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RESEARCH ARTICLE

Learning Information Regarding the Ancient Chinese Calligraphy Technique via Three-Dimensional in Nature Remonstrations and Evolution

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ABSTRACT

The foundation of Chinese culture lies in the ancient art of calligraphy, which reflects the knowledge of the people at the grassroots level. It is valuable to preserve, from generation to generation, and is a part of the historical legacy, much like many other forms of handicraft. Chinese calligraphy embodies "The Power of Beauty" via its use of 3D brush motions, which include rough-surface geometry and a variety of reflectance qualities. In recent years, virtual calligraphy learning systems have been a centre for study. A technique for evaluating the user's practice results is crucial in this kind of system. Evaluation of handwritten characters may be challenging since they are not always uniform in size, location, or quality. In certain cases, all of the characters may even be crooked. As a result, diagnosis and therapy are often put off. Using the structure-from-motion approach, point clouds of the historic bridge are produced from the UAV photos that were taken. Based on the global graph optimization and super voxel structure, a segmentation technique is created that can efficiently divide bridge components according to geometric characteristics. Ultimately, surface modelling is carried out to provide surfaces reconstructions of the identified components. The potential of the given structural model reconstruction approach employing photogrammetry from unmanned aerial vehicles and point cloud computation in 3D digital documentation of historic bridge is shown via experiments conducted on two bridges in China. Reconstruction inaccuracy of point clouds may be as low as 0.4% when provided markers are used. Additionally, segmentation findings employing testing date have higher than 0.8 precision and recall, and better than 0.8 recognition accuracy is attained.

1. INTRODUCTION

The traditional Chinese calligraphy culture has a rich history of calligraphy art and culture. Calligraphy has a unique lyrical quality that has made it a magic weapon for many generations of literati. It is considered the intangible cultural legacy of the globe and one of the "four essence" of the Chinese nation (traditional Chinese calligraphy instruments). The proverb "To do his work well, one has to first sharpen his equipment" refers to the conventional Chinese calligraphy implements (writing brushes, ink sticks, paper, and ink stones), which are essential for creating Chinese calligraphy and have a significant cultural significance. As a result, Chinese culture and traditional calligrapher instruments are strongly associated in China. If we look back to Chinese history, the reign of the Song Dynasty (960–1279) was one of the dynasties [1]. 18 emperors ruled over its 319-year duration, which saw it split into the northern and southern song dynasties. In one of the poet Mei Yaochen's verses, "the traditional Chinese calligraphy equipment are in your two county [1, 2]." I've been enjoying and playing with the writing brush, which works ink stick, paper, & ink stone you

presented me with lately," the student writes, demonstrating how much academics value and like the classic Chinese calligraphy equipment. As a result of society's continuing growth, the digital era has arrived, bringing with it seismic shifts in the way ideas are disseminated [2, 3]. The demands of consumers for excellent information transmission products and services are also rising, as new media and communication technologies continue to proliferate in daily life and new levels of new media and communication technology continue to be introduced. Against this backdrop, the question of how to give conventional "four the riches of study" development a new age charm and how to use contemporary aesthetics to breathe new life into historical artistic and cultural works has emerged as a trend that will unavoidably follow and become the focal point of the times' development.

1.1 The creation and evolution of "traditional Chinese calligraphy tools": Cultural and creative works in the digital age

The philosophy of design

For thousands of years, the "traditional Chinese calligraphy instruments" have been a symbol of Chinese culture. Traditional Chinese calligraphy tools have been used to show many poetry, calligraphies, and paintings since ancient times, providing us with the chance to continue appreciating the allure of the past and current [3, 4]. Even though they are no longer the primary medium for cross-cultural communication, traditional Chinese calligraphy has progressively developed into an art form. In addition to being an essential tool for painting and calligraphy masters, traditional Chinese calligraphy musical instruments have evolved into a means for individuals to engage in cultural activities and develop their feelings. Put another way, the traditional Chinese calligraphy instruments retain their particular cultural significance while simultaneously avoiding being overwhelmed by the advancing modernity. The classic Chinese calligraphy instruments have a long history in China. They symbolize not only the ancient calligraphic and painting tools but, more significantly, the bearer of thousands of years of cultural inheritance [4, 5]. The emotions and recollections of several Chinese generations are preserved in the ancient calligraphy instruments that have been passed down through the ages. They are used by the Chinese people to express feelings and create exquisite poetry and chapters that are inherited by future generations. This spiritual civilizations and cultural legacy will be helpful to next generations. The advent of the digital age has brought to the quick rise of information goods that are clashing with traditional old culture, emerging from the ground up like mushrooms. We can undoubtedly advance Chinese culture's pride and feeling of purpose if we can encourage cross-cultural understanding and release the allure of this antiquated way of life.

1.2 Conventional Chinese calligraphy instruments: the creation, advancement, and application of imaginative and cultural design components

Products classified as historical or creative are those that individuals have upgraded and transformed using their own knowledge and abilities from traditional cultural assets and everyday demands, adding value via the creation and implementation of the ownership of intellectual property. The result of integrating life necessities with artistic expression, cultural and creative works fall into two categories: first, society's and imaginative life products, like handicrafts for everyday use, creative craft goods, etc.; second, artistic and cultural goods with distinctively local qualities, like products created in partnership with art museums and tourism destinations. Designing cultural and creative items has value when it helps the general public comprehend the cultural meaning that goes beyond the tangible worth of the item [5, 6]. This project follows the tenet of "innovative design, an inheritance of culture" and undertakes element extraction, analysis, and creation design of the pen mountain and pen holders in the four valuables of classical culture from the perspective of continuing the development and inheriting of traditional Chinese culture [7, 8]. This paper, which focuses on cultural and artistic design, integrates aspects of Chinese culture to conduct research and development. It then displays the results via cultural and creative goods, graphics employing colours from Chinese history and culture, and a number of auxiliary products. With any luck, this design will enable more individuals to discover the four riches of study and contribute to their heritage.

Figure 1: Calligraphic paintings in Chinese

The brush is mostly used in Chinese calligraphy [9, 10]. Chinese calligraphy is difficult to computerize because of the complexity of the brush stroke forms and the topology over several strokes. Western calligraphy, on the other hand, depends on Latin alphabets and is extremely easy to computerize. Chinese calligraphy is capable of expressing the writer's feelings in addition to the content of the message. Among other calligraphic arts, Chinese calligraphy is unusual in that it may achieve extremely fragile artistic effects because, for greater perceptual impression, the typical form and topology organization of the font can be greatly modified. An essential component of traditional Chinese painting is Chinese calligraphy [11, 12]. The use goes beyond annotation as calligraphy included into a picture has the potential to influence the viewer's overall emotional and/or visual experience [13 14]. An example is shown in Figure 1. As a result, calligraphy is seen as an individual piece of artwork by many. This viewpoint is especially well-liked when it comes to the unique instance of Chinese calligraphy. The foundation of calligraphic art is typeface, which is a collection of printer types with the same dimensions and face [15, 16]. Font forms may be described using straight lines or cubic Bezier curve. Scientists have attempted to model a calligraphy brush for artistic depiction; for example, the brush may be modelled as a group of bristles that change during the stroke. In, an interactive virtual brush built on solid modelling was shown to be a workable technique for producing authentic Chinese calligraphic letters [17, 18].

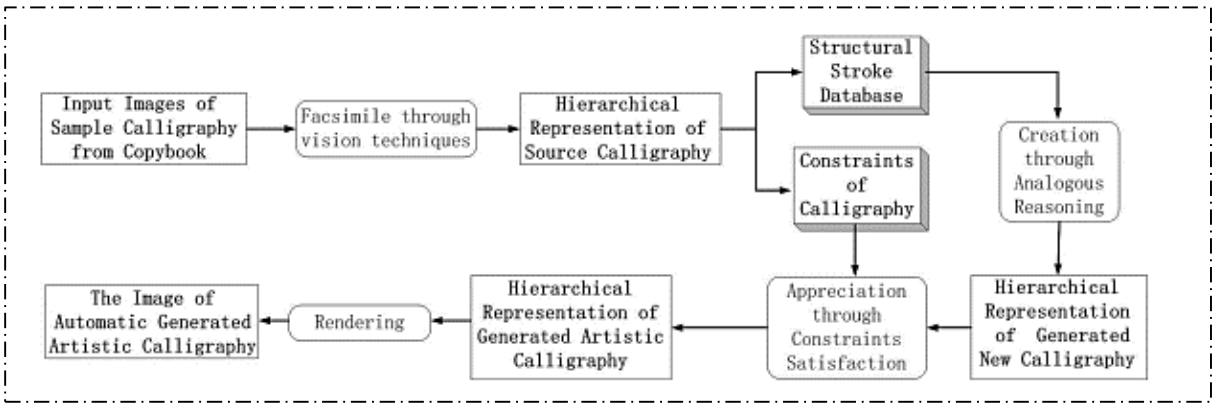

Figure 2: Our system's clever calligraphy generating architecture

The overall design of our intelligent calligrapher system is shown in Figure 2 [19, 20]. An equivalent reasoning component at the system's core generates fresh calligraphic artwork from the learnt examples. Certain aesthetic requirements would be met by the calligraphic artwork that was automatically created.

The writers provided a thorough examination of the writing effect that hairy brushes may create in. Additionally, there have been efforts to automatically create new typefaces. For example, one such attempt used arithmetic of shapes in geometry to create new fonts by combining pre-existing ones. However, calligraphy is not limited to typefaces; for instance, one may combine several character

sizes and styles in a calligraphic piece [21, 22]. No known research on automatically producing attractive calligraphic artwork (as opposed to merely copying it) using calligraphy examples that already exist has been published. Such a smart device is proposed and described in this study. We go over the fundamental ideas and theories and show the calligraphic output from a prototype we put into practice. Our prototype technology can totally autonomously produce original Chinese calligraphic artwork. There are very few input training sample utilized in this process.

But before we can utilize clouds of 3D points for other purposes, we must recognize and isolate certain objects from the background. Prior to identification, the point cloud must often be segmented in order to do this. For many years, researchers have been investigating the process of segmenting point clouds, or grouping 3D points into many homogenous groups that have similar traits. Traditional segmentation techniques, such as region growth or clustering, look at locations near the original seeds or sources and determine whether they meet certain criteria for belonging to the identical set or not [23]. Representative criteria include Euclidean distance, volume, standard vector deviation, surface smoothness, and point curvatures. Additionally, segmentation may be carried out in the space of characteristics. Segmentation criteria also include the introduction of geometric elements or RGB colur information with uniqueness. Nevertheless, anomalies and noise Report Phrase in the dataset may readily affect any of these segmentation techniques, leading to excessively or under-segmentation with varying granularities of the produced segments. Furthermore, the computational cost would be greatly increased by sophisticated segmentation criteria. If we are to obtain a decent division of items from the overall picture, then all these problems need to be resolved.

Technological advancements in graphics programs and photographic processing have ushered in a new era for calligraphy production and study. A large number of academics are studying computer-assisted virtual calligraphy. Modelling calligraphy components including brushes, stroke, drop, and paper; calligrapher retrieving; character recognition; calligraphy creation; calligraphy analysis and assessment; and obtaining features and style synthesis are the key areas of focus for current research. A popular topic these days is creating an enjoyable and user-friendly calligraphy education system built around the aforementioned methods, which is very beneficial for calligraphy students. A judgment process is crucial and very vital in such a system. Users' writing abilities may be enhanced by knowing their assessment results, which provide feedback on their writing proficiency.

In this work, we endeavour to close the gap between bridge engineering applications and satellite positioning and photogrammetry engineering methodologies. With aerial photographing and point cloud analysis, an autonomous design for rebuilding structural surface representations of historic bridges is created. Using the SfM and MVS procedures, detailed point cloud visualizations of a historic bridge are produced from the UAV photos that are taken. A new segmentation technique based on global graph optimization and super voxel structure is suggested to divide the whole point cloud into coherent parts. A Poisson surfaces reconstructions method creates a skeletal surface model after the various structural components are sequentially grouped using an ordering based on a bridge geometry and a classification tree. More specifically, we use bridge engineering using the graph-based segmentation technique. Since graph structure, a statistical backdrop model, is often used to describe the geographical link between neighbouring 2D/3D locations, the graph-based technique was chosen. When building the weighted edges of a graph, a graphical system can encode not just the distinct characteristics of points in its immediate environment but also the links between the point in question and its surrounding neighbour's because the graph structure naturally relates to 3D topology, unlike other data structures (such as regular 3D grids for designed point clouds). The dependence and affinity between nodes that link are captured by the weights of edges. The separation of the bridge point cloud may be simply accomplished by using an optimization feature (e.g., divide) of the graphical visualization of the individual points cloud. Experiments conducted using two Chinese bridges confirm the reliability of the proposed architecture.

1.3 Objectives of the study

- Create immersive experiences by using contemporary technologies like augmented reality (AR) and virtual reality (VR).
- Create 3D replicas of calligraphy implements from antiquity, such as paper, ink stones, and brushes.

- Construct virtual spaces that mimic the old-fashioned Chinese calligraphers' studios.
- Highlight the relationship between calligraphy and other art forms such as painting, poetry, and ceramics.
- Examine the philosophical ideas of harmony, balance, and spontaneity that calligraphers adhere.

2. LITERATURE REVIEW

(Chao, F., Huang, Y., 2017) [24] Writing robots to write is a very difficult undertaking that requires complex image processing and kinematic control systems. On the other hand, this study suggests a robot calligraphy system that utilizes human arm motions to first generate a font database of English letters and basic Chinese character strokes, and then writes Chinese characters and English sentences using the database and human gestures. The human arm trajectories are recorded using a three-dimensional motion sensing input device, and these trajectories are utilized to train an ensemble of classifiers to construct the font database. 26 different human gestures are utilized to write letters in English, while 5 different gestures are used to make 5 basic strokes for writing characters in Chinese.

(Long, J., Xiong, W., 2020) [25] Building integrated functional devices requires precisely placing semiconductor Nanowires are tiny (NWs) into two- or three-dimensional (2D/3D) micro-/Nano structures. However, high-resolution 3D construction of semiconductor NWs remains a long-standing difficulty. Here, we have used two-photon polymerization to produce directed assembling of Zinc Oxide (ZnO) NWs into practically arbitrary 3D structures with great spatial precision. The laser scanning route allows the NWs to consistently align in any direction that is desired.

(Xiong, M., 2022) [26] In order to explore the practical applications of ancient Chinese wisdom, this research will use summarising analysis of contents and qualitative analysis to analyse wisdom-related elements in Zhinang Quanji, an assortment of traditional Chinese wisdom tales authored by Feng Menglong in the late 16th century. The following are the outcomes: (1) There are twenty distinct types of occurrences that are the primary manifestations of ancient Chinese knowledge. The five wise moments that come up most often among them are as follows: When faced with an emergency, one should: (a) respond quickly and calmly; (b) support those in authority (particularly by remonstring or admonishing); (c) pay close attention to details and resolve conflicts sensibly; (d) analyze situations clearly and make long-term plans when in bureaucratic settings; and (e) determine the enemy force's mind-set in order to surprise and defeat them. Zhinang Quanji has 932 smart characters in total. Here, a number of traits are often seen, such as the preponderance of characters with human knowledge, the numerical minority of people under the age of 18 and over 60, and overpowering maleness.

(Li, B., 2020) [27] Local colour is characterized by ancient Chinese civilization. People engage in constant communication activities in an environment that reflects basic local characteristics. The primary means of communication is word-of-mouth and word-of-mouth propagation within a wider network. Both folk songs and proverbs are significant means of communication for common people, but songs are an essential aspect of everyday life for common people. We are aware of pien-wen (bianwen in Chinese means a kind of literature which include prose and chapter, which is delivered in the form of conversation and the tune, with its focus on copying Buddhist the sutra and folk narratives) that are from the fact that folk artists also frequently tell stories from the past and present through dialogue and song.

(Xu, Y., 2023) [28] Understanding cross-cultural empirical aesthetics requires research on non-Western topics and art forms. This research looked at people's choices among five scripts to assess the aesthetic value of Chinese writing in calligraphy a well-known visual art form in East Asia. The main creative writing techniques of Chinese characters are shown in these scripts. We used both subjective and eye-tracking measurements to analyse our experiment, which included Chinese volunteers (mean age = 22.64, SD = 2.90) and outside of China respondents (globalization students from Africa, Southeast Asia, and Northern American; mean age = 26.76, SD = 2.35). In order to quantify the aesthetic assessment, we used the Pleasure-Interest Model of Aesthetics Liking (PIA

Model) and assessed fluency manufacturing, affective emotions, motivational appraisal, and overall liking as personal measures.

(Zhou, P., Zhao, Z., 2011) [29] There are often just a few Chinese characters in a Chinese calligraphy copybook—far from the whole set required for typesetting. As a result, comprehensive libraries of Chinese calligraphy for popular calligrapher styles must be created. An end-to-end system for generating characters based on certain calligraphy styles is proposed in this study. To be more precise, a content reinforcement network is made to record the finer points of fashionable strokes, while a design transfer network is made to convey character styles. High-quality calligraphy pictures may be produced by our algorithm without the need for human data annotation. A fresh dataset is created for a comparative study among our approach and two additional standard techniques in order to validate the produced calligraphy styles.

(Xu, P., Wang, L., 2018) [30] Chinese calligraphy is a well-liked and highly respected art form both inside and outside of the Chinese cultural community. Chinese calligraphy traditionally uses ink brushes, and the finer points of brush strokes greatly influence the visual appeal of the written letters. But for many calligraphy beginners, learning how to perform the brush movements is a difficult challenge as it takes years of practice and professional guidance. This study introduces a new method for teaching Chinese calligraphy students to evaluate the calibre of brush motions without the assistance of an expert. Our method takes the brush velocities out of a video stream and scores the writing quality by comparing it to templates of well-known calligraphers. To do this, we first create a unique neural network that attempts to extract the video stream's time and spatial motion properties.

3. METHODOLOGY

The five primary phases of the 3D structural model generation framework—point cloud segmentation, UAV flight routing and image capture, image correction 3D reconstruction, and structural element recognition—are shown in Figure 3 [31]. Our structure model generation framework's primary contributions are point cloud separation and structural component identification, which entails categorizing various bridge structural components from the collected point clouds. The following is a quick presentation of these five stages' details.

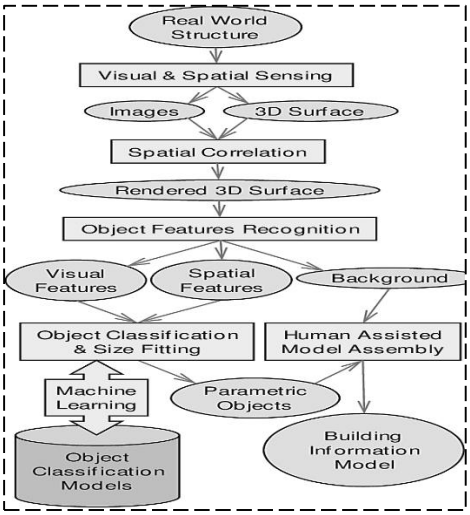

Figure 3: Framework for creating 3D structural models

3.1 Reconstruction in 3D

SfM and MVS procedures are used to do the 3D reconstruction needed to produce the photogrammetric points in clouds. Specifically, sparse reconstructions and dense matching are the two main processes in this procedure. In sparse the rebuilding process, analogous points for features are found and matched, the geometric picture capture configuration is reconstructed, and sparse point clouds are produced [31, 32]. A projection connection found by sparse reconstructing is then used in dense matching to boost the overall density within the 3D point cloud. All procedures in this investigation are carried out using the Airsoft Photo scan program's execution. The SfM and MVS

procedures in picture Scan are described, along with frequently used parameters. Additionally, these point clouds undergo a statistical outlier's elimination filtering (SOR) prior to point cloud processing. The PC Library provides the SOR filter that we needed. The average range between each point and its neighbour's is first calculated, taking into account each point's k-nearest neighbours. Next, taking into account the standard divergence, it excludes the spots that are further apart than the normal radius.

3.2 Point division of the cloud

The segmentation stage is essential to breaking down the whole point cloud into useful primitives of geometry in the framework that is provided. It divides all of the points into many consistent areas with one or more shared features. A brand-new point cloud segmentation technique based on global graph optimization and the super volumetric architecture is put forward. Three phases make up the workflow of the suggested segmentation approach, which is shown in Figure 4: global graphs creation, graph-based grouping, and supervoxelization.

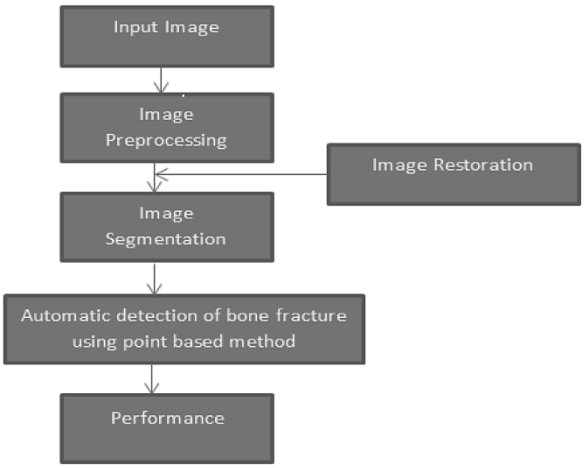

Figure 4: The suggested segmentation method's workflow

$$w_{IJ}^{c} = \begin{cases} (\alpha_1 - \alpha_1)^2 + \pi^2 & , \alpha_1 > \alpha_1 + \theta \\ (\alpha_1 - \alpha_1)^2 + (\alpha_1 + \alpha_1 - \alpha^1, \alpha_1 < +\theta. \end{cases} \text{.....1}$$

$$W_{IJ} = \prod_{k\epsilon[p,s,c]} \exp(-\frac{W_{IJ}^{k})^2}{2\lambda^2}), \text{.....2}$$

$$D = \sqrt{\omega_n \frac{N_1}{N_1}} + \omega_d(|X_1| - |X_b|), \text{.....3}$$

$$S_{sal} = \left[\frac{S_h}{max_{k=1,....n(S_h^k)}}, \left(1 - \frac{S_s}{max_{k=1,....n}}\right), \frac{S_v}{\pi/2}\right], \text{.....4}$$

$$\nabla(x_M * \acute{F})(q_0)\acute{} = \int_{\delta M}^{0} \acute{F}\ (q0) \underset{N\delta_M}{\longrightarrow} (p)dp. \text{.....5}$$

4. RESULTS

We initially provide our bridge testing results and two bridge field locations in the experiments section. It also states how point clouds are generated for these two bridges. Next, benchmark-based tests are conducted to evaluate the effectiveness of our suggested segmentation techniques. The two bridges listed above are subjected to field testing utilizing point clouds, and the resulting data is analysed and discussed.

4.1 Bridge testing data

Two bridges were chosen as testing locations to evaluate the effectiveness of the framework that was given. The first example is the Hongde Bridge, which is situated in Shanghai, China's Hongsan Village,

Tang Town. It has been standing for a duration of over 250 years, having been constructed during the Qianlong as era of the Qing dynasty. This stone bridge has a span of 4.9 meters, a length of 14.5 meters, and a width of 2 meters on the bridge deck. The Tongxin Bridge, the second one, is situated in Shanghai, China, near Tongji University. The bridge is a double-arch brick structure that is 9.5 meters long and 5 meters wide. It was constructed more than 50 years ago. Views of the test bridges are shown in Figure 5.

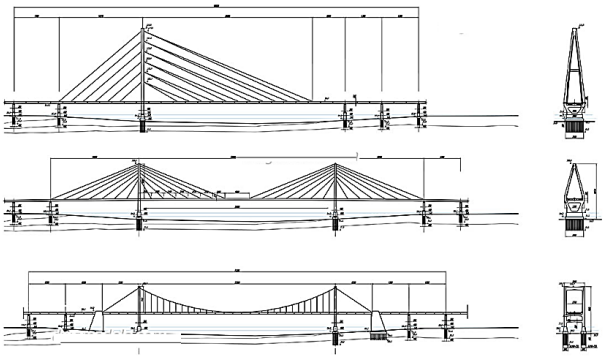

Figure 5: Evaluating bridges. Hongde Bridge (a). Tongxin Bridge (b)

We evaluated the distances among each of the three pairs of markers in the Hongde Bridge clouds of point clouds by juxtaposing them to the real-world distance in order to assess the quality of the corresponding point cloud reconstructions. Table 1 displays the outcome. The chart shows that, when all UAV photos from various scales are used, the reconstruction error may be as low as 0.4%, which may be considered enough for the preservation of historic bridges.

Table 1: Reconstruction precision across various scales

Scale	UAV distance to bridge	Measured distance	Ground truth distance	Error
Small	2.0	0.894	0.9	0.8%
Medium	5.0	0.649	0.6	0.6%
Large	9.0	0.526	0.9	0.9%
Others	-	0.685	0.6	8.4%

$$precision = \frac{|TP|}{|TP|+|FP|}. \ldots\ldots\ldots 6$$

$$recall = \frac{|TP|}{|TP|+|FN|}. \ldots\ldots\ldots\ldots 7$$

We show the relationship between segmentation performance and voxel sizes in Figure 6. Here, the $F1$ score is used to assess the segmentation result. The voxel size in this test runs from 0.1 m to 1.0 m, with a set threshold for dividing the graphical model. The corresponding super voxels' seed resolution is three times more than the voxel size. The test results demonstrate that our segmentation approach may provide excellent results with suitable spatial sizes (i.e., 0.2 m–0.4 m), with $F1$ scores spanning from around 0.8 to 0.67.

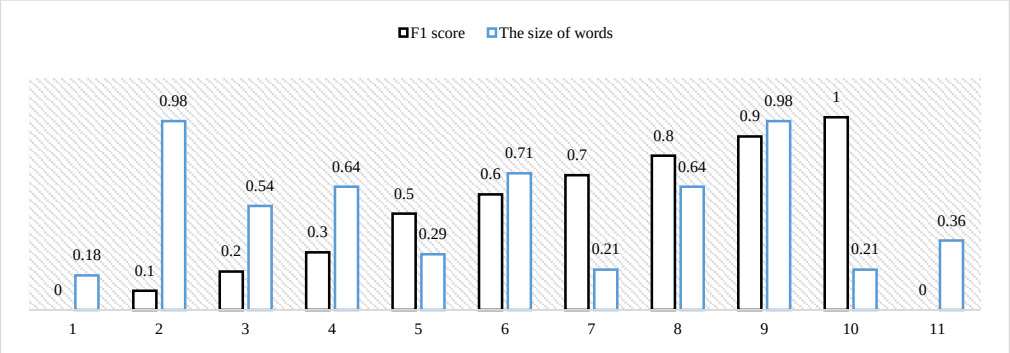

Figure 6: The impact of various voxel sizes on the outcomes of segmentation.

Table 2: Hongde Bridge and Tongxin Bridge segmentation findings

Name	Number of point	Number of segments
Tongxin bridge	5,134,138	29
Hongde bridge	18,896,23	16

The segments were grouped using the above-mentioned classification tree based on these saliency values. Table 2 displays the findings together with each segment's matching saliency levels.

Table 3: Hongde Bridge and Tongxin Bridge recognition outcomes

Name	Total segments	Segments of decks	Segments of bases	Segments of fences
Hongde bridge	35	9	9	15
Tongxin bridge	19	8	7	8

Table 4: Hongde Bridge and Tongxin Bridge recognition outcomes

	Hongde bridge			Tongxin bridge		
Truth	**Bases**	**Decks**	**Fences**	**Bases**	**Decks**	**Fences**
Bases	9	7	8	8	0	0
Decks	1	8	1	4	9	0
Fences	1	0	18	0	9	7
Overall Accuracy (OA)	0.89			0.9		

We provide the modelling results of the identified components of structure. The figure makes it clear that the modelling quality is greatly influenced by the segment quality. The surfaces are accurately rebuilt for the segments that have distinct borders. With approximated and documented dimensions, orientation, and geometric features, ranging the surface models that are created provide a thorough documentation of these ancient bridges.

The significance of passing down and developing traditional Chinese the calligraphy tools is further shown by the Ministry of Commerce and Communication Technology's Strategic Thoughts on Promoting the Evolution of the Four Treasures of Study, which was released in recent years. Therefore, for the preservation and advancement of the superb ancient traditions of the Chinese people, it is crucial for innovation and growth in the cultural and artistic goods of traditional Chinese calligraphy instruments [33, 34]. One of the best examples of traditional Chinese culture is the calligraphy instruments, which have unique national traits and humanistic sentiments [35]. They are also an important part of the culture's legacy. The Chinese people will be much encouraged to adhere to the traditional cultural roots and preserve the national spirit if we can continue to support the growth and investment of this sector in the future. The creation of and listing of outstanding cultural and artistic goods will, in the future, support the economic growth of the cultural and creative sector, contribute to the passing down of Chinese culture, and increase awareness of Chinese culture abroad with the help of a number of supportive state policies. These factors indicate that this sector has enormous market potential, and the future is not to be undervalued.

5. CONCLUSION

This research proposes an efficient technique that utilizes Photometric Stereo and the algorithm known as ICP for Chinese calligraphy reconstruction and evaluation. Photometric Stereo is used for 3D surfaces reconstruction with the goal of understanding the fundamental properties of 3D surface morphology derived from conventional Chinese calligraphy and the handwriting of calligraphy enthusiasts. In the evaluation phase, the user's handwriting (probe input) and the 3D forms of the calligraphy in a Galleries set align themselves using the ICP method. The use of UAV photogrammetric point clouds that relate to historical bridges in China is the main emphasis of this work. The segmentation technique, which may effectively divide bridge elements based on geometrical features, is based on voxel structuring and global graph optimization. Then, various structural components are identified from the acquired segments using category according to a hierarchy of groups and bridge geometry. In order to create surface modelling of the identified segments, surface modelling is finally carried out. Promising results were obtained in experiments using the Hongde and Tongxin bridges to illustrate the potential of photogrammetry using drones in 3D digital

recording of cultural heritage monuments. More specifically, the two bridges' 30 and 15 lengths each have identifiable basic structural parts. On the basis of the identified segments, surface models are also produced, which may provide reliable evidence for the ongoing maintenance of these bridges. Furthermore, our proposed segmentation technique shows promise for facilitating the division of structural parts in the area of civil engineering, as shown by experimental findings utilizing reference datasets.

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