LiDAR-Based 3D Modeling for Cultural Heritage Preservation in Nepal

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SUMMARY

Cultural heritage sites play a vital role in preserving history, identity, and traditions while also contributing to tourism and local economic development. However, rapid urbanization, pollution, natural disasters such as earthquakes, and human activities like theft or neglect have placed many of these sites under serious threat. Once damaged, their restoration is often difficult or impossible.

Modern LiDAR technology provides an efficient and accurate alternative to traditional conservation and documentation methods, particularly in regions with limited resources and infrastructure. This study demonstrates the use of handheld LiDAR technology for the 3D documentation of the Chilancho Stupa in Kathmandu—one of the oldest and most revered Buddhist monuments in the valley.

Scanning was carried out from multiple angles to ensure complete surface coverage. Overlapping scans, real-time visualization, and field validation were carried out to maintain accuracy. For higher-definition texturing, photographs were captured and used. To generate the 3D surface, Gaussian splatting technique was implemented. The resulting point clouds achieved centimeter-level precision (±2 cm) across all surfaces. The 3D model thus generated shows detailed architectural details with surface deformations. Challenges faced such as reflective golden surfaces and shadowed areas was mitigated by adjusting exposure settings and conducting additional scans under uniform lighting conditions.

The final outputs include a high-resolution LiDAR point cloud, textured 3D model, orthographic projections, and 2D drawings useful for surface deformation analysis. The 3D model also enables virtual exploration, supporting digital preservation and virtual tourism. This work thus highlights how portable LiDAR systems can significantly aid cultural heritage preservation by creating

accurate digital archives for restoration, education, and sustainable tourism. Particularly in earthquake-prone regions like Nepal, such technologies play a vital role in safeguarding and celebrating cultural heritage for future generations.