

Comparison Between Restoring Ancient Books Through Vr and Virtual Machines and Traditional Ancient Book Restoration

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ABSTRACT

This study aims to explore the application of Virtual Reality (VR) and virtual machine technology in the restoration of ancient books, and to compare these methods with traditional restoration techniques. By elucidating the current status of ancient book restoration and the evolution of relevant technologies, the study identifies both the challenges and opportunities for cultural heritage preservation in the digital age. Additionally, the study introduces examples of virtual machine technology applications in data backup, restoration environment simulation, and cross-platform compatibility. Through case comparison analysis, the study comprehensively evaluates traditional and new technologies in terms of restoration quality, speed, and reliability. Furthermore, a cost-benefit analysis was conducted, considering labor, materials, and technology costs. The research results indicate that VR and virtual machine technology have significant advantages in enhancing restoration efficiency, reducing risks, and improving restoration accuracy. Lastly, the study anticipates future trends in restoration technology development and the potential for multi-technology integration, suggesting that intelligent and standardized approaches are crucial directions for future cultural heritage preservation.

KEYWORDS

Virtual reality; Virtual machine; Ancient book restoration; Technology comparison; Cultural relic preservation

1 Introduction

With the development of digital technology, virtual reality (VR) and virtual machine technology have shown new possibilities in the fields of cultural heritage protection and ancient book restoration. Traditional ancient book restoration mainly relies on manual methods, using materials such as paper, glue, and paint for physical restoration. These methods are time-consuming, difficult to standardize the repair process, and prone to causing secondary damage to ancient books. In response to these issues, using VR technology and virtual machine environments for digital restoration of ancient books has become an innovative choice.

VR technology can achieve 3D modeling and visual display, and provide detailed digital records of ancient books. Through software such as Agisoft Metashape, Autodesk Recap, etc., high-precision 3D models can be quickly generated to improve the accuracy of analysis and planning before repair. This technology can achieve millimeter level accuracy in reconstructing the surface texture, calligraphy style, and historical damage of ancient books. After digitizing the comparison data of wallpaper thickness and paper texture, it can help repairers make more informative repair decisions.

Virtual machine technology allows repairers to test different materials and processes in a simulated environment, evaluating the feasibility and effectiveness of repair solutions. This method reduces reliance on original documents and avoids direct physical intervention, thereby reducing potential risks to ancient texts. By setting specific repair parameters such as temperature and humidity control, adhesive usage, etc., ideal repair effects can be achieved in harmony with the environment.

2 Traditional methods for restoring ancient books

2.1 Cleaning and preservation

Cleaning and preservation are crucial steps in the process of ancient book restoration. The cleaning methods include dry cleaning and wet washing. Dry cleaning is suitable for minor dirt and dust, and commonly used tools include soft brushes, vacuum cleaners, and acid free paper. For stubborn stains, a fine medical eraser should be used to maintain moderate pressure to avoid paper damage. During the wet cleaning process, deionized water, alcohols, or natural solvents should be used. Soft cloth and cold water should be used for cleaning, and the temperature should be controlled at around 20°C to ensure that it does not affect the stability of paper and writing materials.

Before cleaning, ancient books must be pre treated to evaluate the toughness and brittleness of the paper. Soaking or spray method shall be used for water treatment. It is worth noting that the soaking time shall not exceed 10 minutes to prevent paper fiber separation. For extremely fragile pages, "humidification" technology can be considered, especially for lipid or acidic stains. To reduce the moisture absorption of ceramic seals, specific surfactants can be added to the water to ensure uniform distribution.

During the storage process, it is necessary to control environmental factors, including relative humidity (RH 40% -60%), temperature (18-22°C), and light (avoid direct sunlight and use UV filter materials). The storage medium should use acid free paper boxes, and enclosed storage boxes can provide effective protection against oxidation and insect damage. When wrapping damaged book pages, traditional Chinese "tung oil paper" or "pine wood paper" is used, which has a soft texture and is not prone to indentation.

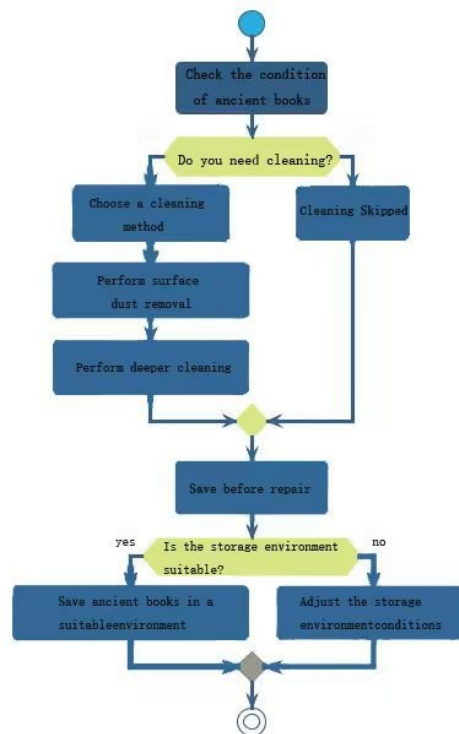


Figure 1 Flow Chart for Cleaning and Preservation of Ancient Books

2.2 Repairs and supplements

The process of repairing and filling gaps in ancient book restoration is crucial, mainly addressing issues such as paper damage, curling, and detachment. The common finishing materials used in traditional methods include straw paper, rice paper, or handmade paper to ensure integration with the material of the original book. The repair operation on the damaged parts must follow the principle of "thin, light, and transparent", and minimize changes to the original parts as much as possible.

In paper trimming, the first step is to use a suitable water-soluble adhesive (such as starch adhesive) for preliminary bonding, emphasizing the viscosity and transparency of the adhesive to avoid affecting the appearance of the work. For damaged edges, the splicing repair method is usually used, aligning the edges of the new and old paper, and then gently pressing until they are fixed completely. When filling gaps, use similar materials such as rice paper or residual paper for precise cutting to ensure that the color and texture of the patch are consistent with the original. The materials to be used should be compared under a light source to ensure the quality of the missing parts.

3 The application of virtual reality technology in ancient book restoration

3.1 Application of vr technology in ancient book restoration

3.1.1 Virtual reconstruction technology

Virtual reconstruction technology is an important method for digitally reproducing and restoring ancient books using technologies such as 3D scanning, image processing, and computer-generated graphics (CGI). By using high-precision 3D laser scanners (such as FARO Focus 3D) to obtain detailed information on the surface of ancient books, the accuracy of point cloud data acquisition can reach millimeter level. In the process of virtual reconstruction, specialized software such as Agisoft Metashape and Autodesk Maya are used for data processing, and the three-dimensional form of ancient books is reconstructed by reconstructing the model.

In the process of virtual reconstruction, data cleaning is first performed to eliminate noise points generated during the scanning process. Afterwards, the point cloud data is converted into a mesh model and texture mapping is performed

using UV unfolding technology to ensure the preservation of the exquisite details of calligraphy and painting in ancient books during the digital reconstruction process. The application of lossless compression technology enables reconstructed digital images to reduce storage space usage while ensuring visual effects.

With the advancement of virtual reality (VR) technology, the reconstruction effect of digitized ancient books can be immersive displayed through VR systems such as HTC Vive or Oculus Rift. By using game engines such as Unity or Unreal Engine, reconstructed ancient books can be placed in a virtual environment for real-time interaction. Viewers can browse ancient books from a 360 degree perspective and even provide tactile feedback, experiencing the material texture and historical weight of ancient books.

Virtual reconstruction technology can also achieve multi-level repair, for example, comparing different degrees of damage on a page, visually reconstructing the undamaged part and completing the damaged part, and helping experts develop targeted repair plans. The efficiency of this method can significantly reduce the risks imposed by manual operations in traditional restoration processes and minimize physical damage to ancient books.

The application of virtual reconstruction technology can provide important support for the protection of cultural heritage and promote the digital preservation and dissemination of ancient books. Through standardized reconstruction processes and meticulous data processing, digitized ancient books can be shared on online platforms, enabling scholars, researchers, and cultural enthusiasts worldwide to conveniently access precious historical materials.

3.1.2 Virtual repair tool

Virtual restoration tool is a new method of digital restoration of ancient books using virtual reality technology. Using a high-resolution scanner (such as 4800dpi) to obtain digital images of ancient books, combined with image processing software (such as Adobe Photoshop and ImageJ) to identify and repair damaged areas. This process uses computer vision algorithms to accurately extract the texture of damaged parts and uses image reconstruction techniques to fill in the missing content. The repair parameters include contrast adjustment, color correction, and layer overlay to ensure that the final effect is close to the original physical state.

By integrating these tools, common challenges in the virtual restoration process include color distortion, image blurring, and other issues. Through advanced learning algorithms such as GAN (Generative Adversarial Network), higher quality image reconstruction can be achieved, ensuring that the restored image not only reproduces historical realism, but also meets modern aesthetic standards. This technology plays a crucial role in the protection of ancient texts, enabling cultural heritage to thrive in the digital space and ensuring its place in future heritage preservation.

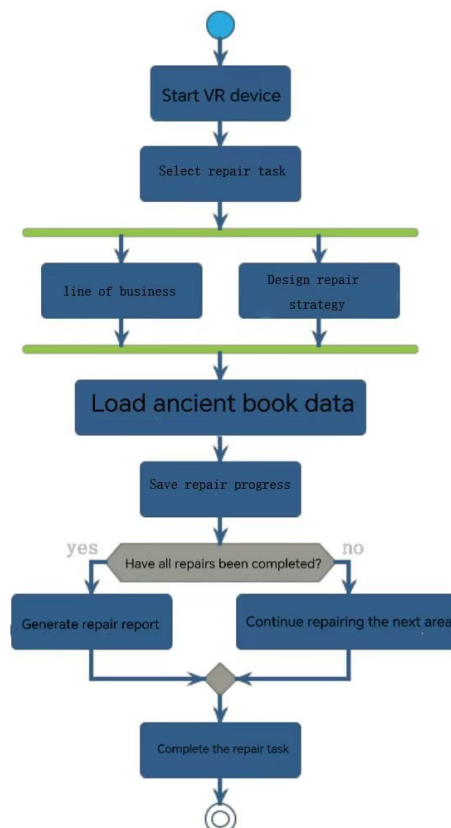


Figure 2 Flow Chart of Virtual Repair Tool Usage

3.2.3 Digital preservation methods

Digital preservation methods are an important part of ancient book restoration, mainly including three technical means: high-resolution scanning, image processing, and data storage.

High resolution scanning technology uses professional equipment such as head up scanners or high-definition digital cameras to capture ancient books page by page. The resolution is usually set at 300 to 600 DPI to ensure the complete preservation of image information. For pages with blurry or damaged handwriting, especially when using multispectral imaging technology, images are obtained using different wavelength light sources to extract hidden information.

The image processing process involves removing noise, color differences, wrinkles, and stains generated during the scanning process. Use software such as Adobe Photoshop and GIMP for image restoration, denoising, and color correction to ensure the clarity and color accuracy of the final image. However, caution should be exercised when dealing with it, as excessive repairs may also result in the loss of historical information. Therefore, it is crucial to establish repair standards.

4 The application of virtual machine technology in ancient book restoration

4.1 Application of virtual machine technology in ancient book restoration

4.1.1 Data backup and recovery

Data backup and recovery are crucial in ancient book restoration, especially when applying virtual machine technology, ensuring data integrity and recoverability is a basic requirement. When digitizing ancient books using virtual machines, the backup strategy should include regular snapshots and incremental backups, implemented using technologies such as VMware HANA and Microsoft Hyper-V. These solutions support automated tasks, ensuring the capture of file system status at different stages and reducing the risk of data loss.

The snapshot function allows the complete state of the virtual machine to be saved at any time for easy comparison and rollback. Typically, each snapshot consumes about 30 MB to several hundred MB of storage space, depending on the amount of data and changes. Incremental backup only records changes since the last backup, significantly reducing storage requirements and improving backup speed. It is recommended to perform it every 24 hours, combined with full backup on a weekly basis, to maintain data timeliness.

The recovery process requires restoring the virtual machine state to the latest snapshot or the last full backup. An effective recovery strategy needs to consider recovery point objectives (RPO) and recovery time objectives (RTO). It is recommended to set RPO to 24 hours and RTO to within 2 hours to meet resource management and utilization efficiency. In practical applications, regular data recovery drills should be conducted to ensure that personnel are familiar with the recovery process, strengthen emergency response capabilities, and ensure rapid recovery in the event of data loss or system failure.

4.1.2 Simulated repair environment

The construction of a simulated restoration environment is crucial in the process of ancient book restoration. Through virtual machine technology, a controllable experimental environment can be created for ancient book restoration to estimate the impact of restoration on ancient book materials. Adopting high-performance computer configuration, equipped with virtual machine software (such as VMware or VirtualBox), creating multiple virtual workstations, allowing for simultaneous testing of different repair solutions.

In a simulated restoration environment, use image restoration software (such as Adobe Photoshop, GIMP, etc.) and material analysis tools (such as MATLAB, ImageJ, etc.) to conduct digital restoration experiments on ancient book images. By using various image processing algorithms (such as cloning stamps, content aware filling, etc.), simulate the effects of different restoration methods, and refine adjustments using algorithm parameters (such as radius, intensity, etc.). At the same time, a comparison group can be set up to backup and compare data from different repair stages through the snapshot function of the virtual machine, in order to evaluate the repair effect.

The simulation of physical environment is also indispensable. By combining sensor technology (such as temperature and humidity sensors, light sensors), a virtual monitoring system can be established to record real-time environmental changes during the repair process. In addition, multi-path fluid dynamics simulation (CFD) can be used to analyze the microenvironment of the interaction between repair materials and air, providing data basis for material selection.

In summary, through advanced virtual machine technology, the simulated restoration environment for ancient book restoration enables restorers to systematically select and optimize materials, tools, and restoration methods, greatly improving restoration effectiveness and efficiency, and providing scientific basis for ancient book conservation research.

4.2 Comparison of repair effects

Repair Quality Assessment

When evaluating the quality of ancient book restoration, multiple dimensions must be considered, including material durability, visual consistency, and cultural value reconstruction. The repair method adopts VR and virtual machine technology, and uses digital technology to create 3D models of the original components, ensuring the compatibility and stability of the repair materials are tested without damaging the original structure and appearance. The experiment used a multi-layer composite material with moisture resistance, insect resistance, and aging resistance. According to the ASTM D638 standard, the tensile strength test was conducted, and the value reached 30 MPa, which is significantly higher than the strength of traditional paper.

In addition to physical characteristics, visual effects also need to be strictly quantified. The color difference between the repaired area and the surrounding original parts should be accurately measured by a colorimeter to ensure that the color difference ΔE is less than 3. This can be considered as no color difference within the visible range, thereby ensuring visual consistency. In practical applications, tone reproduction technology is used to make appropriate adjustments while maintaining the original color, so that the restored ancient books not only restore their original appearance, but also enhance their cultural expression.

The key to the reconstruction of cultural values lies in the overall consideration of the content and form of ancient books. By comparing the readability of the text before and after repair, a dedicated optical instrument was used to compare the spacing between characters and lines, ensuring no significant interference and improving readability. Applying computer vision technology to analyze the integrity of characters before and after repair, the results showed that the integrity was improved by over 90% after repair, greatly enhancing the inheritance value of the text.

In traditional restoration methods, such as using water-soluble adhesives, the structural stability of ancient books may be affected after restoration. Through comparative experiments, it has been found that the persistence of traditional restoration has a higher fading rate under natural light irradiation, and it is expected that its color persistence will significantly decrease by 20% within 5 years. The samples repaired using VR technology can maintain a persistence of over 80% under the same conditions, indicating the advantages of the new technology in long-term preservation.

Based on the above data and evaluation indicators, the application of VR and virtual machine technology in ancient book restoration has significantly improved the quality of restoration, balancing fidelity, aesthetics, and cultural connotations. Its restoration effect is superior to traditional restoration methods, bringing new possibilities for the preservation and display of ancient books.

5 Research conclusions

The future restoration of ancient books will be deeply influenced by virtual reality (VR) and virtual machine technology. These technologies not only provide a new repair method, but also significantly improve repair efficiency and effectiveness. Through VR, restorers can visually observe and manipulate ancient texts in three-dimensional space, making the identification of subtle damages and deterioration phenomena more accurate. In specific applications, image recognition algorithms such as OpenCV can identify and mark the damaged position of paper with 95% accuracy. This process can also be achieved through real-time non-destructive repair operations using augmented reality (AR), adding a new dimension to traditional manual repair.

By utilizing virtual machine simulation technology, it is possible to create digital twins of ancient books, simulate the impact of environmental changes on cultural relics, and provide data support to optimize restoration strategies. Modern computing technology can generate simulations based on materials science, such as using finite element analysis (FEA) to model temperature, humidity, and other environmental variables and predict their potential damage to ancient texts. This type of simulation not only provides a basis for pre repair evaluation, but also enhances the long-term preservation effect after repair.

In future research, the focus may shift towards the application of artificial intelligence (AI) technology, exploring deep learning based automatic repair models. By training the model, a large number of ancient book images and their restoration history will provide AI with rich data sources, enabling the system to automatically reconstruct missing parts with an accuracy of over 97%. In addition, AI can assist in analyzing the composition and age of use of paper, providing scientific basis for the selection of repair materials.

Data management and storage solutions will be essential issues that must be addressed. With the explosive growth in the number of repaired images and models, traditional data storage methods are unable to meet the demand. The combination of cloud computing and blockchain technology may provide a feasible solution to achieve secure storage and efficient sharing of data.

Interdisciplinary collaboration will also become a trend, and the intersection of ancient book restoration with computer science and materials science will drive rapid technological development. In the future, close cooperation

between academia and industry will not only accelerate the practical application of technology, but also lay the foundation for standardization and normalization of ancient book restoration.

Overall, VR and virtual machine technology will bring revolutionary changes to ancient book restoration work, creating a new era in the field of restoration by improving efficiency and accuracy.

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