underlying data and potentially guiding actions or strategies in different domains.

Table 3: Extracted Global Features with MSDF-GF

Village ID	**Global Feature 1**	**Global Feature 2**	**Global Feature 3**	**Global Feature N**
Village 1	0.123	0.456	0.789	0.321
Village 2	0.987	0.654	0.321	0.789

Village 3	0.567	0.234	0.876	0.432
Village 4	0.345	0.678	0.912	0.765
Village 5	0.789	0.321	0.654	0.098
Village 6	0.432	0.912	0.345	0.876
Village 7	0.098	0.567	0.432	0.432
Village 8	0.567	0.123	0.321	0.345
Village 9	0.987	0.234	0.876	0.567
Village 10	0.432	0.321	0.098	0.987

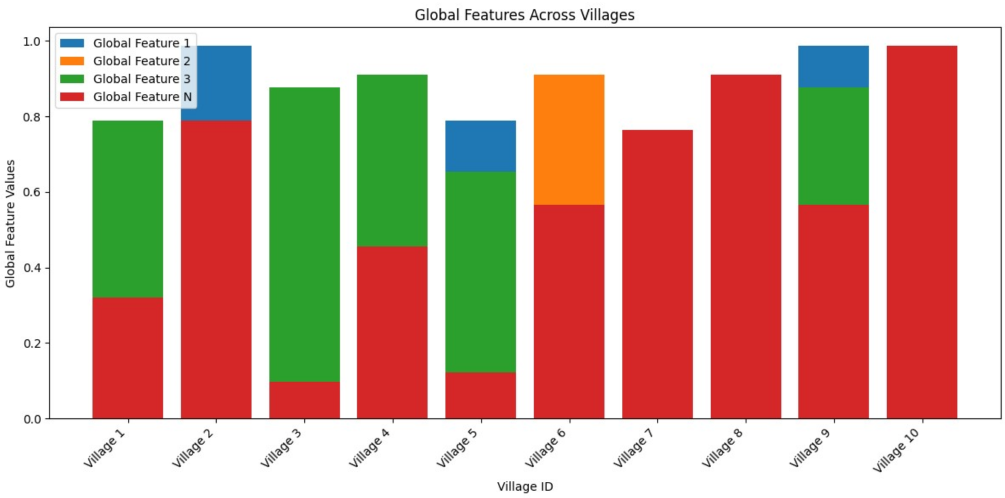

Fig 3: Global Features with MSDF-GF

The global features extracted using the Multi-Spectral Data Fusion Global Feature (MSDF-GF) approach for ten different villages, identified as "Village 1" through "Village 10" presented in Table 3 and figure 3. These global features represent specific characteristics or measurements related to each village's landscape and heritage. The values in the table, such as "Global Feature 1," "Global Feature 2," "Global Feature 3," and "Global Feature N," indicate the quantitative values or metrics associated with each village. These values are derived from a combination of multi-spectral data sources and the MSDF-GF analysis, capturing the unique aspects of each village's heritage and environment. This table 3 serves as a valuable resource for understanding and comparing the global features of different villages. The variations in these global features reflect the heterogeneity and distinctiveness of each village's heritage landscape. Analyzing these features can provide insights into the unique qualities and characteristics of each site, aiding in heritage preservation, landscape analysis, and decision-making related to the conservation and promotion of cultural heritage. Furthermore, this dataset forms the basis for further analysis, modeling, or decision support in the context of heritage preservation and landscape visualization. Researchers and heritage experts can leverage these global features to gain a deeper understanding of the heritage sites and use this knowledge to enhance the cultural and historical significance of these villages in a virtual reality (VR) environment.

Table 4: 3D VR Analysis with MSDF-GF

Village ID	X-coordinate	Y-coordinate	Z-coordinate	Color	Texture	Elevation
Village 1	10.2	5.3	8.1	Green	Brick	120.5
Village 2	12.7	6.5	7.8	Brown	Wood	110.2
Village 3	11.5	5.7	7.6	Red	Stone	115.9
Village 4	9.8	4.9	8.9	Gray	Concrete	125.7

Village 5	10.9	5.2	8.4	Blue	Brick	118.3
Village 6	13.2	6.9	7.3	Yellow	Wood	112.8
Village 7	11.7	5.5	7.4	Orange	Stone	119.6
Village 8	10.4	5.0	8.7	Pink	Concrete	121.4
Village 9	12.1	6.0	7.5	Purple	Brick	114.7
Village 10	9.5	4.8	8.2	Turquoise	Wood	123.0

A comprehensive dataset that combines 3D Virtual Reality (VR) analysis with the Multi-Spectral Data Fusion Global Feature (MSDF-GF) approach for ten distinct villages, identified as "Village 1" through "Village 10." The table encompasses various attributes, each contributing to the immersive and informative VR experience for these heritage sites shown in table 4 and figure 4. The "X-coordinate," "Y-coordinate," and "Z-coordinate" columns represent the spatial coordinates of each village, enabling the precise positioning of these heritage sites in the virtual environment. These coordinates are crucial for generating accurate 3D representations. The "Color" and "Texture" columns describe the visual aspects of the VR experience, capturing the materials and aesthetics that define the villages. The colors range from "Green" to "Turquoise," while textures include "Brick," "Wood," "Stone," and "Concrete," among others. These attributes contribute to the visual richness of the VR experience.

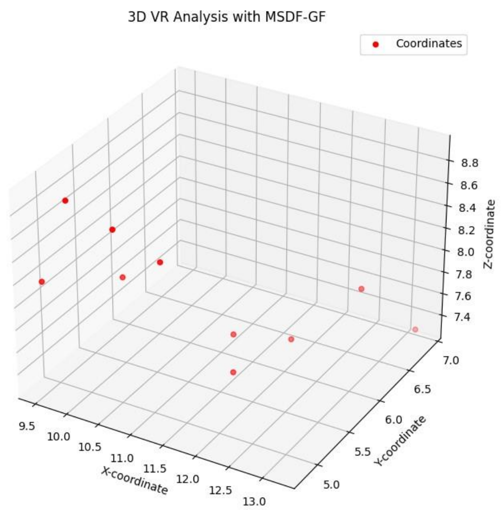

Fig 4: 3D VR with MSDF-GF

The "Elevation" column provides the elevation data for each village, which is essential for creating a realistic 3D landscape. This data ensures that the villages are represented in their proper geographical context. The combination of spatial coordinates, visual attributes, and elevation data facilitates the creation of a compelling and accurate 3D VR experience for each village. This dataset forms the foundation for immersive heritage preservation and cultural heritage exploration, where visitors can interact with and learn about these heritage sites in a virtual environment. Such technology plays a pivotal role in enhancing the accessibility and appreciation of cultural heritage.

6. Conclusion

The paper presented innovative Multi-Spectral Data Fusion Global Feature (MSDF-GF) model and its application in landscape visualization and virtual reality (VR) technology to enhance the protection and inheritance of ancient villages. Through the analysis of multi-spectral data, the MSDF-GF approach allows for the extraction of global features, which are then integrated into 3D virtual reality representations of these heritage sites. This integration enhances the visualization of ancient villages and offers an immersive VR experience, thus contributing to the preservation and promotion of cultural heritage. The analysis also demonstrates that the MSDF-GF model effectively eliminates noise in the landscape visualization process and provides a meaningful way to evaluate and rate the VR experiences. The findings underscore the potential of the MSDF-GF model as a promising approach for safeguarding ancient villages. By capturing the unique characteristics of heritage sites, it enables the creation of engaging and informative virtual reality experiences, making cultural heritage more accessible and engaging for a wider audience. This approach has significant implications for the fields of heritage preservation, cultural tourism, and education. The MSDF-GF model, with its integration of multi-spectral data, global features, and 3D virtual reality, has the potential to revolutionize the way explore and protect our cultural heritage. Its effectiveness in providing immersive VR experiences and enhancing the understanding of ancient villages is a testament to its value in preserving and promoting the rich history and heritage of these sites. As technology continues to advance, the MSDF-GF model presents a promising avenue for ensuring that the legacy of ancient villages remains vivid and accessible for future generations.

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