A FREE STYLE HANDWRITTEN CHARACTER RECOGNITION: FEATURE EXTRACTION AND CLASSIFICATION

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ABSTRACT

An off-line free style handwritten character recognition continues to be an active area for research towards exploring the new techniques that would improve recognition rate. There are various new technologies are emerging for the handwritten character/numeral recognition in the field of pattern recognition. The goal of pattern-recognition is to build machines, called, classifiers, that will automatically assign measurements to classes. With the spread of computers in public/private organizations and individual homes, automatic processing of tabular forms, bank checks, and postal mail is rapidly gaining importance in India. Our aim is to present a comprehensive study of previous attempts at Character Recognition using neural network and Genetic Algorithms (GA) in Pattern Recognition (PR) applications, with a special focus on Marathi handwritten script. We also investigate different feature extraction and classification methods for offline character recognition system.

KEYWORDS: Character Recognition, Feature Extraction, Classification, Pattern Recognition, Shape Descriptor, Moment Invarient

Pattern recognition is formally defined as the process whereby received patterns are assigned to one of a prescribed number of classes (categories)[1] [2] [22]The goal of pattern-recognition is to build machines, called classifiers that will automatically assign measurements to classes. A natural way to MSE class assignment is to define the decision surface. The decision surface is not trivially determined for many real-world problems. The central problem in pattern recognition is to define the shape and placement of the boundary so that the class-assignment errors are minimized.[3][23] In classification problem, the task is to assign new inputs to one of a number of discrete classes or categories. Here, the functions that we seek to approximate are the probabilities of membership of the different classes expressed as functions of the input variables. In classification, we accept a priori that different input data may be generated by different mechanisms and the goal is to separate the data as well as possible into classes[4] However, such automation needs research and development of handwritten character recognition methodology for Indian scripts. A major obstacle to research on handwritten character recognition of Indian scripts is the nonexistence of standard/benchmark databases. Previous studies were reported based on small databases collected in laboratory environments. Driven by the challenge of matching human performance and by the numerous possible applications in data processing, hundreds of researchers have contributed to this field.

Many systems have been developed but more work is still required before human performance is matched [24]. The handwritten character recognition can be carried out in the form of: on-line and off-line. The on-line method uses a stylus and electronic equipments like tablets, mobile phones connected to a system to extract information like character or image and in off-line recognition, the handwritten script is usually captured by a scanner and complete writing is available as an image. Image processing play an important role in research area within engineering and computer science fields. [21][22][23] The output of recognition system is can be analyzed by various factors such as accuracy, recognition rate or classification error. The systems can be implemented for various languages. There are still a lot of researches to do towards the improvement, and we can make a further exploration about the research of character recognition [24].

FEATURE EXTRACTION

Feature identification for handwritten digit and character recognition is an important problem. The selection of appropriate feature extraction method is probably the single most important factor in achieving high performance. The widely used feature extraction methods are Template matching, Deformable templates, Unitary Image transforms, Graph description, Projection Histograms, Contour profiles, Zoning, Geometric moments invariants, Zernike Moments, Spline curve approximation, Fourier descriptors, Gradients feature and Gabor features.[6] [7] There are two main approaches to feature extraction. The more traditional approach is to handcraft the feature extraction process, as opposed to the other approach whereby the raw input is presented to a learning algorithm to discover whatever features are inherent in the domain. Each approach has its own merits and weaknesses. In the former approach, the main difficulty lies in determining the appropriate class of features to extract as well as in extracting those

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features in a robust and reliable way [9][20]. Automatic Feature Generation for Handwritten Digit Recognition different evaluation measures orthogonality and information, are used to guide the search for features. The performance of character recognition system is largely depending on proper feature extraction and correct classifier selection. Slow Feature Analysis (SFA) is an unsupervised algorithm by extracting the slowly varying features from time series and has been used to pattern recognition successfully [9] There exist many feature extraction methods which have their own advantages or disadvantages over other methods, a rapid feature extraction method is proposed and named as Celled Projection (CP) that compute the projection of each section formed through partitioning an image. Method of recognizing handwritten digits by fitting generative models that are built from deformable Bsplines with Gaussian "ink generators" spaced along the length of the spline. The splines are adjusted using a novel elastic matching procedure based on the Expectation Maximization (EM) algorithm that maximizes the likelihood of the model generating the data[10][11] Feature sets play one of the most important roles in a recognition system. A good feature set should represent characteristic of a class that helps distinguish it from other classes while remaining invariant to characteristic differences within the class.[20][21] .

SHAPE DESCRIPTOR AND MOMENT INVARIANT

In this section give an overview of the shape based techniques used in object matching, object identification and object classification tasks. Shape descriptors are a powerful tool used in wide spectrum of computer vision and image processing tasks such as object matching, classification, recognition and identification.

The fact that the shape invariance under simple transformations like scaling can be achieved by point normalization motivates us to explore general shape invariance under affine transformation. In real-world problems, shape distortions caused by perspective projection, nonrigid deformation or articulated motion can be approximated by locally affine transformations [13]

The history of moment invariants begun many years before the appearance of first computers, in the 19th century under the framework of the theory of algebraic invariants. The theory of algebraic invariants probably originates from famous German mathematician David Hilbert [14] Moment invariants were firstly introduced to the pattern recognition community [15], employed the results of the theory of algebraic invariants and derived his seven famous invariants to rotation of 2-D objects. Since that time, numerous works have been devoted to various improvements and generalizations of Hu's invariants and also to its use in many application areas. Zernike invariants of 2nd and 3rd orders are equivalent to Hu's ones when expressing them in terms of geometric moments. He presented the invariants up to eight orders in explicit form but no general rule how to derive them is given. Significantly to the theory of moment invariants by correcting the Fundamental Theorem and deriving invariants to general affine transform. Several papers studied recognitive and reconstruction. All the above mentioned invariants deal with geometric distortion of the objects. Much less attention has been paid to invariants with respect to changes of the image intensity function and to combined radiometric-geometric invariants. In fact, just the invariants both to radiometric and geometric image degradations are necessary to resolve practical object recognition tasks because usually both types of degradations are present in input images.

CLASSIFIERS

The classification phase is the decision making part of the recognition system. The performance of a classifier relies on the quality of the features. There are many existing Classical and soft computing techniques for handwriting recognition. They are given as:

1. Template matching
2. Statistical techniques
3. Structural techniques
4. Neural networks (NNs)
5. Fuzzy- logic technique
6. Evolutionary computing techniques
7. Genetic algorithm

In this section we mainly focused on neural network and genetic algorithm as a classifier. Artificial neural networks have been recognized as a powerful tool for pattern classification problems. A neural network performs pattern recognition by first undergoing a training session, during which the network is repeatedly presented a set of input patterns along with the category to which each particular pattern belongs. Later, a new pattern is presented to the network that has not been seen before, but which belongs to the same population of patterns used to train the network. The network is able to identify the class of that particular pattern because of the information it has extracted from the training data. Pattern recognition performed by a neural network is

statistical in nature, with the patterns being represented by points in a multidimensional decision space. The decision space is divided into regions, each one of which is associated with a class. The decision boundaries are determined by the training process. The construction of theses boundaries is made statistical by the inherent variability that exists within and between classes. It is very difficult to know which training algorithm will be the fastest for a given problem. It depends on many factors, including the complexity of the problem, the number of data points in the training set, the number of weights and biases in the network, the error goal, and whether the network is being used for pattern recognition (discriminate analysis) or function approximation (regression). Sophisticated neural network classifiers to solve complex pattern recognition problems: multiple multilayer perceptron (MLP) classifier, hidden Markov model (HMM)/MLP hybrid classifier, and structure adaptive self-organizing map (SOM) classifier, based on the SOM classifier, which can adapt its structure as well as its weights.[16][17]

MLP NEURAL NETWORK ARCHITECTURE

The multilayer feed-forward neural network can be used for both function fitting and pattern recognition problems. With the addition of a tapped delay line, it can also be used for prediction problems [18] [19]. Feed-forward networks often have one or more hidden layers of sigmoid neurons followed by an output layer of linear neurons. Multiple layers of neurons with nonlinear transfer functions allow the network to learn nonlinear relationships between input and output vectors. The linear output layer is most often used for function fitting (or nonlinear regression) problems. On the other hand, if we want to constrain the outputs of a network (such as between 0 and 1), then the output layer should use a sigmoid transfer function. This is the case when the network is used for pattern recognition problems (in which a decision is being made by the network). The configuration of the MLP NN is determined by the number of hidden layers, number of the neurons in each of the hidden layers, as well as the type of the activation functions used for the neurons. It has been established that an MLP NN that has only one hidden layer, with a sufficient number of neurons, acts as universal approximations of non-linear mappings [20][23][24]. Experimentally, it can be verified that the addition of extra hidden layer can enhance the discriminating ability of the NN model. However, it does so at the cost of the added computational complexity.

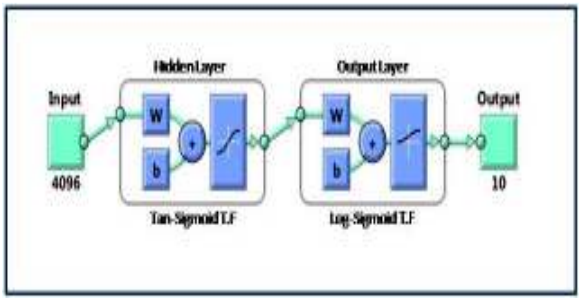

Figure 1: MLP Neural Network

MLP NN architecture as mentioned in fig. 1 shows use of tan sigmoid neurons in hidden layer output layer. As apparent from the network, it has 4096 inputs connected to predefined neurons in hidden layer and 10 neurons in the output layer. Neurons in hidden layer are varied from 16 to 128 in step of 16.

As a classifier the final output is always percentage error on misclassification on individual output classes (digits), the confusion matrix as mentioned in Figure 2 portray the % misclassification rate

Class	Training Set				Validation Set				Testing Set				Total DataSet			
ID	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
0	369	364	5	1.36	35	35	0	0	46	46	0	0	450	445	5	1.111
1	358	338	20	5.59	43	38	5	11.6	**49**	**38**	**11**	**22.4**	450	414	36	8
2	367	363	4	1.09	42	36	6	14.3	41	40	1	2.44	450	439	11	2.444
3	350	350	0	0	47	44	3	6.38	53	45	8	15.1	450	439	11	2.444
4	356	354	2	0.56	52	48	4	7.69	42	40	2	4.76	450	442	8	1.778
5	357	328	29	8.12	54	48	6	11.1	39	32	7	17.9	450	408	42	9.333
6	359	348	11	3.06	44	37	7	15.9	47	44	3	6.38	450	429	21	4.667
7	362	359	3	0.83	40	37	3	7.5	48	45	3	6.25	450	441	9	2
8	358	354	4	1.12	46	40	6	13	45	42	3	6.67	449	436	13	2.895
9	335	319	16	4.78	44	37	7	15.9	37	32	5	13.5	416	388	28	6.731
Total	3571	3477	94	2.63	447	400	47	10.5	447	404	43	9.62	4465	4281	184	4.121

A : Total No. of instances B:Total No. of instances classified as a designated class
C: Total No. of instances misclassified D: % misclassification rate

Figure 2: Overall performance of the neural network as a classifier

GENETIC ALGORITHM

The genetic algorithm (GA) is a powerful tool to handle optimization problems. This is especially useful for complex problems with a large number of parameters that make the global analytical solutions difficult to obtain. It has been widely applied in different areas such as fuzzy control , path planning, greenhouse climate control. The determination of optimal similarity threshold value is very important for the accurate classification. As we already discuss the genetic algorithm selection method maintained maximum performance so, to determine optimal similarity threshold value genetic algorithm (GA) is used.

Genetic algorithm consists of following steps:

1. Start with randomly generated population of n chromosomes.

2. Evaluate each chromosome in the population by calculating a fitness function.

3. Apply mutation and reproduction as the parents chromosomes mate.

4. Delete chromosomes from the current population to make room for the new chromosomes

5. Evaluate new chromosomes and insert it into new population.

6. If the stop condition is satisfied then stop and return the best chromosomes, otherwise repeat step 3.

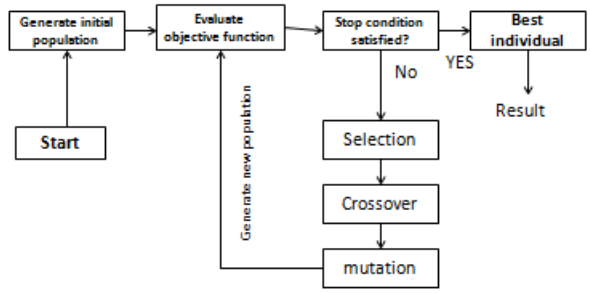

Figure 3: Basic steps of genetic Algorithm

Selection Operators

Give preference to better individuals allow them to pass on their genes to the next generation. fitness may be determine by an objective function.

Crossover

It is a used to vary the programming of a chromosome or chromosomes from one generation to the next

Mutation

It alters one or more gene values in a chromosome from its initial state. In mutation, the solution may change entirely from the previous solution. Hence GA can come to better solution by using mutation. Mutation occurs during evolution according to a user-definable mutation probability. This probability should be set low. If it is set too high, the search will turn into a primitive random search[23]

CONCLUSION

In this paper a comprehensive review in the literature review in the stage of an offline character recognition. Classifier like neural network and genetic algorithm discuss here and the feature extraction methods which help to improve recognition accuracy. In neural network approach As a classifier the final output is always percentage error on misclassification on individual output classes. The best one hidden layer MLP NN with log-log activation function for hidden and output layer investigated gives an impression to perform reasonably. When it is evaluated on the training instances, it works as an almost good classifier with error rate of 2.63% on training. Here, the regression fit is found to be 0.985.

The recognition problem is solved by the GA, which may yield a different solution for the same word each time, depending on the population and number of iteration. However, there is currently high similarity between the original solution and the anticipated oneThe research in the field of pattern recognition shows: For a complex problem of identification and classification, only one method always is difficult to identify the object well separated, while among the different classification methods, the high complementary exist, the integration of multiple classifiers can clearly improve the recognition rate

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