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THE TEMPORAL ROBUSTNESS OF CLASSIFICATION ALGORITHMS: INVESTIGATING THE IMPACT OF TEMPORAL CHANGES ON MODEL PERFORMANCE

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Article Info

Abstract

Classifiers are the main source of processing of identification application task, So the performance of classifiers effect the work of any application. In this paper, author is working in the Digital Image Processing (DIP) domain, In License Plate Recognition (LPR) application of it. The purpose of this paper is, to introduce systemic literature review on why classification algorithms don't work effectively after some period of time in some countries. Which decrease the performance of classifiers while processing License Plate Recognition (LPR) application or any identification application. Recognition of characters in any identification system take most important than other steps.

Keywords:
Digital Image Processing (DIP), License Plate Recognition (LPR), Template Matching (TM), Artificial Neural Network (ANN), Support Vector Machine (SVM)

Introduction

This paper studies the accuracy of Number Plate Recognition System in all around the world. It has been shown in the past that accuracy of this recognition system is decreasing after some period of time in some countries like Pakistan, India, on the other hand the accuracy remain constant in other countries like America, China. Recognition is an important step for any identification applications, which are using for any identification like Number Plate Recognition, Hand Gesture identification or many more and effectiveness of these applications are significantly identify by their accuracy rate. The main theme of this paper is, first of all gives the reasons which things cause to decrease the accuracy rate and how developers are increasing accuracy rate again. The Fig 1 Show is showing the Performance of LPRA in Pakistan

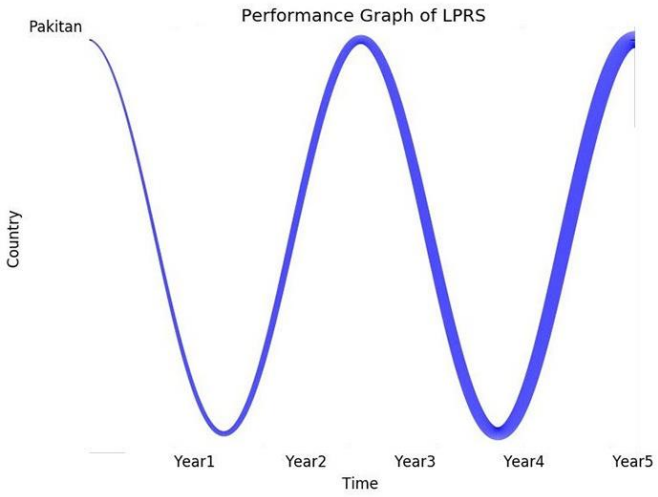

Fig. 1. LPRA Performance in Pakistan

The goal of this survey paper to identify the reasons, why the accuracy rate of identification system or classification algorithms not remains constant in all around the world and paper is providing some suitable solution on the basis of previous solution paper of this problem. This paper will also give comparison of some classification algorithm, which are using in recognition step for identification purpose. In this survey paper, Artificial Neutral Network and Pixel Matching algorithms of classifier are focusing point of this research.

Number of font families are increasing. Every year about 20% to 30% new font styles add due to unsatisfactory of the people styling requirement. The new font families are not only different from the previous font families, but also avoid people to use previous deprecated font families. This case problem in industry of digital image processing. Which effect the Number Plate Recognition application in its recognition step. Each identification system works on some core of their mechanism. There are two part of any identification system in their recognition step, one is known as training data set and other known as testing data set. These system show their 100% accuracy, if provided test data set in their train set limit. Otherwise accuracy rate of these systems reduce. The reason behind this deficiency, people who not follow the allow font style by law agencies. So when identification system try to recognition any font on which system can't train. The result of this recognition not accurate. In Pakistan and India the accuracy rate of identification system varies 80% to 100% due to people. Which can't use allow font style? Which cause problem in recognition step. On other hand, in America and China accuracy rate of this system 100%. To overcome this deficiency, the developer should update their system after some accuracy rate or any limit which show to update their system. Update means here, they should increase training data set of their identification system to increase its accuracy rate. The aim of this survey paper to target those countries, where the identification system not work properly after some period of time and provide some suitable

solution to this deficiency. After successful achieve the constant accuracy rate all around the world, Fig 2 is showing the constant accuracy rate in all countries.

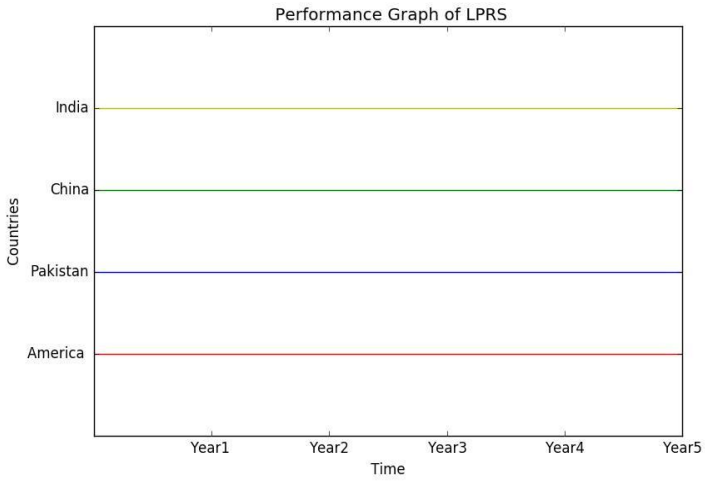

Fig. 2. Performance of LPRA in all World.

To summarize the idea of this survey paper, the paper is providing the below contribution in field of digital image processing.

i. Author is introducing the quality survey solution, by analyzing the previous solution paper on this problem.
ii. Author is providing, how to achieves the 100% accuracy if this identification system all around the world.
iii. Author is giving the key problem to all developer, why the accuracy of identification system decrease after some period of time in some countries and how to overcome with remarkable solution of this deficiency.

This paper is manage as follows. Section II describe the background of License Plate Recognition Application with running example. Sections III Explain the Literature review in tabular as well as textual manners.

II. BACKGROUND

License Plate Recognition application helps Law Enforcement Agencies like Police and Traffic Control Department to efficiently track and monitor the increasing number of cars, cars use in attach and any service which can be provide by this identification system can use etc.

The Figure 3 is showing the Flow chart of identification system.

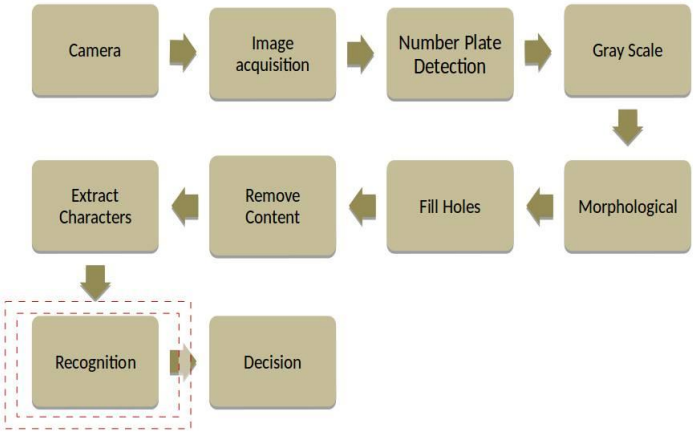

Fig. 3. LPRS Flow Chart

A. Image Acquisition

Automatically acquires the image of an incoming car. As show in Fig 4.

Fig. 4. Acquires Image

B. Plate Detection

A License Plate has either light script on the dark background or vice versa, hence license plate is characterized by row of transitions from light to dark or vice versa. As show in Fig 5.

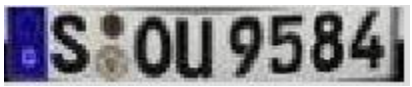

Fig. 5. Plate Detection

C. Gray Scale Image

The gray scale conversion algorithms are composed of three main steps and also in Fig 6.

Fig. 6. Gray Scale Image

1) Obtain the values of multi-channel pixel

2) Calculate the central pixel value from the below mentioned formula

Gray Scale = (‘Blue’ +’Red’ + ‘Green’) / 3

3) Replace the original pixel value with the new calculated value

D. Morphological Processing

Useful for the analysis of Gray Scale images and common usages include edge detection, image enhancement and image segmentation. As show in Fig 7

Fig. 7. Morphological Process

E. Fill Holes

Holes within objects filled for increase in Area. A useful step in character extraction/segmentation. As show in Fig 8.

Fig. 8. Hole Filling

F. Remove Extra Content

Characters on the License Plate usually have more Area than non-character objects. We can use this information to remove all non-character objects. As show in Fig 9.

Fig. 9. Remove Content

G. Extract Characters

Characters on the License Plate usually have more Area than non-character objects. We can use this information to remove all non-character objects. As show in Fig 10.

Fig.10. Extract Characters

H. Recognition

Identify the extracted characters by use of Pixel matching algorithm or Artificial Neutral Network. As show in Fig 11

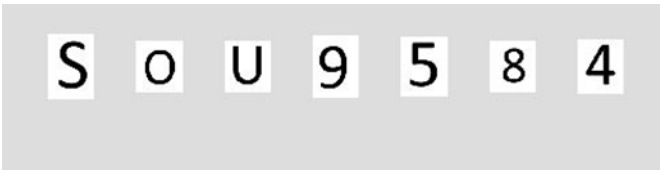

Fig. 11. Recognition

III. LITERATURE REVIEW

A large part of literature review for this survey project is, about the deficiency and efficiency of License Plate recognition application in different countries. And what reasons behind the deficiency of Character Recognition Algorithms based on the Template Matching and Artificial Neutral Network, which are playing important role in identification step of it.

In [1] authors have explained the work of how to use the binary matrix of extracted characters for recognition purpose. By the help of weighted match degree of the pixels and showing the 100% accuracy rate of classifier in term of binary pixel the matching technique. The authors are achieving 100% accuracy rate on some features alike training classifier with ~500-~1000 template styles than authors are testing their train classifier within the range of trained ~500 - ~1000 temple styles. Which is showing accurate result on trained styles otherwise it shows poor result.

In [2] authors have explained the use template matching for recognition, where take the input characters sample images and rescale them to n X n (e.g. '20x20'). These rescaled images are then matched with predefined character templates and the maximum matched template is the recognized character. The extracted characters are matched with each of the character templates, pixel to pixel match. The character characterized as the template having maximum match.

In [3], authors have respectively explained the benefit of using our proposed work and the disadvantage without using our project. He has collected 305 agencies which give response to the survey. 70 of the agencies indicated that they were using LPRA with use of Pixel Matching as Artificial Neutral Network. While three quarters of the agencies not using it or facing many problems.

In [4-6] authors have explained the work of their modified template matching algorithm. Their propose methodology of classifier result is showing 98% success with their approach. The authors use 500 images of cars to, verify their approach.

In [7] authors have explained the work of how to use the binary matrix of extracted characters for recognition purpose. By the help of weighted match degree of the pixels and showing the 96% accuracy rate of classifier in term of binary pixel the matching technique. The authors are achieving accuracy rate on some features alike training classifier with some data set of binary files of 1000 cars, authors are testing their train classifier within the range of trained 1000 temple styles of binary files. Which is showing accurate result on trained styles otherwise it shows poor result.

In [8-9] authors have respectively explained that, Automatic License Plate Detection and Recognition software system automatically acquires the image of an incoming car, convert it into gray scale image, then perform each of morphological process, fill holes, remove extra content, recognition ('by using Artificial Neutral Network') than stored the binary of extracted characters and compare that binary text file with the train databases. The authors are achieving ~94% accuracy rate o with their approach.

In [10] authors have explained the use of ANN work for recognition purpose and show the application of identification system e.g. In toll collection system have focused on Indian number plate database image. Recognition Success rate of 96 Percentage. The authors are achieving 96% accuracy rate with their approach.
In [11-12] authors have explained the work of how to use the Artificial Neural Network classifier algorithm for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained characters. The authors are achieving sufficient accuracy rate with their approach.
In [13-18] authors have respectively explained that, Automatic License Plate Detection and Recognition software system automatically acquires the image of an incoming car, convert it into gray scale image, then perform each of morphological process, fill holes, remove extra content, recognition ('by using Artificial Neutral Network') than stored the binary of extracted characters and compare that binary text file with the train databases. The authors are achieving ~94% accuracy rate o with their approach
In [19] authors have explained the work of how to use the Artificial Neural Network classifier algorithm for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained characters. The authors are achieving sufficient accuracy rate with their approach.
In [20] authors have explained the work of how to use the Artificial Neural Network classifier algorithm for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained characters. The authors are achieving sufficient accuracy rate with their approach.
In [21-22] authors have respectively explained that, Automatic License Plate Detection and Recognition software system automatically acquires the image of an incoming car, convert it into gray scale image, then perform each of morphological process, fill holes, remove extra content, recognition ('by using Artificial Neutral Network') than stored the binary of extracted characters and compare that binary text file with the train databases. The authors are achieving ~94% accuracy rate o with their approach.
In [23] authors have explained the work of how to use the Support Vector Machine classifier algorithm for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained characters. The authors are achieving sufficient accuracy rate with their approach.
In [24] authors have explained the work of how to use the Support Vector Machine for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained

Ref No.	ANN	TM	SVM	Ref No.	ANN	TM	SVM
[1]	No	yes	no	[16]	yes	no	no
[2]	No	yes	no	[17]	yes	no	no
[3]	yes	yes	no	[18]	yes	no	no
[4]	No	yes	no	[19]	yes	no	no
[5]	no	yes	no	[20]	yes	no	no
[6]	no	yes	no	[21]	yes	no	no
[7]	No	yes	no	[22]	yes	no	no

[8]	yes	no	no	[23]	yes	yes	yes
[9]	yes	no	no	[24]	no	no	yes
[10]	yes	no	no	[25]	no	no	yes
[11]	yes	no	no	[26]	no	no	yes
[12]	yes	no	no	[27]	no	no	yes
[13]	yes	no	no	[28]	no	no	yes
[14]	yes	no	no	[29]	no	no	yes
[15]	yes	no	no	[30]	no	no	yes

TABLE I DIFFERENT CLASSIFIER

In [25-28] authors have respectively explained that, Automatic License Plate Detection and Recognition software system automatically acquires the image of an incoming car, convert it into gray scale image, then perform each of morphological process, fill holes, remove extra content, recognition ('by using Support Vector Machine') than stored the binary of extracted characters and compare that binary text file with the train databases. The authors are achieving ~94% accuracy rate o with their approach

In [29] authors have explained the work of how to use the Support Vector Machine for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained.

In [30] authors have explained the work of how to use the Support Vector Machine for extracted characters for recognition purpose. The algorithm is showing the sufficient accuracy rate of classifier in term of learning rate of trained characters.

The above given table show the summarize foam of all papers, Which paper is using which classifier for recognition purpose with its accuracy rate as well as Performance on non-train characters (test algorithm with non-train template styles).

In this table, author is focusing on three classifier Artificial Neural Network, Template Matching and Support Vector Machine which are using in License Plate Recognition Application and Hand Writing Recognition for recognition purpose. The 1th, 5th column of this table is showing the reference no of paper and 2tnd-4th and 6th - 8th columns of this table are showing the applied approach for recognition purpose. The literature review of this survey paper is completed from the study of 30 paper, which are using mention classifier in their paper.

TABLE II
DISTRIBUTION OF STUDIES ACCORDING TO THE PUBLICATION CHANNEL

Publication source	Type	Number
Image	Conference	1
Communications Technology	Conference	1
Pattern Recognition Letters	Journal	3
International Journal of Research in Engineering and Technology	Journal	2
International Journal of Intelligent Systems and Applications	Journal	1

Advances in Environmental Biology	Conference	1
Circuit, Power and Computing Technologies	Conference	1
Contemporary Computing	Conference	1
International Journal of Computer Applications	Journal	3
IEEE International Conference on Imaging Systems and Technique	Conference	1
International Journal of Computer Science and Network	Journal	1

To summarize the idea of Literature review of these 30 paper, in following points.

1) Classifiers train with some range of font style.
2) Classifiers test with train range of font style.
3) Classifiers show 92-99.9% accuracy, when test on train font style.
4) Classifiers show poor result when test on non-train fonts style.
5) Classifiers need to train with non-train font style to increase their accuracy but how much range of train font style is enough.

Decreasing the efficiency of classifiers after some period of time in some countries like Pakistan and India reason behind this deficiency is, when License Plate Recognition application try to perform recognition step on non-train characters. In result of this deficiency, identification system lose its accuracy rate. After analyzing the 30 paper, solution of this deficiency to increase the training data set after some period of time in those countries where people can't follow the allow font style. Is this accurate solution of this problem? At this stage author will not be able to provide its own solution of this deficiency. This survey paper is providing only reasons behind the problem and solution of these problem solve by previous paper.

After SLR of 30 papers, which can't directly relate to author mention problem. But these papers are providing efficient source of information to conclude the reason behind the author mention problem, why classification algorithms don't work effectively after some period of time in some countries. The main reason of it, when the classification algorithm try to recognition those characters, on which it can't be train than the result of this recognition failure can't provide accurate identification. But as we would increase the nod of training data set, classification algorithm increasing its efficiency rate. The effect of train data set is also show in below Table-III. But how much train will sufficient for constant success rate?

TABLE III
SUCCESS FACTOR

Success factor	Data set (n)	Percentage %
Effect of training	10000	80
	20000	83
	30000	89
	50000	92

The above given table show the summarize conclusion of success factor for all studies papers.

In this table, author is focusing on three classifier Artificial Neural Network, Template Matching and Support Vector Machine which are using in License Plate Recognition Application and Hand Writing Recognition for recognition purpose. The 1thcolumn of this table is showing the success factor and 2tndcolumn of this table is showing the number of fonts style on which classifier is train and 3rd column of this table is showing Percentage.

IV. CLASSIFICATION & CATOGARIZATION

In Table-I, Author is providing the study of 30 papers. In which seven paper relate to Template Matching classifier, sixteen paper relate to Artificial Neural Network classifier and remaining papers relate to Support Vector Machine. In these 30 paper, 56% (17 of them) papers from journal, 33% (10 of them) papers from conference and 10% (3 of them) papers from workshop.

After study the Table-I, The SLR of classification algorithms don't work effectively after some period of time of this surrey paper is focusing three type of classifier (Artificial Neural Network, Template Matching, Support Vector Machine) and also guide that studies are more focusing on Journal across the publication venues. The Journal publication more focused (17) than Conference (10) and (3) Workshop. This reflect that, most of study for this surrey paper conduct from Journal.

In these 30 paper, all author are providing same solution. But these solution did not give any significant studies reflect to mine research topic. The type of studies papers, published from 2012 to 2016, is providing with their related work of classifiers and also give the links to access them.

The studies of these 30 paper category in following meaner, Fig.13 show that 58% of ANN classifier are on recognition practice and 41% of the ANN classifier are newly proposed ideas in the foam of algorithm.

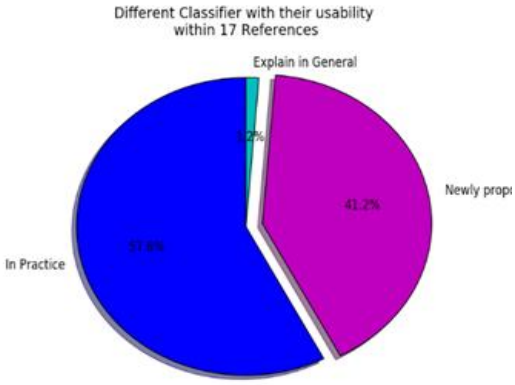

Fig. 13. Different Classifier with their usability within 17 references

80% of SVM classifier are on recognition practice and 20% of the SVM classifier are newly proposed ideas in the foam of algorithm. As show in Fig.14.

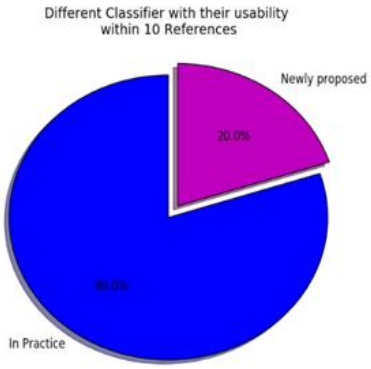

Fig. 14. Different Classifier with their usability within 10 references

Fig.15 show that 42% of TM classifier are on recognition practice and 57% of the TM classifier are newly proposed ideas in the foam of algorithm. While the other studies of sources, which just refer, are showing the classifier in general meaner.

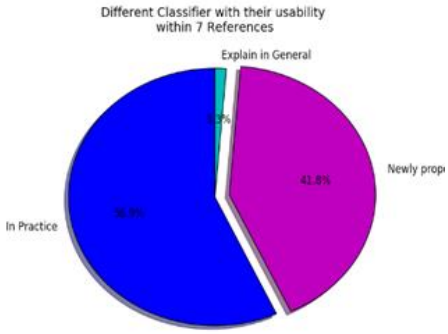

Fig. 15. Different Classifier with their usability within 30 references

After the studies of the 30 paper, author know that most of the authors of paper were affiliated to abroad countries like America, India and China. If we consider the locational division per study. We can short most of them from America and Saudi Arab, some of them from India and only 2 to 3 of them from Pakistan.

TABLE IV
SUMMARY OF CHALLENGES AND REASONS OF LOSING CLASSIFIER SUCCESS RATE

No.	Challenge	Success Rate%	Explanation
1.	Facing Multiple non-trained data set. (George, A., and V. J. Pillai., 2016: Wenying, Mo, and Ding Zuchun, 2013: Das, Nibaran, et al. 2012)	ANN~85 TM~82 SVM~86	People not follow the allow fonts style, which have specified by law enforcing agencies
2.	Multiple Fonts at time (Alavi, S. Mohammad, &. AlipourVarmazabadi, 2015: Roberts, David J., and Meghann Casanova, 2012: Djeddi, Chawki, et al, 2013)	ANN~86 TM~80 SVM~80	People, who are using different fonts style for each character in their number plate, In most of such cases, classifier enable to accurately recognize all listed characters due to limited train data set.

The above given table show the summarize foam of listed papers, Which paper is facing which challenge for recognition purpose with its accuracy rate as well as Performance on non-train characters (test algorithm with non-train template styles).

In this table, author is focusing on three classifier Artificial Neural Network, Template Matching and Support Vector Machine which are using in License Plate Recognition Application and Hand Writing Recognition for recognition purpose. The 1thcolumn of this table is showing the no and 2tndcolumn of this table are showing the challenges and 3rd column of this table is showing the success rate and 4th column of this table is showing the explanation for that challenges.

Table -IV is showing the reasons & challenges for the losing the algorithm efficiency after, some period of time in some countries like Pakistan, India Africa etc. and why the same algorithm is efficiently working in other law enforcing countries like America, China, Arab etc. In general, the success rate of any classifier in any application depend upon its training data. Training data trained with some range of data set. On which, the classifier work with 100% success rate. The main reason of failure of any classifier in any application depend upon, In which range of non-trained data set it work accurately. If this range across than the classifier start to lose its accuracy rate. In this table-IV, author is also providing the success rate in different case of all above studies classifier which has listed in the Table-I.

V. FUTURE DIRECTION

After the detail studies of 30 papers, author have come up with one success factor as mention in Table-III. This success factor was marked as essential factor for all listed type of classifier in this paper. The identification of this factor lead these classifier to maintain their accuracy rate in all around the world.

Author is also comparing this factor in different area of applications and with combination of these classifier. The main purpose of this paper to provide the guide line to all the developer of the world, which help them in designing and implementing successful software outsourcing contract. Author is suggesting developer to focus not only general factors of development of any software but also consider social factor as well. Why the author is asking to consider general as well as social factor in the development and successful implementation of software?

The answer of the above question will be clear after analyzing these two example, first of all consider those countries in which all people follow the allow font style. In these countries efficiency of classification algorithms remain constant. Because classifiers have trained within the range of allow font style, so whenever the classifiers try to perform identification of any specific application the 100% accuracy of rate. Why, because these classifier can't try to recognize any specific task, on which classifier can't be train. On the other consider those countries in which 40% of people can't follow the allow font style. In these countries efficiency of classification algorithms does not remain constant. Because classifiers have trained within the range of allow font style, but classifier is trying to recognize non train data, so whenever the classifiers try to perform identification of any specific application the accuracy of does not 100% rate. Why, because these classifier is trying to recognize any specific task, on which classifier can't be train. This is a social issue of research area not technical issue. Author has come up with the following goals that plan to follow in future.

1) In classification algorithm, we need to introduce some or one step or method, which will be able to detail with non-train data set after some range of facing non-train data set in recognition step.

2) In classification algorithm, we need to introduce time factor, which will be able to update its self automatically after some period of time.

The aim of this SLR paper is, to provide the guide lines for the developer of any country to, which help them in designing and implementing successful software outsourcing contract and also introduce the social factor in technical development of software design and how to achieving constant success rate after and after year of time.

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