EXPLAINABLE AI IN INTRUSION DETECTION SYSTEMS

Nikita Nerkar[1], Atharva Nile[2], Amit Kulkarni[3], Onkar Kadlag[4], Prashant Gadakh[5]

Abstract: As the use of internet in increasing day by day and the chances of system get compromised due to various types of attacks has increased. Intruders are finding new techniques to compromise the system. The concern about the cyber security is growing and for the user most of the model is perceived as a black box. There is need of finding the attack correctly and then proper reports should be generated to show how the system got compromised. So we are proposing a system where Intrusion Detection System (IDS) can detect the attack and Explainable artificial intelligence tell us about what type of attack is being performed on the system. Intrusion Detection System keeps track of the malicious packets entering in the system. Explainable Artificial Intelligence will show the report on which type of attack took place. In the proposed system we have use the NSL-KDD dataset for classification of attack detected by our proposed Intrusion Detection System.

Keywords: Intrusion detection System, Explainable artificial intelligence, NSL-KDD, classification.

I. INTRODUCTION

Today internet is been used in vast number of areas like organizations, businesses, entertainment industry, personal day to day activities etc. One of the most important issues nowadays is security. When an intrusion takes place the security of the system is compromised. The assumption of the behaviour of the intrusion is different from the legal user in the system. To deal with intrusions in the network is the main aim of the IDS.

Explainable Artificial Intelligence presents the results of the solution that can be understood by the system administrators effectively. Our system consists of four classes of the intrusion like User to Root (U2R), Denial of Service (DoS), and Remote to User (R2U), Probing attacks. An IDS alone is only able to detect that attack has taken place and alarms admins but it is not able to detect type of attack. Using Explainable Artificial Intelligence when can detect which type of attack has took place from the four classes and generate the reports for the same. For Classification purpose we have used NSL-KDD dataset for training a model which classifies the attack. Pre-processing over the model is done by using one hot encoding, label encoding and standard scalar techniques.

II. LITERATURE SURVEY

We have referred "Intrusion Detection System Using Data Mining Technique: Support Vector Machine" [4] In which they have Classified the attack done on the system using support vector machine(SVM) method and using the

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"AutoML for Model Compression and Acceleration on Mobile Devices using Reinforcement Learning"

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Abstract

Background: *Model compression has been described as a crucial skill which resourcefully implement neutral network model on mobile devices possessing scarce computation assets and also operating under a tight budget. Most of the ancient model compression depend on methods which are handmade and also they operate under a rule-based procedure which only function under a domain expert so as to investigate one of the greatest design location for trading off for all the model size, speed, and the accuracy i.e. a sub-optimal and time consuming.*

Aim: *The major aim of this paper is to explore AutoML proposal for Model Compression which can leverage corroboration learning in a bid to offer the model compression strategy. Comparing the learning dedicated compression strategy with the ancient rule based one, its performance its far better and advanced in that it has a high compression ratio, accuracy and less human labor is required.*

Results: *Working under the 4 x FLOPs reduction, it was able to attain an accuracy level at 2.7 percent than the conventional compressional model. Also, it attained 1.81x speedup for the calculated inference latency on an android phone and a 1.43x speedup for the Titan XP CPU with a greater accuracy than the ancient techniques.*

Keywords: AutoML, Mobile vision, Model compression

1. Introduction

Evidently, if you observe keenly across most of the machine learning devices i.e. self-driving cars, robots, and advertisement ranking, the deep original network for mobile devices are inhibited by either energy, latency, and model size budget. A lot of the approaches which have been tabled out aims to enhance the hardware effectives and efficiency of the neutral networks by the model compression. The major component of the model compression skills aims to ascertain the compression procedure for every layer as they possess various redundancy requiring the one which are man-made heuristics and area expertise so as to be employed to be investigated for the great space exchange off among the speed,

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Novel Approach for Measuring Nutrition Values Using Smartphone

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Abstract Food is the source of energy, and it plays a vital role in human existence. The quality of food is suffering day by day such as adulteration and heavy use of various pesticides. The traditional approach to analyze food nutritional values involves the use of various sensors and laboratory procedures to detect the quality, but such sensors and methods really take lots of time. There is a need of a system which we can use to quickly evaluate the quality of food by methods which are ubiquitous. The number of handheld devices and their processing capabilities has increased manifolds over the last few years. In this paper, the novel methodology has been proposed which uses the smartphones to take the image, and instantly, it provides the nutrition value. The proposed model helps detect the nutritional quality of the food by utilizing the various sensors which are present in smartphones such as cameras and microphone. The model uses the classifiers to detect the type of food and process all the algorithms in cloud. Four datasets are used with multi-class level. Machine is trained with various algorithms such as CNN and RNN, and we have used transfer learning. The whole system is implemented successfully, and the accuracy of 82% has been achieved.

Keywords Statistics · Data mining · NLP · Object detection · Machine learning · DietCam

1 Introduction

As per the economist in 2016, more than 1.9 billion adults aged 18 years and older were overweight. Of these, over 650 million adults were obese [1]. Similarly, about 13% of the world's adult population (11% of men and 15% of women) were obese in 2016 [2]. Obesity increases the risk of various diseases and health conditions such

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TPR, PPV and ROC based Performance Measurement and Optimization of Human Face Recognition of IoT Enabled Physical Location Monitoring

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Abstract: This paper describes the construction of Internet of Things (IoT) enabled system which not only captures the sensors data in textual and numeric form but also performs live human face recognition to monitor physical location effectively. The dataset used in order to apply supervised machine learning algorithms is the combination of automatically captured live sensor data along with name of the human face recognized or unknown and additional manually introduced class label. Performance measurement of face recognition is done with the help of Decision Tree (DT), K-Nearest Neighbors (KNN), Naïve Bayes (NB) and Logistic Regression (LR). The results show that DT gives the best performance with respect to classifier's accuracy; True Positive Rate, Positive Predictive Value and area under curve of Receiver Operating Characteristics (ROC) for face recognition prediction whether the recognized face is true or false.

Index Terms: Machine Learning, Physical Location Monitoring, Confusion Matrix, ROC, Decision Tree, Naive Bayes, Logistic Regression, K-Nearest Neighbors.

I. INTRODUCTION

Internet of Things (IoT) is the one of the emerging and rapidly developing technology in the field of Information Technology and Communication Engineering. Lots of devices can be connected to each other with the help of IoT to communicate and exchange their information and data. In today's life, it is necessary to monitor the physical location with the help of IoT where numbers of different sensors are connected to single board computer. Analysis of physical location is required in order to identify any abnormal conditions in the environments like home locations, sensitive laboratories, hospitals, educational institute, industries etc. Abnormal conditions can be sudden increase or decrease in temperature and humidity, increase in intensity of light, increase in gas sensor values, unknown person's detection in the premises which in turn can cause severe damage to the location and surroundings. So it is essential task to capture sensor data continuously on regular intervals and perform statistical as well as systematic analysis of the same to create decision support system which is required to avoid further loss in the environment. IoT enabled system with multimedia data such as digital images of human faces are useful for face detection and recognition. Face recognition is useful in various scenarios such as intrusion detection, identifying the several actions such as switch ON/OFF various devices, identifying user's routine in the environment to know when user is at home and interacting with the devices and so on. Development of IoT enabled system with face recognition makes significant change in safety and security of premises. More robust and powerful system can be achieved with the help of IoT and face recognition. The objective of this paper is to present prescient scientific models for IoT enabled with face recognition system for monitoring physical location. Location considered here is the living room of a home and data is captured for one month continuously. The system employs four supervised machine learning predictive models with DT, KNN, NB and LR for analysis of human face recognition to find accuracies of applied classifiers, precision, recall and ROC curve and compare them.

II. RELATED WORK

Sankar Mukherjee et al. addressed an issue of meeting sensor connect with the Mobile Adhoc Network (MANET) organizes on the grounds that hubs have distinctive power levels, heterogeneous conventions and have odds of co-channel obstructions another design of IoT systems, where sensor systems and MANET are joined together for proficient correspondence with the Internet Gateways [1].

Neelesh Mishra et al. presented an overview of different congestion control calculations utilized at transport layer. IoT requires a vehicle layer convention which offers blockage control, adaptability and dependability as indicated by necessity of gadgets [2]. Dragos Mocrii et al. presented a survey of real advancements of IoT-based smart homes and current difficulties of brilliant home advances and their scattering, and indicate some interesting arrangements and future patterns [3]. Adel Alkhalil et al. recommended the usage of information provenance as an imperative instrument that can improve the security and protection of IoT frameworks and reviewed the most difficult issues in IoT information provenance. Seven issues have been talked about including provenance security, monstrous measure of information, ordering, different customers, change, question, and interoperability [4]. Nallapaneni Manoj Kumar et al. expounded the conceivable security and protection issues considering the segment cooperation in IoT and concentrates how the Distributed Ledger based Block Chain (DL-BC) innovation add to it [5].

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A Review Paper on Face Recognition Methodologies

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Abstract— **In the previous few years, the procedures of face recognition have been researched thoroughly. Well-versed reviews, for various human face recognition methodologies, are provided in this paper. Initially, we proffer a summary of face recognition with its application. Followed by a literature review of various face recognition techniques. Several face recognition algorithms are analyzed and elaborated with their limitations as well. It also includes brief overviews regarding various modern approaches like neural networks, line edge mapping, and many others, which are widely used nowadays to make the process of face recognition more efficient. Conclusively, the research results are reviewed and are summarized.**

I. INTRODUCTION

In various fields and disciplines, face recognition is traversing as a modern research problem. Generally, face recognition includes 2 steps, face detection, and face recognition. Face detection means catching or discovering a face in an image. Then it is followed by recognition which includes identifying or recognizing the detected face. To date, various effective approaches have been introduced. In [1], a conventional method for distinguishing faces is used i.e. Eigen faces. To collect different profiles int the form of curves, calculating their norm and differentiating other profiles based on the deviation from the norm, is what proposed by the author. This results in a vector with independent standards, and further, it can be compared with the other vectors. While in [2] the author proposes a more complex but effective approach. This approach is the combination of KFDA and nearest neighbor where one performs feature extraction and the other performs recognition. [4] Proposes the approach called Hidden Markov Model. In this approach, the hardware is also upgraded to achieve better results. The next methodology [6] is one of the most commonly used approaches in machine learning applications. The support vector machine is a simplistic, yet efficient machine learning model which can be used to classify profiles into multiple classes. In the next approach [9] author proposes the use of neural networks for face recognition. This approach uses various algorithms concurrently to obtain the best possible result.

II. LITERATURE REVIEW

In this section, we elaborate on different face recognition techniques by reviewing some of the works. The methodologies include Eigen faces, KFDA with Nearest Neighbor, Hidden Markov Model, SVM, and Neural Networks. The OCR architecture is broken down in following stages:

1. *Eigen Faces*

The Eigen face algorithm is the most commonly used approach when it comes to face recognition. In the Eigen face algorithm, the Eigen faces are the eigenvectors. These eigenvectors are derived from the covariance matrix of the dataset. Eigen faces are also sometimes referred to as ghostly images. The main reason for using the Eigen face approach is that it represents the input data efficiently. This is done by representing each face in terms of the linear combination of Eigen faces. To achieve this, a dimension reduction technique is required. Conventionally, the dimension reduction technique, which is used here, is Principal Component Analysis.

The author in this paper [1] is using face recognition to mark the attendance of the students in the class. So the author here [1] starts by elaborating what is Principal Component Analysis. The author states it used to examine face recognition issues by using it as a dimension reduction technique. It is also mentioned that is comprehended as Eigen face projection. The principal component analysis is used to reduce the dimension of the data and accurately decompose the face structure into orthogonal principal components which we know as 'Eigen faces'. In simple words, PCA is used to remove information that is not useful to generate Eigen faces. Moreover, PCA gives a suitable representation for the face space which otherwise forms a cluster.

Furthermore, it is also stated that PCA has major applications in various fields, such as image analysis, identifying anonymous faces, and dimensional data reduction. A comparison of test images, with training images, is done by

ADHYAYAN—An Innovative Interest Finder and Career Guidance Application

Akshay Talke, Virendra Patil, Sanyam Raj, Rohit Kr. Singh, Ameya Jawalgekar and Anand Bhosale

Abstract ADHYAYAN is an innovative mobile application which determines a user's interest in a particular domain and nurtures them effectively so that they can pursue career in the field which they are interested in. The system takes into account social media posts, results of a test and application activity to find out the interest of users in different fields and then assists, guides and evaluates them continuously to improve their skills in these fields. ADHYAYAN is a three-tier system which consists of a front-end, middle layer, and back-end. Front-end is an Android application which provides personalized GUI for each user. Middle layer is Firebase, while back-end is a server hosted on 'Google Cloud Platform'. An algorithm has been developed for ADHYAYAN which calculates the ratio of user's interest in different domains and eventually feeds are generated in the same ratio on user's profile. To cater the increasing need of skilled employees in different fields and promote interest-based learning, ADHYAYAN has been proposed to overcome various limitations and drawbacks of existing solutions.

Keywords Unemployability · Social media · Continuous evaluation · Test · Feeds · Profile · Skills · Career · Short term profile · Long term profile · Personalized · Real-time

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Aspect Category Extraction for Sentiment Analysis using Multivariate Filter Method of Feature Selection

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Abstract: Aspect-oriented sentiment analysis is done in two phases like aspect term identification from review and determining related opinion. To carry out this analysis, features play an important role to determine the accuracy of the model. Feature extraction and feature selection techniques contribute to increase the classification accuracy. Feature selection strategies reduce computation time, improve prediction performance, and provides a higher understanding of the information in machine learning and pattern recognition applications etc. This work specifically focuses on aspect extraction from restaurant review dataset but can also be used for other datasets. In this system, we proposed a multivariate filter strategy of feature selection which works on lemma features. This method helps to select relevant features and avoid redundant ones. Initially, the extracted features undergo preprocessing and then the "term-frequency matrix" is generated which contains the occurrence count of features with respect to aspect category. In the next phase, different feature selection strategies are applied which includes selecting features based on correlation, weighted term frequency and weighted term frequency with the correlation coefficient. The performance of weighted term frequency with correlation coefficient approach is compared with the existing system and shows significant improvement in F1 score.

Keywords: Aspect-Based Sentiment Analysis (ABSA), Natural Language Processing(NLP), Machine Learning (ML), feature selection, correlation coefficient, Term Frequency-Inverse Document Frequency (TF-IDF).

I. INTRODUCTION

Due to the quick expansion of the social networking sites, people post their opinions freely. The growth of internet technologies led to increase in online shopping and posting reviews about the products. This helps customers to compare multiple products and gives them further options to choose from. It is a difficult task to analyze products by overall comparison and hence the need to compare products. Comparison can be done on the basis of aspects. ABSA has become a research interest and a challenging task for the researchers. ABSA includes different subtasks namely aspect

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term identification, opinion target extraction and corresponding sentiment determination. The sentiment classification is done at three levels like aspect level, sentence level and document level.

Following is the example from a restaurant review dataset. Restaurant reviews can have major aspect categories as price, ambiance, food, service, etc. So instead of determining overall review sentiment, it is useful to extract the aspect from review and then determine sentiment for that aspect. In the following example, sentence 1 denotes food aspect category and sentence 2 shows price and food aspect categories.

- "The food was great."
- "The food was pricey and not too tasty."

The aspect categories may be explicit or implicit. In sentence 2, price aspect is explicit but the food aspect is implicit.

The focus of this work is to extract aspect categories from review sentences. Hence, this is a text categorization problem. This system is trained and tested using SemEval 2014 restaurant review dataset. The reviews in the given dataset had 5 aspect categories like food, ambiance, price, service and miscellaneous. When enough review data is available and aspect categories are defined, then supervised algorithms can be used to forecast the aspect categories. The accuracy of the supervised algorithms is reliant on the quality of the features extracted and selected. We proposed a multivariate filter method of feature assortment to reduce the dimensionality of feature space.

Existing feature selection methods are classified to major classes like wrapper, filter, and hybrid. In the wrapper approach, at first different feature subsets are selected and then the feature sets are evaluated using the selected classifier. In a filter-based approach, the selection of features is not reliant on any machine learning algorithm. In this, features are preferred on the basis of their numerical weight [9], [12]. The hybrid approach is the union of the above two approaches. Filter method is further divided into two parts namely univariate and multivariate approach. In univariate filter method, features are evaluated with respect to relevance and in the multivariate approach, the correlation between features is calculated and redundant features are avoided. We are proposing a multivariate filter approach which selects relevant features and avoids redundant ones. The paper catalogueis as below. Section II is related work, the proposed system is described in section III, section IV shows the results of experimentation and section V contains the conclusion followed by the future scope.

Statistical Analysis of Accelerometer,Gyroscope with State Estimation

Ashvini Kulkarni, Augusta Sophy Beulet P.

Abstract: This paper describes the tracking of the object with the utility of a three-axis accelerometer and gyroscope for navigation. The sensor fusion is receiving enormous research interest which is used in monitoring and tracking position. For dynamic modeling, for real-time data, the perceptual mixing of the signals is required. For proper mixing of the signals, sensor fusion techniques are used. This paper presents the comparative review analysis for the three-axis accelerometer and gyroscope for linear acceleration and angular rotation.

Keywords: IMU, Kalman Filter, Sensor fusion

I.   INTRODUCTION

Navigation is the process of monitoring and controlling object position. This navigation is undergoing with various techniques and methods over these years, viz. compass, coastal navigation, dead reckoning, charts. Over these methods, the most popular method for navigation is preferred as GPS (Global Positioning System) nowadays. This is a preferred method to assist in knowing object location in computers and mobile phones. The problem with GPS is signal degradation particularly caused in the environment, loss of the signal because of the obstacles, trilateration to know the exact point of intersecting derived by the satellite signals and inaccurate signal due to the multipath [1].

Un'   ...ately GPS for navigation needs the clear sky to receive signals even though with more precise GPS signals in clear sky, signals are prone to errors. Thus some sort of filtration is required to provide navigation with certain conditions of the environment so that GPS receiver signals should not get affected by environmental conditions. It is required for GPS receiver signals to be noise-free, to get the exact position of the object. The presence of noise in received signals from GPS satellites may affect its position and it becomes difficult to maintain track of these objects in surveillance. Continual reception of noise-free signals is more important for navigation under such applications [2],[3]. To overcome the limitation of an inaccurate position of any object in GPS based navigation, DGPS (Differential Global Positioning) is promoted.

DGPS is mentioned to give location accuracy based on a ground-based reference station to calculate the difference between the actual position and the position received by GPS satellite [3] [4].

These base station roles are to broadcast the internal pseudo-range and actual pseudo-range and calculate the difference between two ranges and transmit through ground-based stations [5]. In order to support GPS the time based synchronization has to be taken for consideration of traffic with timely stability [6]. With respect to the time based synchronization, pseudo-range is one more factor for calculating the distance between the satellites. The navigation receivers among which determines the distances from them for calculating pos'ion along with Non-linear least squares method to identify position with the clock bias [7].To aid in navigation for the GPS signal to bear with erroneous signal, inertial navigation systems are taken into lead the navigation [8].

Vision-based approach is an approach for navigation which is gaining numerous interest in the field of navigation [9],[10].

In addition to these methods, another approach for navigation is MEMS (Micro Electro Mechanical System) based [11]. These sensors provide position through the accelerometer and gyroscope. These sensors acquire acceleration and the rotational movements of object position. Such signals from the sensors are prone to drift error, sampling error, etc. The three-axis accelerometers measure the inertial forces on the three axes. Similarly, each gyroscope measures the rotation in each axis. Accelerometer and gyroscope are the most widely used sensors for navigation. These sensors deliver velocity and angular rate information around the axis. Through this type of information the exact location of an object can be obtained. Visual monitoring and tracking, security, surveillance are some of the applications of navigation. There are various techniques implemented with high-end precision in navigation with state estimation recursive algorithm. This paper presents the analysis of the various methods for detecting acceleration and angular position of an object with a different approach for knowing its position in navigation applications.

The paper is organized as follows. Section II describes the basic formulation of a three-axis accelerometer and its implementation and describes three-axis gyroscopes for measurement of rotation around axes. Section III consists of accelerometer and gyroscope testing on the Kalman filter.

All the results are discussed in section IV followed by a conclusion and future work is discussed in section V.

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RADIATIVE PROPERTIES OF AEROSOL MIXTURES OBSERVED OVER ARID AND ISLAND AERONET STATION

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Abstract

We have examined multiyear observational data at the AERosol RObotic NETwork (AERONET) sites at Jaipur (26.90° N, 75.80° E), and Hanimaadhoo (6.74° N, 73.17° E), were utilized to study the climatological characteristics of aerosol radiative properties. Both sides shows linear fall in SSA against FMF suggests aprobable combination of a linear mixture of fine and coarse aerosol components. Under clear sky conditions, change in the sign of radiative forcing from negative (cooling) to positive (warming) occurs at SSA about 0.85, while in the presence of clouds it can occur even at higher SSA due to the semi-direct effect. A change of 0.07 in SSA is shown to produce a 21% change in radiative flux at the top of the tropopause over the ocean at constant aerosol optical depth. The refractive index (RI) is one of the important optical parameters providing information relating to the nature of aerosols and is highly dependent on the chemical composition of the aerosols. Values of RI give an indication of highly scattering (real RI) or highly absorbing (imaginary RI) aerosol types.

Keywords: AEROSOL RADIATIVE FORCING, SINGLE SCATTERING ALBEDO, REFRACTIVE INDEX, HEATING RATES.

INTRODUCTION

Aerosols participate in the Earth's energy budget "directly" by scattering and absorbing radiation and "indirectly" by acting as cloud condensationnuclei and, thereby, affecting cloud properties [1]. Moreover, the direct absorption of radiant energy by aerosols can influence the atmospheric temperature structure and, thereby, cloud formation - a phenomenon that has been labelled the "semi-direct effect" [2]. The indirect effect of aerosols on weather and climate system takes place through the modification of cloud optical and microphysical properties [3]. A large number of studies have found that the anthropogenic aerosols change clouds and their optical properties [4, 5, 6]. Atmospheric aerosols change the concentration and size of the cloud droplets which in turn lead to a change in cloud albedo, its lifetime and thereby affect the precipitation [3, 7]. The picture of aerosols is more complex due to their large spatio – temporal ambiguity, diversity in the atmosphere associated life span [8, 9, 10, 11]. The addition of anthropogenic aerosols to the atmosphere may change the radiative fluxes at the top-of-atmosphere (TOA), at the surface, and within the atmospheric column. A positive radiative effect at the TOA indicates the addition of the energy to the earth-atmosphere system (i.e., a warming effect) whereas a negative effect indicates a net loss of energy (i.e., a cooling effect).The aerosol single scattering albedo (SSA), the ratio of scattering to extinction

Recent Trends in Power Quality Improvement and Demand Side Load Management in Smart Grids

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Abstract - - The growing consumer demand on electrical energy sources every day and the aging transmission and distribution power grid infrastructure is causing new challenges for electrical engineers. In recent years, the focus of power system engineers and consumers has been shifted to "power quality" due to increased usage of voltage sensitive equipment such as computers, servers, network infrastructure and precision electronic manufacturing equipment by consumers. The variations in bus voltage mainly occur due to electromagnetic transients, harmonic distortion, voltage sag, voltage swell and flicker due to switching of large capacitor banks in power grid. In addition, recently there have been numerous small to mid-size installations of renewable energy sources such as solar photovoltaic (PV) systems and wind power generation which are connected to the grid at the distribution side. The nature of these renewable energy sources is that they produce intermittent power generation based on solar and wind energy availability and their high penetration poses problems of voltage and frequency instability in the grid.

Another cause of poor power quality is that load demand is not predictable and consumption or daily behaviour of load patterns is not known, hence there is difficulty in matching the demand and supply of power. Demand side management helps energy providers to reduce the peak load demand and adjust the load profile to a certain extent. In this paper, several latest publications related to the improvement of power quality such as passive and active filters, Active Power Line Conditioning (APLC), static VAR compensation, electric spring and smart loads are reviewed. Also various methods of demand side management such as estimation of load patterns, peak clipping, valley filling, intelligent load switching, electric spring and smart loads for reducing the peak demand on utilities are discussed. Proposed work in this area includes development of new topologies and control methodologies of electric spring to get fast response to the changing load and maintain grid stability. Another area of proposed work includes development of algorithms for accurate estimation of demand load patterns so as to reduce the peak load demand on the system.

Keywords - - Smart grid, Electric spring, Active Power Line Conditioning (APLC), Smart loads, ICT

I. Introduction

In recent years, consumers are paying more attention to power quality due to increased usage of voltage sensitive equipment such as computers, power electronic motor drives, inverters and network infrastructure such as servers, routers, modems etc. Any power line interruption, frequency variation, transient noise can permanently damage the electronic equipment at the consumer end. If the consumer equipment is damaged, it can be concluded that power quality problem exists and it needs to be addressed immediately as the consumers can lose their business competitiveness and incur financial losses. [4].

The generation of power is distributed these days with small to mid-size installations of renewable energy sources such as solar photovoltaic (PV) systems and wind power generation systems at the distribution side. The nature of these renewable energy sources is that they produce intermittent power generation based on solar and wind energy availability during the day and their high penetration in utility grids is posing problems of voltage and frequency instability. Due to distributed nature of renewable energy sources, fast response to the user demand needs to be achieved in efficient manner and it is required to balance the demand and supply patterns more closely in order to maintain power and frequency stability and also to reduce voltage imbalance.

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