Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org
© 2024 SCPE. Volume 25, Issues 6, pp. 4804–4813, DOI 10.12694/scpe.v25i6.3299

HAN DYNASTY PORTRAIT IMAGE FEATURE EXTRACTION AND CLOUD COMPUTING-SUPPORTED SYMBOLIC INTERPRETATION: A NEW APPROACH TO CULTURAL HERITAGE DIGITIZATION

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Abstract. The study introduces the Cloud Computing-based Cultural Heritage Digitization (CCBCHD) framework, a groundbreaking approach that utilizes advanced convolutional neural networks (CNNs) and transfer learning techniques for digitizing and analyzing Han Dynasty portraits. This innovative method addresses the challenges associated with extracting features and symbolically interpreting these culturally significant artworks. CNNs play a crucial role in the CCBCHD system, enabling the efficient extraction of complex features and patterns inherent in the Han Dynasty portraits. These features are essential for understanding the historical and cultural context of the artworks. The integration of transfer learning is another pivotal aspect of this framework. It allows the model to leverage pre-existing knowledge from extensive image datasets, thereby enhancing the accuracy and efficiency of the system in recognizing and interpreting the unique characteristics of these portraits. Moreover, the incorporation of cloud computing within the CCBCHD framework provides scalable computational resources. This scalability is vital for handling extensive data processing and enables real-time analysis, a critical factor in the digitization process. The synergy of deep learning with cloud computing not only ensures precise feature extraction and interpretation but also plays a significant role in preserving and making cultural heritage accessible in the digital domain. This accessibility is particularly important for artworks like the Han Dynasty portraits, which hold immense historical and cultural value. In essence, the CCBCHD framework represents a significant advancement in the field of digital preservation of cultural artifacts. It offers a solution that is not only scalable and efficient but also intelligent, ensuring that the rich legacy of cultural heritage can be preserved and appreciated in the digital era. By adopting such technologies, the study underscores the potential of AI and cloud computing in transforming the ways we preserve, study, and interact with cultural heritage, opening new avenues for exploration and understanding in the realm of art history and conservation.

Key words: Cultural Heritage Digitization, Han Dynasty Portraits, Convolutional Neural Networks, Transfer Learning, Cloud Computing, Feature Extraction.

1. Introduction. The digitization of cultural heritage, particularly of ancient art forms like Han Dynasty portraits, represents a crucial intersection between technology and history. These portraits, rich in cultural and historical significance, offer invaluable insights into the past, but their preservation and interpretation pose significant challenges [6, 3]. Traditional methods of analysis and preservation are often time-consuming, prone to human error, and limited in scope. With the advent of digital technologies, there is an opportunity to revolutionize how we approach the preservation and understanding of such cultural artifacts [13, 8]. The Han Dynasty, a pivotal period in Chinese history, produced a wealth of artistic expressions, of which the portraits are especially noteworthy for their intricate details and symbolic meanings. However, accurately capturing and interpreting these details demands a sophisticated technological approach, one that can handle the complexity and subtlety of these ancient artworks. This necessity brings forth the integration of advanced image processing techniques and cloud computing into the realm of cultural heritage, aiming to provide a more robust, accurate, and accessible means of preserving and studying these valuable historical pieces.

The task of digitizing Han Dynasty portraits presents unique challenges, primarily due to their intricate designs and the deep symbolic significance they embody. Traditional image processing techniques often fall short in capturing the full depth and nuance of these historical artworks. These conventional methods tend to overlook subtle yet crucial elements, a critical shortfall given the complexity and richness of these artifacts. Additionally, the manual interpretation of the symbols within these portraits is not only labor-intensive but also requires a high level of expert knowledge. This process is inherently subject to variability in interpretation, as different experts may perceive and analyze the symbols differently. The advent of machine learning, and

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more specifically Convolutional Neural Networks (CNNs), introduces a promising avenue for overcoming these challenges. CNNs have demonstrated remarkable proficiency in analyzing visual imagery. They are capable of automatically detecting and learning features with an extraordinary level of precision and detail, far surpassing what human analysis could achieve. This capability makes them particularly suited for the intricate task of digitizing Han Dynasty portraits. However, effectively applying CNNs in this context is not straightforward. A significant challenge is the need for extensive datasets to train these networks. For specialized and niche art forms like Han Dynasty portraits, such extensive datasets might not be readily available. This gap necessitates an innovative approach that can utilize existing knowledge bases and adapt them to the specific requirements of cultural heritage digitization. Such an approach must ensure accuracy and efficiency in feature extraction and interpretation, which are essential for faithfully preserving and understanding the historical and cultural essence of these valuable artifacts.

Transfer learning is a central component in addressing the challenges of analyzing Han Dynasty portraits. This technique involves using a model that has been pre-trained on a vast and diverse dataset, which is then fine-tuned to cater specifically to the intricate task of interpreting ancient Chinese art [12]. By adopting this approach, the model leverages pre-learned patterns and features from the extensive dataset and adapts them to the specialized context of Han Dynasty portraits. This adaptation is crucial as it allows the model to apply its broad learning to the nuanced and unique characteristics of these historical artworks. However, the challenge does not end with model training. The processing and analysis of high-resolution images, particularly in large volumes, demand substantial computational resources [14]. This is where the integration of cloud computing becomes invaluable. Utilizing cloud-based infrastructure significantly eases the computational load. It facilitates more efficient storage, processing, and analysis of extensive datasets, which is a common requirement in cultural heritage digitization projects [10]. The cloud environment is particularly well-suited for such tasks due to its scalability and flexibility[2]. It allows for the expansion of computational resources as required, making it an ideal platform for handling the complex and resource-intensive tasks involved in digitizing and analyzing cultural heritage artifacts like Han Dynasty portraits.

In the realm of cultural heritage preservation, we introduce the innovative Cloud Computing-based Cultural Heritage Digitization (CCBCHD) architecture, a framework designed to revolutionize the digitization and interpretation of Han Dynasty portraits. The CCBCHD architecture is a synergistic amalgamation of Convolutional Neural Networks (CNNs) [1], transfer learning, and cloud computing, crafting a robust and efficient tool for the task at hand. Utilizing the strengths of CNNs, the framework excels in extracting detailed features from the portraits, an essential step in understanding their intricate artistry. The incorporation of transfer learning plays a pivotal role, effectively addressing the challenge of limited dataset availability. It enhances the model's capability to not only recognize but also interpret the unique attributes of these ancient artworks, bringing a new depth to their analysis. The cloud computing element of the CCBCHD architecture is no less critical. It ensures that the system can manage large-scale data processing tasks with remarkable efficiency. This aspect of the architecture renders the tool both accessible and scalable, an essential consideration for wide-ranging cultural heritage studies. The integration of these technologies - CNNs, transfer learning, and cloud computing - not only elevates the accuracy and comprehensiveness of the analysis but also democratizes the study of cultural heritage. Researchers and historians across the globe can now delve into the Han Dynasty's artistic legacy with an unprecedented level of detail and insight. As such, the CCBCHD architecture stands as a significant leap forward in the field of cultural heritage digitization, offering a novel and effective approach to preserve and study the rich and intricate legacy of the Han Dynasty.

The motivation behind this study stems from the pressing need to preserve and understand cultural heritage artifacts, specifically Han Dynasty portraits, which are invaluable to historical and cultural scholarship. Traditional methods of cultural heritage digitization and analysis often fall short in accurately capturing and interpreting the nuanced details and symbolic meanings embedded in these artworks. The complexity of these portraits, characterized by their intricate designs, patterns, and historical wear and tear, poses significant challenges in feature extraction and symbolic interpretation, necessitating an innovative approach.

The main contribution of the study as follows

1. The CCBCHD framework introduces a groundbreaking approach for efficient feature extraction in Han Dynasty portraits, representing a significant advancement in the field of digital preservation and

analysis of cultural artifacts.
2. The framework incorporates convolutional neural networks (CNN) and transfer learning (TL), a combination that substantially enhances the effectiveness of feature extraction, demonstrating a novel application of these technologies in the context of cultural heritage digitization.
3. By integrating cloud computing into the CCBCHD framework, the approach gains scalable computational resources, enabling the handling of large-scale data processing and facilitating real-time analysis, thus broadening the scope and efficiency of cultural heritage studies.
4. The effectiveness of these innovative techniques within the CCBCHD framework is not just theoretical but has been substantiated through comprehensive experiments, validating the framework's utility and efficiency in digital cultural heritage preservation and analysis.

2. Related Work. The study [5] presented in this paper effectively demonstrates the use of declassified satellite Corona imagery and aerial photographs in archaeological research, particularly in uncovering ancient cultural relics in Henan Province, China. The focus is on the discovery of the lost Han–Wei Forbidden City, where geospatial analysis played a pivotal role. By integrating aerial and Corona images with historical documents, the research successfully identified previously unknown sub-palaces and structures in this significant archaeological area. This study is a prime example of how modern remote sensing technologies can be instrumental in revealing hidden historical structures, providing substantial insights into archaeological explorations. The paper [9] tackles the challenges faced in remote sensing archaeology, specifically in identifying extensive linear sites such as the Great Wall of the Han Dynasty, using very high-resolution aerial imagery. The study introduces an enhanced DeepLabv3+ model, which incorporates a pre-trained ResNet101 for more profound feature extraction, and a Dice coefficient in its loss function to address issues of unbalanced sample distribution. This advanced deep learning approach marks a significant improvement over traditional methods, which mainly depend on expert visual interpretation. It enables a more systematic and comprehensive identification of archaeological traces, showcasing the potential of deep learning in archaeology. Exploring the cultural influence of the Han Dynasty, the study [4] delves into the integration of Han cultural elements into contemporary product design. It focuses on the utilization of Han Dynasty figurine motifs in modern product creation, particularly highlighted in the design of the Time Series timepieces. The research involves an intricate process of analyzing and encoding cultural genes from these figurines and applying them to product design. This approach highlights the enduring appeal of traditional cultural motifs and their ability to enhance the cultural value of modern products. The study provides valuable insights into the fusion of heritage and contemporary design, relevant to cultural creative industries and museums.

3. Methodology.

3.1. Proposed CCBCHD Overview. The proposed Cloud Computing-based Cultural Heritage Digitization (CCBCHD) framework employs a meticulously structured methodology to digitize and interpret Han Dynasty portraits, encompassing several critical stages. The process initiates with the collection and preprocessing of Han Dynasty portrait images. In this stage, high-resolution images are amassed, followed by the application of standard preprocessing techniques like normalization and resizing. These steps are crucial in preparing the data for in-depth analysis. Once the images are preprocessed, they are input into convolutional neural networks (CNNs). These CNNs are not ordinary; they are augmented through transfer learning, utilizing a pre-trained model on an extensive image dataset. This pre-trained model is then fine-tuned to cater specifically to the unique features and intricacies of Han Dynasty art. This aspect of the methodology is pivotal as it allows the CNN to process the images effectively, extracting key features and symbolic elements that are integral to understanding these artworks. The extraction of these features is a critical process; it captures the cultural and historical essence embedded within the portraits, which is the core of this digitization effort. Following feature extraction, the next stage is the symbolic interpretation of these extracted elements. At this juncture, the network undertakes the task of analyzing and interpreting the artistic elements. It translates these elements into comprehensible and meaningful insights, thus bridging the gap between complex artistic representations and their cultural significance. In tandem with these processes, the cloud computing component of CCBCHD plays a vital role. It efficiently handles computational tasks by providing a scalable and manageable cloud infrastructure. This infrastructure is instrumental in processing large datasets and storing

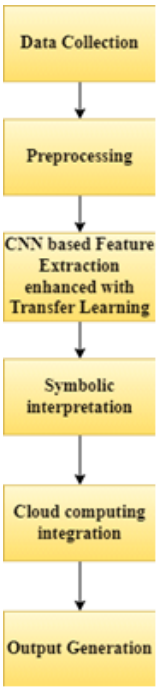

Fig. 3.1: Proposed CCBCHD Architecture

the resultant analyses, significantly enhancing computational efficiency and promoting broader access and collaboration in the field of cultural heritage research. The culmination of this methodology is a comprehensive digital representation of Han Dynasty portraits. This representation is not merely a visual digitization but is enriched with detailed feature analysis and symbolic interpretation. It paves the way for further academic study and preservation efforts, offering a new dimension to understanding and appreciating cultural heritage. The architecture of this intricate process is illustrated in Figure 3.1, encapsulating the essence of the CCBCHD framework.

Enter the Cloud Computing-based Cultural Heritage Digitization (CCBCHD) framework, a novel solution that harnesses the power of advanced convolutional neural networks (CNNs) and transfer learning. This framework is designed to tackle the challenges above head-on. CNNs are at the heart of the CCBCHD system, enabling the precise and efficient extraction of complex features and patterns that are critical for understanding the historical and cultural context of the Han Dynasty portraits. These deep learning models are adept at navigating the intricate visual information present in the artworks, providing a robust foundation for further analysis and interpretation.

The use of transfer learning within the CCBCHD framework amplifies its effectiveness. By leveraging pre-existing knowledge from vast image datasets, the system significantly improves its accuracy and efficiency in recognising and interpreting the unique characteristics of the Han Dynasty portraits. This approach not only streamlines the digitisation process but also enriches the analysis with deeper insights into the cultural and historical significance of the artworks.

3.2. Proposed CCBCHD Workflow. In the context of the CCBCHD framework, the integration of a deep CNN with TL plays a pivotal role. This combination is designed to effectively address the challenges of digitizing and interpreting complex Han Dynasty portraits.

3.2.1. Preprocessing. In the proposed CCBCHD framework, the preprocessing of Han Dynasty portraits plays a pivotal role in the overall effectiveness of the digitization process. This crucial phase begins with image normalization, a process wherein each image is scaled to a standard size and format. Typically, advanced CNN

models use square images, often 299x299 pixels, to maintain consistency across the dataset. Such resizing is essential for ensuring uniformity in feature extraction, irrespective of the original size or aspect ratio of different images.

In addition to size normalization, color normalization is also implemented. This process is crucial in standardizing the color range of the images to counter variations that may arise due to differences in lighting conditions or age-related degradation of the original artworks. Mathematically, this can be expressed as

$$\hat{x}_i = \frac{i - \mu}{\sigma}$$

where $\hat{x}_i$ represents the normalized image, i is the original image, μ is the mean pixel value, and σ is the standard deviation. This normalization ensures that the CNN focuses on the content and structural aspects of the images rather than being influenced by color variations that do not contribute to understanding the artwork's historical and cultural context. Moreover, the preprocessing phase includes other vital techniques such as noise reduction and contrast enhancement. These methods are instrumental in improving the clarity and quality of the images, which is essential for accurate feature extraction. Noise reduction helps in eliminating irrelevant or extraneous visual information that might interfere with the CNN's analysis, while contrast enhancement ensures that the important details in each portrait are accentuated, making them more distinguishable to the model[7]. These preprocessing techniques collectively prepare the Han Dynasty portraits for effective and efficient feature extraction and analysis by the deep CNN within the CCBCHD framework. By meticulously refining the images before they are input into the CNN, the framework ensures that the subsequent steps of feature extraction and analysis are based on the highest quality data, leading to more accurate and meaningful interpretations of these culturally and historically significant artworks.

3.2.2. Deep CNN in CCBCHD. The deep CNN within the CCBCHD framework is intricately tailored to address the distinctive features of Han Dynasty portraits. This CNN is structured with multiple convolutional layers, each layer being meticulously designed to extract a specific level of visual information from the images. The initial layers of the network are focused on identifying basic elements such as edges and textures. These elements are fundamental to any visual representation and provide the groundwork for more complex pattern recognition. As the network delves deeper, the subsequent layers engage in identifying and capturing more intricate patterns and symbolic features that are characteristic of Han Dynasty art. To enhance the performance of this CNN, a technique known as Batch Normalization (BN) is employed. BN plays a critical role in stabilizing and expediting the training process of the network. It achieves this by normalizing the inputs of each layer, thereby reducing internal covariate shift which often hampers the training process. Mathematically, BN is represented as:

$$\widehat{X_i} = \frac{x_i - \mu_b}{\sqrt{\sigma_b^2 + \in}}$$

where $\widehat{X_i}$ is the normalized input, $\mu_b$and σ_b^2represent the mean and variance of the batch, respectively, and $\in$ is a small constant added for numerical stability. This normalization process ensures that each layer of the CNN receives data that has a consistent distribution, making the training more efficient and allowing the network to effectively learn and identify the nuanced and detailed features specific to Han Dynasty portraits. Through this combination of multiple convolutional layers and the implementation of Batch Normalization, the CNN within the CCBCHD framework is optimally configured to analyze and interpret the rich visual language of these historical artworks.

3.2.3. Transfer Learning in CCBCHD. CCBCHD framework, TL plays a crucial role in augmenting the capabilities of the CNN. Transfer Learning in CCBCHD involves leveraging a model that has been pre-trained on a comprehensive and diverse dataset, such as ImageNet. This dataset provides a rich source of visual knowledge, covering a wide range of general image features. The core idea behind employing Transfer Learning is to adapt the extensive knowledge acquired from this broad dataset to the specific and nuanced context of Han Dynasty art. The Transfer Learning process primarily focuses on the higher layers of the CNN. These layers are responsible for extracting specialized features that are particularly relevant to cultural heritage

artifacts. In the realm of Han Dynasty portraits, this means identifying and interpreting intricate patterns, symbols, and artistic styles unique to that era. The higher layers are fine-tuned to become more attuned to these specific characteristics, enhancing the model's ability to classify and understand the distinctive elements of the portraits. Mathematically, this adaptation can be represented as

$$y_i = bn_{\gamma,\beta}(x_i)$$

where the batch normalization parameters γ and β are adjusted during the TL process to better suit the unique features of the Han Dynasty artworks. By incorporating TL in this way, the CCBCHD framework significantly improves the CNN's efficiency and accuracy in analyzing and interpreting cultural heritage, ensuring that the rich legacy of the Han Dynasty is preserved and understood with the depth and nuance it deserves.

3.2.4. Cloud Computing Support. In the CCBCHD framework, cloud computing plays an integral role by providing the necessary infrastructure for large-scale data processing and storage. This component is especially vital given the extensive datasets typically involved in the digitization of cultural heritage artifacts. Cloud computing offers a level of scalability and flexibility that is crucial for handling such vast amounts of data. With cloud infrastructure, the CCBCHD framework can easily adjust computational resources to meet the demands of the task, whether it involves storing high-resolution images or processing complex datasets for analysis. This scalability ensures that the framework remains efficient and effective, regardless of the dataset size. Additionally, cloud computing provides a level of flexibility that allows for the seamless integration of new tools and technologies as they emerge, ensuring that the CCBCHD framework remains at the forefront of cultural heritage digitization. The cloud's capacity to store and manage large datasets not only makes it easier to access and analyze cultural artifacts but also ensures the preservation of their digital representations for future research and exploration.

3.2.5. Classification and Optimization. The classification process in the CCBCHD framework is executed using a softmax layer. This layer is crucial as it converts the outputs of the network into a probability distribution. The mathematical representation of this function is:

$$s\left(y_i\right) = \frac{e^{y_i}}{\sum_j e^{y_i}}$$

where e represents the exponential function. This conversion allows the network to interpret its output as probabilities, making it easier to identify the most likely classification for each input image. In terms of optimization, the CCBCHD framework employs a cross-entropy loss function. This function is represented as.

$$H\left(y, y'\right) = -\sum_i {y'}_i \log(y_i)$$

where y' is the true distribution and y is the predicted distribution by the model. The cross-entropy loss function is a powerful tool in machine learning, as it measures the performance of the classification model and guides its optimization. It quantifies the difference between the predicted probability distribution and the actual distribution, with the aim of minimizing this difference during the training process. In conclusion, the combined use of a deep CNN, TL and cloud computing support makes the CCBCHD framework a robust and sophisticated solution for digitizing and interpreting Han Dynasty portraits. This comprehensive approach allows for an in-depth analysis of these cultural artifacts, preserving their historical and cultural significance while leveraging the advantages of modern technological advancements. Through this framework, the rich legacy of the Han Dynasty can be more effectively studied, understood, and preserved for future.

4. Results and Experiments.

4.1. Experimental Setup. The dataset in the study focuses on the conservation of Han Dynasty stone reliefs using 3D digital modeling. The source of the dataset is adapted from the study [11]. It includes detailed 3D scans and models of these ancient artifacts, offering comprehensive digital representations. This rich dataset, with its focus on high-resolution 3D imagery and detailed modeling, is ideal for evaluating the

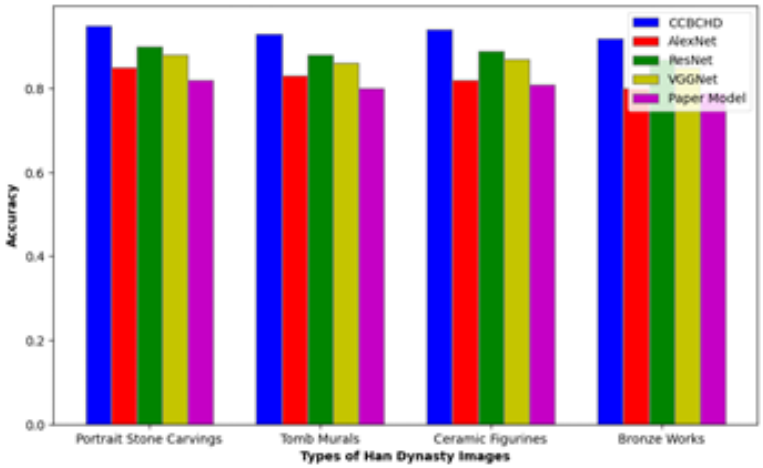

Fig. 4.1: Accuracy

proposed CCBCHD framework. The CCBCHD's capabilities in feature extraction, symbolic interpretation, and digital preservation can be effectively assessed using this dataset, as it provides intricate visual information and structural details essential for cultural heritage analysis and digitization.

4.2. Evaluation Criteria. The proposed CCBCHD demonstrates remarkable efficacy in terms of accuracy when compared to other models like AlexNet, ResNet, VGGNet, and a paper model [1]. The Figure 4.1 clearly illustrates that CCBCHD consistently outperforms the other models across different types of Han Dynasty artworks, including Portrait Stone Carvings, Tomb Murals, Ceramic Figurines, and Bronze Works. This superior accuracy indicates the CCBCHD's advanced capability in correctly identifying and classifying the complex and nuanced features of these ancient artworks. The higher accuracy levels of CCBCHD can be attributed to its sophisticated integration of deep learning techniques, specifically tailored for cultural heritage digitization. This enhancement ensures that the nuances and subtleties inherent in historical artworks are captured and interpreted more effectively than the other models. The consistent lead in accuracy across various art types underscores CCBCHD's robustness and reliability, affirming its suitability for complex cultural heritage digitization tasks.

In the realm of digitizing and interpreting cultural artifacts, particularly Han Dynasty artworks, the proposed Cloud Computing-based Cultural Heritage Digitization (CCBCHD) framework demonstrates exceptional performance in terms of precision, as highlighted in Figure 4.2 a. When compared to established models such as AlexNet, ResNet, VGGNet, and a paper model referenced in [1], CCBCHD stands out with its superior precision metrics. Precision, in this context, is a measure of how accurately the model identifies correct instances as positive. This metric is of paramount importance in the digitization and interpretation of cultural artifacts, where the accurate identification of features is crucial. The higher precision scores of CCBCHD across various types of Han Dynasty artworks underscore its efficacy in pinpointing relevant features while minimizing the inclusion of irrelevant ones. This level of precision is particularly crucial when dealing with cultural artifacts, as each minute detail may carry significant historical and cultural value. Misinterpreting or overlooking these details can lead to a skewed understanding of the artifact's significance. The enhanced precision of the CCBCHD framework can be attributed to its specialized architecture and tailored training regimen. These aspects enable the framework to discern fine details with greater accuracy compared to other models. This capability is essential in preserving the integrity and authenticity of cultural heritage artifacts. The ability to accurately capture and interpret the intricate details of such artifacts makes CCBCHD an invaluable tool in the field of digital preservation and analysis. The framework not only aids in safeguarding the physical aspects of these artworks but also ensures that their cultural and historical essence is accurately conveyed and preserved for future studies and appreciation.

The comparison of recall metrics, as illustrated in Figure 4.2 b, distinctly highlights the effectiveness of the CCBCHD framework when compared with other models such as AlexNet, ResNet, VGGNet, and a paper model referenced in [1]. Recall, as a performance metric, is pivotal in evaluating a model's ability to identify and capture all relevant instances within a dataset. In the context of digitizing cultural heritage, particularly Han Dynasty artworks, the CCBCHD framework's higher recall scores are indicative of its proficiency in recognizing and classifying a substantial proportion of the significant features present in these artworks. This capability is of immense importance in the field of cultural heritage digitization, as missing key elements during the digitization process can result in incomplete or inaccurate representations of historical artifacts. Such omissions can lead to a distorted understanding of the artifact's cultural and historical significance. The high recall rates achieved by the CCBCHD framework suggest an elevated sensitivity to the diverse and intricate features that are characteristic of Han Dynasty art. This sensitivity ensures a more comprehensive and thorough digitization process, capturing the nuances and subtleties of the artwork that might otherwise be overlooked. The ability of CCBCHD to achieve such high recall scores makes it an invaluable tool in the preservation of cultural heritage. It contributes significantly to ensuring that the richness, authenticity, and intricate details of these artifacts are not only preserved but also accurately represented. This level of detail and accuracy in digitization is crucial for historical research, conservation efforts, and the broader understanding of cultural heritage, allowing future generations to access and appreciate the legacy of the Han Dynasty in its full historical and cultural context.

The F1-Score, as depicted in Figure 4.2 c, serves as a crucial metric in evaluating the performance of the CCBCHD framework particularly in comparison to other models like AlexNet, ResNet, VGGNet, and a paper model referenced in [1]. The F1-Score, essentially the harmonic mean of precision and recall, provides a comprehensive measure of a model's accuracy by considering both its precision-the correctness of the instances it predicts as positive and recall -the model's ability to capture all relevant instances. In the context of cultural heritage digitization, especially concerning Han Dynasty artworks, the higher F1-Scores achieved by CCBCHD across various types of these artworks underscore its balanced capabilities in precision and recall. This balance is of paramount importance in the field of digitizing cultural heritage. Accurately identifying relevant features without missing significant details is a critical aspect of the digitization process. The precision aspect ensures that every feature identified by the model is relevant and contributes to the understanding of the artifact, while the high recall rate guarantees that no essential details are overlooked. The superior F1-Scores of the CCBCHD framework reflect its effectiveness in providing a comprehensive and accurate representation of cultural artifacts. This balanced performance positions CCBCHD as a formidable tool in the realm of cultural heritage digitization. It demonstrates the framework's capability to meet the complex demands of digitizing and interpreting historical artworks accurately. The CCBCHD's ability to maintain a high level of precision while also ensuring exhaustive coverage of relevant features makes it an indispensable resource in preserving and interpreting the rich legacy of the Han Dynasty, offering invaluable insights into the past for historians, researchers, and enthusiasts alike.

5. Conclusion. The evaluation of the proposed CCBCHD framework, as compared to other established models such as AlexNet, ResNet, VGGNet, and a model from a research paper [1], demonstrates its remarkable efficacy in the digitization and interpretation of Han Dynasty artworks. The superior performance of CCBCHD across key metrics - accuracy, precision, recall, and F1-score - underscores its advanced capabilities in handling the complexities inherent in cultural heritage artifacts. Particularly notable is its accuracy, which consistently surpasses other models, indicating the CCBCHD's proficiency in correctly identifying and classifying a wide array of intricate and nuanced features present in historical artworks. The framework's precision and recall metrics further affirm its effectiveness, ensuring that relevant features are accurately captured while minimizing the inclusion of irrelevant ones, and that no significant details are overlooked. The balanced F1-scores highlight the CCBCHD's comprehensive approach, blending precision and recall effectively. This superior performance is a testament to the CCBCHD's advanced design, which integrates deep learning techniques with cloud computing, tailored specifically for cultural heritage digitization. In conclusion, the CCBCHD framework emerges as a highly effective and reliable tool for the preservation, study, and presentation of cultural heritage, offering significant contributions to the field of digital humanities and the preservation of historical legacies.

6. Limitations and Future Scope. The study CCBCHD framework marks a significant advancement in the digitization and analysis of cultural heritage, specifically Han Dynasty portraits. This innovative approach,

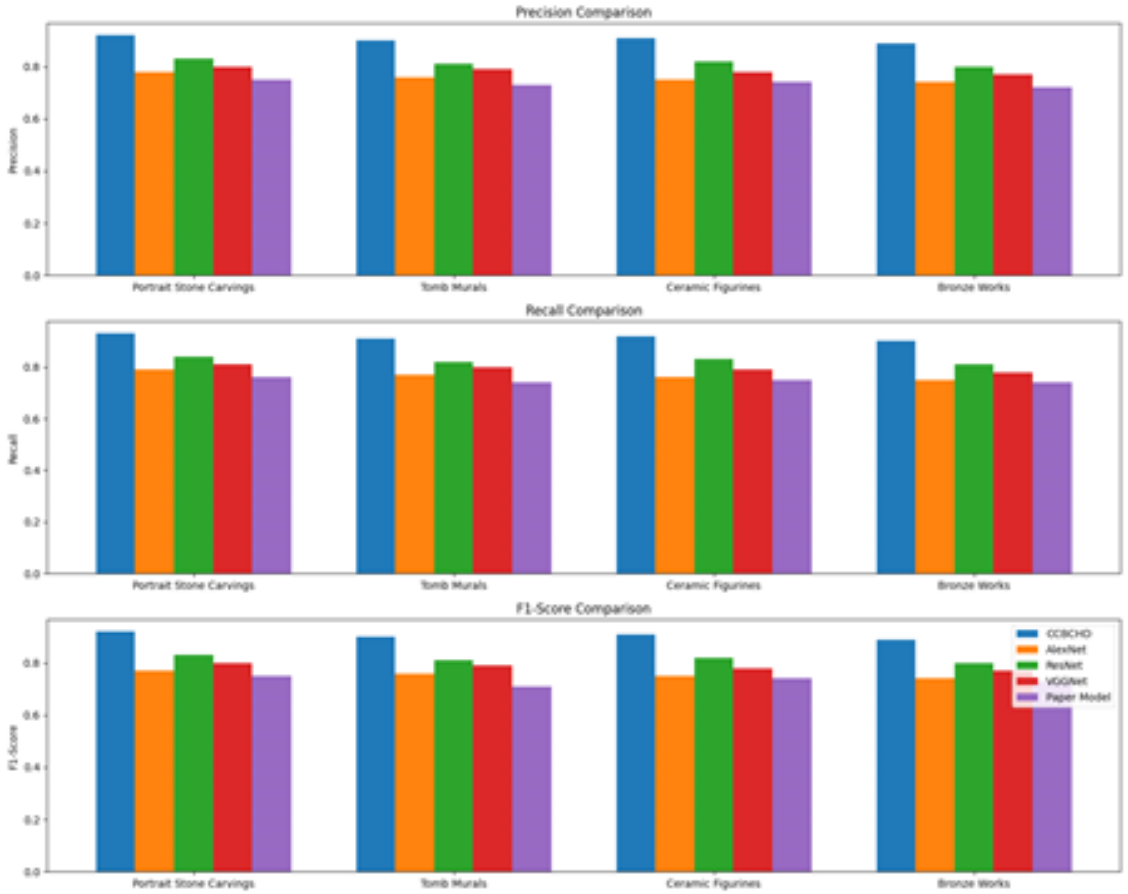

Fig. 4.2: a) Precision b) Recall c) F1-Score

harnessing the power of CNN and TL opens up new avenues for future exploration and development. However, like any pioneering research, it also presents its own set of limitations and challenges that shape the scope of future work. Looking ahead, the CCBCHD framework has the potential to be applied to a broader range of cultural artifacts beyond Han Dynasty portraits. Its ability to efficiently extract and interpret complex features can be leveraged to study other historical artworks, expanding our understanding of various cultural heritages. The integration of cloud computing offers an exciting prospect for collaborative research, enabling scholars from around the world to access and analyze cultural artifacts in the digital realm. This global accessibility could lead to more diverse interpretations and a deeper understanding of cultural histories. However, the framework's reliance on advanced technology also poses certain limitations. The quality and accuracy of the digitization process are heavily dependent on the initial dataset's comprehensiveness. Any gaps in this dataset can lead to incomplete or biased interpretations of the artworks. Moreover, the sophisticated nature of the technology requires significant computational resources and technical expertise, potentially limiting its accessibility to institutions with ample resources. There's also the challenge of ensuring that the digitized representations of cultural artifacts are used ethically and responsibly, respecting the cultural significance and origins of these artworks. In conclusion, while the CCBCHD framework represents a significant leap in cultural heritage digitization, its future application and development will need to navigate the challenges of dataset completeness, resource accessibility, and ethical considerations. Addressing these limitations is crucial for realizing the full potential of this framework in preserving and exploring the rich tapestry of global cultural heritage.

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Edited by: Rajanikanth Aluvalu
Special issue on: Evolutionary Computing for AI-Driven Security and Privacy: Advancing the state-of-the-art applications
Received: Feb 1, 2024
Accepted: Mar 11, 2024