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Neural & AI

Machine Learning Algorithms

Using Neural Networks to Design

Highlights

Handwritten Digit Recognition

Analysis of Emotion & User Behavior

Discovering Thoughts, Inventing Future

VOLUME 18 ISSUE 1 VERSION 1.0

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Has Machine Learning Arrived for Banking Risk Managers?

By Manoj Reddy

Abstract- Machine learning is one of the most exciting and powerful cognitive levers out there in the Industry and today Risk managers are grappling to make sense of whether it is just a hype or does it really have a value to add in Banking Risk Management. The article attempts to give a brief introduction into foundational concepts of machine learning and highlights some of the problems with the current predictive models and also some of the most popular pilot or candidate Use cases for Machine learning adoption. It also highlights the critical success factor which one needs to consider or be aware of in in adoption of Machine leaning to solve business problems. The paper intends to demystify the conundrum called as Machine learning and elucidate it to an extent which will enable the new age Risk & Regulatory managers to carefully evaluate and decide on an adoption of Machine learning techniques and solutions to solve specific Business problems.

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I. Background and Business Context

The Digital revolution is in the process of transforming the Banking Industry like never before. From understanding the customer proactively and deciding your next best action to gaining greater efficiencies and scale in running the Business, technology has played a huge role in enabling delivery of maximum business value to the customer in the shortest possible time. Artificial Intelligence is challenging the very realms of possibilities in how you run your Business and what seemed fiction or theoretical a few years back is now becoming a reality which Banks will need to consider seriously to stay in the game.

Machine Learning is powering the Artificial Intelligence revolution through its effort to make the predictive capabilities of Business lot more accurate, repeatable and scalable. Though the early adopters of Artificial Intelligence have been the customer centric functions of Bank, there has been a gradual progression towards exploring its potential to solve Banking Risk Management problems.

II. So, are there any Limitations with how Things Work now?

One of the foundational principles of Risk management is the need to not only assess or quantify your risk, but also to do it early enough to effectively mitigate it. The Industry has relied very heavily on algorithm based and conventional statistical models driven by knowledge, experience and judgment of the Business Subject matter experts across banks globally. Though the Conventional Risk models have stood the test of time and have helped Banks identify and manage their risk, they are yet to achieve highest levels of accuracy and additionally they are not equipped to handle huge chunks of structured and unstructured data which potentially hold critical risk insights.

For Instance, The Industry average of the accuracy of a PD model or a Loan Default prediction model typically could be anywhere between 80 to 90%, and in most cases we are unable to scale up the model to process greater volumes of historical data due to technology and infrastructure limitations. Additionally since the variable selection and its corresponding Significance in prediction is largely humanly defined with some statically inferences, we at most times are not able to fully derive the benefit of drawing insights from the breadth and depth of historical data. Similarly Industry is still battling with high number of false positives in the Anti-Money Laundering space and is excessively erring on the side of safety which is hurting operating margins and efficiencies. There are number of such other predictive outcomes in Risk management where leveraging of additional insights could very positively increase the accuracies.

III. What is Machine Learning in the Context of Risk Management?

At a very high level there are two most popular approaches to machine learning they are namely supervised and Unsupervised learning.

Supervised Learning: This is an approach to Machine learning where the historical Inputs data is tagged with its corresponding Business outcomes and the Machine learning solution is expected to identify and learn the patterns in the inputs data associated with a Business outcome and self-develop an algorithm based on this learning to predict a Business outcome for a future instance. There are two primarily utilities of Supervised learning:

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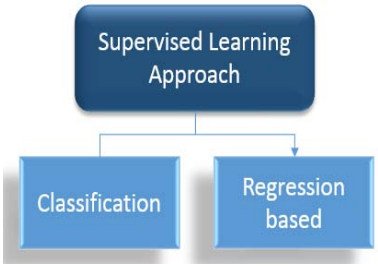
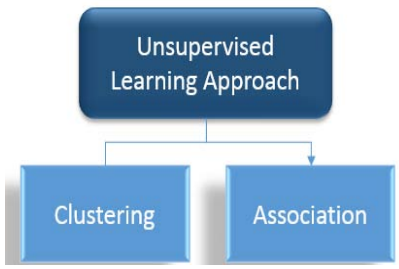


Classification: This is used for Business problems where the prediction deals with classification. For Eg: Whether a Loan will default or not. (Yes or No).

Regression: This is used for Business problems where a quantified value is being predicted. For example what is the Probability of Loan default? (Expressed in percentage).

In case of Supervised Learning it is important to have a good mix of historical data supporting both the positive and negative hypothesis both for the training set and a test set. It is recommended that we have them almost equal. Additionally it is recommended to have 80% of your historical data as Training and 20% as the Test set.

Unsupervised Learning: This is an approach to Machine learning where the historical Inputs data is fed into the machine learning solution without any tagging of the Business outcomes and the solution is expected to decipher or self-develop an algorithm for prediction based on its own interpretations of the patterns in the data without any guidance or indicators. The Primary difference between supervised and unsupervised learning is that the historical Input training data is tagged with Business outcomes as well in cased of supervised learning. There are two Primary utilities of Supervised learning:



Clustering: This is used for Business problems where records with homogenous characteristics are clustered together. For Eg: Customer Segmentation for Consumer Credit Risk Calculations.

Association: This is used for Business problems where the prediction is looking at the association of variables. For Eg: Impact of increased draw-down on credit lines prior to default.

Depending on the problem we are trying to solve any of the above mentioned techniques can be used. The end objective is to leverage the ability of machines to crunch huge amounts of historical data and uncover the hidden insights which are beyond human compression and conventional statistical analysis.

IV. So What ARE Some of the Problems Machine Learning can Solve?

There is definitely a lot of buzz and excitement around leveraging Machine learning for predictive models needed by Risk Managers, but a clear understanding of the business value and the specific need for leveraging it should be carefully understood and evaluated before zeroing in on the USE cases. Leveraging machine learning for processes which are already fairly accurate with a Business rule or statistical models may not be good candidates for early adoption.

Following are some of the top candidate processes or USE cases being explored in the Industry for Machine Learning Adoption in the Banking Risk management space.

- *Anti-Money Laundering (AML) Transaction Monitoring:* Historical data on Suspicious transactions can be analyzed through machine learning techniques to understand patterns that are associated with suspicious transactions from those that are not.
- *Risk Based Credit Approvals:* For high dollar value credit approvals which are largely judgement based and not business rule driven, there could be certain factors or combination of factors which the underwriters might have used to approve them. Machine leanring could help analyze and interpret a pattern associated with approvasls and develop an algorithm to predict it more consistently.
- *Loan Default Prediction:* Some initial studies have shown that Machine learning techniques have been able to uncover some hidden insights and pattern of credit deterioration from historical data which can now enable us to identify early signs of credit deterioration or eventual default based on time series data of defaults. This specially has significance both from a strategic Loan Default management perspective and also from perspective of Regulatory expectations in IFRS 9 and CECL to identify early warning signals of Credit deterioration.
- *Risk Forecasting Models:* Similar to classification related problem statements, machine learning techniques can be effectively used for Regression based forecasting as well. Primarily, forecasting models for Probability of Default (PD), Loss Given Default (LGD) and Credit Conversion factor (CCF) can show greater levels of accuracies in forecasting the quantum of risk with greater degree of precision and Accuracy.
- *Consumer Loan Risk Segmentation:* Consumer loans need to be segmented in pool of loans exhibiting homogenous characteristics. This is

done based on rule based categorization today based on business knowledge and experience built over the years. However, clustering techniques in machine learning provide tremendous scope and potential for the consumer loan segmentation using methods such as KNN.

V. Critical Success Factors in Machine Learning Adoption

- It is important to understand that *different problems statement could warrant different machine learning techniques.* So there is no one size fits all. It is an iterative processes. Sometimes you might use a hybrid approach of using more than one technique as well.
- It is important to use actual historical data which carries the *real insights, and any attempts to synthetically create data may not be able to capture the idiosyncratic insights and pattern* for a given business outcome which your historical data might carry.
- A machine learning algorithm needs to be given time to improve its accuracy. The *more the historical data the deeper is the learning and greater will be the accuracy.*
- It should be viewed as *a Solution that is there to assist the Business and Subject matter experts and not to replace them.* They should at best recommend and not be given a final Business decision making role.
- There needs to be *gradual adoption of Machine learning solutions* as against a Big bang approach.
- *Machine learning solutions can be combined with Robotic Process Automation* (RPA) solutions to develop Cognitive RPA solutions which have tremendous business value and efficiencies.
- There needs to be at *the very least 4 quarters of parallel run* of the Machine learning solution with existing predictive models prior to moving them to production.
- *It is not purely a statistical or a technical exercise. Machine learning requires equal amounts of domain or subject focus* to identify the right data sources, data sets and data variables. The qualification of relevant data will optimize your iteration cycle.

VI. Conclusion

Machine learning is here to stay and is making rapid strides across multiple Industries. Though Machine learning as a concept has existed for more than three decades now, it's the advancement in Data storage and data management powered by the Big Data and Digital revolution has made Data mining more affordable and easier. There are number of Banks and financial institutions which have commenced their exploratory journey into machine learning world and for all new age Risk Mangers Machine learning is no more a work of fiction but is a reality with tremendous potential to proactively and effectively predict and manage their Risk. The Journey has just begun.

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An Analysis of Emotion and user Behavior in Context-Aware Travel Recommendation Systems using Pre-Filtering and Tensor Factorization Techniques

By Piumi Ishanka UA & Takashi Yukawa
Nagaoka University of Technology

Abstract- The emotion-based context-aware recommendation systems have been widely adapted by a wide variety of recommendation domains despite the fact only a few studies have been analyzed in tourist destination recommendations. To utilize the concept of user emotion and incorporate it into the recommendation process along with user behavior, we proposed a travel destination recommendation system. Also, we compare and clarify the effectiveness of using emotion and user behavior in the recommendation process by suggesting a framework based on two techniques: filtering and contextual modeling. For the filtering based approach, we used Prefiltering, and for the contextual modeling, we employed Tensor Factorization. Both these approaches performed excellently with the selected contexts in the proposed framework, and the results of the Tensor Factorization approach proved to be highly effective in tourist destination recommendation compared to other Pre-filtering.

Keywords: *context-aware place recommendation, pre- filtering, tensor factorization.*

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An Analysis of Emotion and user Behavior in Context-Aware Travel Recommendation Systems using Pre-Filtering and Tensor Factorization Techniques

Piumi Ishanka UA[α] & Takashi Yukawa[σ]

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Keywords: context-aware place recommendation, pre-filtering, tensor factorization.

I. Introduction

Currently, information systems are mainly being confronted by the challenge of information overload and alleviative methods are required to cope with and ultimately overcome this problem effectively and efficiently. Recommendation systems act as intelligent agents that provide solutions; the actual recommendation procedure is being stated as "the process of utilizing the opinions of a community of customers to help individuals in that community for more effectively identifying the content of interest from a potentially overwhelming set of choices."[1]. The of context-awareness has been introduced to the recommendation domain to increase the efficiency and usability of information filtering systems while providing solutions to information overload. Context-awareness emerged to acquaint users with the influence of the external environment on his/her appreciation of the items. Recently, however, not only the physical status but also users' psychological conditions are considered in the recommendation process. In the context-aware recommendation domain, many contextual features have been identified as contextual parameters, for instance companion in the movie recommendation domain, time and mood constraints in the music recommendation, and weather, season, travel type, etc., in the travel recommendation domain [2].

Much research has examined the application of context on the effective recommendation solutions in a variety of domains [3], [4], [5], [6]. In our study, we mainly focus the incorporation of emotion and user behavior as contextual parameters and try to compare the feasibility of the selected parameters on one of the challenging domain, travel recommendation compared to classical recommendation domains like movies, music, books, etc. Emotion has been used as a contextual parameter in several studies recently, and a few studies have made an effort to discuss the effectiveness of emotion in the recommendation process [7] with a real-world dataset, for example, LDOS-CoMoDa which is a movie dataset. Recently, recommendation systems have revealed a prodigious tendency to adapt emotion due to its effectiveness in human decision-making processes. These research efforts have been conducted independently and extended to two major research domains, i.e., Recommender systems and Affective computing. In particular, the user behavior actions; rating and tagging emotion were added to our study to analyze the effectiveness in the presence of both parameters together and individually in the proposed travel destination recommendation system. The context-aware dataset on travel recommendation is hard to find compared to traditional recommendation domains. Firstly, we derived our dataset based on user reviews for each destination chosen for the study by employing Semantic Analysis concepts. Secondly, we compared each parameter's effectiveness on travel destination recommendation by using the Pre-filtering technique and Tensor Factorization. Consequently, this study focuses on investigating the context-aware recommendation based on the parameters, user behavior, and emotion. The key objective of this paper is

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to propose a framework for the traveler destination recommendation system, exploiting the emotion and user behavior while optimizing each contextual parameter in the recommendation.

a) Our contribution

In this paper, we propose two foremost contributions for context-aware travel recommendation. We chose two contextual parameters - emotion and user behavior, and we implement the recommendation engine by using Pre-filtering techniques and then compare the effectiveness of the recommendation systems with the absence of any contextual parameter. Furthermore, we associate how individual contexts perform in the recommendation process by implementing the recommendation system with Tensor Factorization and comparing the results for each parameter. Finally, we compare two approaches, specifically Pre-filtering and Tensor Factorization for each context. We evaluate all the implemented methods with precision, mean average precision, mean average precision with emotion groups, the t-test (to check the difference in average precision and average preference ratings) and overall user satisfaction. The results of the study conclude the feasibility of selected contexts in travel recommendation. The rest of the paper is structured as follows.

The next section provides a brief overview of the related work, i.e., context and context selection, context awareness, the state-of-the-art of travel recommendation systems, contextual pre-filtering and context modeling techniques. Section three discusses an overall structure and implementation process of our proposed travel destination recommendation system. Section four evaluates the performance of the proposed system. The final section documents the concluding remarks on the major themes covered here and directions for further research.

II. Background

a) Context and context-awareness

The context has been defined in multiple ways and described as a multifaceted concept in different research domains [8]. Most of the contextual information concerns characteristics of an activity such as location, time and some dynamic features of user profiles, for example users' emotional state [9]. Hence, information e.g. location, time, social companion, and mood, etc., can be considered as the context in the case of recommendation systems [10]. Most of the domains introduce context-awareness to increase the efficiency and usability of information systems particularly when such a system is accessed by mobile devices [11]. However, this is applicable to other domains as well since usability of an information system is highly concerned in development process. The context-aware recommendation systems have been categorized into two kinds: firstly, as systems that use contextual information as a criterion to filter items; and secondly, systems employing contextual information at the time users can evaluate items devised by some authors [12].

b) Emotion in other recommendation domains

Recently, more efforts have been made to use emotion in the recommendation process. Research has been conducted on individual domains or combining domains such as an affective computing and recommendation systems. The role of emotion in the recommendation systems' consumption chain has been discussed in three stages, namely the entry stage, the consumption stage and exit stage. All three wield great influence on human decision-making [13]. User emotion can be described by modeling it using the Universal model or Dimensional model. The universal model describes emotion categories as happiness, anger, sadness, fear, disgust, and surprise while the dimensional model uses valance, arousal and dominance. Adapting emotion as a context parameter to the recommendation system was first done by Gonzalez et al. (2007) [14]. From then on, many applications arose on this topic due to the success of various research work. Emotion-based music recommendation is one of the domain both recommendation systems and affective engineering studies are merged [15], [16], [17]. Due to the diversity and richness of music content and in context-based music recommendation systems, it often needs multidisciplinary efforts such as emotion description, emotion detection, etc., to achieve success. The movie recommendation domain has also been enriched by applying emotion to the recommendation and a few studies incorporated emotion in various stages of movie consumption [18], [7], [19]. Thus, for an example emotion in each stage is monitored and incorporated into the LDOS-CoMoDa dataset for the recommendation process with reference to emotional contexts: Mood, Dominant Emo and EndEmo [7].

c) Travel recommendation systems

In Table 1 below we summarize a few travel recommendation systems by focusing the attention on the contextual parameters and recommendation approaches used.

Table 1: Travel Recommendation Systems

Author	Context	Contextual Parameters	Recommendation Process
Bian (2009) [20]	User Behavior	Location, Open Hours, Close Date, Mini Time Stay, Age Range, Occupation	Bayesian network techniques and analytic hierarchy process
Castillo (2008) [21]	User Behavior	Previously visited places in user profiles	Case-based reasoning and the K-Nearest Neighborhood algorithm
Yong, Robin and Bamshad (2012) [22]	User Behavior	Trip Type, Trip duration, Origin City, Destination City, Month	CF with differential context relaxation
Soha, Tayasir and Adel (2016) [23]	Use Behavior and User Mood	Weather, Time of the day, Users Location User Mood: Happy, angry, Excited, Tired User's speed and travel direction	Genetic algorithm and Matrix factorization
Barranco, Noguera Castro, and Martinez (2012) [24]	Location and Trajectory	User's speed and travel direction	Improve recommendations by using context-aware filtering in CF
Gavalas and Kenteris (2011) [25]	Location, time, weather, user behavior	Location, time, weather	Collaborative filtering while considering contextual information in pervasive environment
Noguera, Barranco, Segura and MartiNez' (2012) [26]	Location	Location	Use both pre and post-filtering approaches
Soe Tsyr Yuan and Chun-Ya Yang (2017) [27]	User emotion	User behavior searching history, destination stores, feedback of emotional words	Use color imagery as the uniform representation of customers' expectation to facilitate the scoring and ranking

All the studies in the table attempted to incorporate various types of contextual information in the recommendation process. For example, Soe Tsyr Yuan and Chun-Ya Yang et al. (2017) in their work tried using emotion in the recommendation process, but their method to extract emotion was, based on color and imagination. Travel recommendation systems serve tourists with relevant and personalized destination suggestions for helping them to make better decisions. State of-the-art of recommendation systems can be analyzed as web-based systems or mobile-based systems, while the web-based are being the predominant type. As well depending on the service, systems' recommendation can be clustered. Suggested here are the destination and construction of a complete tourist package, recommended suitable attractions at one specific place, a detailed multi-day trip schedule, and social capabilities [28].

III. Context-Aware Recommendation

Context-aware recommendation systems try to estimate the rating function *R* by incorporating the contextual information *C* for item *I* by user *U* with initially specified user rating as follows;

$$R: User \times Item \times Context \longrightarrow Rating$$

where the *user x item* pair refers to users, who are not rated yet. Integration of emotion in the recommendation process can take three forms, these being contextual pre-filtering, contextual post-filtering, and contextual modeling according to Adomavicius et al. [29]. In the pre-filtering stage, the contextual information is used to filter and select the most relevant data before applying the recommendation algorithm. On the other hand, the post-filtering applies recommendation algorithm to the original dataset; then the recommendations are filtered according to the contextual information. Both pre-filtering and post-filtering treat the recommendation process as a 2D recommender. In our study, we only use pre-filtering techniques, since we try to compare the effectiveness of contextual modeling over contextual filtering approach. The contextual modeling approach considers the context in the recommendation algorithm and hence the rating function is treated as a 3D function which represents a user, item, and context as *User x Item x Context* and provides a rating for each user.

a) Pre-filtering with context-aware recommendation

The collaborative filtering technique uses the preference for items preferred by users (user-item matrix). Each entry in the user-item matrix represents the preference score or the ratings of the i^{th}user for the j^{th} item, where there is *m* number of users, $U = u_1, u_2, ..., u_m$ and *n* number of items, $I = i_1, i_2, ..., in$. Each user u_i has a list of items i_i, which the user has expressed his/her preference about (see Figure 1). By calculating the similarities between the users, collaborative filtering matches set of users with relevant interest and make the recommendation [30].

Predictions $P_{i,j}$, express the predicted user's preference for item *j* for the active user u_i. The predictive value is a numerical value which is on the same scale as the ratings provided by users.

Recommendation List is a list of top *N* items, that the active user u_i will prefer most and this list represents a no. of items that user hasn't preferred so far. The collaborative filtering can be two categories namely memory-based (user-based) and model-based (item-based) [31], [32].

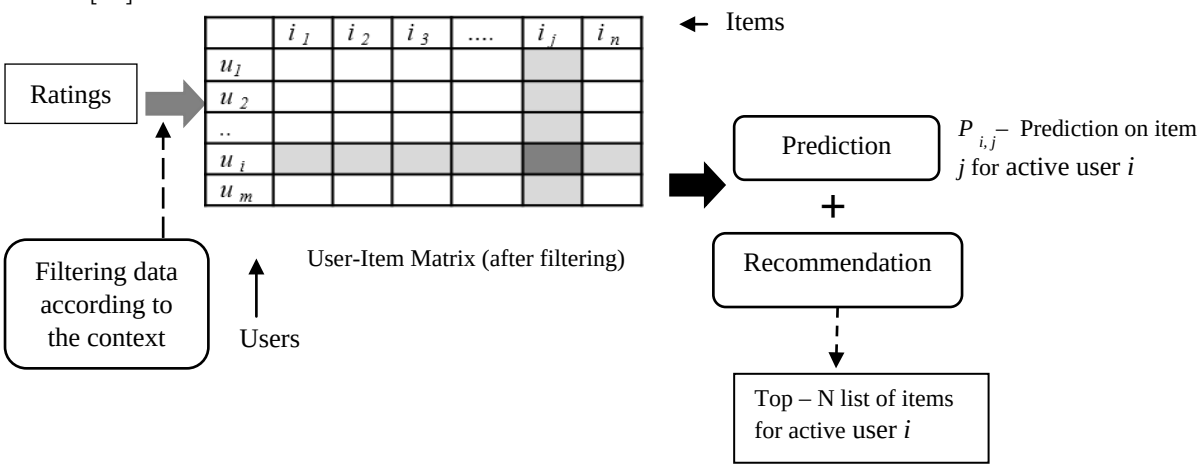


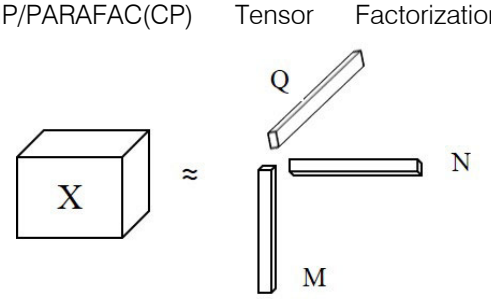
Figure 1: Collaborative Filtering Process with Pre-filtering Technique. The filtered user-item matrix data are used to predict rating for a user.

In the pre-filtering approach, the user-item matrix consisted of the filtered dataset according to the current context in the query.

b) Contextual modeling with context-aware recommendation

In applying Tensor Factorization techniques to recommendation systems, a predictive model is provided by analyzing patterns from the data, linked to the multifaceted nature of the user-item interaction. A tensor is considered to be an array of numbers with more than two dimensions and serve as a natural extension of matrices to a higher order case [33], [34]. Thus, a tensor is a multidimensional array or can refer to a N^{th} order tensor which is an element of the tensor product of *N* vector spaces. We use CANDECOMP/PARAFAC(CP) Tensor Factorization model which uses ratings from *M* users for *N* items under *Q* types of contexts as a three-dimensional tensor $M \times N \times Q$. The latent features stored in $U \in R^{M \times D}$, $I \in R^{N \times D}$ and $C \in R^{Q \times D}$ where *U* represents D-dimensional row vector for *m* users, *I* for latent features for item *i* and *C* represents the latent features of context category *q*; [35] (see Figure 2).The same size vectors are sometimes arranged together to form three matrices in Tensor Factorization model, and for the explanation, we also use it as the size of *d*. Then user m's rating for item *i* under context *q* can be predicted as following:

$$f_{miq} = \sum_{d=1}^{D} U_{md} I_{id} C_{qd}$$



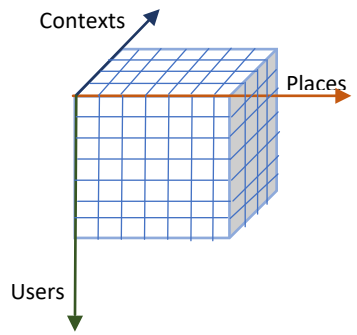


Figure 2: Tensor Factorization Model.

IV. Incorporation of Emotion and User Behavior in Proposed Recommendation System

a) Context acquisition

In the implementation of the proposed recommendation system, the contextual parameters must be acquired and make available for recommendation.

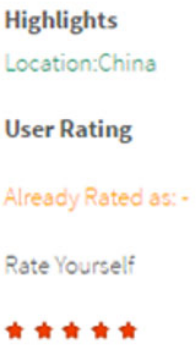


Figure 3: User Rating Capturing. User preference for a place gathered in five-star scale.

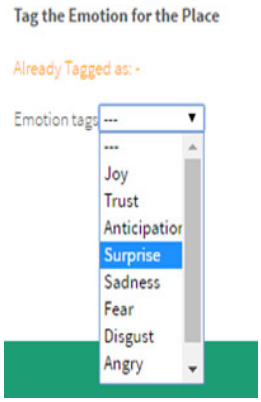


Figure 4: Emotion Tag Creation. The users were asked to tag an emotion for a place when they logged into the system.

The emotion of the users recorded in the system when users logged into it by themselves. Users' current emotions are collected according to the scale of *Happy, Surprise, Disgust, Sad, Afraid, Angry, Confidence* and *Anticipation* based on the Plutchik emotion classification [36]. Concerning user behavior, we recorded user actions such as user rating and emotion tagging for places in the system as illustrated in Figures 3 and 4.

b) Dataset

The dataset used to implement the proposed recommendation system was derived by collecting data for the world's most famous 100 tourist attractions in 2016. This information included place description, location and images and they were collected from Wikipedia[1]while the average rating and one hundred user reviews for each place were collected from TripAdvisor[2]. Then the extracted reviews were analyzed and classified to acquire emotion tags to represent a user's emotional state for a place in two stages. Firstly, stop words were removed, stemming was done using Porter's algorithm and Term Frequencies (TF) were calculated for each review and calculated the total TFs by emotions and with highest frequencies we decided the emotion tag [46]. We collected 9998 ratings for 8470 users, rated on 100 places and derived an emotion tag for each user rated by each place.

c) *Recommendation system implementation*

The implementation of the proposed recommendation system was done based on the selected two approaches, Pre-filtering and Tensor Factorization. We developed two recommendation engines for the system which were, based on collaborative filtering and Tensor Factorization, using the two derived datasets and loaded the place data into the system's database. The proposed framework for the recommendation process with each approach illustrated in Figure 5. The collaborative filtering approach considers the recommendation process with emotion (CFE), user behavior (CFUB) and emotion and user behavior (CFEEUB) together with the Pre-filtering techniques in the proposed context-aware recommendation system. The similarity and predictive rating values were calculated for each user, and the top five places were recommended to the user for each CFE, CFUB, and CFEUB approaches. To compare the effectiveness in recommendation process, the system which is not incorporated with any contextual parameter (CFN) also developed. In the implementation process, we used item-item collaborative filtering to develop and review our contextual parameters on the derived dataset for pre-filtering techniques.

[1]https://en.wikipedia.org
[2]https://www.tripadvisor.com

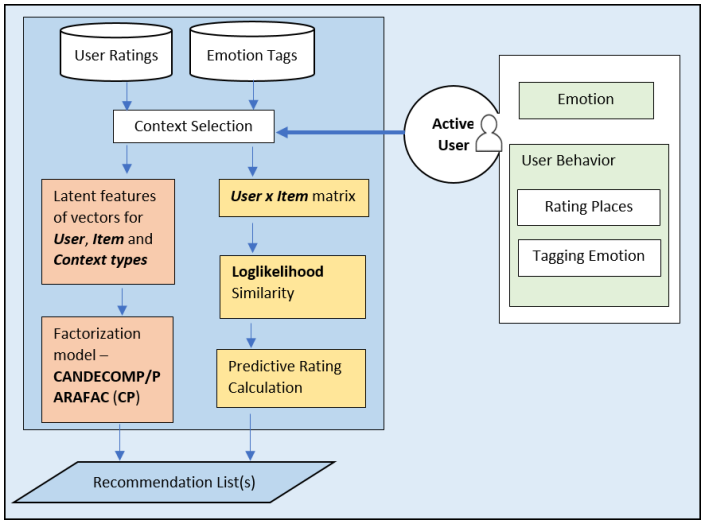


Figure 5: Architecture for the Recommendation System with two Recommendation Approaches. The Tensor factorization follows the CP factorization model while item-item collaborative filtering was used as the Pre-filtering technique.

In the context-aware recommendation process the recommendation based on, emotion was analyzed with reference to three emotion groups based on the Plutchik's emotion classification: Group I: Anticipation (Anticipation, Surprise), Group II: Joy (Joy, Sadness, Fear) and Group III: Trust (Trust, Disgust and Anger). Thus in the collaborative filtering recommendation process, selecting data to be placed in the recommendation engine was done based on these three groups since we assumed that the recommendation should lie on the positive emotion scale. Therefore, Disgust, Fear, Anger, and Sadness are categorized and arranged as three positive groups, i.e., Anticipation, Joy and Trust based on Plutchik's comprehensive list of eight primary emotions arranged as opposing pairs. To refrain from using the negative emotion category in each group, Fear and Anger arranged in the Joy and Trust groups, respectively. We utilized these three groups to evaluate the influence of user emotion on the recommendation. The dataset was input to the recommendation function based on the user's emotion states that were logged in to the system.

To apply Pre-filtering with item-item collaborative filtering, the target user's rating prediction for a target item is made by considering the user-item rating pairs, while the prediction for a certain user for a target item is predicted based on the user's ratings on the observed items. The similarity calculation for item *i* and item *j*, needs to identify set of users who have rated for both items and then compute the similarities for those users [37], [38].

The similarity calculation for the recommendation process was calculated based on the Loglikelihood ratio which relies on calculating the similarity between two items or users based on statistics since the Loglikelihood provided a sufficient number of items for recommendation compared to Pearson's Correlation. The Loglikelihood ratio is derived based on the occurrences relating to the users or items which are users or items overlapping in preferences where both compared users have preferences or not, and the events where both users or items do not have preferences [39], [40].The prediction algorithms play the role of guessing the rating a user would provide for a target item [41]. We calculated the predictive rating $P_{u,i}$, by after a space user u for item i as shown below:

$$P_{u,i} = \frac{\sum_{n \in N} (sim\ (u,n) + 1)\ \times\ R_{u,n}}{\sum_{n \in N}\ (sim(u,n) + 1)}$$

where *sim (u, n)* is the similarity between n^{th} item and user *u* and $R_{u,n}$ is the rating for user *u* on item n for all *N* number of items which are based on the Mahout item based recommendation algorithm [42]. The similarity calculations ranged from -1.0 to 1.0 and to avoid negative values we added 1.0 to similarity values, so the similarity ranges from 0.0 to 2.0. The top five place recommendations list was created based on the highest similarity values to the least in the provided most similar places, set from the places pool. Pu_1, s_1 is the illustration for predictive rating calculation in different contexts. (see Figure 6,7 and 8).

	S1	S2
U1	1	0.45
U2	1	0.5

Figure 6: User-Item matrix U1 and u2 are two users rated for item s1 and s2.

	S1	S2
U1	1	1
U2	0	1

Figure 7: User-emotion matrix

	S1	S2
U1	0	1
U2	1	1

Figure 8: User-user behavior matrix

$$P\ u_1, s_1(\text{Emotion}) = ((1+1)*1+(0.45+1)*1)/(1+0.45) = 1.7$$

$$P\ u_1, s_1(\text{User behavior}) = ((1+1)*0+(0.45+1)*1)/(1+0.45) = 1$$

In the contextual modeling approach, we used Tensor Factorization, because in applying it enhances the ability to consider the multifaceted nature of the user-item interaction as discussed in the Background. In the CP Tensor Factorization, three-dimensional tensors *M x N x Q* are used for *M* users for *N* items with the *Q* types of contexts. Two proposed contextual parameters were analyzed as Tensor Factorization with emotion (TFE), Tensor Factorization with user behavior (TFUB) and Tensor Factorization with emotion and user behavior (TFEUB) in Tensor Factorization approach. So, in each case, at least one parameter was selected for the recommendation process. The recommendation of the tensor-based approach was developed based on CARSkit library [43] and the context appearance for user *m* for item *i* with the context *k* can be either 1 or 0 as a binary value and input to the recommendation process. As an example, for user 4 for Place ID 52, the contextual information is stated below in Table 2.

Table 2: Example of the Results for Contextual Information for a User

		emotion: angry	emotion: anticipation	emotion: disgust	emotion: fear	emotion: joy	emotion: sadness	emotion: surprise	emotion: trust	rated	taggedemo
TFEUB	4	0	0	0	0	0	0	1	0	1	1
TFUB	5	0	0	0	0	0	0	0	0	1	1
TFE	3	0	1	0	0	0	0	0	0	0	0

Figure 9 depicts an example for top five place list provided for a user in Tensor Factorization approaches.

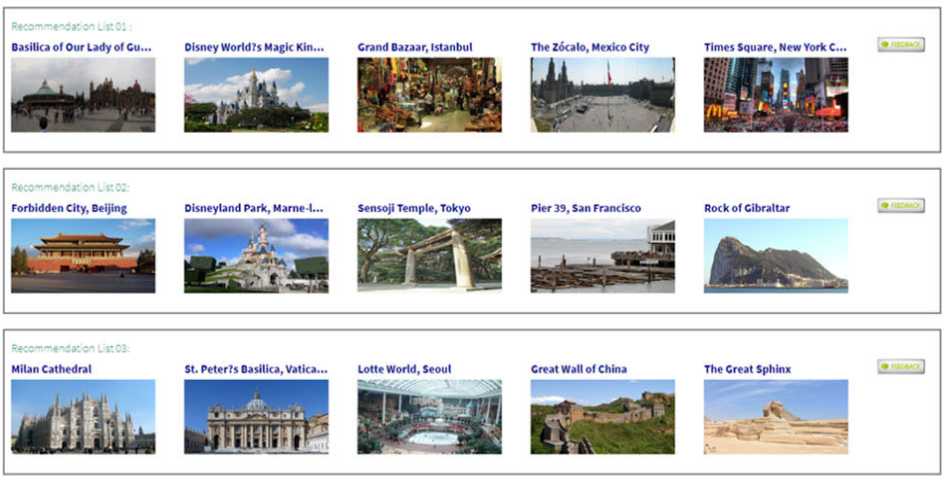


Figure 9: Recommendation Lists. The recommended lists in the figure show places provided by three recommendation approaches TFE, TFUB, and TFEUB

V. Evaluation

a) Experimental setup

First, we describe the evaluation protocols for place recommendation in the proposed system. Then we demonstrate how the contextual parameter selection for Pre-filtering and Tensor factorization performed to assess the effectiveness of the recommendation process. Afterwards, we evaluate the impact of each parameter on each approach in the recommendation process in terms of the recommendation system's quality. For comparison reasons, we separately evaluate each recommendation approach, and especially the collaborative filtering approach against non-context collaborative filtering based recommendation. Also, for each context, the Tensor Factorization and Collaborative Filtering approaches were also compared. The reason for selecting both Tensor Factorization and Collaborative Filtering is because both filtering and contextual modeling approaches can be tested in context-aware recommendation.

The implemented system, *Travel Destination* was presented to 16 users, and they were all asked to experiment with the recommendation process and evaluate the two recommended lists. These lists, which were asked for rating according to the user preference for each place in the list and state the overall preference for the list according to user's current emotion while stating the overall satisfaction for the recommended lists in the five- point Likert scale.

b) Evaluation protocols

Evaluation Protocols for the task of recommendation lists, the following are used:

1) We used Precision and Mean Average Precision (MAP) values of the two approaches.
2) We evaluated the recommendation lists considering the emotion groups derived at the recommendation engine designing stage to track, how the lists fitted with the users' emotions by using Mean Average Precision on Emotional groups(MAPE).
3) To compare contextual recommendation against non-context recommendation we used t-test to examine the superiority of the all context incorporated approaches (CFE, CFUB, CFEUB, TFE, TFUB,TFEUB) against baseline approach (CFN) by evaluating t_{mean} of both Average precision (*AveP*) and Average Preference Rating (*APR)* based on the rating, users marked as Preferred and Preferred much in the five-point Likert scale.
4) The user rating behavior variation for the user emotion was analyzed for the validation of the emotion groups in the recommendation system design.
5) The overall satisfaction of users towards the recommendation system also was analyzed.

Thus, in the experiment, the testing users had to register to the system and then input their emotions in the given emoticon scale and evaluate the two lists, each with five places.

c) Results and discussion

The Classification Accuracy Measure is one of the Accuracy metrics, which measures to what extent a recommendation algorithm can correctly classify items as interested or not. In our study, we use *Precision* one of the common measurers for recommendation system evaluation; recommender system's preference ratings must be converted its rating scale into a binary scale, so we converted rating scale as ratings of 4 and 5 are good recommendations [44]. The Precision expresses the fraction of recommended items that are actually relevant to the user [45].

$$\text{Precision} = \frac{\text{Correctly recommended items}}{\text{Total recommended items}}$$

The precision values for the all the context incorporated approaches (CFE, CFUB, CFEUB, TFE, TFUB, TFEUB) and the non-context approach (CFN) as rated by 16 users, were calculated as below and mean precision values for the all the context incorporated approaches were greater compared to CFN. The Average Precision calculates the precision at the position of every correct item in the ranked results list of the recommender. The mean of these average precision values across all relevant lists is the mean average precision or *MAP*. The *MAP* also outperformed the all the context incorporated approaches compared to CFN (see Table 3).

$$AveP = \frac{\sum_{k=1}^{n}(P(k) \times rel(k))}{\text{number of relevant items}}$$

$$MAP = \frac{\sum_{q=1}^{q} AveP(q)}{Q}$$

where *P(k)* is the precision at k-th element, *rel(k)* is 1 if the i-th item of the list is relevant, and *Q* is the total no. of lists.

Table 3: Precision Values, and Mean Average Precision Values

Algorithm	Precision	Mean Av. Precision
CFN	59.69	61.98
CFUB	61.88	67.28
CFE	65.31	69.83
CFEUB	71.88	79.18
TFUB	63.75	72.27
TFE	68.75	74.81
TFEUB	72.5	81.59

Moreover, we analyzed the Mean Average Precision based on emotional groups (*MAPE*) for each approach.

$$MAPE = \frac{\sum_{c=1}^{C}\sum_{q=1}^{q} AveP(q)}{\sum_{c=1}^{C} Q}$$

where *C* is the no. of emotion groups, and we rely on three groups in our evaluation. In Figure 10, The overall *MAPE* values on Collaborative Filtering approach and Tensor Factorization approach with emotional groups Trust, Joy and Anticipation are illustrated respectively. Thus, the emotional group vise *MAP* showed increased results compared to general approach.

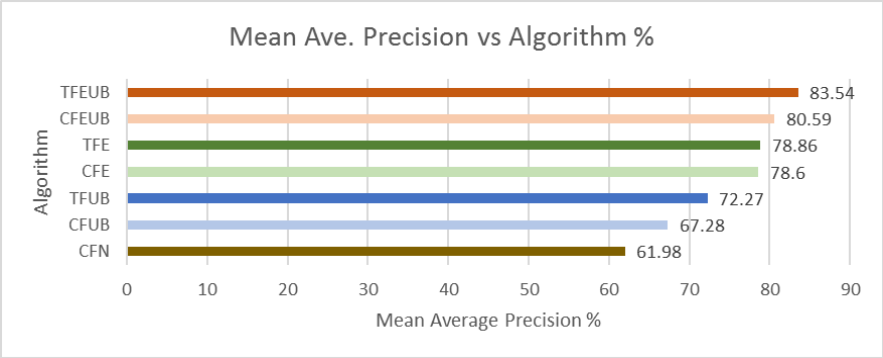


Figure 10: Average Precision Values with Emotion Groups

We, statistically compared the performance of the Collaborative Filtering approaches and Tensor Factorization approaches with non-context approach CFN; in terms of average precision values and average preference ratings. So, the hypotheses are:

- H_0: $\mu_c = \mu_{CFN}$ and alternative hypotheses are H_a: $\mu_c \neq \mu_{CFN}$, H_a: $\mu_c > \mu_{CFN}$. where μ_c and μ_{CFN} are Mean of average precision rating of context-aware approaches and non-context collaborative filtering approach respectively.
- H_0: $\mu_{cp} = \mu_{CFN}$ and alternative hypotheses are H_a: $\mu_{cp} = \mu_{CFN}$, H_a: $\mu_{cp} > \mu_{CFN}$. where μ_{cp} and μ_{CFN} are Mean of preference ratings of context-aware approaches and non-context collaborative filtering approach respectively.

Since T value (Test Statistic) $< t_{\alpha,\ v}$(Critical Value), we reject the null hypothesis in both cases and concluded that the two population means are different at the 0.05 level of significance, while at the alternative hypothesis $\mu_c > \mu_{CFN}$ and $\mu_{cp} > \mu_{CFN}$ are true in all contexts incorporated approaches. Table 4 illustrates *p-values* obtained for the t-test from the *MAP* and *Mean Rating Preferences*.

Table 4: Precision Values and Mean Average Precision Values

Algorithm	Mean Average Precision (p-value)	Mean Rating Preference (p-value)
CFUB	0.6221	0.8386
CFE	0.4389	0.5094
CFEUB	0.1012	0.0940
TFUB	0.2614	0.2408
TFE	0.1631	0.7061
TFEUB	0.039	0.2018

Therefore, the t-test results showed that the difference with the baseline recommender (CFN) in terms of average precision and average rating preferences of the contextual approaches are statistically significant. The user rating behavior showed that users have rated as preferred and much preferred when they have Joy, Surprise, Trust and Anticipation emotion, compared to Fear, Sad, Disgust and Angry emotions. Thus, these results showed that suggesting places, incorporated with positive emotion is much suitable and the used emotional group classification in the recommendation system design process, works fine in this regard (see Figure 11).

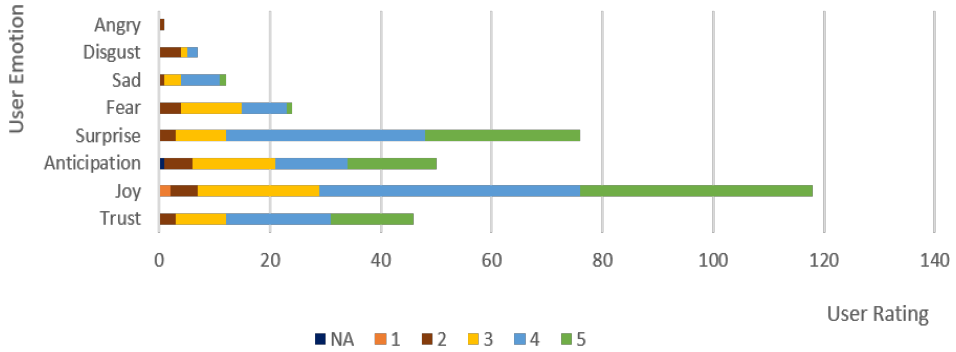


Figure 11: User Rating Behavior based on User Emotion

Finally, we collected users' feedback on how they overall satisfied with the recommended place list, their opinion based on their current emotion stated as shown in Table 5. According to the results, CFEUB and TFEUB lists are highly preferred by users as well matched with their current emotions.

Table 5: Preference Values for Algorithms for the Top Five Places

Algorithm	Overall preference	Preference with the emotion of user
CFN	46.77	-
CFUB	80	-
CFE	60	53.33
CFEUB	87.5	87.5
TFUB	68.75	-
TFE	73.33	80
TFEUB	73.33	86.67

VI. Conclusion and Future Work

In this study, we analyzed the effectiveness of using user emotion and behavior in context-aware tourist destination recommendation. This was achieved by utilizing Pre-filtering and Tensor Factorization techniques in the recommendation process. User emotion and behavior are much employed in classical recommendation domains like music, movies, and books, but the travel destination recommendation is still in the early stages of development in using the selected parameters. Since adapting emotion in the consumption stage of the recommendation is difficult, in our study we focused on the effectiveness of using emotion along with user behavior in the proposed recommendation. Our system can outperform several state-of-the-art context-aware travel recommendation systems. In both Pre-filtering and Tensor Factorization incorporation of context outperformed well. We employed Plutchik's emotion classification for both emotion word detection derived from reviews and acquired users' current emotions into the system. Based on the emotion selected by the user, we suggested that the recommended place list should consist of positive emotion categories: Joy, Anticipation, and Trust.

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Handwritten Digit Recognition using Machine Learning Algorithms

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Abstract- Handwritten character recognition is one of the practically important issues in pattern recognition applications. The applications of digit recognition includes in postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize hand written digits and which is submitted by users by the way of a scanner, tablet, and other digital devices. This paper presents an approach to off-line handwritten digit recognition based on different machine learning technique. The main objective of this paper is to ensure effective and reliable approaches for recognition of handwritten digits. Several machines learning algorithm namely, Multilayer Perceptron, Support Vector Machine, Naïve Bayes, Bayes Net, Random Forest, J48 and Random Tree has been used for the recognition of digits using WEKA.

Keywords: pattern recognition, handwritten recognition, digit recognition, machine learning, WEKA, off-line handwritten recognition, machine learning algorithm, neural network, classification algorithm.

GJCST-D Classification: I.7.5, I.2.7, I.5.m

Strictly as per the compliance and regulations of:

Handwritten Digit Recognition using Machine Learning Algorithms

S M Shamim [α], Mohammad Badrul Alam Miah [σ], Angona Sarker [ρ], Masud Rana [ω] & Abdullah Al Jobair [¥]

Abstract- Handwritten character recognition is one of the practically important issues in pattern recognition applications. The applications of digit recognition includes in postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize hand written digits and which is submitted by users by the way of a scanner, tablet, and other digital devices. This paper presents an approach to off-line handwritten digit recognition based on different machine learning technique. The main objective of this paper is to ensure effective and reliable approaches for recognition of handwritten digits. Several machines learning algorithm namely, Multilayer Perceptron, Support Vector Machine, Naïve Bayes, Bayes Net, Random Forest, J48 and Random Tree has been used for the recognition of digits using WEKA. The result of this paper shows that highest 90.37% accuracy has been obtained for Multilayer Perceptron.

Keywords: pattern recognition, handwritten recognition, digit recognition, machine learning, WEKA, off-line handwritten recognition, machine learning algorithm, neural network, classification algorithm.

I. Introduction

Intelligent image analysis is an appealing research area in Artificial Intelligence and also crucial for a variety of present open research difficulties. Handwritten digits recognition is a well-researched subarea within the field that is concerned with learning models to distinguish pre-segmented handwritten digits. It is one of the most important issues in data mining, machine learning, pattern recognition along with many other disciplines of artificial intelligence [1].The main application of machine learning methods over the last decade has determined efficacious in conforming decisive systems which are competing to human performance and which accomplish far improved than manually written classical artificial intelligence systems used in the beginnings of optical character recognition technology [2]. However, not all features of those specific models have been previously inspected.

A great attempt of research worker in machine learning and data mining has been contrived to achieve efficient approaches for approximation of recognition from data [3]. In twenty first Century handwritten digit communication has its own standard and most of the times in daily life are being used as means of conversation and recording the information to be shared with individuals. One of the challenges in handwritten characters recognition wholly lies in the variation and distortion of handwritten character set because distinct community may use diverse style of handwriting, and control to draw the similar pattern of the characters of their recognized script.

Identification of digit from where best discriminating features can be extracted is one of the major tasks in the area of digit recognition system. To locate such regions different kind of region sampling techniques are used in pattern recognition [4].The challenge in handwritten character recognition is mainly caused by the large variation of individual writing styles [5]. Hence, robust feature extraction is very important to improve the performance of a handwritten character recognition system. Nowadays handwritten digit recognition has obtained lot of concentration in the area of pattern recognition system sowing to its application in diverse fields. In next days, character recognition system might serve as a cornerstone to initiate paperless surroundings by digitizing and processing existing paper documents.

Handwritten digit dataset are vague in nature because there may not always be sharp and perfectly straight lines. The main goal in digit recognition is feature extraction is to remove the redundancy from the data and gain a more effective embodiment of the word image through a set of numerical attributes. It deals with extracting most of the essential information from image raw data [6]. In addition the curves are not necessarily smooth like the printed characters. Furthermore, characters dataset can be drawn in different sizes and the orientation which are always supposed to be written on a guideline in an upright or downright point. Accordingly, an efficient handwritten recognition system can be developed by considering these limitations. It is quiet exhausting that sometimes to identify hand written characters as it can be seen that most of the human beings can't even recognize their own written scripts. Hence, there exists constraint for a writer to write apparently for recognition of handwritten documents.

Before revealing the method used in conducting this research, software engineering module is first presented. Pattern recognition along with Image processing plays compelling role in the area of handwritten character recognition. The study [7], describes numerous types of classification of feature extraction techniques like structural feature based

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methods, statistical feature based methods and global transformation techniques. Statistical approaches are established on planning of how data are selected. It utilizes the information of the statistical distribution of pixels in the image. The paper [8], provided SVM based offline handwritten digit recognition system. Authors claim that SVM outperforms in the experiment. Experiment is carried out on NIST SD19 standard dataset. The study [9] provide the conversion of handwritten data into electronic data, nature of handwritten characters and the neural network approach to form machine competent of recognizing hand written characters. The study [10] addresses a comprehensive criterion of handwritten digit recognition with various state of the art approaches, feature representations, and datasets. However, the relationship of training set size versus accuracy/error and the dataset-independence of the trained models are analyzed. The paper [11] presents convolution neural networks into the handwritten digit recognition research and describes a system which can still be considered state of the art.

II. Methods and Materials

a) Multilayer Perceptions

A neural network based classifier, called Multi-Layer perception (MLP), is used to classify the handwritten digits. Multilayer perceptron consists of three different layers, input layer, hidden layer and output layer. Each of the layers can have certain number of nodes also called neurons and each node in a layer is connected to all other nodes to the next layer [12]. For this reason it is also known as feed forward network. The number of nodes in the input layer depends upon the number of attributes present in the dataset. The number of nodes in the output layer relies on the number of apparent classes exist in the dataset. The convenient number of hidden layers or the convenient number of nodes in a hidden layer for a specific problem is hard to determine. But in general, these numbers are selected experimentally. In multilayer perceptron, the connection between two nodes consists of a weight. During training process, it basically learns the accurate weight adjustment which is corresponds to each connection [13]. For the learning purpose, it uses a supervised learning technique named as Back propagation algorithm.

b) Support Vector Machine

SVM or Support Vector Machine is a specific type of supervised ML method that intents to classify the data points by maximizing the margin among classes in a high-dimensional space [14]. SVM is a representation of examples as points in space, mapped due to the examples of the separate classes are divided by a fair gap that is as extensive as possible. After that new examples are mapped into that same space and anticipated to reside to a category based on which side of the gap they fall on [15]. The optimum algorithm is developed through a "training" phase in which training data are adopted to develop an algorithm capable to discriminate between groups earlier defined by the operator (e.g. patients vs. controls), and the "testing" phase in which the algorithm is adopted to blind-predict the group to which a new perception belongs [16]. It also provides a very accurate classification performance over the training records and produces enough search space for the accurate classification of future data parameters. Hence it always ensures a series of parameter combinations no less than on a sensible subset of the data. In SVM it's better to scale the data always; because it will extremely improve the results. Therefore be cautious with big dataset, as it may leads to the increase in the training time.

c) J48

The J48 algorithm is developed for the MONK project along with WEKA [17]. The algorithm is an extension for C4.5 decision tree algorithm [18]. There are many options for tree pruning in case of J48 algorithm. The classification algorithms convenient in WEKA try to clarify the results or prune. This method will help us to produces more generic results and also can be used to correct potential over fitting issues. J48 helps to recursively classify until each of the leaf is pruned, that is to classify as close knit to the data. Hence this will helps to ensure the accuracy, although excessive rules will be produced. However pruning will cause to less accuracy of a model on training data. This is due to pruning employs various means to relax the specificity of the decision tree, hopefully improving its performance on the test data. The complete concept is to increasingly generalize a decision tree until it gains a balance of accuracy together with flexibility. The J48 applies two pruning methods. First one is known as subtree replacement. This concludes that nodes in the decision tree can be replaced with a leaf -- which reduces the number of tests along a particular path. This process begins from the leaves of the completely formed tree, and attempts backwards toward the root. Second category of pruning adopted in J48 is termed subtree rising. In this respect, a node can be moved upwards towards the root of the tree, replacing other nodes another way. Subtree rising repeatedly has a insignificant effect on decision tree models. There is generally no clear way to anticipate the utility of the option, though it may be desirable to try turning it off if the induction process is catching a long time. This is because of the fact that subtree rising may be somewhat computationally complicated. Error rates are needed to make actual conclusions about which parts of the tree to rise or replace. There exist multiple ways to perform this. The straight forward way is to reserve a portion of the training data in order to test on decision

tree. Reserved portion may then be adopted as test data for the decision tree, aiding to reduce potential over fitting. This method is recognized as reduced-error pruning. Though the approach is straightforward, it also decreases the overall volume of data available for training the model. For specifically small datasets, it may be advisable to avert using reduced error pruning.

d) Random Forest Algorithm

Random forest as is an ensemble of un-pruned regression or classification trees, activated from bootstrap samples of the training data, adopting random feature selection in the tree imitation process. The prediction is made by accumulating the predictions of the ensemble by superiority voting for classification. It returns generalization error rate and is more potent to noise. Still, similar to most classifiers, RF may also suffer from the curse of learning from an intensely imbalanced training data set. Since it is constructed to mitigate the overall error rate, it will tend to focus more on the prediction efficiency of the majority class, which repeatedly results in poor accuracy for the minority class.

e) Naive Bayes

The Naive Bayes classifier [19] contributes a simple method, representing and learning probabilistic knowledge with clear semantics. It is termed naive due to it relies on two important simplifying assumes that predictive attributes are conditionally self-reliant given the class, and it considers that no hidden attributes influence the prediction method. It is a probabilistic classifier which relies upon Bayes theorem with robust and naive independence assumptions. It is one of the best basic text classification approaches with numerous applications in personal email sorting, email spam detection, sexually explicit content detection, document categorization, sentiment detection, language detection [20]. Although the naïve design and oversimplified assumptions that this approach uses, Naive Bayes accomplishes well in many complicated real-world problems. All though it is often out performed by other approaches such as boosted trees, Max Entropy, Support Vector Machines, random forests etc, Naive Bayes classifier is very potent as it is less computationally intensive (in both memory and CPU) and it needs a small extent of training data. Moreover, the training time with Naive Bayes is considerably smaller as opposed to alternative approaches.

f) Bayes Net

Bayesian networks are a powerful probabilistic representation, and their use for classification has received considerable attention [21]. It reflects the states of some part of a world that is being modeled and it describes how those states are related by probabilities. Bayesian network is a graphical model that encodes probabilistic relationships among variables of interest. When used in conjunction with statistical techniques, the graphical model has several advantages for data analysis. One, because the model encodes dependencies among all variables, it readily handles situations where some data entries are missing. Two, a Bayesian network can be used to learn causal relationships, and hence can be used to gain understanding about a problem domain and to predict the consequences of intervention. This classifier learns from training data the conditional probability of each attribute given the class label [22, 23].

g) Random Tree

The algorithm may deal with both regression and classification problems. Random trees is a ensemble of tree predictors which is called *forest* .The classification performs as follows: random trees classifier takes the input feature vector, categories it with individual tree in the forest, outputs the class label which received the most of "votes". In the event of a regression, the classifier response is the average of the responses over all the trees in the forest [24]. In random tree algorithm all the trees are trained with the same parameters but on different training sets. These sets are created from the original training set adopting the bootstrap procedure and for each training set, randomly choose the same number of vectors as in the initial set. The vectors are chosen with replacement. That is, some vectors will occur more than once and some will be absent. In random trees there is no need for any accuracy estimation techniques, like cross-validation or bootstrap, or a separate test set to obtain an estimate of the training error. The error is estimated internally during the training.

h) Dataset Description

The handwritten digit recognition is a extensive research topic which gives a comprehensive survey of the area including major feature sets, learning datasets, and algorithms [25]. Contrary to optical character recognition which focuses on recognition of machine-printed output, where special fonts can be used and the variability between characters along with the same size, font, and font attributes is fairly small.

The feature extraction and the classification technique play an important role in offline character recognition system performance. Various feature extraction approaches have been proposed for character recognition system [26]. The problems faced in handwritten numeral recognition has been studied while using the techniques like Dynamic programming, HMM, neural network, Knowledge system and combinations of above techniques [27]. Wider ranging work has been carried out for digit recognition in so many languages like English, Chinese, Japanese, and Arabic. In Indian mainly worked in Devanagari, Tamil, Telugu and Bengali numeral recognition [28].

In our experiment we used digit dataset provided by Austrian Research Institute for Artificial Intelligence, Austria. This data set indicate that arbitrary scaling and a blur setting of 2.5 for the Mitchell down-sampling filter should perform well and used down-sample to 16x16 pixels.

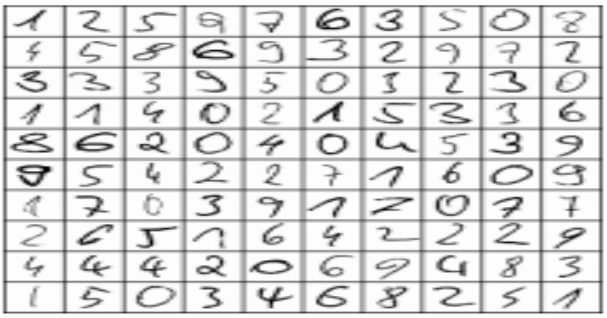

Figure 1: A small portion of handwritten dataset example

This dataset is divided in two parts training set and testing set. Training set has 1893 samples and test set has 1796 samples. The detail of the dataset is provided in [29].

III. Experimental Tools

Waikato Environment for Knowledge Analysis (WEKA) is a prominent suite of machine learning which is written in Java and developed at the University of Waikato. It is free software accessible under the GNU General Public License. It contains a collection of algorithms and visualization tools for predictive modelling, data analysis, along with graphical user interfaces for smooth access to this functionality [30]. It supports various standard data mining tasks, more particularly, data pre-processing, classification, visualization, clustering, feature selection, regression. All of Weka's approaches are predicated on the assumption that the data is convenient as a single flat file or relation, where each data point is characterized through a fixed number of attributes [31].

WEKA has numerous user interfaces. Its main user interface is the Explorer, however essentially the same functionality can be accessed by the component-based Knowledge Flow interface and from the command line. The Experimenter allows the systematic comparison of the predictive performance of the Weka's machine learning algorithms on an accumulation of datasets.

IV. Experimental Result and Discussion

WEKA has several graphical user interfaces that enable easy access to the underlying functionality. To gauge and investigate the performance on the selected methods or algorithms namely Support Vector Machine, Multilayer Perceptron, Random Forest Algorithm, Random Tree, Naïve Bayes, Bayes Net and j48 Decision tree algorithms are used. We use the same experiment procedure as suggested by WEKA.

In WEKA, all dataset is considered as instances and features in the data are also known as attributes. The experiment results are partitioned into several sub division for easier analysis and evaluation. In the first part, correctly and incorrectly classified instances will be divided in numeric and percentage value and subsequently Kappa statistic, mean absolute error and root mean squared error will be in numeric value. Experiment shows the relative absolute error and root relative squared error in percentage (%) for references and in evaluation process. Our simulation results are shown in below tables-1 and tables-2. In table-1 mainly summarizes the result based on accuracy and time taken for each simulation in our experiment. Moreover, table-2 shows the result based on error during the simulation in WEKA.

Table 1: Simulation result based on accuracy and time consumption

Name of Algorithms	Correctly Classified Instances % (value)	Incorrectly Classified Instances % (Value)	Time Taken (seconds)	Kappa Statistic
Multilayer Perceptron	90.37	9.63	3.15	0.893
Support Vector Machine	87.97	12.03	0.56	0.8664
Random Forest	85.75	14.25	0.44	0.8416
Bayes Net	84.35	15.65	0.86	0.8262
Naïve Bayes	81.85	18.15	3.45	0.7983
J48	79.51	20.49	0.53	0.7722
Random Tree	85.6	24.94	0.55	0.7228

Table 2: Simulation result based on different error

Name of Algorithms	Mean Absolute Error	Root Mean Squared Error	Relative Absolute Error (%)	Root Relative Squared Error (%)
Multilayer Perceptron	0.023	0.1231	12.78	41.04
Support Vector Machine	0.1611	0.2734	89.49	91.15
Random Forest	0.0593	0.1532	32.97	51.06
Bayes Net	0.0312	0.1745	17.36	58.15
Naïve Bayes	0.0361	0.1879	20.06	62.65
J48	0.0444	0.1957	24.66	65.25
Random Tree	0.0499	0.2234	27.72	74.45

Based on the above table-1, the highest accuracy is 90.37 % and the lowest is 75.06%. The other algorithm yields an average accuracy of around 83.89%. In fact, the highest accuracy belongs to the Multilayer Perceptron classifier, followed by Support Vector Machine with a percentage of 87.97% and subsequently Random Forest Algorithm 85.75%, Bayes Net 84.35%, Naïve Bayes 81.85%, j48 79.51% and Random Tree 75.06%. Kappa statistics value ranges from 0 to 1. Value 0 means totally disagreement and 1 means full agreement. It checks the reliability of Classifying algorithm on dataset. The total time, mean absolute error, root mean absolute error, relative absolute error and root relative absolute error is also a crucial parameter to build the model in comparing the different classification algorithm. Mean absolute error is the mean of overall error made by classification algorithm and least the error will be best classifier. In the table-2 Multilayer Perceptron has least 0.023 mean absolute errors among all seven algorithms.

In [32] experimental results reveal that it is possible to train a face detector without having to label images as containing a face or not. Their experiment is only sensitive to high-level concepts such as cat faces and human bodies. Multi-column deep neural networks for image classification have been presented in [33]. They only improve the state-of-the-art on a plethora of common image classification benchmarks. Supervised learning unsupervised learning, reinforcement learning & evolutionary computation, and indirect search for short programs encoding deep and large networks has been presented in [34]. They only proposed how different

technique can be used for pattern recognition. In [35] recognition of handwritten bangla basic characters and digits using convex hull based feature set has been proposed. Their experiment result shows that with a database of 10000 samples, the maximum recognition rate of 76.86% is observed for handwritten Bangla characters. Online and offline handwritten Chinese character recognition has been proposed in [36]. Their experiment result reported that the highest test accuracies 89.55% for offline. In our experiment different machine learning algorithm has been used for handwrite digit recognition and obtained highest 90.37% accuracy obtained for Multilayer Perceptron.

V. Conclusion

The main objective of this investigation is to find a representation of isolated handwritten digits that allow their effective recognition. In this paper used different machine learning algorithm for recognition of handwritten numerals. In any recognition process, the important problem is to address the feature extraction and correct classification approaches. The proposed algorithm tries to address both the factors and well in terms of accuracy and time complexity. The overall highest accuracy 90.37% is achieved in the recognition process by Multilayer Perceptron. This work is carried out as an initial attempt, and the aim of the paper is to facilitate for recognition of handwritten numeral without using any standard classification techniques.

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Using Neural Networks to Design Transistor Amplifier Circuits

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Abstract- This paper is an extension of previous work that addressed the application of bipolar transistor amplifier design using neural networks. That work addressed the design of common emitter amplifiers by first mathematically determining specific output parameters from a large selection of biasing resistors. Once the outputs had been determined, a neural network was trained, using the aforementioned results as inputs and the biasing resistors as outputs. This was initially performed with ideal emitter bypass capacitors, but was then followed-up by employing several non-ideal capacitors, making it much more interesting and useful. This paper focuses on the common collector and the common base configurations. Bipolar junction transistor amplifier parameters often include voltage gain, input impedance, output impedance, and the voltage difference between the collector and emitter. These will be addressed in this paper as before.

Keywords: feedforward neural networks, bipolar junction transistor circuits, common collector amplifier, common base amplifier.

GJCST-D Classification: F.1.1, I.5.1

Strictly as per the compliance and regulations of:

Using Neural Networks to Design Transistor Amplifier Circuits

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Abstract- This paper is an extension of previous work that addressed the application of bipolar transistor amplifier design using neural networks. That work addressed the design of common emitter amplifiers by first mathematically determining specific output parameters from a large selection of biasing resistors. Once the outputs had been determined, a neural network was trained, using the aforementioned results as inputs and the biasing resistors as outputs. This was initially performed with ideal emitter bypass capacitors, but was then followed-up by employing several non-ideal capacitors, making it much more interesting and useful. This paper focuses on the common collector and the common base configurations. Bipolar junction transistor amplifier parameters often include voltage gain, input impedance, output impedance, and the voltage difference between the collector and emitter. These will be addressed in this paper as before. There are several methods that can provide a suitable solution for each design, however the objective of this work is to indicate which external resistors are necessary to yield useful results by employing neural networks.

Keywords: feedforward neural networks, bipolar junction transistor circuits, common collector amplifier, common base amplifier.

I. Introduction

This paper addresses two amplifier topologies that use bipolar junction transistors (BJTs). In a previous paper a common emitter amplifier was evaluated and it was determined that the value of the bypass capacitor played a significant role in the voltage gain and other parameters due to the low emitter resistance of the transistor [1]. It was also established through simulations and analysis that the coupling capacitors did not affect the results of required amplifier parameters to any great extent. Here we address the common collector amplifier, otherwise known as the emitter follower, and the common base amplifier. Both configurations employ coupling capacitors, so for this work they will be considered as ideal. The output impedance of the source and the input impedance of the load can be factored in after developing the initial model.

For either amplifier design, and for a given transistor, the designer works through a set of calculations to determine the biasing resistor values, then often has to modify those values to achieve the proper voltage gain (A_v), input impedance (R_{in}), output impedance (R_o), and voltage difference between the collector and emitter (V_{ce}). This latter parameter can affect whether the amplifier enters saturation or cutoff. For the common collector amplifier the voltage gain is just under unity, as shown later.

The goal of this work is primarily intended for engineers, but others may want to evaluate specific amplifier designs based on the results illustrated in this paper. For any specific amplifier design, the neural network should be able to provide reasonably close biasing resistor values, provided that the parameters input by the user are within appropriate limits. It is hoped that with the addition of these two amplifier designs to the common emitter circuit shown in a previous paper, the user will be able to approximate the appropriate resistor values in a streamlined manner.

This paper is organized as follows. First, the design procedure for the dc equivalent common collector circuit is introduced along with some of its defining equations. Next, the expressions needed to solve for the ac equivalent circuit are developed. This is followed by a brief discussion of the neural network architecture and results. The next section addresses the common base ac equivalent circuit and the corresponding results. Finally, some conclusions will be discussed and some thoughts for further work. When analyzing both of these amplifiers there are the dc bias values and the ac signals to contend with, but one must look at each of them separately in order to compute the proper operating points.

II. The Common Collector Amplifier

The common collector circuit is one of the basic configurations introduced when studying the BJT [2]-[4]. It is considered as a voltage buffer providing a high input impedance and a low output impedance, which is useful for impedance matching with other circuits. As stated above, the voltage gain of this circuit is approximately equal to one.An example of the common collector amplifier is shown in Fig. 1 where the 2N3904 NPN transistor is used with β=160. The ac input is Vi while the output is taken from the emitter terminal.For this amplifier the neural network is designed to accept three input parameters: input resistance (R_{in}), output resistance (R_{out}), and the voltage across the collector-emitter junction (V_{ce}). The objective of the network is to provide the biasing resistors R_{b1}, R_{b2}, and R_e, needed to achieve the desired results.

Initially, the dc circuit is analyzed with all capacitors considered as open circuits in order to find

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the currents and voltages from the power supply and biasing resistors. The coupling capacitors isolate the dc component where its circuit equivalent is shown in Fig. 2.As in the previous work, the dc biasing voltage was 15 volts for both circuits described in this paper. All input signals were set to 3 kHz sinusoids.

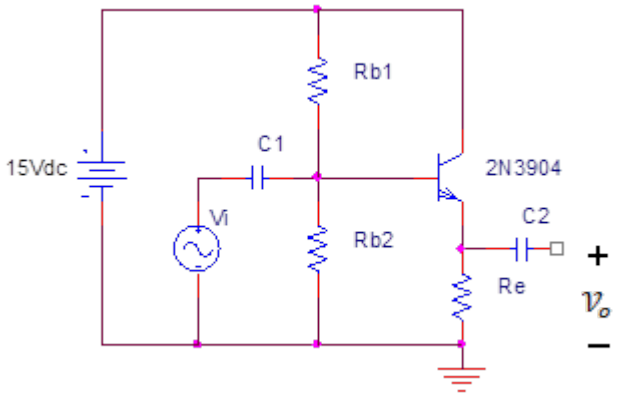

Fig. 1: Common collector amplifier circuit.

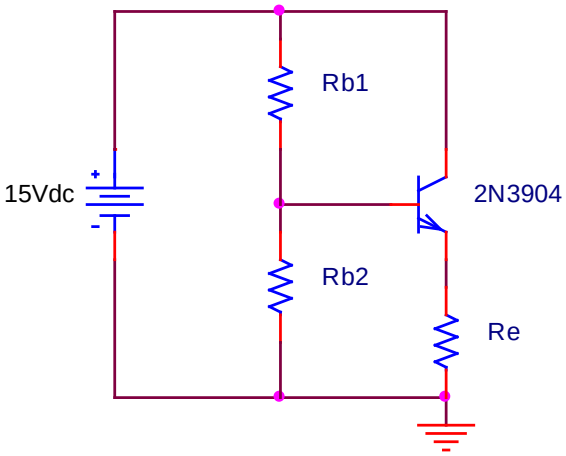

Fig. 2: The dc equivalent circuit of a common collector amplifier.

To determine the dc biasing values, the base resistors and source are replaced with their Thevenin equivalents as shown here.

$$V_{th} = V_{cc}\left(\frac{R_{b2}}{R_{b1}+R_{b2}}\right) \quad \text{and} \quad R_b = R_{b1}||R_{b2} \tag{1}$$

This allows a single loop circuit to be analyzed as in (2) where the base current, I_B, can be determined.

$$-V_{th} + R_b\, I_B + 0.7 + (\beta + 1) I_B R_e = 0 \tag{2}$$

After the dc bias values have been found those sources are set to zero and only the ac components are considered. Recall that the dc voltage sources become short circuits to ground when set to zero. The ac equivalent of the transistor circuit is shown in Fig. 3 using the hybrid – π model [4]. The ac values of input and output resistance, along with V_{ce} are computed from the dc bias currents.

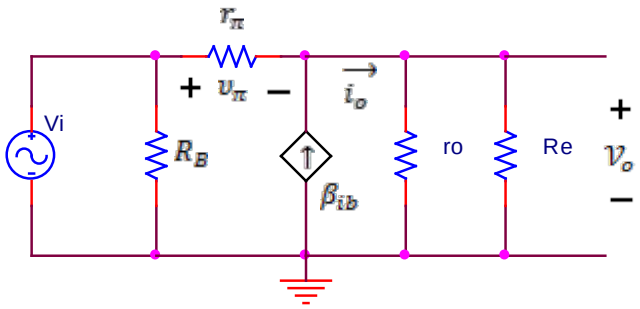

Fig. 3: The ac equivalent circuit of the common collector amplifier.

Most of the ac equivalent expressions can be found in texts on microelectronics so they are only summarized here. As shown below, the total collector current i_C is ascertained where v_{be} is the ac base to emitter voltage and V_T is the thermal voltage, usually approximated at 25 mV yielding:

$$i_C \approx I_C\left[1 + \frac{v_{be}}{V_T}\right] = I_C + \left(\frac{I_C}{V_T}\right) v_{be} \tag{3}$$

From now on the ac component is of interest and the DC sources are shut down. By looking at the far right term from equation 3 it can be seen that the ac equivalent is:

$$i_c = \left(\frac{I_C}{V_T}\right) v_{be} \tag{4}$$

The component in parenthesis is referred to as the transconductance, with symbol g_m so:

$$g_m = I_C / V_T \tag{5}$$

therefore:

$$i_c = g_m\, v_{be} \tag{6}$$

The ac input resistance of the transistor itself is given as

$$r_\pi = v_{be}/i_b = v_{be}/(g_m\, v_{be}/\beta) = \beta/g_m \tag{7}$$

Or alternatively

$$r_\pi = \beta/(I_C/V_T) = \beta/(\beta\, I_B/V_T) = V_T/I_B \tag{8}$$

Note from Fig. 3 that:

$$i_o = (\beta + 1) i_b \tag{9}$$

So the output voltage can be computed as:

$$v_o = i_b(\beta + 1)(r_o||R_E) \tag{10}$$

where r_o is the resistance seen looking into the collector and is often calculated as $100/I_C$.

By writing a KVL equation around the base-emitter loop we arrive at:

$$v_{in} = i_b[r_\pi + (\beta + 1)(r_o||R_E)] \quad (11)$$

The small signal input impedance results from dividing the expression above by the base current yielding:

$$R_{ib} = \frac{v_{in}}{i_b} = r_\pi + (\beta + 1)(r_o||R_E) \quad (12)$$

Taking into account the two biasing resistors R_{b1} andR_{b2} which are in parallel withR_{ib} the overall input impedance of the amplifier is:

$$R_{in} = R_{b1}||R_{b2}||R_{ib} \quad (13)$$

As one might expect, the input impedance of this amplifier is significant, resulting in a very low loading effect on stages that might precede it. By combining equations (10) and (12) the voltage gain is determined to be:

$$A_v = \frac{(\beta+1)(r_o||R_E)}{r_\pi+(\beta+1)(r_o||R_E)} \approx 1 \quad (14)$$

Computing the output impedance,R_o, is somewhat involved, so only the result will be presented here where it can be seen as being very low due to the $\beta + 1$ factor. It can be on the order of tens of ohms.

$$R_o = \frac{r_\pi}{\beta+1}||R_E||r_o \quad (15)$$

III. Neural Networks

Neural networks are most commonly considered as pattern recognition systems. This author has used them to develop a method of impedance matching using feed-forward neural networks [5] and also in the design of common emitter amplifiers [1]. They are non-linear systems and are often employed to separate input patterns by setting up a set of hyperplanes in n-dimensional space [6] - [8].

In order to train the neural networks in this project a set of "for" loops was created in MATLAB®for the three biasing resistors. For all of the tests, the resistor values ranged as shown in table I. Since the voltage gain is near unity for the common collector amplifier it was not addressed in this work.

Table 1: Resistor values used to Develop Output Parameters

Resistor	Start value	Step Value	Stop Value
Rb1	4 kΩ	250 Ω	10 kΩ
Rb2	4 kΩ	250 Ω	10 kΩ
Re	400 Ω	100 Ω	1.5 kΩ

The values of R_{in}, R_o, and V_{ce} were calculated for all of the resistor combinations. Once this was completed a neural network was trained using the new input values of the three parameters above to compute the three biasing resistor values. In developing the network, the inputs and outputs were normalized to ensure convergence. For this circuit there were 7,500 training patterns, limited to realistic output values. For example, V_{ce} was held to the range of 2 volts to 12 volts. The test sets consisted of a larger number of patterns, none of which had been used in training.

The neural network package in MATLAB® was employed to train the networks, by utilizing the Levenberg-Marquardt algorithm, using one hidden layer of 14 sigmoidal (Tanh) neurons each [9]. As noted in the previous work, a lesser number of nodes yielded unacceptable results, and more nodes or more than one hidden layer did not provide any improvement in performance. The network was trained for 2000 epochs resulting in a mean-squared error (mse) of $2.45x10^{-8}$. Further training did not seem improve performance. A comparison between the neural network results and those by direct calculation is shown in table II. Fig. 4 shows the architecture of the neural network. This network employs hyperbolic tangent activation functions to map the transistor parameters to the values of the resistors.

Table 2: Statistical performance of neural network

Data type	Number of patterns	Upper base resistor Rb1(mse)	Lower base resistor Rb2(mse)	Emitter resistor Re(mse)
Training set	7500	0.784	6.00	0.0131
Test Set #1	8316	1.48	7.80	0.0225
Test Set #2	10440	1.39	7.20	0.020
Test Set #3	11160	1.23	6.71	0.018
Test Set #4	13728	1.41	7.24	0.020

The training set was included for comparative purposes.

The number of patterns changes with all of the training and testing scenarios because as the values of the biasing resistors change, the outputs can fall out of the ranges specified earlier. Only those that fall within those ranges are employed in the tests. When using the resistance values illustrated in table I the output parameters have the ranges shown in table III. It is not required that these ranges be followed precisely but it is likely a good practice to stay within them when considering an input set.

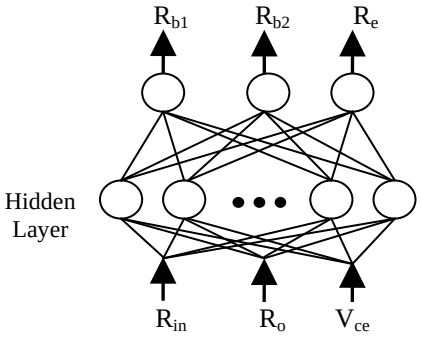

Fig.4: Architecture of the neural network with 14 hidden nodes.

Table 3: Input parameter ranges

Parameter	Minimum value	Maximum Value
Rin	1.94 k Ω	4.90 kΩ
Ro	1.4 Ω	10.5Ω
Vce	5.1 V	11.6 v

It is important to realize that not all input parameter combinations are feasible. For example, if the base bias resistors are kept to a low value the collector and emitter currents can be greater, resulting in a smaller value of V_{ce}. In this case it would not be appropriate to set a small value of dc input resistance and a large value of V_{ce}, since they can be mutually exclusive. However, by judiciously choosing realistic inputs the results can be close to the desired values. Some comparisons of the neural network out against calculation are shown in table IV. During the testing phase the network was asked to determine the resistor values for three different ac parameters. The input impedances, output impedances, V_{ce}, and the values of the resistors predicted by the network were recorded. The resistor values from the network were then used to calculate those same ac values directly. The results were remarkably good as shown in table IV.

Table 4: Expectedac parameters and the associated percent errorsagainst the neural nework output

Rin (Ω)	%error	Ro (Ω)	% error	Vce	%error
2402	0.083	2.634	0.076	6.67	0.075
3101	0.032	3.386	0.003	5.695	0.004
4310	0.001	3.583	0.002	7.547	0.013

The resistor values from the last trial from table IV were used in a P-Spice simulation. The values were $R_{b1} = 7.96k\Omega$, $R_{b2} = 9.98k\,\Omega$ and $R_e = 1.07k\,\Omega$. The results are summarized in table V along with the percent errors.

Table 5: Comparison of neural network results against the P-Spice simulation

Parameters	Neural Network	P-Spice	% difference
Rin	4310Ω	4274Ω	-0.835
Ro	3.583Ω	3.546Ω	-1.033
Vce	7.547V	7.549V	0.027

IV. The Common Base Amplifier

The second circuit addressed in this paper is the common base amplifier. The hybrid – π model of the transistor is also used. The DC analysis of this circuit is essentially the same as for the previous one except that it has collector resistor, so it will not be addressed here. The ac equivalent of a common base amplifier is shown in Fig. 5 in which the base is at signal ground. The input is at the emitter and the output is at the collector. A summary of the voltage gain, current gain, input impedance, and output impedance is presented here. As in the other configurations, the output impedance of the signal source is not included, since that parameter would be unknown for the individual amplifiers.

$$A_v = g_m R_C \tag{16}$$

The current gain can be approximated by:

$$A_i \approx \frac{\beta}{\beta+1} = \alpha < 1 \tag{17}$$

The input resistance of the amplifier R_{ie} is quite low where the input signal sees the emitter resistance r_e:

$$R_{ie} = \frac{r_\pi}{\beta+1} = r_e \tag{18}$$

The output resistance R_o is approximated as:

$$R_o = r_o || R_C \tag{19}$$

One may wonder about the significance of this circuit but since the output impedance looking back into the collector is very large. However due to this characteristic it behaves almost like an ideal current source. It is sometimes referred to as a current buffer.

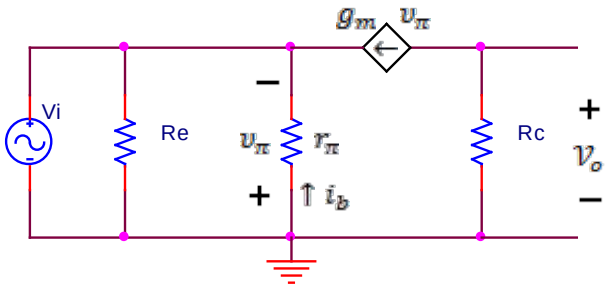

Fig. 5: This is the ac equivalent circuit of the common base amplifier.

Table VI lists the biasing resistors used in the common base configuration.

Table 6: Resistor values used to develop output parameters

Resistor	Start value	Step Value	Stop Value
Rb1	4 kΩ	250 Ω	10 kΩ
Rb2	4 kΩ	250 Ω	10 kΩ
Rc	1 kΩ	100 Ω	3 kΩ
Re	400 Ω	100 Ω	1.5 kΩ

As in the common collector circuit, the values of Rin, Ro, and Vce were calculated for all of the resistor combinations. Again, V_{ce} was held to a range of 2 volts to 12 volts.

Here the network consisted of one hidden layer of 14 sigmoidal neurons. The network was trained for 1904 epochs resulting in a msetargetof$1.0x10^{-8}$. A comparison of the results obtained from the network against the true values of resistance are revealed in table VII for several different test sets.

Table 7: Resistor values used to develop output parameters

Data type	Number of patterns	Upper base resistor Rb1(mse)	Lower base resistor Rb2(mse)	Collector resistor Rc(mse)	Emitter resistor Re(mse)
Training set	5676	0.704	1.24	0.031	0.038
Test Set #1	6242	0.656	1.20	0.030	0.035
Test Set #2	8108	0.603	1.10	0.027	0.031
Test Set #3	9135	0.560	1.10	0.281	0.030
Test Set #4	10938	0..627	1.11	0.029	0.323

The training set was included for comparative purposes.

The number of patterns changes with all of the training and testing scenarios because as the values of the biasing resistors change, the can fall out of the ranges specified earlier. Only those that fall within those ranges were employed in the tests. When using the resistance values illustrated in table VI the output parameters have the ranges shown in table VIII. It is not required that these ranges be followed precisely but it is likely a good practice to stay within them when considering an input

Table 8: Input parameter ranges

Parameter	Minimum value	Maximum Value
Ro	950 Ω	2.092 kΩ
Av	93.9 V/V	210 V/V
Vce	2.02 V	9.11 V

For the common base amplifier the voltage gain was the primary focus, however the output impedance and V_{ce} were also determined. The input impedance was more problematic. For this amplifier, several combinations of resistor values yielded the same input impedance values. Therefore, when training from the input impedance to find the bias resistors, the network experienced multiple targets meaning that the network could not converge. Several experiments that included input impedance were conducted, but the results were unsuccessful. For this amplifier the input impedance is very low, and from the bias resistors contained in table VI, Rin only ranged from about 4.7Ω to 10.6Ω. In this case it might be prudent to approximate the value as 7.5Ω for most applications. The results between the neural network and those by direct calculation are shown in table IX.

Table 9: Expected AC parameters and the associated percent errorsagainst the neural nework output

Ro (kΩ)	% error	Av V/V	% error	Vce	% error
1.305	0.19	206	2.12	4.17	0.84
1.748	-0.34	202	1.03	5.78	-0.76
1.045	0.012	207	2.51	3.24V	0.24

The resistor values from the last trial from table IX were used in a P-Spice simulation with $R_{b1} = 9\ k\Omega, R_{b2} = 4.5k\Omega$, $R_C = 1.1k\Omega$, and $R_E = 600\Omega$. The results are summarized in table X along with the percent errors.

Table 10: Comparison of neural network results against the P-Spice simulation

Parameters	Neural Network	P-Spice	% difference
Ro	1.045kΩ	1.05kΩ	0.478
Av	207V/V	211V/V	1.93
Vce	3.24V	3.27V	0.926

V. Conclusions and Further Work

It was remarkable how well the network results compared against those from direct calculation and from P-Spice. Several experiments were conducted more than once, and the output values checked frequently, to be certain there were no errors.

This has been an interesting research project as a follow-up to previous work. Here, two classical BJT amplifiers have been analyzed, then synthesized by a set of neural networks. In both cases the capacitors did not play a significant role and were considered to be ideal. This neural network paradigm should be useful to engineers and faculty members when looking for solutions to various designs. The research described in this paper can help to resolve and verify transistor solutions for both configurations and can illustrate the efficacy of neural networks as a tool for this branch of amplifier design. It is the intension of this author to look into other, more complex amplifier designs, such as the cascode circuit which is a multistage system, consisting of a common emitter amplifier driving a common base amplifier.

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Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Computer Science Research Paper

Techniques for writing a good quality computer science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of computer science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10.Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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