Proposed algorithm for image classification using regression-based pre-processing and recognition models

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ABSTRACT

Image classification algorithms can categorize pixels regarding image attributes with the pre-processing of learner's trained samples. The precision and classification accuracy are complex to compute due to the variable size of pixels (different image width and height) and numerous characteristics of image per se. This research proposes an image classification algorithm based on regression-based pre-processing and the recognition models. The proposed algorithm focuses on an optimization of pre-processing results such as accuracy and precision. To evaluate and validate, the recognition model is mapped in order to cluster the digital images which are developing the problem of a multidimensional state space. Simulation results show that compared to existing algorithms, the proposed method outperforms with the optimal amount of precision and accuracy in classification as well as results higher matching percentage based upon image analytics.

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1. INTRODUCTION

An image does not contain a structured form of digital data but rather an unstructured pattern. In order to analyze an image and curate such data however the unstructured form of data needs to be converted to a vector representation accordingly. Deep learning and embedding methods help recover the numeric pattern from unstructured data. The quality and accuracy of clustering images depend on firstly the accuracy of pre-processing and secondly the subsequent embedding algorithm [1]. An image is segmented in order to classify the pixels correctly in a decision-making application. This approach is beneficial in the field of the complicated image such as pattern recognition, medical image processing, or traffic image. Different approaches for image segmentation described in [1] opt clustering, training, threshold-based value for the computation. Clustering techniques include fuzzy c-means (FCM) and K-means method.

Farhang [2] has introduced a new K-means clustering algorithm as the implementation of K-means algorithm per se is simple. The proposed algorithm is applied to face image mining. Experimental images are chosen from the database system. The experimental results improve accuracy rate, reduce processing time due to a reducible number of iterations and smaller cluster distance. However, image classification and recognition model are not cited. These interesting occurrences need extra investigation.

Xin and Sagan [3] have proposed an image clustering algorithm using multiple agents for optimizing cluster center. The algorithm based on fuzzy logic maps the image clusters as intelligent agent moving in the state space. Simulation results support the proposed algorithm compared to existing methods can optimize a number of cluster centers, the number of categories and the classification accuracy (CA) is higher. The size of big data state space is reduced by optimizing the collection of center. The paper somehow needs to additionally consider the processing time.

This paper presents the proposed algorithm for classifying digital images based upon pre-process and recognition models. Firstly, in this regards, widely used three image classifications are examined. The proposed algorithm characterized by regression-based pre-processing and recognition models is introduced. Secondly, the proposed algorithm compared to three traditional approaches is evaluated using the classification accuracy (CA) and precision metrics. Thirdly, several algorithms used for recognition model and their evaluation are scrutinized. Lastly, experimental results and analysis are discussed in order to state the further research investigation.

2. IMAGE CLASSIFICATION

Several approaches have been presented to improve the classification quality of digital images. The algorithm developed by fuzzy logic to deal with ambiguity in digital images [4], [5]. The classification and space vector relationship have been inspected based on Markovian models as introduced in [6], [7]. The hierarchical classification has been also employed for image classification. Artificial Intelligence (AI) technology has been opted to choose the variables in order to increase the exclusive classification quality. The neighborhood decision is introduced by cellular network reconfiguration in order to improve judgment classification quality. In this section, pre-processing approaches are presented. Our proposed method which is applicable for image classification and the algorithm is discussed.

2.1. Preprocessing approaches

The objective is to ensure classification accuracy (CA), precision and to accelerate the pre-processing time. K-means, Naïve Bayes and Ada Boost and the proposed classification models are presented in this section. To excel the post-processing computation, the recognition model as presented in [8] is used. The MOA simulation [9] results and their performance are evaluated.

2.1.1. K-Means classification (KM)

K-means classification [10] is a kind of unsupervised classifier, which is employed as data is not yet labeled (i.e., data without groups). The algorithm's objective is to classify defined K groups for data. The algorithm calculates repeatedly to allocate each data to one of variable K groups based on data characteristics. Data is classified based upon the similarity of their characteristics. Closest with K groups (K-means) employed in classification has different but unique functions which differ from other algorithms. It is unsupervised which requires no input probability density function. This K-means is a lagging learning algorithm, which computes data during the testing period, rather than in the learning phase. A benefit of K-means is that it quickly adapts any alterations. But a drawback is the computational cost due to state space complexity.

2.1.2. Naïve Bayes classification (NB)

The Naive Bayes Classification [11] based on the Bayesian theory is appropriate for autonomous input variables. Regardless of its incomplexity and low computational cost, NB can outperform more advanced classification. NB classifiers can lever a number of independent variables whether classified or repeated. Given a set of dimensional attribute vector of $X = \{x_1,x_2,x_3,...,x_d\}$, and the subsequent probability for the event C_j among all possible outcomes $C = \{c_1,c_2,c_3,...,c_d\}$, in a conventional language, X is called the predictors and C is the set of different classes presented in the dependent variable. Assume x_d can take different C_j values, namely, $P(C_j/X) > P(C_k/X)$ for $1 \leq k \leq d$ and $k \neq j$. The NB classifier computes a probability of C_j as following $P(C_j/X) = P(X/C_j)\ P(C_j) / P(X)$. The values $P(X/C_j)$ and P(X) are estimated from the training. The NB algorithm is shown in Figure 1.

```
**Algorithm: NB**
**Require**: Data matrix $[D]_{xy}$ with $x$ rows and $y$ columns

**for** $p$= 1 to $x$ do
        **for** $k$ = 1 to $y$ do
        Construct a frequency table for all characteristics for C$p$
        Build the prospect table for all characteristics for C$p$
        Calculate the conditional probability for C$p$
        Calculate the maximum probability for C$p$
        **end for**
**end for**
```

Figure 1. NB algorithm

2.1.3. Ada Boost classification (AB)

Ada Boost (AB) algorithm [12] repairs delicate to a tough learning environment. The weight divides the data matrix D_{xy} into 2 parts symmetrically. First tough part of the weight is set to be the perfect classified part, and the delicate part is allocated to the non-classified part. The Poisson distribution function for calculating the random probability in order to classify the data model has opted. The idea of AB is to agree on a series of delicate learners. The weighted variable is designed to a data model which is misclassified in the previous repetition. Only the present the weighting variable changes according to the AB weight as proceeding through each iteration of calculation. The approximation moves on with iteratively computing through the weighted classification until the terminal round. The algorithm is depicted in Figure 2.

```
Algorithm: AB
Require: Data matrix $[D]_{xy}$ with $x$ rows and $y$ columns
Ensure:$[D]_{xy} \rightarrow [D_1]$ and $[D_2]$, Q = dimension of [D]
Set:Weight variable is initially set to be $w_q$ (=1/Q)
for $i = 1$ to $x$ do
          for $j = 1$ to $y$ do
          for $k = 1$ to $K$ do
          Take $C_k$ ($a$) after minimizing error of weight variable $E_k$
          Calculate $E_k = \sum_{q=1}^{Q} w_q^{(k)} y_k(a_q)$
          Calculate $\alpha_k = \sum_{q=1}^{Q} w_q^{(k)} y_k(a_q) / \sum_{q=1}^{Q} w_q^{(k)}$
          Calculate $\beta_k = \frac{1}{2} \log_e \left(\frac{1-\alpha_k}{\alpha_k}\right)$
          Using Poisson distribution function to randomize and update the weight
                  variable
          $w_q^{(k+1)} = w_q^{(k)} \exp\{\beta_k y_k(a_q)\}$

          end for
          Approximate through final round $Y_K(a) = \mathrm{sgn} \sum_{k=1}^{K} \beta_k y_k(a) \in \{-1, 0, 1\}$
        end for
end for
```

Figure 2. AB algorithm

2.2. Proposed algorithm

The proposed algorithm is based upon a logistic regression-based learning environment which integrates multiple classifications in order to maximize the observed probability figure. At the low level of computation, there are miscellaneous learning algorithms which are trained independently. This is not similar to other algorithms which take the sample values that minimize the total of mean squared errors. The proposed method deals with the grouping of pre-processing techniques for the post-processing of the outcome at higher learning level. Notice that the original learning environment is not tailored while the proposed algorithm targets at achievable higher accuracy (as well as precision) in the classification of data. The proposed model is iteratively trained through the outcomes from the low level of computation. The proposed algorithm is listed in Figure 3.

```
Proposed Algorithm
Require: Data matrix $[D]_{xy}$ with $x$ rows and $y$ columns
Ensure:$[D]_{xy}$, Z = number of classifiers, Q = dimension of [D]
for $I = 1$ to $x$ do
for $j = 1$ to $y$ do
for $k = 1$ to $P$ do /** Low level computation **/
          Learner $Z_k$ applying for data matrix D
          end for
         for $n = 1$ to $Q$ do /** Regression-based computation to maximize
         probability**/
          $D_z = \{x'_n, y_n\}$, in which $x'_n = z_0 + z_1 x_n + z_2 x_n + ... + z_P x_n$
          end for
         Apply learner Z with $D_z$ /** High level computation **/
          Return $Z$

 end for
end for
```

Figure 3. Proposed algorithm

3. RECOGNITION MODELS

To search databases of digital images is a provoking job particularly for image data retrieval. Search engines compute the match between the query image and all images stored in the database and classify the sequence of images due to their matches. One drawback is that time to sort all matched images requires O(log *d!*) in case of *d* data images. To train to recognize images requires numerous images. This includes inputting several million images into deep learning level [13]. In between, the process produces characteristics from the digital image. These characteristics are just the outlines or image extraction. The idea is that those characteristics can dig deeper down to another layer, for instance, the distance vector from each class or the density of each characteristic. Once these characteristics are saturated then other recognition jobs or the image matching requires only machine learning level. It is positive to make use of an algorithm which has already been trained on lots of images while a collection and a training of several million images is next to impossible. For instance, ResNet [14] is a deep learning model trained for image recognition in computer vision. With built-in function, the software can generate a model with a vector representation of 4,096 characteristics between zero and one from input images. The image recognition model based upon these characteristic vectors is developed without the workload of training at deep learning level onto massive data images. In this research, the open-source based simulation tool, MOA is used for the image analytics. Twenty digital images in the database have been chosen. The experiment has been executed on an Asus Windows 7 with Intel® Core ™ i7 CPU, 2.2 GHz Processor and 8 GB RAM on board. The images have been chosen in order that they are all different in size, number of attributes, instances, and contents. The experimental model is given in Figure 4. In order to evaluate the performance of the proposed algorithm for an improvement of CA and precision is also denoted by the pre-processing results from randomly selected four images as presented in Table 1.

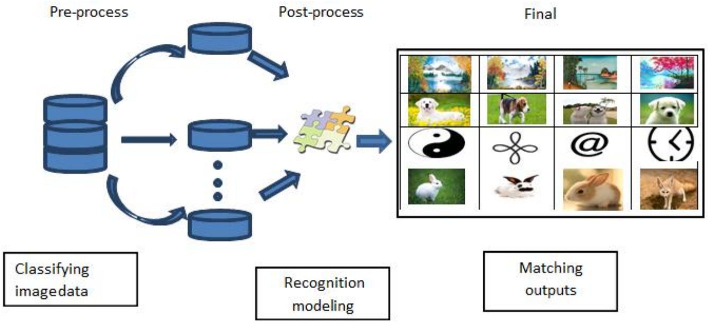

Figure 4. Experimental model

Table 1. Results from Pre-processing Evaluation

Classifier Type	CA(%)	Precision(%)
	Image 2	
Classifier Type	CA(%)	Precision(%)
KM	52.2	47.2
NB	50.2	74.3
AB	73.9	75.2
Proposed	82.6	84.3
	Image 6	
Classifier Type	CA(%)	Precision(%)
KM	41.9	37.2
NB	22.6	38.3
AB	51.6	42.2
Proposed	58.4	62.4
	Image 11	
Classifier Type	CA(%)	Precision(%)
KM	53.6	43
NB	17.9	3.2
AB	46.4	35.9
Proposed	60.7	46.9
	Image 14	
Classifier Type	CA(%)	Precision(%)
KM	48	50.5
NB	36	36.9
AB	44	67
Proposed	68	84.8

In the recognition model, the speed of matching calculation depends on its P(n) which is the n^{th} pixel moves with velocity (v). In Figure 5, one pixel moves at a velocity of v at t. The position of the matching pixel in the state space at $t + 1$ can be given by Equation (1).

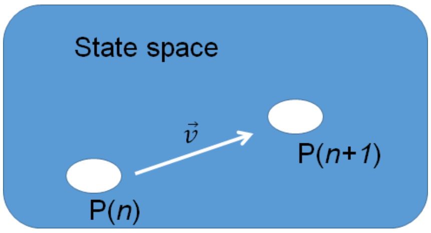

Figure 5. Matching check of the pixels in the state space

$$P_{n+1}(t+1) = P_n(t) + v \qquad (1)$$

Let ῡ be the average velocity and q be the dimension of a digital image then the computational cost for recognizing an image is O(q). Twenty digital images in the database as listed in Table 2 have been employed by post-process with different embedding algorithms (GLN, ILSVRC and CPVR) in order to recognize the matches. A processing for reducing of state space problem and time is demonstrated in [15].

Table 2. Feature of twenty images

Image	Dimension (pixels)	Size (KB)
1	255x198	9.025
2	275x183	8.142
3	200x231	7.223
4	275x183	5.906
5	400x325	80.420
6	400x294	76.870
7	259x194	9.984
8	290x178	12.959
9	400x226	88.894
10	400x326	117.366
11	400x317	103.177
12	1024x849	726.251
13	335x151	8.908
14	400x286	102.382
15	318x159	10.995
16	400x261	96.226
17	384x247	17.360
18	400x269	41.717
19	225x225	6.089
20	229x220	10.135

4. RESULTS AND ANALYSIS

The computation of the image matching based on the input parameters from pre-processing algorithms and their final results including match percentage and acceptance range of high (hi: above 51), medium (med: between 25 and 50) and low (lo: lower than 24). Image number one is used as a reference image in the recognition model and in finding for another two matches. The retrieval similarities (matching percentage) for the GLN embedding algorithms with the four pre-processing methods are summarised in Table 3. As seen the matching percentage for the proposed method is higher than others, but a few percentage points. The difference in this percentage helps reduce a clarification in decision making for image similarity. Results from the ILSVRC-2014 algorithm are also seen in the identical direction. The results obtained by the proposed method are higher in matching percentage. A more thorough evaluation using CPVR-2015 algorithm confirms the results obtained from the proposed method still outperform. The performances depicted in Table 3 are similar to the corresponding results in Table 1 demonstrating that there is no degradation in the retrieval performance when the pre-process is chosen in order to classify images from the database. Not to mention for all three different investigations, the proposed method results in a mid-range-acceptance level while others give only low-range-level.

Table 3. Results of twenty images matching

Preprocess	Embedding	Image No.	Matching (%)	Acceptance
KM	GLN	19	13.49	Lo
		2	18.22	Lo
NB		10	13.8	Lo
		19	17.06	Lo
AB		15	23.32	Lo
		19	26.85	Med
Proposed		20	28.9	Med
		2	29.45	Med
KM	ILSVRC-2014	15	14.5	Lo
		16	23.7	Lo
NB		15	15.51	Lo
		16	18.07	Lo
AB		11	18.07	Lo
		16	23.5	Lo
Proposed		5	27.0	Med
		9	27.62	Med
KM	CPVR-2015	20	14.94	Lo
		15	16.6	Lo
NB		2	15.51	Lo
		9	16.47	Lo
AB		2	18.31	Lo
		4	19.96	Lo
Proposed		5	27.04	Med
		9	30.1	Med

5. CONCLUSIONS AND FUTURE WORK

The results obtained with the proposed algorithm demonstrate that pre-process increases the classification accuracy and precision without sacrificing the amount of required matching computation. The proposed technique can be used for a scalable digital image from large databases. The proposed algorithm outperforms other three algorithms in the pre-processing phase, even though only marginally in all cases. In the post-processing phase, three algorithms namely (GLN, ILSVRC and CPVR) are applied for recognizing image similarity. In the post-processing phase, results from proposed method also marginally improve the matching percentage. More sophisticated similarity measures [16] which have been used in the video stream are being currently investigated and these results will be presented in the near future. Another direction of future work is to identify a benchmark against which the different matching ranges can be set. The execution time in each phase will be taken into account as well.

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