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Research on the Identification of Modern Ceramic Ornaments Based on Wireless Network-Guided Artificial Intelligence Model and the Communication Strategy of Chinese Ceramic Culture and Creative Industry in Southeast Asia

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***Abstract*:** The functional and artistic qualities of ancient Chinese ceramic are desired across the globe. Recognizing the cultural interchange, wherein the identification for ancient ceramic is a critical feature, necessitates a thorough examination of ancient ceramic. Artificial intelligence (AI) has been used to assist in the recognition of ancient ceramics in this work. This research proposes a novel Unconfined Weed Optimization Algorithm (UWOA). Initially, the Chinese ceramic datasets are gathered and are pre-processed using canny edge detection (CED). Then the features of the pre-processed dataset are extracted using Hough circular transformation (HCT) that can be properly performed by employing both direct grey level symmetric similarity calculation (DGLSSC) and principal component analysis based texture symmetric similarity detection (PCA-TS) techniques. The extracted data are feed to the prediction process of ceramic properties using Artificial Neural Network (ANN) in AI. To optimize the ANN, the proposed approach can be utilized. Finally, the performances of the proposed approach are examined and the outcomes are depicted using the MATLAB tool.

Keywords: *Artificial intelligence (AI), Artificial Neural Network (ANN), Canny Edge Detection (CED), Chinese ceramic, DGLSSC, Hough circular transformation (HCT), MATLAB, PCA-TS, Unconfined Weed Optimization Algorithm (UWOA)*

1. Introduction

Initially, the ceramics that our forefathers invented and made were simply utilized as containers for drinking water and storage. Our ceramic artists, on the other hand, have evolved over thousands of years to create more unusual shapes and brilliant decorative designs. Porcelain in ancient China was always founded on everyday porcelain, with ornate porcelain added on top. Traditional ceramic technology and colored drawing embellishment have influenced modern ceramic art. Ceramic artists' joyful and carefree mental state while manufacturing porcelain is reflected through avant-garde ceramic art pieces. Porcelain, which was popular and was produced using pressing machines and injection molding, was progressively abandoned by the public more than 50 years ago. In modern porcelain modeling, the manual method has become the primary aesthetic expression. [1]

Ceramics from ancient China are valuable like a set and as transmitters of Chinese civilization. They show a crucial appearance in the transmission of Chinese old times. The decorations, forms, and writings of ancient pottery have evolved in tandem with the advancement of science and technology. [2], [3], [4] All of the pottery items exhibit the dynasty's humanistic features at the period. The goal of ceramic identification is to determine genuineness, age, and origin. The selection of raw materials, the acquisition of shape, and the decoration colors all play a role in the evolution of ancient pottery. Among the irregular designs of tools decorated with rich decoration such as figures, birds, landscape, and trees are jugs, ovens, pans, plates, bowls, flasks, cans, basins, boxes, sofas, cylinders, and inked rocks. [5], [6] Furthermore, the handmade Chinese symbols on the products provide a property of semantic & circumstance data that makes them more valuable for identification than other embellishments. The exterior qualities of ancient ceramics are made up of all of these factors.

Visual identification is a widely utilized approach, which relies on specialists' knowledge and focuses on the antique items' exterior presence & tactile features. Its key benefits are that it is non-destructive, quick, and easy to use and that it may be used to make a fairly accurate judgment on the common features of ceramics, thereby assuming the generation span, furnaces, and worth of the artifacts. Naturally, only individuals who have

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worked in the ceramic domain as specialists for a lengthy period may recognize the ceramic, yet mistakes and misidentification are bound to happen. [7]

Thermoluminescence is an unlimited dating technique, which includes detecting the amount of irradiation stored in ceramic artifacts and also determining the period since the fire. Elemental composition analysis is a way of comparing and identifying elements. It entails identifying the exact information architecture of ancient pottery, matching the data to the basic data including ceramic architecture, and examining the discrepancy among datasets. X-ray fluorescence (XRF) methodology is currently in widespread use. [8], [9], [10] This method necessitates the use of specialist assessment equipment and the creation of a massive, accurate, dependable, full, and systematic database to serve as a backbone. In addition, when compared to visual identification, it overlooks exterior traits and humanistic values and uses quantitative identification data to draw comparable conclusions via information examination, making it a targeted approach. AI has grown widely used in science and technology during the last decade. Before becoming mainstream, certain aspects of AI went through cycles of the invention. AI approaches were used in excavation for a variety of purposes, including, (i) the identification of historical sites; (ii) the identification & rearranging of archaeology pottery; (iii) the content separation & NER; (iv) the human remains assessment; (v) mural & graffiti arts; and (vi) robots. [11] Artistic representations, [12], [13] Wear and tear on archaic instruments, [14] antique coin & historic glassware items [15] were among the first AI archaeology applications, focusing on the categorization, segmentation, and research of material culture. The rest of this study can be designed as: Section II explains the proposed research; Section III depicts the result and analysis. Section IV summarizes the total research.

2. Proposed Work

Fig. 1 depicts the overall structure of this research. First, the set of data is collected, and then that is used in the pre-processing task. Then the pre-processed data are performed in the extraction process. The ceramic properties prediction task can be done on the extracted dataset using ANN and then the ANN can be enhanced by employing the proposed approach.

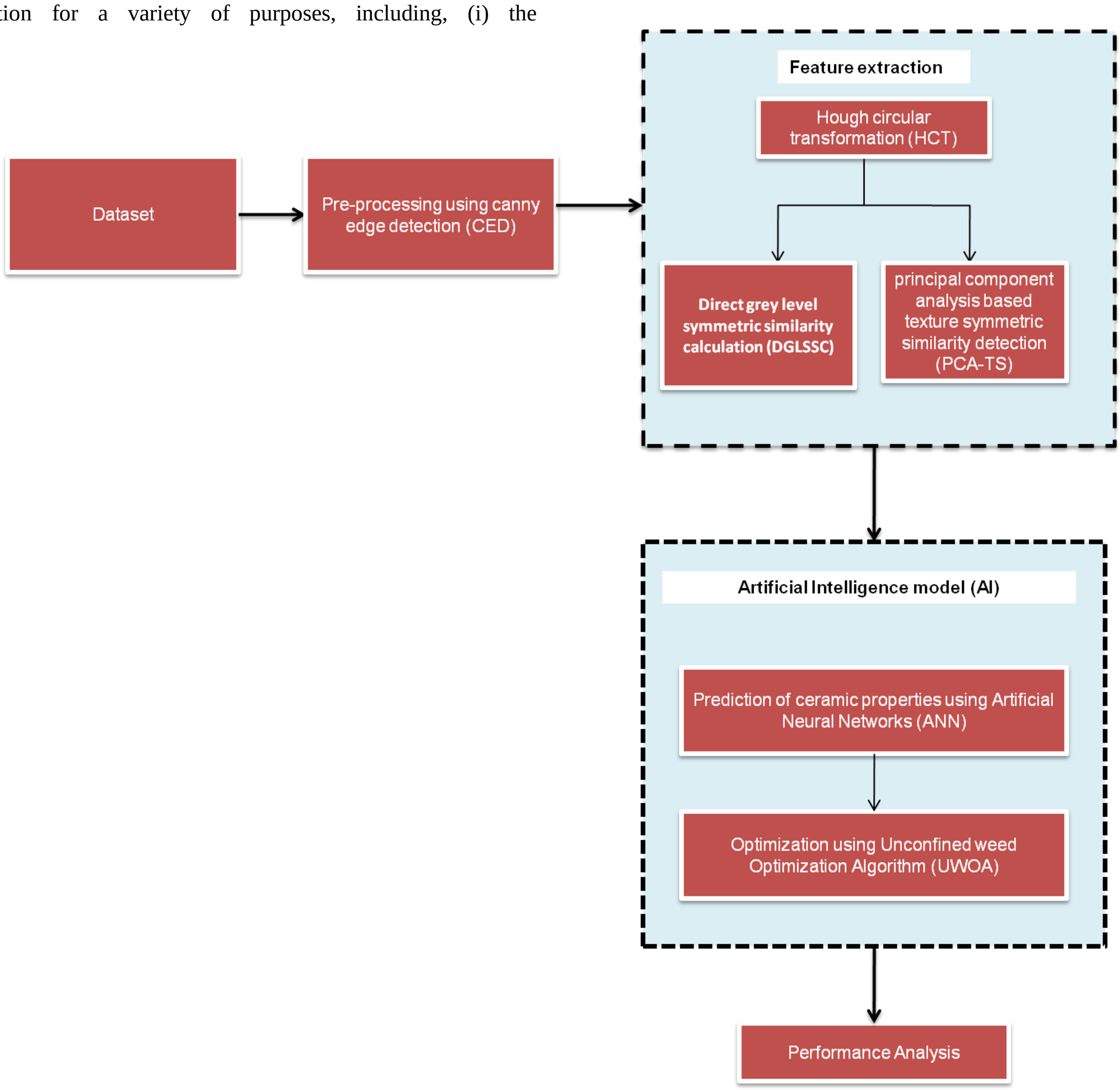

Figure 1. Overall structure of the research dataset

The dataset in this study is made up of the levels of chemical compositions in ancient celadon forms & enamels that have been examined using the Energy Dispersive X-ray Fluorescence (EDXRF) on the Energy Dispersive X-Ray Analysis (EDAX)

Eagle III analyzer just at the Chinese Academy of Sciences' Institute of High Energy Physics in Beijing. [16] During all of the experiments, we used an identical set of characteristics. A ceramic reference sample prepared by the lab has been used to calibrate instruments to ensure the accuracy of measurements.

2.1. Pre-processing using Canny Edge Detection (CED)

CED is a method for collecting relevant architectural data from a collection of visualized elements while drastically lowering the quantity of information, which can be examined. It's been employed in a collection of computerized vision applications. It has been discovered that criteria for edge detection are comparable in various vision technologies, allowing for the implementation of an edge detection scheme having a broad potential application. The following are some basic criteria regarding edge detection:

- Monitor the border with minimal error.
- The identified border must be perfectly aligned with the true border's center.
- If ever reasonable, the picture distortion must not generate inaccurate borders, as well as the provided border in the picture can only be tagged once.

The CED's optimal function is defined by the total of four exponential items, which may be closed by the Gaussian function's first derivative. The CED approach is one of the most widely used edge detection algorithms, and it is among the few, which are well-detailed and capable of accurate identification.
The CED method should be broken down into five phases below.

1. Smooth the image and remove noise with a Gaussian filter. The (2m+1)(2m+1) Gaussian kernel filter's generating equation is,

$$H_{ij} = \frac{1}{2\pi\sigma^2} exp\left(\frac{(i-(m+1))^2+(j-(m+1))^2}{2B^2}\right) \quad i \geq 1, j \leq (2m+1) \qquad (1)$$

   Where B is the filter's bandwidth and m is the image's size parameter.
2. Determine the fitness & directionality of every frame in the picture's gradient. Because picture edges can point in any direction, the Canny algorithm detects horizontal, vertical, and diagonal edges in the image using four operators. Edge detection operators (such as Roberts, Prewitt, Sobel, and others) return the first derivative values in the horizontal gx and vertical gy directions, allowing them to determine the pixel's gradient g and direction.

$$g = \sqrt{g_x^2 + g_y^2} \qquad (2)$$

$$\theta = arctan\,(g_y/g_x) \qquad (3)$$

   The gradient intensity is g, and the gradient direction 'θ'.
3. Use non-maximum suppression to eliminate erroneous edge detection responses.
4. Determine real and probable edges using double-threshold detection.
5. Suppress isolated weak edges to complete edge detection.

MATLAB was used to implement the above five CED stages.

2.2. Feature extraction using Hough circular transformation (HCT)

Each non-zero frame on the picture could be a feasible circle, according to the HCT. A cumulative coordinate plane is constructed with cumulative weight is established to detect the circle as a result of "voting."

The Cartesian Equation in Circular Form is given in the equation is:

$$(x-c)^2 + (y-d)^2 = s^2 \qquad (4)$$

Where (*c*, *d*) is the circle's center and *s* is the circle's radius. The parameter space is represented by (*c, d, s*), and a spot in the dimensional area relates to a circle in the picture coordinate area. Allowing *c* & *d* to enhance inside the parameter limits as well as solving the parameter of s meeting the statement is the computation procedure. The array element A (*c, d, s*) adds 1 for each value of (*c, d, s*), which represents the voting process. After the voting, determine the greatest A (*c, d, s*) corresponding to *c, d, s* being the circle's parameter. MATLAB is used to implement the HCT processes listed above. CED and HCT can be used to accomplish the gray-scale matrix of each circle. Then we calculate the symmetry similarity of all circles around the axis to see if the symmetry axis exists.

2.3. Direct grey level symmetric similarity calculation (DGLSSC)

DGLSSC is a straightforward method for determining an object's symmetry. The procedure can be broken down into four steps:
Depending on the direction of the strip axis as well as the characteristics of the composites, various possible symmetrical axes are discovered, and or the linear function for the abovementioned symmetric axis is as regards:

$$cx + dy + v = 0 \qquad (5)$$

- Estimate the symmetry point's area info (x, y) with relation to a specific axis.

$$x^1 = \frac{(d^2-c^2)x_0-2cdy_0-2cv}{c^2+d^2} \qquad (6)$$

$$y^1 = \frac{(c^2-d^2)y_0-2cdx_0-2dv}{c^2+d^2}$$

  Where (x_0,y_0) is the location of a specified spot in the circle separated by the HCT, and (x_1, y_1) is the symmetry point's location related to an axis.
- Estimate the similarity in symmetry across the circle's specified spot as well as its symmetry spot. The following is the technique for DGLSSC.
- $$L_s = \sqrt{\frac{\Sigma\{I_D(x,y)-I_C(x^1,y^1)\}}{\Sigma I_D(x,y)^2}} \qquad (7)$$

  The symmetry spot related to the correspondent spot (x, y) around a given axis is the coordinate point (x_1, y_1). The grey values IC(x, y) and ID(x, y) correspond to the locations of (x, y) & (x_1, y_1), respectively. *Ls* is a parameter that can be used to describe how symmetrically similar two patterns are. The lesser the *Ls* number, the greater the similarity between the two decorations. We use this approach to calculate the symmetry similarity of pictures as well as use it for symmetric similarity recognition.
- Estimate the mean of all circles' symmetry similarity concerning every axis, and also discover the symmetry axis.

MATLAB was used to implement the above procedures for picture decorations. The DGLSSC approach is a quick and easy way to assess symmetry similarity. However, because it is susceptible to location data, the technique's resiliency would be severely harmed whereas if the information is inaccurate.

2.4. Principal Component Analysis Based Texture Symmetric Similarity Detection (PCA-TS)

The PCA-TS was invented to strengthen the symmetry similarity calculation's reliability. The goal of PCA is to lower the grey matrix's aspect by filtering out undesired noise signals while keeping the texture's essential qualities. Furthermore, calculating symmetric similarity with a lower-dimensional grey matrix is greater effective. We can determine if the axis is symmetrical by computing the symmetry similarity of the grey matrix after PCA. The procedure can be broken down into four steps: Calculates the grey matrix to obtain the grey level statistics for every circle, as well as the symmetric circle related to the certain axis.

- Reduce the grey matrix's dimension by doing a principal component analysis (PCA). The PCA process can be broken down into the following steps: (a) In the grey matrix, detect the mean of every row. Calculate the covariance matrix in step b. (c) Determine the covariance matrix's eigenvalues and accompanying eigenvectors. (d) According to the corresponding eigenvalue, the eigenvectors are organized in a matrix according to starting to finish.
- Calculate the degree of similarity across the circles and the axis-corresponding symmetry circles. The following is the similarity calculating method:

$$\theta = arccos\left(\frac{G_1.G_2}{|G_1|.|G_2|}\right) \quad (8)$$

Where *G1* is the circle's grey matrix and *G2* is the symmetry circle's grey matrix. The smaller the number, the closer the two grey matrices are to each other.

2.5. Prediction of ceramic properties using Artificial Neural Network (ANN)

Innovative AI breakthroughs show that ANNs can understand to overcome multiple issues in a short amount of duration. ANNs are non-linear statistical information modeling tools that may be used to represent relationships between input and output data. They can also be used to create an adaptive technique, which may change its design relying on the specifics that pass through the network throughout the learning procedure. Layers of feed-forward networks are used to organize the neurons. All possible neurons are linked to one another in the different layers, but there is no attachment between neurons in the same layer. The initial layer is usually referred to as the input layer, and it specifies the ANN's input parameters, with an identical amount of neurons in the input resulting in an ANN with an identical quantity of neurons as the problem outcome. Between these two layers lie the hidden layers. Because of the difficulty under investigation, the identical quantity of hidden blocks, as well as the identical amount of neurons in each block, could not be recognized earlier. The ANN chose a cycle from the hidden layer's input to its output. The ANN model's process is depicted in Fig. 3. This study's activation function was adapted from previously published research.

2.6. Optimization using Unconfined Weed Optimization Algorithm (UWOA)

During this point, the UWOA approach is applicable to augment the Ann architecture. This implies that the correctness of ceramic characteristic forecasts could be enhanced by using the developed model. The measures taken by UWOA are as regards:

Step-1: Initialization: Throughout the d-dimensional challenge field, a set of starting responses is dispersed at unexpected times.

Step-2: Reproduction: Every sample of the group is permitted to generate seeds relying upon according to their wellness as well as the colony's highest & lowest wellness, such that the quantity of seeds by a weed rises from the minimum available seed for the weed with the worst wellness to the biggest possible seed for the plant with the fittest.

Step-3: Spatial distribution: The seeds are dispersed at irregular intervals over the d-dimensional search area using uniformly dispersed random variables with a mean of zero and a fluctuating variance. This stage guarantees that the seeds generated are generated close to the parental weed, resulting in a local search surrounding every plant. Despite this, the randomized function's standard deviation (SD) is changed to fall across iterations.

Here, the *Smax* and *Smin* are the maximum and minimum SDs, correspondingly, and r is a real number, the SD for a provided iteration could be estimated as:

$$S_{iter} = \left(\frac{iter_{max}-iter}{iter_{max}}\right)^r (S_{max} - S_{min}) + S_{min} \quad (9)$$

This phase assures which the probability of dropping a seed in a distant site reduces non - linearly with duration, leading to the gathering of fitter plants as well as the removal of unsuitable plants. As a consequence, it is a UWOA-approved technique of choosing.

Step-4: Competitive Exclusion: If a plant does not generate children, that becomes dead; otherwise, this will take over the earth. As a consequence, plant competition is vital to maintain the variety of plants in a colony under control. Plants in a colony proliferate swiftly at the beginning, and all freshly created plants are joined to the colony till plmax, the maximum number of plants in the colony. Nevertheless, it is expected that by this time, the fitter plants may have reproduced higher than the undesirable plants. Stages 1 to 4 were continued till the higher amount of iterations is reached, during which point the colony size is set to plmax. This method, which seems to be a UWOA selection procedure, is considered a competitive elimination. Fig. 2 displays the procedure of UWOA.

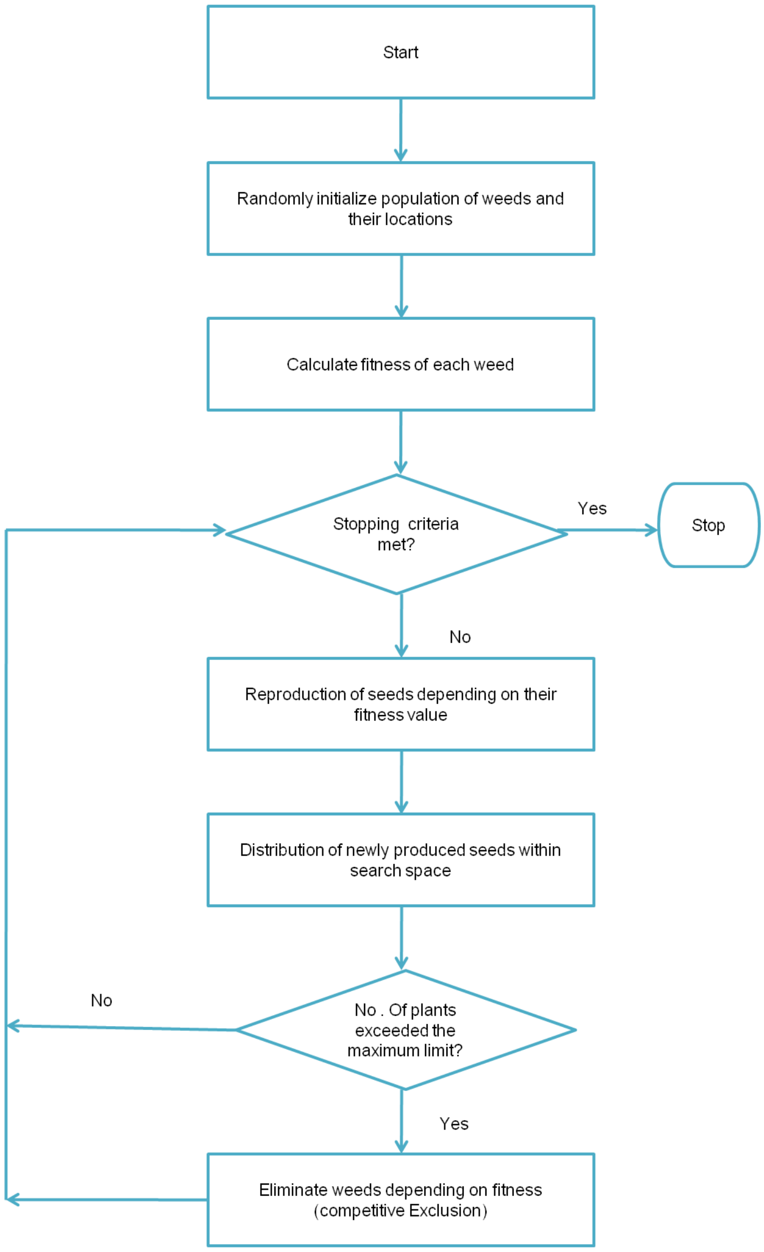

Figure 2. Flow steps of UWOA

3. Result and Analysis

In this stage, the performances are examined and the outcomes of that performance are depicted as graphical representation using the MATLAB tool.

3.1.1. Accuracy

The proportion of perfectly-identified cases could be used to assess the accuracy and it is formulated as follows.

$$\text{Accuracy} = (TP + TN)/(TP + TN + FP + FN) \quad (10)$$

From the above equation, the metrics TP, FN, FP, and TN depict the quantity of (true positive, false negative, false positive, and true negative) accordingly. Fig. 3 depicts the comparison of accuracy (%) with proposed and existing techniques. For every dataset, the accuracy can be varied among proposed and existing approaches. That implies how many quantities of the dataset were gathered with the greatest proportion of accurateness.

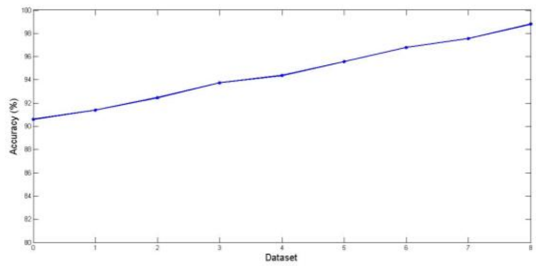

Figure 3. Comparison of accuracy (%) with proposed and existing techniques

3.1.2. Sensitivity

The proportion of true positive items that are accurately detected is measured by sensitivity.

$$\text{Sensitivity} = (TP)/(TP + FN) \quad (11)$$

Fig. 4 depicts the comparison of sensitivity (%) with proposed and existing techniques. For every dataset, the sensitivity can be varied among proposed and existing approaches. That implies how many quantities of the dataset were gathered with the greatest proportion of sensitivity.

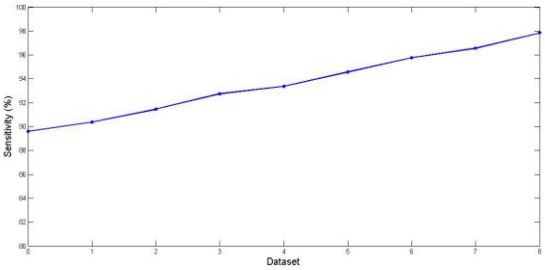

Figure 4. Comparison of sensitivity (%) with proposed and existing techniques

3.1.3. Prediction rate

While estimating the potential of a successful outcome, "prediction" corresponds to the result of an algorithm once it has been tested on previous data & adapted to new data. Fig. 5 depicts the comparison of prediction rate (%) with proposed and existing techniques. For every dataset, the prediction can be varied among proposed and existing approaches. That implies how many quantities of the dataset were gathered with the greatest rate of prediction.

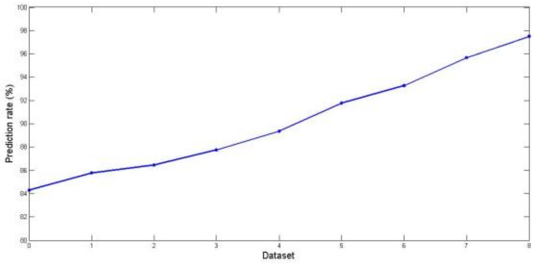

Figure 5. Comparison of prediction rate (%) with proposed and existing techniques

4. Conclusion

The unconfined Weed Optimization Algorithm (UWOA) was employed to identify the decoration of the Chinese ancient ceramics. First, the dataset was collected from the "Chinese Academy of Sciences' Institute of High Energy Physics" in Beijing. The dataset was pre-processed by employing the CED approach and then the feature extraction task was done on the pre-processed dataset using the DGLSSC and PCA-TS of the HCT technique. These extracted data were performed for the prediction procedure. The prediction function was executed by applying the ANN approach and the prediction procedure was enhanced by utilizing the proposed UWOA approach. Due to this proposed approach, we accomplish the greatest proportion of accurateness (98.8%) in the identification of the ceramic decoration.

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