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Highlights

- Simulation of Reliability
- Analysis of Data Mining
- Decision Tree Technique
- Algorithms and Applications

Discovering Thoughts, Inventing Future

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Analysis of Data Mining Classification with Decision tree Technique

By Dharm Singh, Naveen Choudhary & Jully Samota
Maharana Pratap University of Agriculture and Technology, India

Abstract- The diversity and applicability of data mining are increasing day to day so need to extract hidden patterns from massive data. The paper states the problem of attribute bias. Decision tree technique based on information of attribute is biased toward multi value attributes which have more but insignificant information content. Attributes that have additional values can be less important for various applications of decision tree. Problem affects the accuracy of ID3 Classifier and generate unclassified region. The performance of ID3 classification and cascaded model of RBF network for ID3 classification is presented here. The performance of hybrid technique ID3 with CRBF for classification is proposed. As shown through the experimental results ID3 classifier with CRBF accuracy is higher than ID3 classifier.

Keywords: data mining, classification, decision tree, ID3, attribute selection.

GJCST-C Classification : H.2.8

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Analysis of Data Mining Classification with Decision Tree Technique

Dharm Singh [α], Naveen Choudhary [σ] & Jully Samota [ρ]

Abstract- The diversity and applicability of data mining are increasing day to day so need to extract hidden patterns from massive data. The paper states the problem of attribute bias. Decision tree technique based on information of attribute is biased toward multi value attributes which have more but insignificant information content. Attributes that have additional values can be less important for various applications of decision tree. Problem affects the accuracy of ID3 Classifier and generate unclassified region. The performance of ID3 classification and cascaded model of RBF network for ID3 classification is presented here. The performance of hybrid technique ID3 with CRBF for classification is proposed. As shown through the experimental results ID3 classifier with CRBF accuracy is higher than ID3 classifier.

Keywords: data mining, classification, decision tree, ID3, attribute selection.

I. Introduction

With the rapid development of information technology and network technology, different trades produce large amounts of data every year. The data itself cannot bring direct benefits so need to effectively mine hidden information from huge amount of data. Data mining deals with searching for interesting patterns or knowledge from massive data. It turns a large collection of data into knowledge. Data mining is an essential step in the process of knowledge discovery (Lakshmi & Raghunandhan, 2011).The data mining has become a unique tool in analyzing data from different perspective and converting it into useful and meaningful information.Data mining has been widely applied in the areas of Medical diagnosis, Intrusion detection system, Education, Banking, Fraud detection.

Classification is a supervised learning. Prediction and classification in data mining are two forms of data analysis task that is used to extract models describing data classes or to predict future data trends. Classification process has two phases; the first is the learning process where the training data sets are analyzed by classification algorithm. The learned model or classifier is presented in the form of classification rules or patterns. The second phase is the use of model for classification, and test data sets are used to estimate the accuracy of classification rules.

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With the rising of data mining, decision tree plays an important role in the process of data mining and data analysis. Decision tree learning involves in using a set of training data to generate a decision tree that correctly classifies the training data itself. If the learning process works, this decision tree will then correctly classify new input data as well. Decision trees differ along several dimensions such as splitting criterion, stopping rules, branch condition (univariate, multivariate), style of branch operation, type of final tree (Han, Kamber & Pei, 2012).

The best known decision tree induction algorithm is the ID3. ID3 is a simple decision tree learning algorithm developed by Ross Quinlan. Its predecessor is CLS algorithm. ID3 is a greedy approach in which top-down, recursive, divide and conquer approach is followed. Information gain is used as attribute selection measure in ID3. ID3 is famous for the merits of easy construction and strong learning ability. There exists a problem with this method, this means that it is biased to select attributes with more taken values, which are not necessarily the best attributes. This problem affects its practicality. ID3 algorithm does not backtrack in searching. Whenever certain layer of tree chooses a property to test, it will not backtrack to reconsider this choice. Attribute selection greatly affects the accuracy of decision tree (Quinlan, 1986).

In rest of the paper, a brief introduction to the related work in the area of decision tree classification is presented in section 2. A brief introduction to the proposed work is presented in section 3. In section 4 we present the experimental results and comparison. In section 5, we conclude our results.

II. Related Work

The structure of decision tree classification is easy to understand so they are especially used when we need to understand the structure of trained knowledge models. If irrelevant attribute selection then all results suffer. Selection space of data is very small if we increase space, selection procedure suffers so problem of attribute selection in classification. There have been a lot of efforts to achieve better classification with respect to accuracy.

Weighted and simplified entropy into decision tree classification is proposed for the problem of multiple-value property selection, selection criteria and property value vacancy. The method promotes the efficiency and precision (Li & Zhang, 2010).A comparison of attribute selection technique with rank of attributes is presented. If irrelevant, redundant and noisy attributes are added in model construction, predictive performance is affected so need to choose useful attributes along with background knowledge (Hall & Holmes, 2003). To improve the accuracy rate of classification and depth of tree, adaptive step forward/decision tree (ASF/DT) is proposed. The method considers not only one attribute but two that can find bigger information gain ratio (Tan & Liang, 2012). A new heuristic technique for attribute selection criteria is introduced. The best attribute, which have least heuristic functional value are taken. The method can be extended to larger databases with best splitting criteria for attribute selection (Raghu, Venkata Raju & Raja Jacob, 2012).Interval based algorithm is proposed. Algorithm has two phases for selection of attribute. First phase provides rank to attributes. Second phase selects the subset of attributes with highest accuracy. Proposed method is applied on real life data set (Salama, M.A., El Bendary, N., Hassanien, Revett & Fahmy, 2011).

Large training data sets have millions of tuples. Decision tree techniques have restriction that the tuples should reside in memory. Construction process becomes inefficient due to swapping of tuples in and out of memory. More scalable approaches are required to handle data (Changala, R., Gummadi, A., Yedukondalu & Raju, 2012).An improved learning algorithm based on the uncertainty deviation is developed. Rationality of attribute selection test is improved. An improved method shows better performance and stability (Sun & Hu, 2012).

Equivalence between multiple layer neural networks and decision trees is presented. Mapping advantage is to provide a self configuration capability to design process. It is possible to restructure as a multilayered network on given decision tree (Sethi, 1990).A comparison of different types of neural network techniques for classification is presented. Evaluation and comparison is done with three benchmark data set on the basis of accuracy (Jeatrakul & Wong, 2009).

The computation may be too heavy if no preprocessing in input phase. Some attributes are not relevant .To rank the importance of attributes, a novel separability correlation measure (SCM) is proposed. In input phase different subsets are used. Irrelevant attributes are those which increase validation error (Fu & Wang, 2003).

III. Proposed Method

The input processing of training phase is data sampling technique for classifier. Single layer RBF networks can learn virtually any input output relationship (Kubat, 1998). The cascade-layer network has connections from the input to all cascaded layers. The additional connections can improve the speed. Artificial neural networks (ANNs) can find internal representations of dependencies within data that is not given. Short response time and simplicity to build the ANNs encouraged their application to the task of attribute selection.

IV. Process Method

1. Sampling of data from sampling technique
2. Split data into two parts training and testing part
3. Apply CRBF function for training a sample value
4. Using 2/3 of the sample, fit a tree the split at each node.
   For each tree
   - Predict classification of the available 1/3 using the tree, and calculate the misclassification rate
     = out of CRBF.
5. For each variable in the tree
6. Compute Error Rate: Calculate the overall percentage of misclassification
   - Variable selection: Average increase in CRBF error over all trees and assuming a normal division of the increase among the trees, decide an associated value of feature.
7. Resulting classifier set is classified
   - Finally to estimate the entire model, misclassification.
8. Decode the feature variable in result class

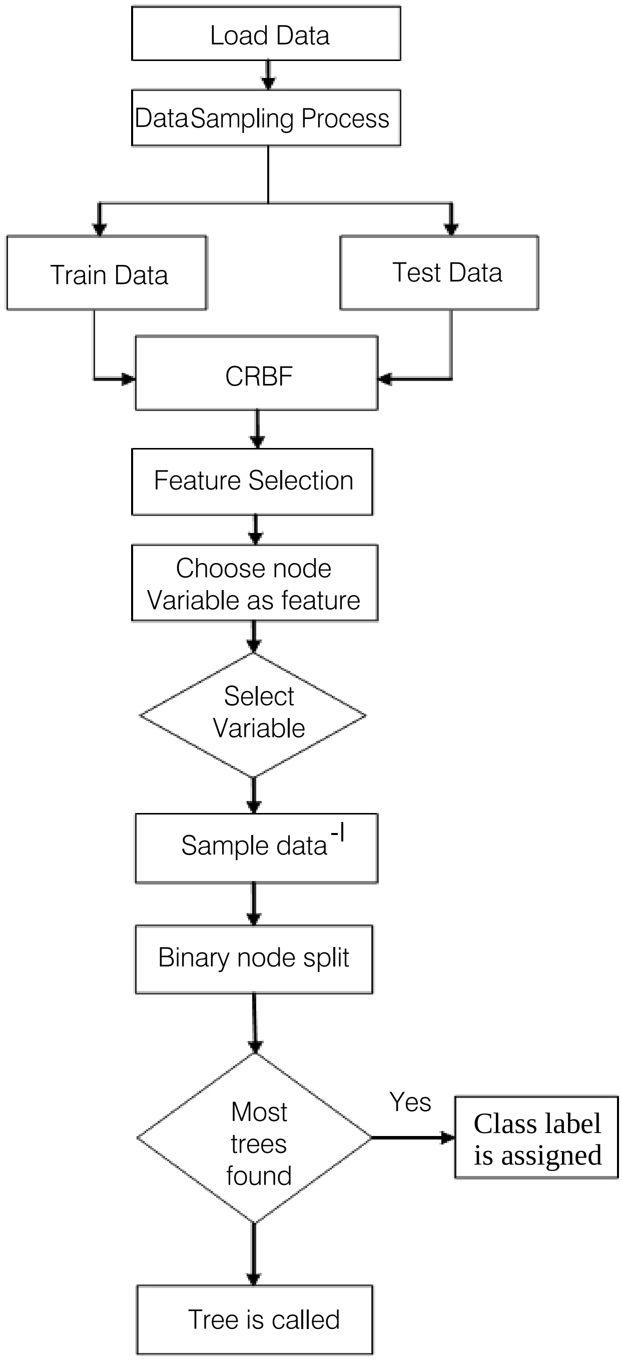

Figure 1 : Process block diagram of modified ID3-CRBF

V. Experimental Results

For the performance evaluation cancer dataset from UCI machine learning repository is used.

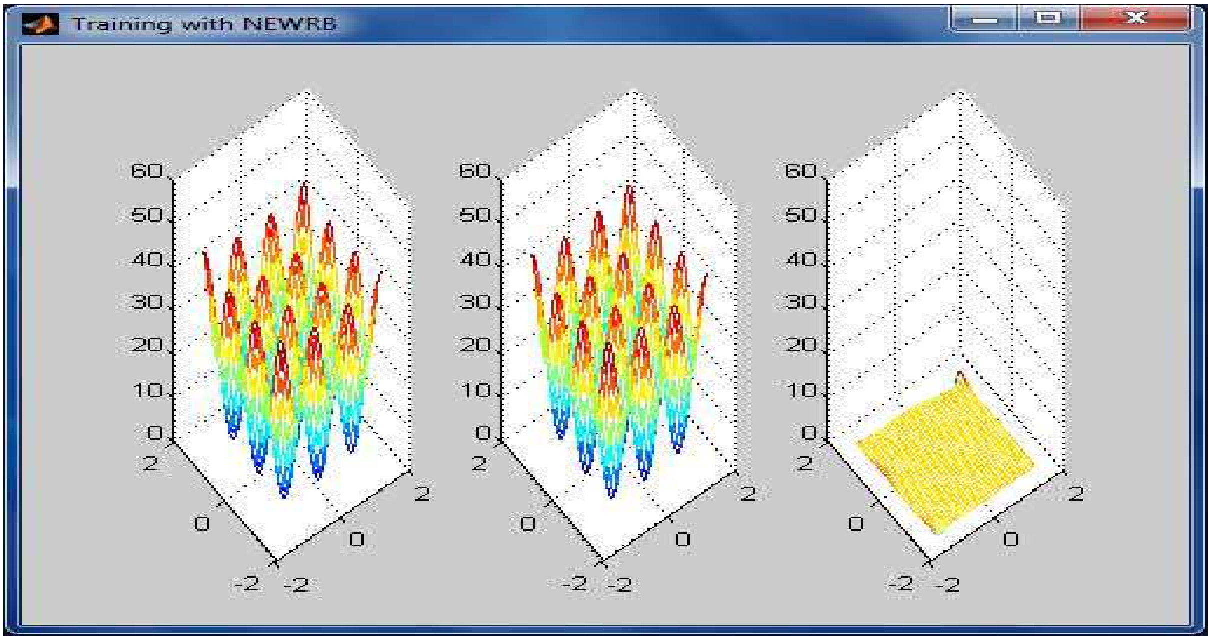

Figure 2 : Trained data, test data and unclassified region classification

Accuracy based on cross fold ratio of classifier.

Table 1 : Comparison of Accuracy

Cross Fold Ratio	Accuracy	
	ID3	ID3_CRBF
5	86.18	97.18
6	81.95	92.95
7	81.95	92.95

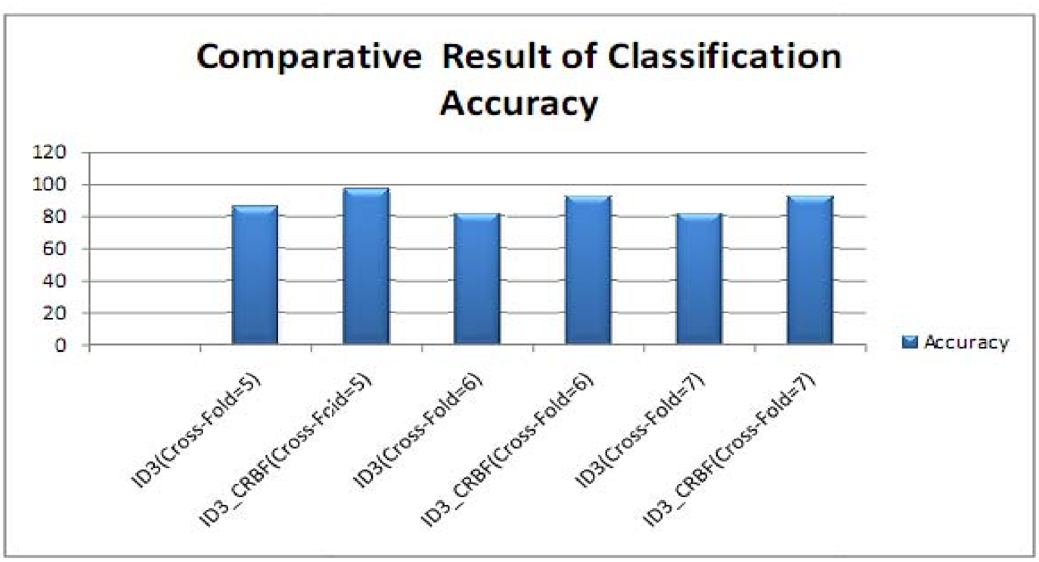

Figure 3 : Graphical representation of Table 1

VI. Conclusion

In this paper, we have experimented cascaded model of RBF with ID3 classification. The standard presentation of each attribute on selected ID3 is calculated and the Classify the given data. We can say from the experiments that the cascaded model of RBF with ID3 approach provides better accuracy and reduces the unclassified region. Increased classification region improves the performance of classifier.

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TPA Ensuring Data Integrity in Cloud Environment

By Jaspreet Kaur & Jasmeet Singh
Mandi Gobindgarh/ Punjab Techincal University, India

Abstract- Cloud computing is an internet based computing where virtual shared servers provide software, infrastructure, platform and other resources to customers on a pay-as-you-use basis. In one of the services offered by cloud viz. Storage as a Service, users outsource their data to cloud without having direct possession or control on it. Storage of large data in cloud reduces costs and maintenance. But the customer is unaware of the storage location. Here risk involved is modification of data or tampering of data. In this paper we propose a data correctness scheme in which Third Party can audit the data stored in the cloud and assure the customer that the data is safe. Hence we implemented a scheme for verifying integrity of data. Such verification systems prevent the cloud storage archives (storage) from misrepresenting or modifying the data stored by using frequent checks on the storage archives.

Keywords: *audit, cloud, integrity, station to station protocol, SHA-2, third party auditor, XOR.*

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TPA Ensuring Data Integrity in Cloud Environment

Jaspreet Kaur [α] & Jasmeet Singh [σ]

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Keywords: audit, cloud, integrity, station to station protocol, SHA-2, third party auditor, XOR.

I. Introduction

Cloud Computing is emerging as the next evolution of computing for its numerous contribution to the IT enterprise. In contrast to traditional solutions, Cloud Computing has a number of essential characteristics, such as: on-demand self-service, ubiquitous network access, location independent resource pooling, rapid elasticity, and measured service.[3]

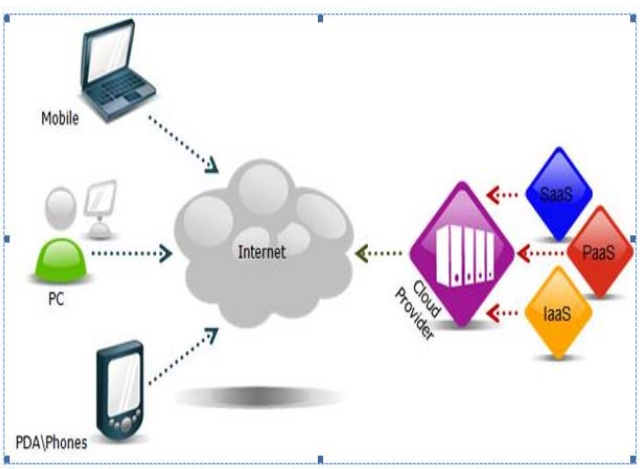

Figure 1 : Cloud Computing

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Data outsourcing, one of the fundamental components of Cloud Computing, centralizes users' data to the cloud server (CS). Users including both individuals and enterprises move their data or store their data in cloud storage centers to minimize the costs and enjoy benefits, such as: release the pressure from storage management, universal data access with independent geographical locations.[4]

Despite these distinct advantages outsourcing brings, there are also many security issues.

1. Firstly, although the cloud service provider (CSP) can provide more powerful and reliable infrastructures than users, a huge mass of data storing in the CS makes it more vulnerable to active attack.
2. Secondly, towards the cloud users, the CSP may deliberately distort the status of users' outsourced data for some benefits. For example, the CSP may discard the data that users rarely or never access to save costs, or even hide data loss incidents for the sake of reputation .[4]

So we can see, although data outsourcing can bring advantages and convenience to users, it can not ensure the integrity of data. But integrity monitoring is essential in cloud storage for the same reasons that data integrity is critical for any data center. Data corruption can happen at any level of storage and with any type of media. The truth is that data corruption can happen anywhere within a storage environment. Data can become corrupted simply by migrating it to a different platform, i.e., sending your data to the cloud. Cloud storage systems are still data centers, with hardware and software, and are still vulnerable to data corruption. [13]

Generally speaking, users like to outsource a huge mass of data in the CS, so simply downloading the data to verify the integrity is not a feasible solution. To solve the security problems of data outsourcing mentioned above, researchers proposed auditing protocols to ensure the correctness of the outsourced data. The integrity of data should be guaranteed in a relatively low computation and communication overhead through an efficient auditing protocol.[4]

So he appoints a Third Party Auditor to check the availability of data and its correctness without devotion of their computation resources. [1] TPA checks the correctness of data stored in the cloud and

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communicates this with the client. Whenever the client needs the data the cloud returns the data with full guarantee of delivery, availability and correctness. As TPA verifies for its correctness and availability he considers the data is safe.

Figure 2 represents data outsourcing in cloud environment where user delegates task of monitoring integrity to third party auditor(TPA).

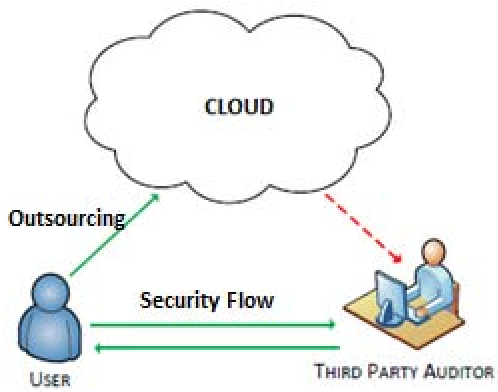

Figure 2 : Data Outsourcing in Cloud

II. Problem Definition

In Cloud Computing, it is difficult to maintain data integrity because the user usually has no control over the security mechanisms that are used to protect his/her data. User cannot trust cloud service provider to handle the data by himself as he himself can modify or delete the original data and integrity may be lost. If any intruder attacks and steals the data and modifies it then in some cases the modification is not even noticed by the cloud server or data loss or corruption is intentionally hidden. So, user can rely on a trusted third party auditor to check for the integrity of his data. To trust third party entity authentication is needed. For auditing (on user's request or at regular intervals), strong and secure cryptographic hash function is required to check for integrity of cloud data and informs the user about data corruptions or loss if any.

III. Methodology

We propose a data correctness scheme which involves verifying integrity of data with the help of third part auditor as shown in figure 3.

For ensuring the integrity of the data we will be using combination of three approaches-

1. Station-to-Station protocol (based on Diffie-Hellman key exchange algorithm) generates mutual key which is known to both user and auditor. It also provides entity authentication to both.
2. Exclusive-OR (XOR) to perform a xor operation between the message and the key generated using Station-to-Station protocol.
3. Secure Hashing Algorithm (SHA-2) to generate a digest by passing the original message to the hash function. This is done by both the user and the auditor and the value obtained from the hash function by both of them is compared and hence the data integrity is verified.

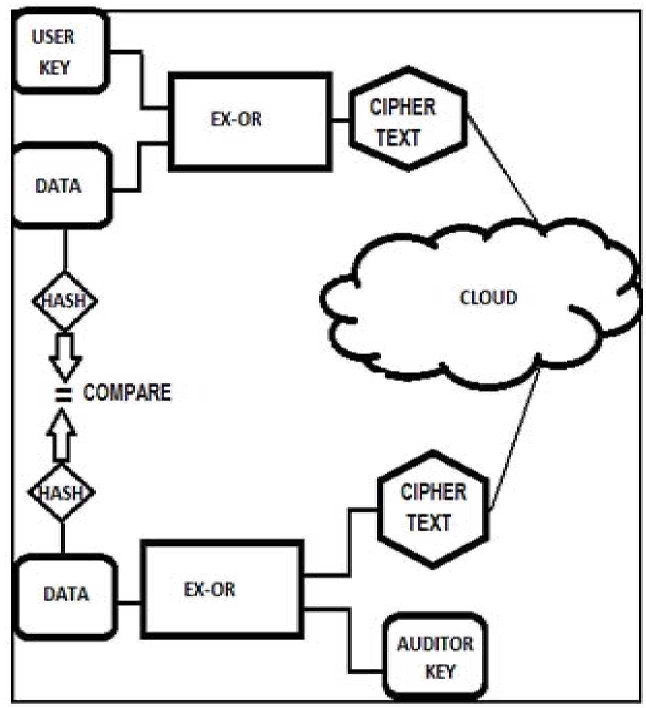

Figure 3 : Methodology

IV. Implementation

Using java netbeans IDE and XAMPP, we have implemented methodology in which TPA ensures integrity of data outsourced by user in the cloud storage and thus reduces overhead of user.

We have created three pages(forms)-

1. client side(figure 4)
2. cloud server (figure 5)
3. auditor side(figure 6)

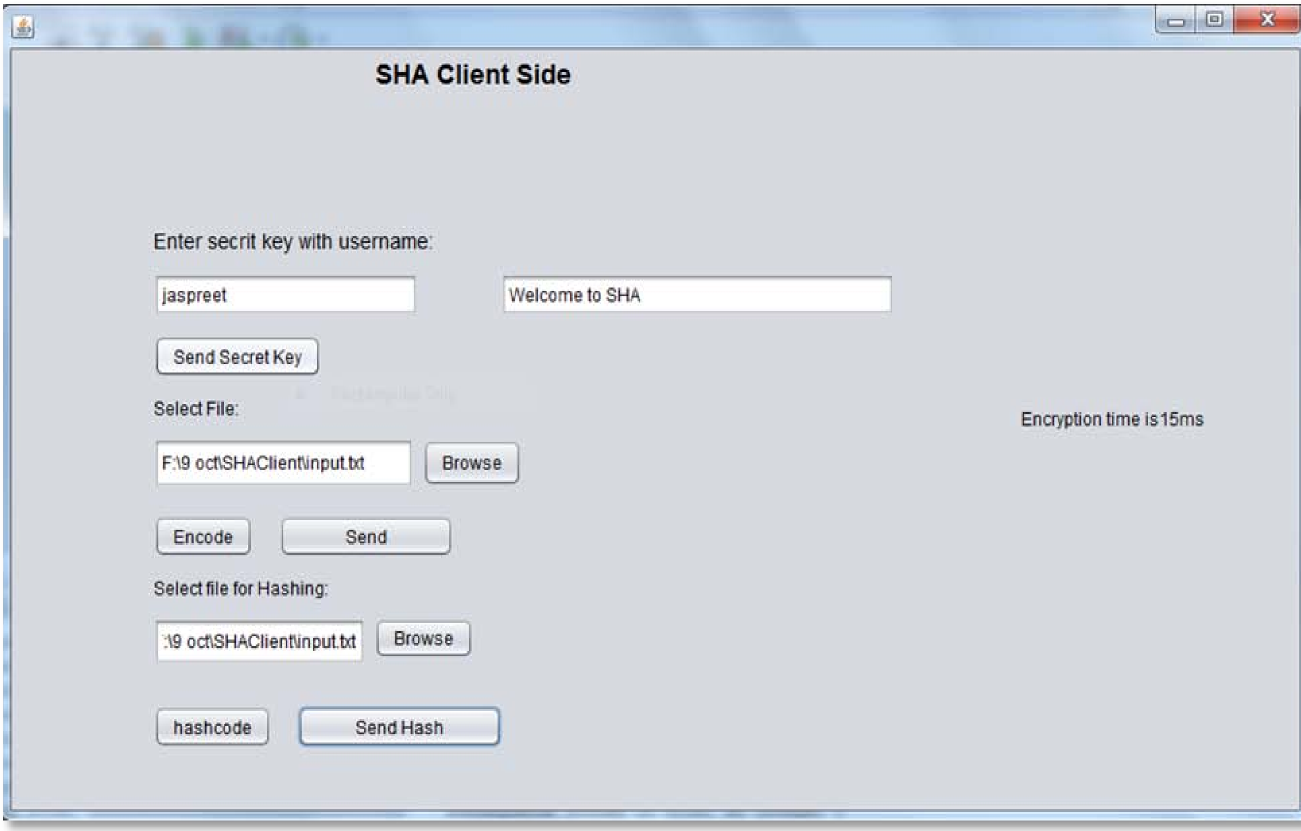

Figure 4 : Client page

Figure 5 : Cloud page

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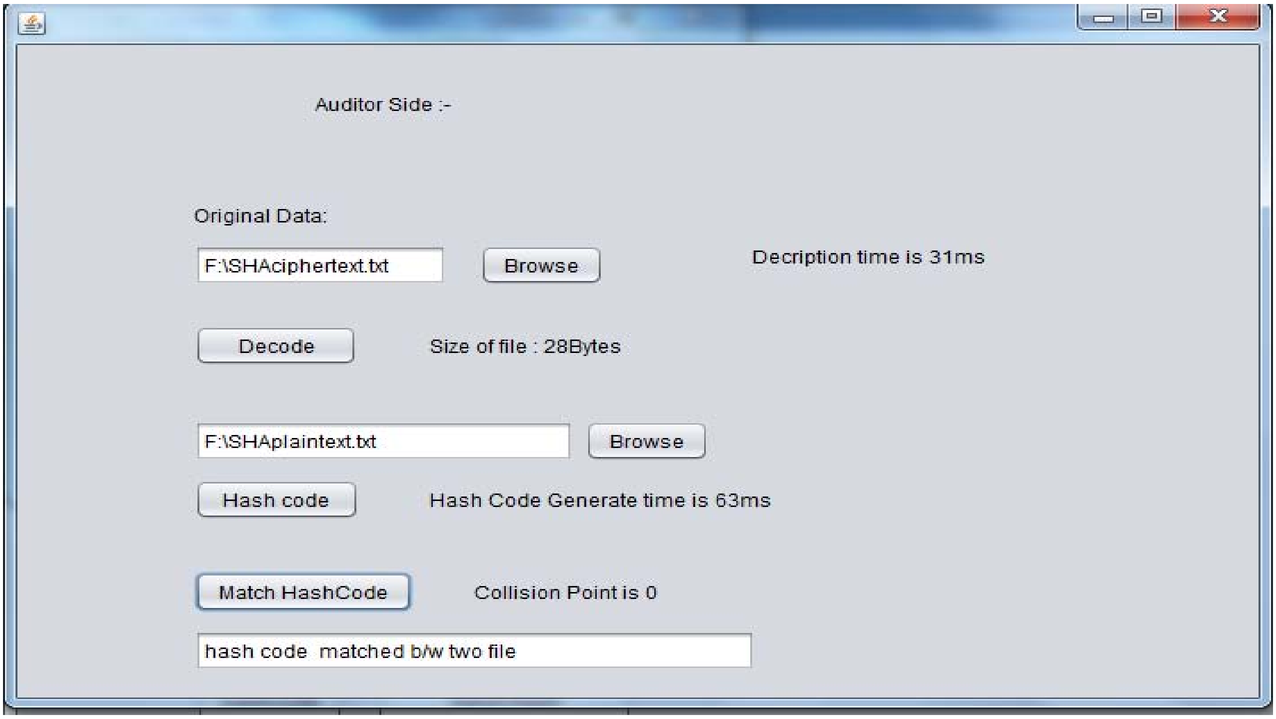

Figure 6 : Auditor Page

The steps of implementation are as follows-

1. A secret key generated using STS protocol (that is known to both user and auditor. Also, mutual authentication is done using this protocol.
2. XOR operation is done between the data and the key generated to create cipher text which is stored in cloud.
3. Separately the data is passed in a hash function (using SHA-2) and the hash value is obtained by the user.
4. Auditor gets the cipher text from the cloud and performs an XOR operation with the secret key generated by the station to station protocol and gets a plain text.
5. Auditor passes this plain text to the same hash function (using SHA2) and obtains a hash value.
6. He then compares this hash value with the hash value received from the user .If both the values are identical then the data integrity is maintained else data is tampered.

V. Results

The results of the above mentioned system are shown in Table 1 and Figure 7.

Table 1 : Result Analysis

	File Size(in Bytes)			
	28	99	124	205
Encryption Time	16	94	141	211
Decryption Time	31	141	187	265
Hash Time	63	78	93	108
Collision Point	0	0	0	0

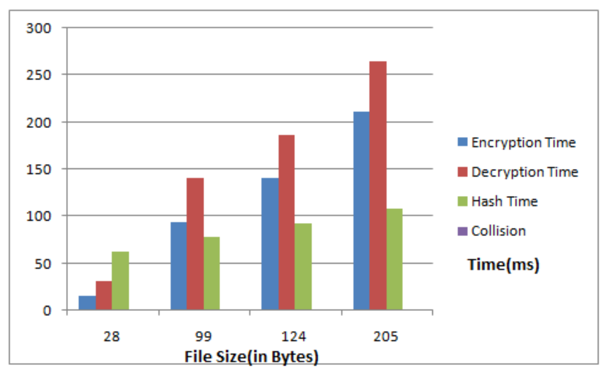

Figure 7 : Graph Showing Results of Encryption, Decryption, Hash Time and Collision

If hash of both files matches, collision point is 0.

If hash of both files do not match , collision point is 1.

VI. Conclusion and Future Work

This paper focuses on auditing mechanisms (using hash function) to ensure data integrity where users can safely delegate the integrity checking tasks to Third Party Auditors and be worry-free to use the cloud storage services. This scheme reduces the computational and storage overhead of the client as well as the computational overhead of the cloud storage server.. We are trying to improve the scheme for auditing multiple files from multiple clients simultaneously as with the increasing development of Cloud Computing technologies, it is believed that more and more users will prefer to store their data in the cloud.

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Simulation of Reliability of Software Component

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Simulation of Reliability of Software Component

Dr. P. K. Suri [α] & Er. Karambir [σ]

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I. Introduction

With the popularity of the web and networked computers are finding their way into a wide and spread range of working environments. This new computing model have made a competition of early development, reliable and distributed software components that communicate with one another across the underlying networked and extendable infrastructure as per the requirement of different user. A distributed software component can be plugged into distributed applications and can be used for some specific purpose. The intention of most of the developers behind is reuse or slight modification of old or reliable component and this makes more reliable by using distributed software components to build new systems. Even though, it is also important for developer to know the functionality of distributed or compatible software component in any system. The design of component and requirement specification should clearly document the functional input, output with conditions and moreover it is the reliability percentage wise. Software reliability has been defined as the probability that a software system operates with no failure for a specified time on specified operating conditions. In other words, by estimating or predicting the reliability [1] of component, the quality of software product can be estimated. The satisfaction of customers is directly dependent on the quality of that software. The analysis report that is commonly used to describe software reliability has been derived from observed or failure intensity. Failure intensity is defined as the number of failures observed per unit time period. Failure intensity is a also good measure for reflecting the user perspective of software quality. As Computer applications are going more diverse and spreading through almost every area of everyday life then reliability factor becomes a very important characteristic of software or component systems. The reliable component is a base of system and part of system i.e. client, administrator and working environment. Since it is a matter of cost and performance to produce a system having documented and estimated reliability [2] of system. Therefore, it is necessary to measure its reliability before releasing any software. When reliability reaches at threshold level then the software component can be released for further use. To do this, a number of models [3] have been proposed and has been being developed. Software modeling is a statistical estimation [4] method applied to failure data collected or simulated the software component or system developed after integration of software component by different approach of joining in software engineering .This can be one after a component testing has been executed so that failure data are available. The implementation of newly developed and modified models tries to make system better and help in predicting the reliability in a accurate way. The most important parameter of any software product are level of quality, time of delivery, and final cost of the product. The time of delivery and cost should be quantitative and pre decided, whereas these attributes is difficult to define Quantitatively. Reliability is one, and probably the most Software reliability is related directly to operation and performance instead of designing of a component.

Therefore, software reliability is estimated by analyzing the observed failure data [5] of component and then applying Goel –Okumoto Model [6][7] , rather than the number of remaining faults in a component. So, estimation of reliability of system is more useful than finding the number of remaining fault. The uncertainty involved in the estimation for a specific interval expressed in terms of confidence interval and estimation of parameter used. This paper evaluates the estimates the reliability of component by using the Goel- Okumoto

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model on the set of failure data taken from simulating the real software applications. This should be done before any component release .The reusability of that component enhances the overall reliability of system and gives accurate estimation of value of reliability. The result shows that the proposed model has a technical point for improving software reliability and providing additional metrics for development project evaluation, management and time of delivery of new developed system.

II. Goel Okumoto Model : NHPP SRGM Exponential Model

Non Homogeneous Poisson Process (NHPP) based software reliability growth models are generally classified into two groups. The first group contains models, which use the machine execution time or calendar time [8] as a unit of fault detection/removal period. Such models are called continuous time models. The second group contains models, which use the number of test occasions/cases as a unit of fault detection period. Such models are called discrete time models [9], since the unit of software fault detection period is countable. A Goel Okumoto Model also known as exponential NHPP model is based on the following assumptions:(a) All fault in a component are independent from the failure detected. (b)The number of failures detected at any time is proportional to the current number of fault in a component. (c) The fault is removed immediately as soon as the failure happens, no new faults are introduced during the removal of fault.

The following differential Equation1 include the above assumptions. Where m(t) is expected number of component failures by time t, a is Total fault content rate function, i.e., the sum of expected number of initial software faults and introduced faults by time t and b is Failure detection rate per fault at time t.
important, aspect of software quality. S

$$\frac{\partial m(t)}{\partial t} = b[a - m(t)] \qquad (1)$$

The mean value solution of above differential equation is given by Equation 2 where tn is time of nth failure occurrence

$$m(t) = a\left(1 - e^{-bt_n}\right) \qquad (2)$$

Failure intensity function is given by Equation 3 as follows

$$\lambda(t) = abe^{-bt_n} \qquad (3)$$

III. Estimation of Parameter

The different a and b parameter also reflect different assumptions of the software testing processes. In this section, we derive a new NHPP model for an interrelationship dependent function between a and b parameter by a common parameter from a generalized class of model. The most common method for the estimation of parameters is the Maximum Likelihood Estimation (MLE) method. MLE method of estimation of a broad collection of software reliability for grouped data is discussed in detail. To estimate a and b for a sample of n units, first obtain the likelihood function: take the natural logarithm on both sides. The equation for estimation of a and b is given in Equation 4 where

$$a = \frac{y_n}{(1-e^{-bt_n})} \qquad (4)$$

Where yn is actual value of nth failure observed at time t. The parameter a can be estimated using MLE method based on the number o failures in a particular interval. Suppose that an observation interval {0, tk} is divided into set of sub intervals (0,ti],(t1,t2]………(tk-1,tk] , Equation 5 was used to determine the value of b .

$$\frac{y_n t_n e^{-bt_n}}{1-e^{-bt_n}} = \sum_{k=1}^{n} \left(\frac{(y_k - y_{k-1})(t_k e^{-bt_k} - t_{k-1} e^{-bt_{k-1}})}{(e^{-bt_{k-1}} - e^{-bt_k})} \right) \qquad (5)$$

The number of failures per subinterval [8] is recorded as ni(i=1,2,3..,k) with respect to the number of failures in(ti-1,ti].The parameters a and b are estimated using iterative Newton Raphson Method, which is given as in Equation 6 Equation 7 and Equation 8 .

$$b = b_0 - \frac{f(b_0)}{f'(b_0)} \qquad (6)$$

$$f(b) = \frac{y_n t_n e^{-bt_n}}{1 - e^{-bt_n}} - \sum_{k=1}^{n} \left(\frac{(y_k - y_{k-1})(t_k e^{-bt_k} - t_{k-1} e^{-bt_{k-1}})}{(e^{-bt_{k-1}} - e^{-bt_k})} \right) = 0 \qquad (7)$$

$$f'(b) = \sum_{k=1}^{n} \left(\frac{(y_k - y_{k-1})(t_k - t_{k-1})^2 e^{-b(t_k + t_{k-1})}}{(e^{-bt_{k-1}} - e^{-bt_k})^2} \right) \qquad (8)$$

IV. Model Analysis and Results

a) Data and Model Criteria

Once the analytical expression for the mean value function m(t) is derived, in this paper, the model parameters to be estimated in the mean value function can then be obtained with the help of a developed octave program based on the least squares estimate (LSE) method. Goel and Okumoto described failure detection as a non-homogeneous Poisson process with an exponentially decaying rate function .It is a simple non-homogeneous Poisson process model. The data of failure of 25 days have been observed here for estimating the reliability [10]. In table 1, the data of 25 days failure and cumulated failure have been shown here.

The two function of Reliability and Remaining fault function can be used to find the release of date or the additional testing time is required to reach ready state. After simulation the result of 25 days of testing were observed. Based on these data and using the MLE

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method, the estimated values for the two parameter are given in the table. Each data set provides the cumulative number of faults by each week up to 25 weeks. The Fig. 1 represents the cumulative number of faults versus the cumulative system test hours at the end of each The Phase 2 data set is given in Table 2. We developed a Octave program to perform the analysis and all the calculations for LSE estimates. The parameter a is the number of initial faults in the software and the parameter b is related to the failure detection rate during testing process.

Table 1 : Number of Failure Observed

Days	Failure Observed	Cumulative Failure	Days	Failure Observed	CumulativeFailure
1	32	32	14	5	127
2	23	55	15	5	132
3	11	66	16	6	138
4	10	76	17	3	141
5	11	87	18	5	146
6	7	94	19	1	147
7	2	96	20	1	148
8	5	101	21	3	151
9	6	107	22	1	152
10	2	109	23	2	154
11	4	113	24	1	155
12	7	120	25	1	156
13	2	122			

The software reliability R(x/t) is defined as the probability of a failure free operations of a complete software for a specified time i.e. interval (t, t +x) in a specified environment in Equation 9. The interval methods of estimation are explained by applying the results to the software failure data .The set of software errors analyzed here is borrowed from a simulated data (an 1 days interval). where R(s|t) is reliability of component during (t, t+s) time.

$$R(xIt) = e^{-a(e^{-bt} - e^{-b(t+x)})} \quad (9)$$

Table 2 : Remaining Fault,Reliability, Failure Intensity

Day	A	B	Remaining Fault	Reliability	Failure Intensity
15	138.38	0.1333	16	80.5	2.1844
16	133.71	0.1432	12	84.66	1.6769
17	141.25	0.1274	14	83.48	1.8162
18	139.72	0.1304	12	85.91	1.5286
19	138.85	0.1322	10	87.86	1.3030
20	140.34	0.1290	9	88.71	1.2052
21	140.10	0.1295	8	90.09	1.0495
22	141.91	0.1255	8	90.60	0.9929
23	142.03	0.1252	7	91.62	0.8801
24	142.3154	0.1246	6	92.48	0.7869
25	141.13	0.1275	5	93.71	0.6538

b) *Analysis*

In fig 1 the cumulative failure observed have been shown as per number of days of testing. It is obviously seen that the number of fault observed is decreasing with days. The number of fault is initially is more but with time the number of fault is decreasing. The estimation of remaining fault decreases rapidly then it becomes straight and it is at low level in fig 2. The remaining fault is never zero as per fig 2. The reliability graph 3 shows that the growth is initially is fast but with time it is also decreasing. It reaches above of 90% after 21 days. The graph of comparision of reliability versus remaining fault describes that the as the reliability is not inversely proportional to the remaining fault as shown in fig 4. The failure intensity of component is slightly decreasing with the number of days of testing from fig 5. As per the solution of problem definition mentioned in 25 days of additional testing is required to get an benchmarks level of reliability and acceptable number of remaining faults so that the software can be released for final delivery.

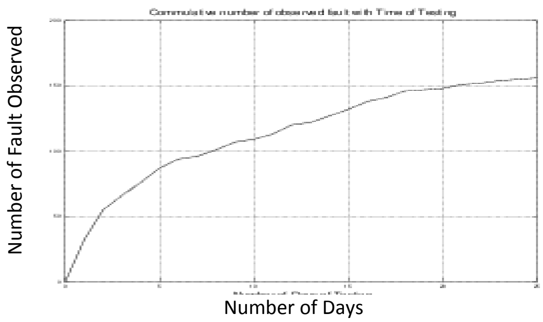

Figure 1 : Number of Fault Observed Wrt Number of Days of Testing

For example the component can be released the software if the expected reliability is greater than the threshold value i.e 90.09778 %and above 90%.

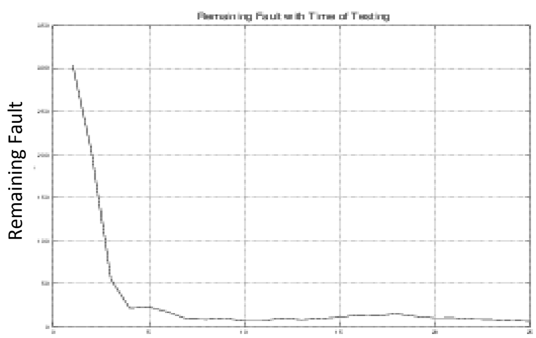

Figure 2 : Remaining Fault wrt number of Days of testing

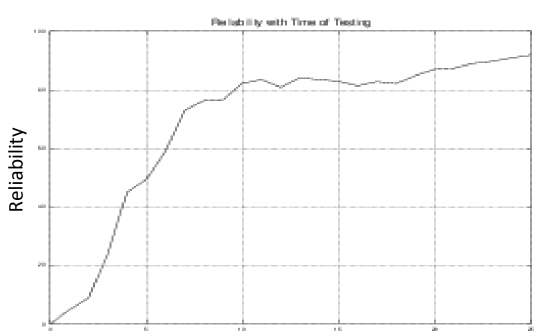

Figure 3 : Reliability wrt Number of Days of Testing

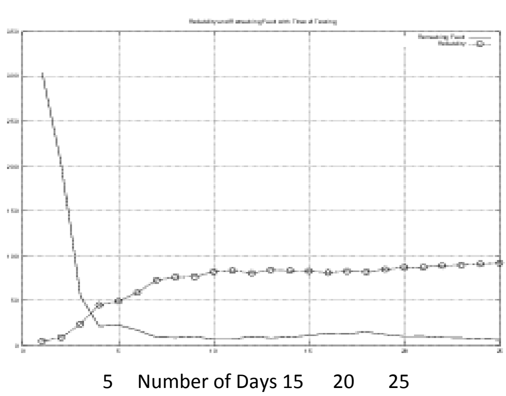

Figure 4 : Comparision of Remaining Fault and Reliability wrt Number of Days of Testing

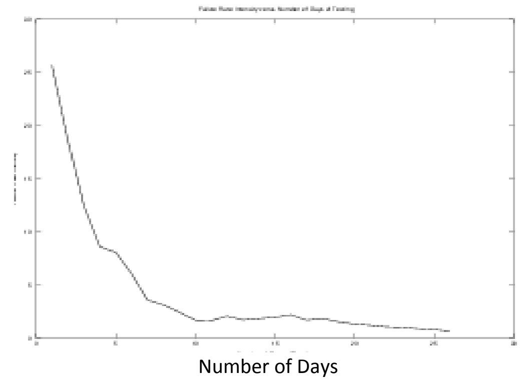

Figure 5 : Failure Intensity wrt Number of Days of Testing

V. Conclusion

This work has proposed a method of estimating the reliability of reusable architecture which can be used to build a software by using Goel-Okumoto Software Reliability Growth Model. The data available from an exponential distribution are grouped and the this model used to illustrate the parameter estimation problem. The measurement of reliability decides the quality and level of reliability decides the time of delivery of any software the reliability is increased with testing time but the reliability never becomes 100% even when the observed fault is close to zero. As per the other criteria in the above analysis, the best estimate for the remaining fault is less than 10 and then the component can be released. The integration of more reliable component can make the system more reliable. This solution will help the developer of third party component to predict the release the component with the specified marked reliability.

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Periodic Pattern Mining – Algorithms and Applications

By G.N.V.G. Sirisha, M. Shashi & G.V. Padma Raju

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Abstract- Owing to a large number of applications periodic pattern mining has been extensively studied for over a decade. Periodic pattern is a pattern that repeats itself with a specific period in a give sequence. Periodic patterns can be mined from datasets like biological sequences, continuous and discrete time series data, spatiotemporal data and social networks. Periodic patterns are classified based on different criteria. Periodic patterns are categorized as frequent periodic patterns and statistically significant patterns based on the frequency of occurrence. Frequent periodic patterns are in turn classified as perfect and imperfect periodic patterns, full and partial periodic patterns, synchronous and asynchronous periodic patterns, dense periodic patterns, approximate periodic patterns. This paper presents a survey of the state of art research on periodic pattern mining algorithms and their application areas. A discussion of merits and demerits of these algorithms was given. The paper also presents a brief overview of algorithms that can be applied for specific types of datasets like spatiotemporal data and social networks.

Keywords: periodic pattern mining; time series; sequence mining; dna sequences; spatiotemporal data, approximate periodic patterns, partial periodic patterns; statistically significant patterns, recommender systems, animal migrations, gene mutations.

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Periodic Pattern Mining – Algorithms and Applications

G.N.V.G. Sirisha [α], M. Shashi [σ] & G.V. Padma Raju [ρ]

Abstract- Owing to a large number of applications periodic pattern mining has been extensively studied for over a decade. Periodic pattern is a pattern that repeats itself with a specific period in a give sequence. Periodic patterns can be mined from datasets like biological sequences, continuous and discrete time series data, spatiotemporal data and social networks. Periodic patterns are classified based on different criteria. Periodic patterns are categorized as frequent periodic patterns and statistically significant patterns based on the frequency of occurrence. Frequent periodic patterns are in turn classified as perfect and imperfect periodic patterns, full and partial periodic patterns, synchronous and asynchronous periodic patterns, dense periodic patterns, approximate periodic patterns. This paper presents a survey of the state of art research on periodic pattern mining algorithms and their application areas. A discussion of merits and demerits of these algorithms was given. The paper also presents a brief overview of algorithms that can be applied for specific types of datasets like spatiotemporal data and social networks.

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I. Introduction

Sequence is an ordered list of elements from any domain. The order among the elements of a sequence may be implied by time order as in stock market data or by physical position as in DNA or protein sequences [1]. If the order is implied by time order the sequences are called event sequences. Sequences where the order is implied by physical position are called biological sequences. Frequently occurring subsequences are referred to as sequential patterns. Sequential patterns with high support extracted from sequence databases are called frequent sequential patterns while the regularly repeating patterns found in a lengthy sequence are called periodic patterns [51]. Periodic analysis is often performed over time-series data which consists of sequences of values or events typically measured at equal time intervals [5]. Periodic patterns are classified based on different criteria. Periodic patterns are categorized as frequent periodic patterns and statistically significant patterns based on the frequency of occurrence. Frequent periodic patterns are in turn classified as perfect and imperfect periodic patterns, full and partial periodic patterns, synchronous and asynchronous periodic patterns, dense periodic patterns, approximate periodic patterns. Periodicity is of two types. The first type is fixed or known periodicity and the patterns with fixed periodicity are daily traffic patterns, daily sales patterns in super market. The second type is unpredictable periodicity and the patterns with this type of periodicity are found in datasets like power consumption, telecommunication traffic, maintenance of vehicles, web click streams, seasonal changes in climate, data sent by sensors, biological sequences. Finding periodicity should be part of mining process for these patterns. Applications of periodic patterns include prediction of drought and flood, stock market price prediction, earthquake prediction, repeat detection in DNA sequences, detection of recurrent illnesses and prediction of fraud and other outlier patterns. [10]. Generalized Sequential Patterns (GSP) [2] proposed by Srikant and Agrawal, Sequential PAttern Discovery using Equivalence Class(SPADE) [3] proposed by Zaki, Prefix and Suffix Projection (PrefixSpan) [4] proposed by Pei et al. are a few algorithms for finding frequent sequential patterns. This paper presents a survey of state of art research on periodic pattern mining.

II. Classification of Periodic Patterns

a) Full and Partial Periodic Patterns

Periodic patterns can be classified as full periodic (complete periodic) or partial periodic. Full periodic pattern is a pattern where every position in the pattern exhibits the periodicity. Periodic patterns in which one or more elements do not exhibit the periodicity are called partial periodic patterns. if {a}{b}{c}{b}{c}{b}{c}{a}{c}{d} is an input sequence {b}{c} is a full periodic pattern with period 2. It is all also called as full periodic pattern because every position in the pattern exhibits the periodicity. The sequence {a}{b}{c}{a}{d}{c}{a}{c}{c} contains a partial periodic pattern {a}{*}{c} with period 3 where the second element is not exhibiting the periodic behavior. Partial periodicity is a looser kind of periodicity than full periodicity and its application is more general because of the mixture of periodic events and non-periodic events in real world data.

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b) Perfect and Imperfect Periodic Patterns

Periodic patterns can also be classified as perfect and imperfect periodic patterns. A pattern X is said to satisfy perfect periodicity in sequence S with period p if starting from the first occurrence of X until the end of S every next occurrence of X exists p positions away from the current occurrence of X.{a}{b}{*} is perfect periodic pattern with period 3 in the sequence {a}{b}{d}{a}{b}{v}{a}{b}{f}{a}{b}{c}. (a}{b}{*} has occurred for 4 times starting from its first occurrence till the end of the sequence. It is possible to have some of the expected occurrences of X missing and this leads to imperfect periodicity. {a}{b}{*} is an imperfect periodic pattern in the sequence {a}{b}{c}{d}{b}{f}{a}{b}{g}{a}{b}{v} and hence the confidence on its periodicity is 3/4. The occurrences of {a}{b}{*} is missed in one of its expected positions. Perfect periodic patterns are first proposed by Ozden et al [6]. They developed an algorithm to find cyclic association rules that reoccur in every cycle for the entire time series. This algorithm finds cyclic association rules from time stamped transactional data. An association rule is called cyclic with cycle $c=(l,o)$ if the association rule holds in every l^{th} time unit starting with time unit t_o Here t_i corresponds to the time interval $[i.t,(i+1).t]$ where ***t is*** the time unit referring to time granularity given as input by the user. For example if the time unit is an hour and if a person buys milk and newspaper daily in the interval 7A.M-8A.M., then newspaper->milk or milk->newspaper has the cycle $c=(24,7)$ (e. starting at 7A.M every 24 hours we can observe the purchase of milk and newspaper together). Given a fixed length period as input Han et al. mined segment-wise periodic patterns by using data cube, bit-array and apriori mining techniques [17]. Segment-wise periodic patterns are full or partial periodic patterns whose number of occurrences in a time series database satisfy the minimum confidence threshold. Cyclic association rules repeat perfectly in the time series with 100% confidence.

Later on Han el al. developed an algorithm called max-subpattern hit set [13] which created a maxsubpattern tree to mine full imperfect periodic patterns and partial imperfect periodic patterns in two scans of the time series. The algorithm can finds the periodic patterns occurring with a given period in two scans of the sequence. It is also extended to detect the patterns for a set of periods (period range is given as input). For a given period the time series is segmented in to different segments called period segments where the length of each period segment is equal to the given period. The time series is scanned once and all *1-patterns* which are found to be frequent in the segmented time series are reported. A *1- pattern* is a pattern where one position in the pattern is defined, for example $(a,*,*)$ or $(*,a,*)$ or $(*,*,a)$. These frequent *1- patterns* are unioned to form max pattern. Now the time series is scanned for the second time. During the second scan of the time series each period segment is intersected with the maxpattern. The result of the intersection called max sub-pattern is either inserted into the tree if it is not already present or its corresponding node count is incremented if it is already present in the tree. Finally the max subpattern tree is then traversed and all patterns whose count is greater than *min_conf* are output as frequent periodic patterns. Max sub-pattern hit set algorithm for multiple periods works in a similar way where max sub pattern trees for all periods are constructed parallely with two scans of sequence. If the number of *1-patterns* mined in the first scan of the sequence is very large, the resultant max-pattern constructed is also very complicated. This results in a very large max-subpattern tree and a lot of time is wasted traversing the tree for finding the frequent periodic patterns.

Aref et al. extended the max-subpattern hit set by introducing algorithms for incremental, on-line and merge mining of partial periodic patterns [7]. Incremental version of max subpattern hit set algorithm allows the users to mine partial periodic patterns in case of insertion and deletion updates of time series database. It requires at most one additional scan of old database. Online version of the algorithm allows users to modify the thresholds used in mining algorithm while the algorithm execution is in progress. Merge mining aims at merging the patterns that are mined from two or more databases. This merging process helps us in discovering the patterns from combined database without having to reapply the mining algorithm.

S-S.Chen et al. proposed an algorithm [26] to find periodic patterns of given periodicity using the encoded period segments database and Frequent Pattern tree. As in max-subpattern hit set algorithm, for a given period *'p'* the given long sequence is segmented into segments where the length of each segment is *'p'*. For example if the given sequence $S_D=\langle a\{b,c\}\{b,e\}aebacb\rangle$, and period p = 3, S_D is segmented into 3 segments. The first period segment $S_1=\langle a\{b,c\}\{b,e\}\rangle$, the second period segment $S_2=\langle aeb\rangle$ and the third period segment $S_3=\langle acb\rangle$. In S_1 *a* is at position 0, ***b and c*** are at position 1 and b and e are at position 2. So, S_1 can be encoded as $\langle(a0),(b1),(c1),(b2),(e2)\rangle$. Similarly S_2 $S_2=\langle aeb\rangle$ is encoded as $\langle(a0),(e1),(b2)\rangle$ and $S_3=\langle ace\rangle$ can be encoded as $\langle(a0),(c1),(e2)\rangle$. After encoding all the period segments in this way, S_1,S_2,S_3 can be treated as separate sequences of a sequence database and frequent pattern tree with multiple minimum supports is used to find all the frequent periodic patterns. The main advantage of this algorithm is in its encoding step. After encoding the period segments in the way illustrated above, any frequent pattern mining algorithm can be used for mining the frequent periodic patterns. Instead of using single minimum support to determine the significance of a pattern, the user can specify different minimum supports for different events based on their real life occurrence frequency. This allows the algorithm to find the rare but important patterns from the data. Recently K.J. Yang et al. proposed projection based partial periodic pattern mining [9] that can efficiently mine all partial periodic patterns that occur with the given period. On giving a period value this algorithm divides the given sequence into segments whose length is equal to period. It then encodes these segments into event tuples. This encoding is similar to the encoding technique discussed above[26]. The usage of event tuples together with recursive projection based algorithm speeds up the mining of partial periodic patterns. Only one minimum support is used to find the significance of the pattern.

All the above algorithms can be applied on datasets with predictable periodicity. However as the algorithms divide a long sequence into equal size segments where the size is equal to given period, the above algorithms can only detect patterns occurring within a segment possibly missing the patterns that overlap across the segments.

c) Perfect and Imperfect Periodic Patterns

All the above periodic pattern mining algorithms require the user to give period as input. These algorithms are appropriate for all the applications where the data consists of natural periods like hour, day, week, month, quarter and year. Some data sets may have patterns that repeat with unexpected periods. In such cases we need algorithms that can extract potential periods and the patterns that appear with these periods.

Pioneering work in this direction is done by Ma el al. to find all partial periodic patterns with unknown periods [28]. Two algorithms were developed to find partially periodic patterns. The former also called period first finds potential periods first and then for each period discovers the associations between events occurring with that period. The potential periods are detected using chi-squared test. A level-wise algorithm is then used to mine partial periodic patterns that appear with these periods. The later algorithm also called association first finds associations between events first. For each temporal association pattern it then discovers its periodicity. These algorithms can find partial periodic patterns even in the presence of replacement, insertion and deletion noise. One of the drawbacks of this work is that some valid periods may not be identified as it considers the difference between adjacent time instants only as potential periods.

People belonging to various areas such as economics, digital signal processing and statistics have also proposed various methods for periodicity search in time series. These methods include the usage of autocorrelation function, FFT, DWT for finding the periodicity of the time series. They focused on finding the periodicity only and did not explore mining of patterns that occur with the detected periodicity. Unlike these methods Berberidis et al. [19] have used autocorrelation to detect all candidate periods from a discretized time series and applied max subpattern hit set algorithm to find the patterns. This algorithm scans the time series once to create a binary vector of size *n* for every symbol in the alphabet of the time series. For each symbol in the alphabet it computes the circular autocorrelation vector that contains the frequency count of each period. Among the periods from 1 to *n/2*, periods whose occurrence frequency is less than minimum confidence threshold are filtered out and the rest are kept as candidate periods. For each candidate period all the symbols occurring significantly with that period are unioned to form max pattern and Han's max subpattern hit set algorithm is applied to mine all frequent partial periodic patterns that occur with that period. The drawback of this method is that for any period, circular autocorrelation produces unexpected frequency values when the length of time series is not an integral multiple of that period. It also produces wrong frequency values for periods when successive occurrences of a symbol are repeated frequently periodically. The overall complexity of the algorithm using FFT as a filter is $O(AN\log N)$ where is A is the size of the alphabet and N is size of the time series.

Usage of different networking resources has lead to the generation of different time series data in telecommunications and network applications. These include total number and duration of calls, number of bytes or electronic mails sent out from one ISP to another, amount of web traffic at a site etc [18]. Sale of a specific item over time also represents time series data. Time series are approximately periodic (noisy signals). Application of FFT on such data involves filtering of data before processing to guarantee accuracy. Even with very good filtering techniques and with no phase shifts in data, FFT cannot find all periodicities that are present in the data. Inorder to identify periodicities in noisy time series, Indyk et al. have proposed an algorithm named representative trends [18] to detect the candidate periods called relaxed periods in $O(n\log^2 n)$ time. This algorithm identifies periodicities but not the patterns that repeat with those periodicities so we need to use a separate periodic pattern mining algorithm that uses the detected candidate periods as input to generate the periodic patterns. Convolution based periodicity detection algorithm [15], WARP [16] and STAGGER [22] are other algorithms that can detect potential periods and periodic patterns in one pass of the time series. P. Huang el al. used an algorithm based on frequent partial periodic pattern tree for wireless spectrum occupancy prediction [48]. This prediction helps unlicensed users to use licensed wireless spectrum bands that are under-utilized i.e. the unlicensed users can use the available slots that are left unused by licensed users. This in turn helps in improving the channel utilization and reduce collision rate.

Dutta et al. have proposed algorithms to find perfect and imperfect calendar based periodic patterns [30][31][32]. These algorithms are used to mine yearly, monthly, daily, hourly periodicities from discrete as well as continuous time series datasets. They find calendar based periodicities of an interval based temporal pattern. An interval based temporal pattern is a pattern that occurs across a sequence of time-intervals in either a discrete or continuous domain. These algorithms have a time complexity $O(n \log n)$ for a continuous domain and only $O(n)$ for a discrete domain.

G. Lee at al. applied parallel computing to efficiently mine frequent partial periodic patterns at all valid periods [34]. They are able to speed up the process of mining partial periodic patterns by partitioning the periods into independent subsets based on independence property of prime numbers. Each independent subset of periods will be assigned to a processor for detection of periodic patterns. Generation of redundant patterns was avoided thus increasing the efficiency of mining process as well as effectiveness and interpretability of generated patterns. A periodic pattern is redundant if the knowledge provided by it is obtained from other periodic patterns. For example in the following patterns 'Stock A's price increases every 2 days', 'Stock A's price increases every 4 days', the second pattern is redundant. Partial periodic correlation is a set of offsets within a particular period such that the data at these offsets are correlated with certain user desired strength. These partial periodic correlations are identified in [35] using principal component analysis method.

d) Synchronous and Asynchronous Periodic Patterns

A pattern which occurs periodically without any misalignment is called as synchronous periodic pattern. In the sequence {a}{b}{c}{a}{d}{c}{a}{c}{c}{d}{e}{f}, {a}{*}{c},{a}{*}{*},{*}{*}{c} are the synchronous partial periodic pattern. These patterns have repeated for three times consecutively in the sequence with a period 3. Asynchronous periodic patterns are patterns with some disturbance between the repetitions of the pattern. Disturbance is allowed not only in terms of missing occurrences but also as insertion of random noise events. {a}{*}{c}, {a}{*}{*},{*}{*}{c} are asynchronous periodic patterns in the sequence {a}{b}{c}{a}{c}{c}{c}{b}{a}{b}{c}{a}{d}{c}. The above patterns have appeared for four times in the sequence where there is a disturbance between second and third occurrences of the patterns. A number of algorithms like LSI [8], SMCA [10], OEOP [11] and E-MAP [12] were developed to find these asynchronous periodic patterns in a single long sequence. Longest Subsequence Identification (LSI) is the pioneering algorithm to mine asynchronous periodic patterns. For each asynchronous periodic pattern the algorithm detects the longest subsequence containing it. LSI is an iterative level wise search algorithm. It works in three phases. In the first phase it detects all potential periods for all events. This requires single scan of the sequence. In the second phase all candidate *1-patterns* are validated. A *1-pattern* is a pattern where one position is the pattern is defined and rest of them are *'s. For example {a}{*}{*},{b}{*} are 1-patterns with periodicity 3 and 2 respectively. An i-pattern is a pattern where I positions in the pattern are defined for e.g. {a}{b}{*} is a 2-pattern with periodicity 3 where 2 positions out of 3 are defined. In the third phase an iterative level wise approach is used where in the *i th* iteration candidate *i-patterns* are formed from *(i-1)-patterns*. Validation of these i-patterns require single scan of the sequence. The second and third phases of LSI require multiple scans of the sequence. Simple Multiple Complex and Asynchronous periodic pattern miner (SMCA) is a four phase algorithm that detects all the subsequences containing asynchronous periodic patterns. It can work with sequence of event sets also. A sequence of event sets is a sequence where each time instant contains one or more events. The first algorithm SPMiner finds *1-patterns.* The second algorithm MPMiner finds *1-patterns* containing simultaneously occurring events. The third algorithm CPMiner finds complex patterns(*ipattern for* $i \geq 2$). For all the *1-patterns, 1-patterns* with simultaneously occurring events and complex patterns the fourth algorithm APMiner finds subsequences where their appearance is significant. A pattern is said to appear significantly if the number of occurrences of the pattern in a subsequence is greater than a threshold *min_rep.* One Event One Pattern (OEOP) algorithm uses a linked list structure to detect single event one patterns in a single scan of a sequence. OEOP can be used to replace the first phase of SMCA for data sets like data streams. It can mine all *1- patterns* of all the events at all periods in a single scan of the sequence. E-MAP was proposed as a further improvement over SMCA model to mine all patterns (*1-patterns, 1-patterns* with simultaneously occurring events, complex patterns) in a single step and single scan of the sequence. Among these algorithms LSI can only handle sequence of events where as the other algorithms can handle sequence of event sets. All these algorithms can handle replacement, insertion and deletion noise that is present in the sequence. These algorithms can detect asynchronous periodic patterns that appear with periods in the range max $2 \leq p \leq L_{max}$. L_{max} is the maximum periodicity that the user wants to check in the sequence. These algorithms produce many redundant patterns and they can be extended to mine only closed and maximal periodic patterns. Inorder to capture the hierarchical nature of asynchronous periodic patterns a meta-pattern model is proposed by Yang et al. [27].

e) Patterns with Symbol, Sequence and Segment Periodicity

Some authors have classified periodic patterns as symbol periodicity or singular patterns, sequence periodicity or partial periodic patterns and segment or full-cycle periodic patterns. A sequence is said to have symbol periodicity if at least one symbol is repeated periodically. For example in the sequence {x}{y}{y}{x}{u}{i}{x}{t}{r}{x}{k}{l}, symbol {x} is periodic with periodicity 3. A pattern consisting of more than one symbol repeating with same periodicity in a sequence leads to sequence periodicity. {x}{y} (*) is partial periodic pattern in {x}{y}{z}{y}{z}{z}{x}{y}{y}{x}{y}{x} If the whole sequence can be mostly represented as a repetition of a pattern or segment then that type of periodicity is called segment or full-cycle periodicity. For example {x}{y}{z} is a full-cycle periodic pattern in the sequence {x}{y}{z}{x}{y}{z}{x}{x}{x}{x}{y}{z}. The periodicity and confidence of the pattern {x}{y}{z} are 3 and ¾ respectively.

Rasheed et al. proposed suffix tree based noise resilient algorithm (STNR) [14] to detect symbol, sequence and segment periodicities that occur in the entire sequence or a subsection of it. Suffix tree is a data structure used in string processing. Suffix trees can be used to solve exact string matching problem, the substring problem, longest common substring of two strings etc. A suffix tree represents all the suffixes of the string for which it is constructed. For each suffix of the string there is a distinguished path from the root to corresponding leaf node in the suffix tree. Given a long sequence of symbols, a suffix tree for the sequence helps us in finding the number of repetitions of all substrings (or subsequences) and the occurrence positions of these subsequences in the sequence. For detecting periodicity, periodicity detection algorithm is applied on the occurrence vector of each subsequence (substring) whose occurrence frequency satisfies the *min_conf* threshold. The major limitation of this algorithm is that it cannot detect patterns like {a}{*}{b}, {a}{b}{*}{c}{d} where the elements represented by {*} do not exhibit the periodicity. It also misses some valid periods because it only considers adjacent time instants in calculating the periods. For example if 0, 3, 5, 6, 10, 13, 15 are time instants at which an event occurs. STNR algorithm considers the difference between every pair of consecutive time instants as candidate period. In the above example 3,2,1,4,3,2 are considered as candidate periods. The period 5 which is present in the data will be unidentified. This algorithm being noise resilient can work with sequences having replacement, insertion and deletion noise. While some of the existing algorithms [15][16][17][18] can only detect periods that span through the entire sequence, STNR can detect periodic patterns that span through the entire sequence as well as a subsection of it. This algorithm cannot be used on eventset sequences. The worst case time complexity of the algorithm is $O(k.n^2)$.

M.G. Elfeky et al. have developed a convolution based algorithm to detect symbol and segment periodic patterns [15]. The algorithm scans the time series once to convert it into binary vector according to proposed mapping. It applies modified convolution on the binary vector to find the underlying periodicities and corresponding symbol and segment periodic patterns in single pass of the time series. To reduce the time complexity, convolution is computed using FFT. The time complexity of the algorithm $O(n \log n)$. It works well in mining synchronous periodic patterns. It fails in the presence of insertion and deletion noise.

Noisy data exists in almost all real world databases due to different reasons like errors in data entry, data transmission errors. In streaming applications data elements may be dropped purposefully for processing reasons. We need noise resilient algorithms in such cases. Elfeky at al. developed an algorithm named WARP [16] that uses time warping to detect the underlying periodicities and periodic patterns. It uses time warping to extend or shrink time axis at various locations to optimally remove noise. WARP is tolerant to insertion and deletion noise. The time complexity of WARP is $O(n^2)$. Though it is tolerant to noise, it can only detect segment periodicities and cannot find symbol or sequence periodic patterns. An online version of WARP called Online WARP was also developed to work with datastreams.

For mining periodic patterns from data streams Elfeky el al. have proposed a one-pass, online and incremental algorithm named STAGGER [22]. STAGGER discovers potential periodicities using multiple expanding sliding windows. With the continuous flow of the streamed data the sliding windows expand in length in order to cover the whole stream. Short length windows help us in identifying the short periods early and in real time. Larger length windows help in identifying the longer periodicities. For each discovered periodicity, STAGGER incrementally maintains a max-subpattern tree to find the corresponding periodic patterns.

f) Dense Periodic Patterns

Most of the periodic pattern mining algorithms can mine the periodic patterns only if they appear in the entire time series. A pattern which occurs in small segments of time series will not be detected by such algorithms because of lack of sufficient support or confidence. STNR can detect periodic patterns that appear in the entire time series or a part of it, but the end user has to give the range i.e. start and end positions of the segment of the time series from which he wishes to mine the periodic patterns. This is a difficult task. Sheng el al. has proposed an algorithm [25] to mine dense periodic patterns from time series database. For each unique symbol the algorithm finds dense fragments from the time series. A dense fragment is a segment of time series where the distance between every pair of consecutive occurrences of the symbol is less than the distance threshold d_{max}. All the dense fragments of all the symbols whose lengths are greater than *min_len* are retained. Then a max-subpattern tree is used to generate the partial periodic patterns using only the dense fragments of the symbols of the alphabet. This algorithm also prunes some periods by finding the lower bound period for each symbol in its each dense fragment. All the periods that are less than lower bound period can be safely pruned.

III. Approximate Periodic Patterns

Noise and imprecision exists in most of the real world data e.g. gene mutations in DNA sequence, so there is a need to mine approximate patterns. The algorithms that we have discussed previously which tolerate replacement, insertion and deletion noise mine approximately repeating periodic patterns. Here approximation is allowed in occurrence position of the patterns. In this section we are going to discuss a few more algorithms that allow approximation in occurrence positions as well as structure of the patterns. Y.L. Zhu el al. has mined approximate periodic patterns from hydrological time series [23]. Multi-event asynchronous periodic patterns were discovered from long sequence of hydrological time series. A modified suffix tree representation and traversal together with dynamic candidate period intervals adjusting method was used to mine all patterns without omitting any periods. Another approach to mine approximate periodic patterns was proposed by Amir et al. [24]. Given an input sequence and a parameter $\varepsilon \in [0,1)$ this algorithm finds for each unique event the longest ε - relative error periodic pattern i.e. the longest subsequence $s_1, s_2, s_3, \ldots, s_k$ of S for which there exists a number *p* such that the absolute difference between any two consecutive occurrences of event in the subsequence is atleast *p* and atmost $p(1+\varepsilon)$. *P* is the approximate period of the relative error periodic pattern. Zhang et el. have proposed an algorithm to find periodic patterns with gap requirement from DNA sequences [33]. The algorithm generates all periodic patterns of the form $a_1 g(N,M) a_2 g(N,M) \ldots a_{l-1} g(N,M) a_l$ where a_i for $1 \le i \le l$ is any symbol from the sequence, $g(N,M)$ is the gap between symbols and N,M are two user supplied numbers that specify the minimum and maximum gap sizes between every pair of consecutive symbols in the pattern.

IV. Surprising Periodic Patterns

In some applications like genomic data, system traces, credit card transactions and seismic data, patterns that occur less frequently yet whose occurrence frequency is beyond prior expectation are considered interesting. But all the periodic pattern mining algorithms discussed so far prefer mining periodic patterns that occur frequently. J. Yang el al. had proposed an algorithm named InfoMiner [29] to mine rare but statistically significant periodic patterns. A pattern is considered significant if its occurrence frequency exceeds its expected frequency by a large margin. Inorder to identify rare and statistically significant patterns a new model called as information model is used instead of support model. Information gain measure is used to identify the degree of surprise of pattern in a data sequence. Information gain of a pattern $G(p)$ is given $G(p) = I(p) * (Support(p) - 1)$. $I(p)$. s the information carried with *p* or surprise of *p*. m is less for a frequent pattern than that of a rare event. In the context of mining surprising periodic patterns a pattern that never repeats is of no use. So *I(p)* is multiplied by $Support(p) - 1$ to identify the true periodic patterns with statistical significance. To improve the efficiency of the mining process, pattern pruning based on bounded information gain is used.

The occurrence positions of a pattern are not taken into account by Infominer. For example in $S_1 = a_1, a_2, a_3, a_3, a_2, a_3, a_1, a_2, a_4, a_5, a_1, a_2$ and $S_2 = a_1, a_2, a_1, a_2, a_1, a_2, a_5, a_3, a_2, a_3, a_4, a_5$ pattern (a_1, a_2) has the same information gain. In the first sequence (a_1, a_2) is scattered where as in the second sequence it repeats perfectly in first half of . In some application like repeat discovery in bio-informatics, consecutive repetitions of a pattern are more significant than the scattered repetitions [20]. Some penalty is associated with the gap between pattern repeats. So we need a new measure that distinguishes between consecutive repeats and scattered repeats of a pattern. J. Yang el al. proposed an algorithm called InfoMiner+ [20] which makes this distinction. It uses generalized information gain (GIG) measure. It detects all partial periodic patterns that are significant in one or more subsequences of an event sequence. For each pattern the subsequence that maximizes the pattern's generalized information gain is reported. It can deal with replacement noise. This algorithm detects all statistically significant periodic patterns whose periodicity is less than or equal to the maximum period bound L_{max}.

Periodic patterns not only help in predicting future events but also help in identifying anomalies in data. F. Rasheed et al. have developed a framework for periodic outlier pattern detection in time series sequences [44]. Frequent periodic patterns are the periodic patterns that satisfy the user specified *min_sup* or *min_conf* . Though *min_sup* and *min_conf* measures can help us in identifying frequent periodic patterns they cannot be used to find outlier periodic patterns. The outlier periodic patterns repeat less often, the repetitions may not be strictly periodic, and the period is generally larger than the regular frequent periodic patterns. Rasheed et al. proposed a new measure based on the relative frequency of the pattern and its coverage area to estimate the surprise of the pattern. Then they used STNR [14] to find the periodicity of these surprising or outlier periodic patterns. As this framework uses STNR in periodicity mining, it can work with noisy data where periodic repetitions are not strict.

If $f(x)$ represents the number of repetitions of the pattern *'X'*, and $segLen(X)$ represents the segment length of the repetitions of *'X'*, then X is candidate outlier pattern if $f(x) < \mu(f(x_i))\ \mathrm{AND}\ segLen(x) > \min SegLen$; $\forall \mathrm{i}$ such that $|x_i| = |x|$ where $\mu(f(x_i))$ is mean of frequency of all patterns of length exactly the same as that of pattern *X*. The measure of surprise of a pattern *X* is defined as one minus the ratio of the frequency of *X* over the average frequency of all patterns with same length as *X*. $Surprise(X) = 1 - \frac{f(x)}{\mu(f(x_i))}$; $\forall \mathrm{i}$ such that $|x_i| = |x|$.

A candidate outlier pattern *'X'* is an outlier periodic pattern *iff* $surprise(X) > surprise_{\min}$ and $Conf(X, i_{st}, i_{end}, p) > Conf_{\min}$ where $Conf(X, i_{st}, i_{end}, p)$ is confidence of pattern *'X'* repeating with period *p* within the segment starting and ending at i_{st} and i_{end} respectively; $Conf_{\min}$ and $Surprise_{\min}$ are respectively the minimum confidence and minimum surprise values provided by the user. STNR-Out mines small number of non redundant outlier periodic patterns.

V. Mining Periodic Patterns from Spatiotemporal Databases and Social Networks

Periodicity is a commonly seen phenomenon in moving objects as well as social networks. People usually go to workplace every day through more or less same route, birds and animals migration from one place to another also show yearly periodicity. Interactions between people and topic discussion in social media also show periodicity, for example delivering news about different budgets in news sites and posting of information corresponding to different events like annual conferences in blogs and websites are done periodically.

The periodic pattern mining algorithms designed for event/symbol sequences cannot be used to find spatiotemporal periodic patterns. This is because the repetitions of spatial locations $\langle x, y \rangle$ may not be identical. Even if objects follow same route regularly, they may not appear at exactly the same location regularly. For example a person may go from home to office in the same route every day between 9.00 A.M. to 10.00 A.M. But it is less likely that he will be at the same location on his route everyday at 9.30 A.M. [37].

Cao el al. have proposed an algorithm to find maximal periodic patterns from spatiotemporal data [37]. This algorithm mines periodic *1-patterns* using spatial clustering. Then bottom-up and top-down mining techniques are used for generating longer patterns. They have also proposed algorithms which can mine periodic patterns that appear in only a time interval instead of whole time span. Another algorithm which can mine shifted or distorted instances of patterns is also proposed.

Algorithm for mining and indexing of spatiotemporal periodic patterns from historical spatiotemporal data was developed by N. Mamoulis el al [42]. Z. Li el al. define a periodic behavior as repeating activities at certain locations with regular time intervals. A two stage algorithm called Periodica [38] is used to detect periods and find the periodic behaviors. In the first stage reference spots which are dense regions that are frequently visited in the movement are identified. Then the periods associated with each reference spot are identified using Fourier transform and autocorrelation [45]. Since every period is associated with a reference spot, if we find the periods associated with each reference spot we can guarantee that all the periods in the movement are detected. A period may be associated with two or more reference spots. In the second stage all the reference spots associated with a period are considered together for mining the periodic behaviors. A periodic behavior is a statistical description of the periodic movement for a period. It is a probability distribution matrix which gives the probability that the object is at each reference spot at different sub intervals of a period. For example when we mine periodicities of a school student we may observe 24 hours period at three reference spots namely class room and play ground and house at different hours of the day. The periodic behavior for the student gives the probability with which the student is at different reference locations namely class room, play ground and house in each hour of the day. In [46] the authors have extended this work by explaining how periodic behaviors can be used for missing data interpolation and future movement prediction.

Z. Li et al, have developed probabilistic model to mine periodic patterns from noisy and incomplete observations [36]. Mobile, GPS and Sensor technologies help us to track human and animal movements. But the data collected by these devices have a large portion of missing and noisy data. The data is also unevenly sampled and the rate of sampling in some cases like data sent by sensors attached to animal is very low. Fourier transforms and autocorrelation generally require evenly sampled data collected at high sampling rate. So these methods fail in this case. So a new probabilistic model is proposed to mine periodic patterns in these types of datasets.

T. Jindal el al. have proposed a method to mine spatiotemporal periodic patterns from traffic data [41]. These patterns can be used to summarize the speed distribution of traffic along any road like inter-state highways, state highways or a local road.

L. Riotte-Lambert el al. have used Fourier and Wavelet analysis to extract periodic patterns from time series of presence/absence, arrival/departure from areas of interest [47]. They have also introduced reliable null models for assessing the statistical significance of the periods detected. This work is an extension of Z. Li el al.'s work [38]. They declare that some of the valid periods may be missed or false periods may be detected if we use a single threshold to find significant frequencies from a periodogram as in [38]. To avoid this, different thresholds were used for different frequencies when finding significant frequencies from a periodogram. Wavelet analysis makes it possible to determine both the periodicities and time intervals during which the different periods are found to appear in the data. Though it is theoretically possible to use only wavelet analysis for periodicity detection the authors suggest to first perform fourier analysis as it is very fast and convenient way to determine the frequencies that are potentially relevant and then apply wavelet analysis. This two stage approach helps in easy interpretation of wavelet power spectrum. Wavelet analysis helps in identifying periodic events that occur in whole time series or only a part of it.

M. Lahari el al. discussed periodic subgraph mining for dynamic social networks [43] and applied it on four real world dynamic networks like Enron e-mails, Plains Zebra. K. Ishida had presented an algorithm to find periodically discussed topics in blogs, news sites and spam [39].

M. Lv et al. have used user's long term activity regularity to find mobile user similarity for location based social network services [50]. A new branch of social network services called location based social network services (try to understand users activities and preferences) recommends places, activities, friends and other geo-related information to the users based on the knowledge of users activities and preferences. Finding user similarity based on their long-term activities is important to achieve this. In [49] the authors have proposed a method to find users similarity based on user's long term activity regularity using GPS trajectory data. So by mining periodic patterns we will be able to develop recommender systems.

S. Parthasarathy el al. have presented robust periodicity detection algorithms to mine periodicities from continuous time series datasets [50]. These algorithms combine short time fourier transform and autocorrelation analysis for finding the periodicity. Various algorithms were developed to find periodicity in stationary, non-stationary, noisy and incomplete datasets. These can also find multiple interleaved periods and discover hidden relationships among attributes in multidimensional time series.

VI. Periodic Patterns Versus Frequent Episodes and Frequent Continuities

Frequent episodes and Frequent Continuities are two classes of patterns that are closely related to periodic patterns. K. Huang el al. has given the following similarities and dissimilarities between them [40]. An episode is defined to as total or partially ordered collection of events in a specific time window. An episode considers only order among events instead of the actual positions of events in a time window bound. Mannila et al. presented a framework for discovering frequent episodes from a single long sequence through a level-wise algorithm WINEPI [21].

Continuity as defined in [40] is a kind of causal relationship which describes a definite temporal factor with exact position between the records. It is similar to a periodic pattern, but without the constraint on the contiguous and disjoint matches. Frequent episodes are a loose kind of frequent continuities since they consider only the partial order between events, while periodic patterns are a strict kind of frequent continuities with constraints on the subsequent matches.

VII. Conclusions and Future Work

Periodic pattern is a pattern that repeats itself with a specific period in a sequence. Periodic patterns can be mined from datasets like biological sequences, continuous and discrete time series data, spatiotemporal data and social networks. Different criteria are used to classify the periodic patterns. This paper presents an overview of different types of periodic patterns and their applications along with a discussion of the algorithms that are used to mine these patterns. We have also discussed about efficiency, user interaction needed and noise resilient nature of these algorithms.

Ideas for future research directions in this area are the following. Major limitation of all the frequent pattern mining algorithms is that they mine a large number of patterns when *min_sup* is set very low. Like any frequent pattern mining algorithm, frequent periodic pattern mining algorithms also generate a large number of periodic pattern when *min_sup* or *min_conf* is set low. In order to reduce the redundancy of the generated output and to improve the efficiency of mining process there is a need for the development of algorithms that mine closed and maximal periodic patterns. Approximate periodic pattern mining is a new sub area of periodic pattern mining and a few algorithms were developed recently to mine such patterns. It needs to be extended to eventset (multidimensional) sequences.

Many of the existing periodic patterns mining algorithms mine patterns from *1* dimension sequences (event sequences). These algorithms were not applicable on multi dimensional sequences. These have to be extended for multi dimensional sequences so that more hidden patterns can be found from such sequences also.

With the growing size of the datasets, development of incremental and distributed periodic pattern mining algorithms has become a necessity. Usage of periodic patterns in constructing classification/prediction and recommender systems should be further explored.

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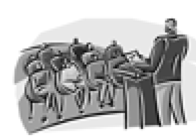

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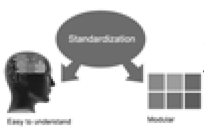

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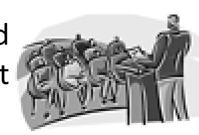

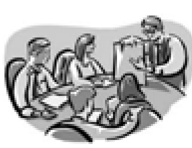

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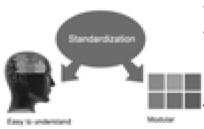

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(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(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, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

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

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Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

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Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

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

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Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin 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 research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

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References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

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Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

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21. 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 to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

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

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

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

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

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33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After 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 to 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 in your research.

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Key points to remember:

- Submit all work in its final form.
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Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

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- Separating a table/chart or figure - impound each figure/table to a single page
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· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

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· Present your points in sound order

· Use present tense to report well accepted

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- Fundamental goal
- To the point depiction of the research
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- Significant conclusions or questions that track from the research(es)

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The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
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- Present a background, such as by describing the question that was addressed by creation an exacting study.
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- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
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- One 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?
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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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