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Various ICIC Schemes

Techniques in High Mobility

Highlights

An Estimation Technique

Simulation of the Stochastic

Discovering Thoughts, Inventing Future

VOLUME 15 ISSUE 7 VERSION 1.0

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Anti-Islanding Strategy for a PV Power Plant

By Esam Zaki, Dalal Helmy & Fahmi Bendari
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Abstract- In this paper: a new strategy of anti-islanding photovoltaic (PV) power plant has been introduced. A new islanding detection strategy depending on power line signaling and control by inverter and numerical relays proposed in the literature. By generating, detecting and comparing between signals on the distribution feeders from the substation to the down-stream *Distributed Generation* (DG), the subtraction value of two signals at the DG site will be indicator for islanding. The scheme is a remote effective detection technique and more expensive than other techniques. The strategy depends on the embedded system containing the power line signaling and both PV inverters and Numerical(microprocessor based) relays. Inverter technology and control have been discussed.

Keywords: anti-islanding, distributed generation, numerical relays, photovoltaic.

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ANTI-ISLANDINGSTRATEGYFORAPVPOWERPLANT

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Anti-Islanding Strategy for a PV Power Plant

Esam Zaki [α], Dalal Helmy [σ] & Fahmi Bendari [ρ]

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Keywords: anti-islanding, distributed generation, numerical relays, photovoltaic.

I. Introduction

The condition of "Islanding" in Distributed Generators (DG) is an electrical phenomenon that occurs when the energy supplied by the power grid is interrupted due to various factors and DG continues energizing some or the entire load. Thus, the power grid stops controlling this isolated part of the distribution system, which contains both loads and generators [1]. Islanding should be anticipated in DG as the grid cannot control the voltage applied to the loads in islanding conditions and uncontrolled reconnection in an isolated DG can damage the generation equipment or hazard workers on grid users, because a line that is supposedly disconnected from any power source can remain active. Islanding detection techniques are explained briefly in [2].

A photovoltaic model has been produced in [3]. A remote technique for islanding detection is chosen. Our problem here is how to face this phenomenon. Firstly by detecting it and then control it. Our strategy here to make a system depending on numerical relays which have lower cost and less panel space besides PV inverter to control this phenomenon.

Numerical relays and different types of relays have been introduced in [4]. Power line signaling which is a reliable detection technique has been discussed in [5]. Inverter usage and control concept is explained in [6].

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II. Power line Signaling for Islanding Detection

This scheme consists of two devices, a signal generator (SG) and a signal detector (SD). In regular the SG is placed at the substation bus. In case of islanding conditions, opening of switching devices between SG and SD or substation outage, the down-stream DG units will trip. Furthermore, the SG can have auxiliary inputs which give flexibility to the system operators when they need the DGs to be shut down. As the signal carrier is the power line itself, the formation of an island can be detected automatically . Fig.1 illustrates the scheme.

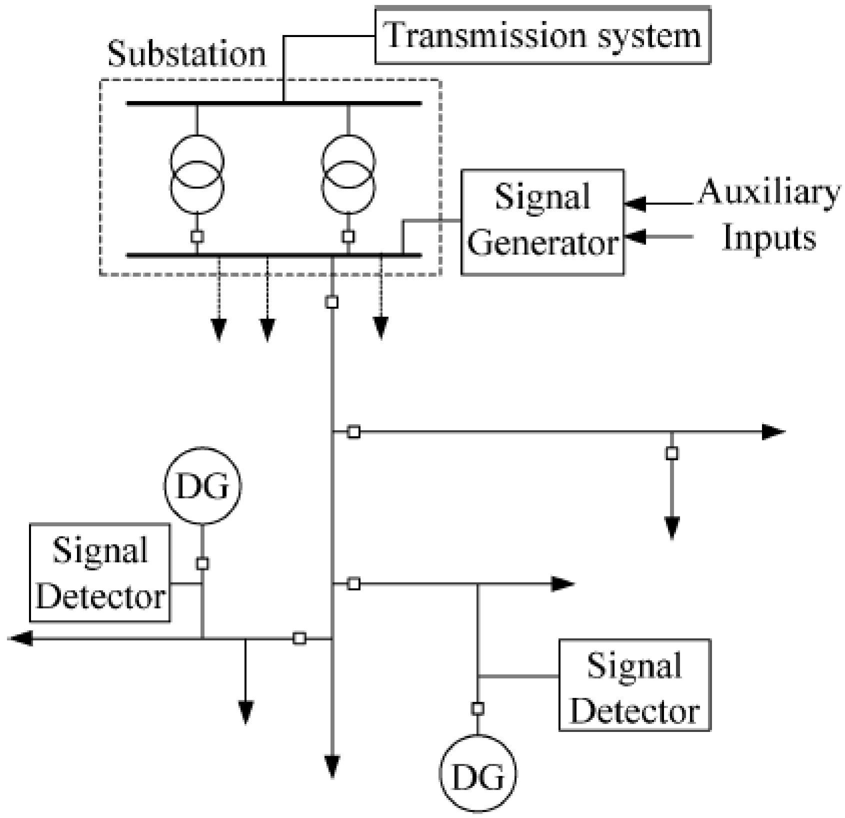

Figure 1 : Illustration for the proposed anti-islanding scheme

Checking the presence of the broadcast signal at the signal detector position is the key to the islanding protection. The detection process includes signal extraction and a subsequent signal processing method. A phase to ground channel (B-G) is selected as the detection channel. In order to extract the signal from this voltage waveform, subtraction of two consecutive cycles is used . Mathematically we can describe this subtraction by:

$$v_{signal}(t) = V_B(t) - V_B(t-T) \tag{1}$$

Where T is the period of fundamental frequency, 60 Hz, waveform. For the dc component, the first harmonic and the other integer harmonics (for which, T will be an integer multiple of their own period) the previous equation will become:

$$a_h sin(h\omega(t)) - a_h sin(h\omega(t-T)) = 0 \tag{2}$$

Figure(2) shows Subtraction pattern for signal extraction. According to this figure, subtraction results in two cycles for every four cycles of the detection channel voltage. For details we can change t-domain to f-domain and have a model comparing between cycles as mentioned in[5]. For disturbances in this model which affects the signal performance, we can deal that by system grounding and system disturbance analysis.

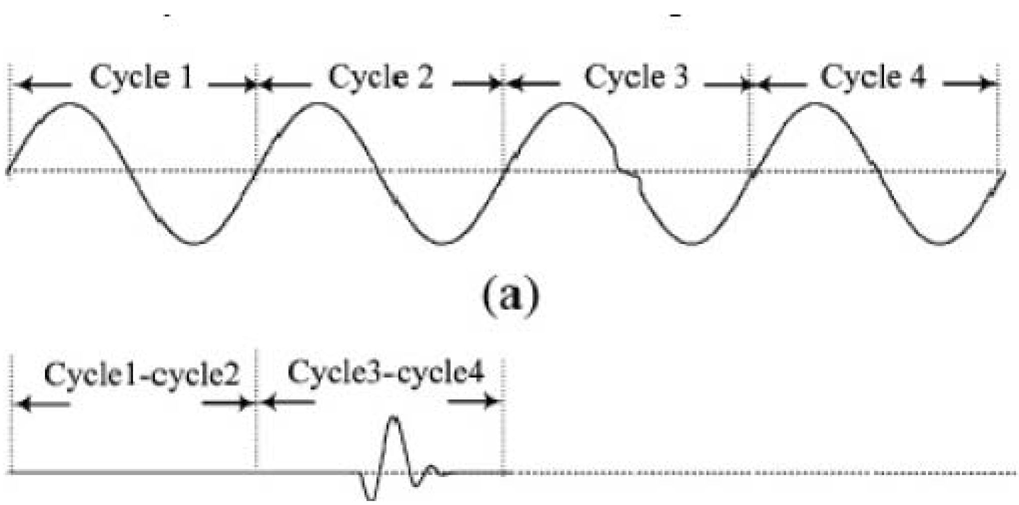

Figure 2 : Subtraction Pattern for signal Extraction

III. Numerical Relays

Numerical relays has benefited many years of successful implementation of electromechanical and static relays. We can replace existing electromechanical distance relays by numerical ones partially and economically. A total of fourteen electromechanical relays will be removed of which six distance relays (3 for phase and 3 for ground) and the remaining devices are timers and auxiliary relays [4].

IV. Inverter Specifications

An inverter used in grid connected PV systems must satisfy some specifications, which are given by national and international standards. The specifications for the PV module to the inverter, and the inverter enhanced with grid are presented.

a) *Ambient Temperature*

The PV cell temperature can reach 78 °C on sunny day (irradiance: 1200 W/m2 and ambient temperature: 40 °C). Thus, if the inverter is to be mounted on the rear side of the PV module, it has to withstand a temperature of almost 80 °C.

b) *Life Time and Reliability*

The inverter should be maintenance-free during the AC-Module's lifetime. This is desirable while the AC-Module is intended to be a 'plug and play' device, which can be operated by persons without specialized training. The inverter lifetime is then directly specified according to the lifetime of the included PV module.

c) *Personal safety*

Some countries require a transformer between the inverter and the grid if a DC monitoring device is not included. Other countries demands HPFI-relay (High-Sensitive, Pulsing direct current, earth Fault circuit breaker), if the transformer is omitted. System ground is required in some countries if the open circuit PV module exceeds 50 V.

System ground is not required for the developed inverter, since the inverter is designed to maximum 50V open circuit voltage, c.f. section 3.2.3. Thus, galvanic isolation is not required between the PV module and the grid, when personal safety is the issue.

d) *PV Module Interface*

Nominal power, starting power, maximum open-circuit voltage, maximum power point tracking, maximum short circuit current, input ripple and over voltage protection must be taken into consideration when setting up the specifications of PV module interface. Also inverter grid interface issues such as voltage, maximum power, standby losses, DC current, frequency, current harmonics, inrush current and grounding have been considered [6].

e) *Description of Inverter Performance*

A primary objective of this work is to develop an inverter performance model applicable to all commercial inverters used in photovoltaic power systems, providing a versatile numerical algorithm that accurately relates the inverter's ac-power output to the dc-power input. The model developed requires a set of measured performance parameters (coefficients). The complexity and the accuracy of the performance model are "progressive" in the sense that the accuracy of the model can be improved in steps, as more detailed test data are available. Manufacturers' specification sheets provide initial performance parameters, field measurements during system operation provide additional parameters and accuracy, and detailed performance measurements as conducted by recognized testing laboratories [7] provide further refinement of parameters used in the model.

f) *Inverter Choice Selection*

For a PV power plant design, the choice of the inverter depends on more factors and national standards. Currently the main standards which govern

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inverters in the IEEE 1547 "Standard for Interconnecting Distributed Resources with Electric Power Systems" and UL 1741 "Standard for Safety for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources." IEEE 1547 establishes criteria and requirements for interconnection of DER with electric power systems [3].

A good inverter must have a system for detecting ground fault errors in the PV array and has an active safely algorithm to protect against islanding phenomenon. Such inverter detects the grid voltage that it must feed in automatically depending on the voltage and the phase angle between L1-N and L2-N, the inverter determines whether a wrong grid voltage is detected giving an error message.

V. ISLANDING MODELLING

Depending on matlab/Simulink model and pss/e program, and referring to model in [5], figures (3,4,5,6) show the behavior of voltage, frequency, active power and reactive power during tripping and a PV power plant became islanded.

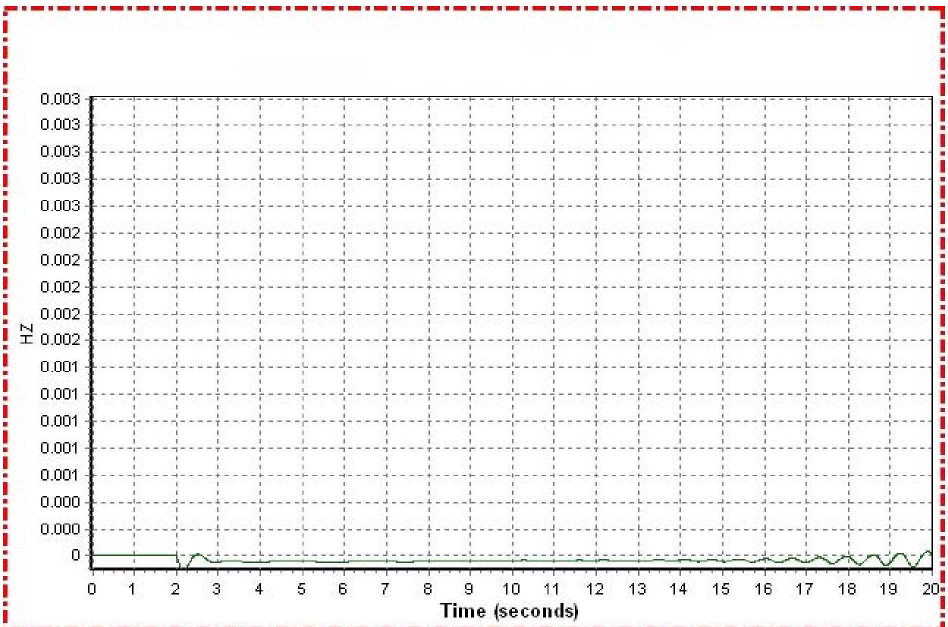

Figure 3 : Frequency during tripping

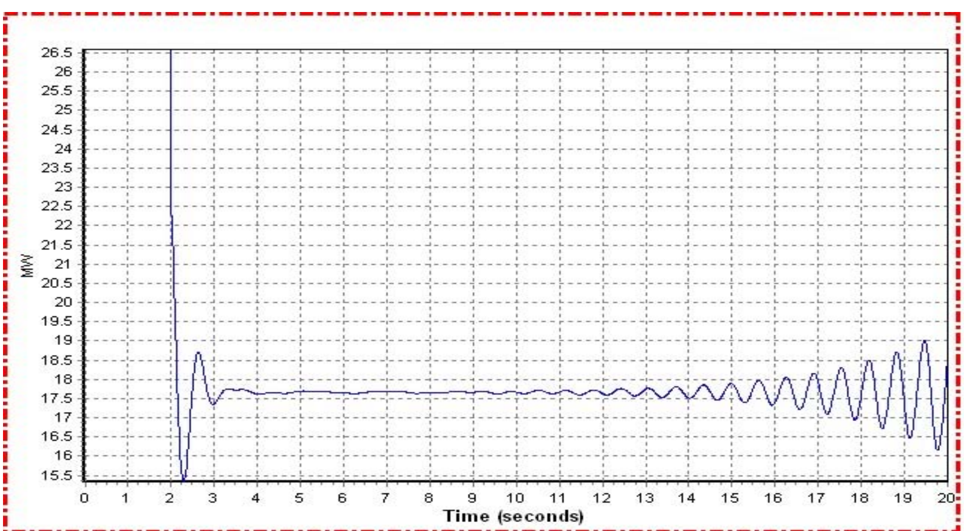

Figure 4 : Active power during tripping

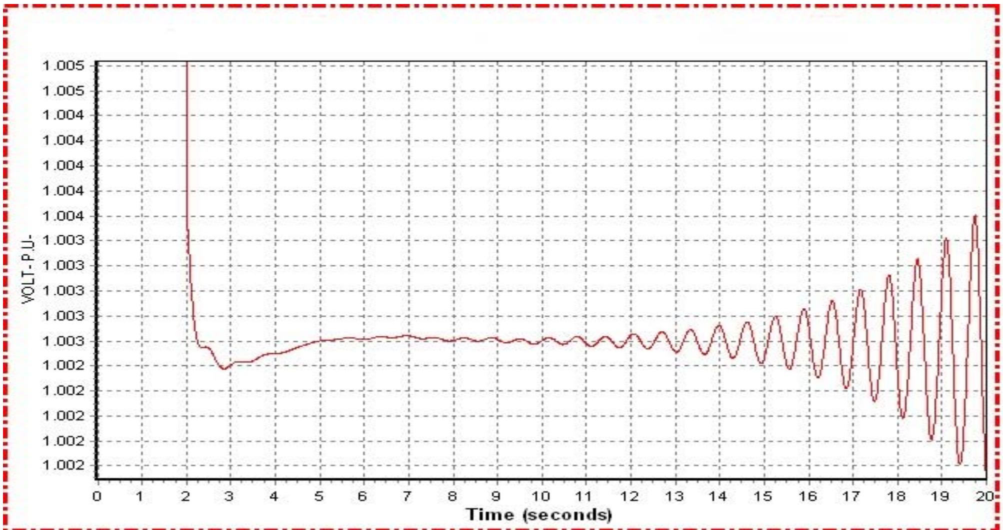

Figure 5 : Voltage during tripping

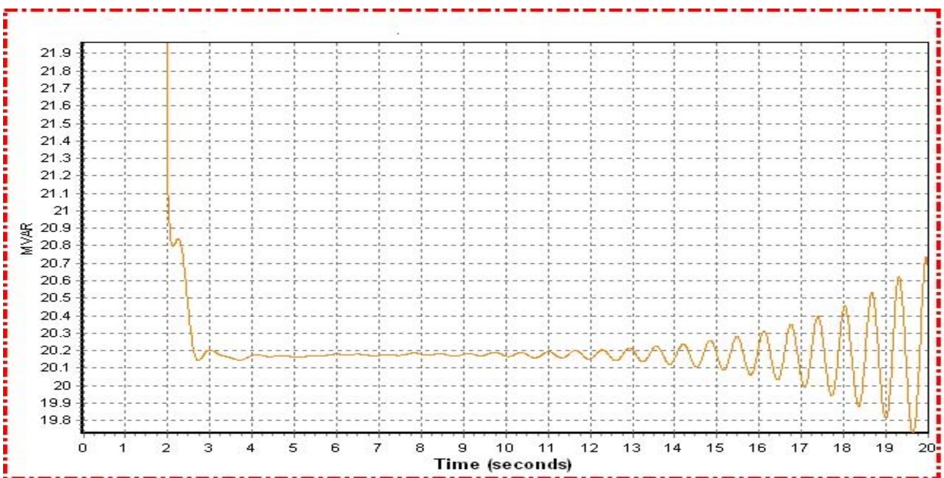

Figure 6 : Reactive power during tripping

From the previous figures, it is clear that there are some oscillations and due to inverter, the system was able to be stable again.

VI. Conclusion

To control islanding phenomenon and making the system protection adaptive and more stable, the strategy depends on three effective elements depending on embedded systems in their construction, which making them adaptive and gives the system stability enough to face islanding phenomenon. These elements are:

1. Remote islanding detection technique depending on power line signaling.
2. Adaptive relays, especially numerical relays which have their own settings, characteristics and logic functions. These functions changed on line a timely manner by means of externally signals or control action.
3. PV inverters : which have a main effect for stabilizing the isolated PV power plant which is out of control of utility grid.

Using a software package and by addressing each element in power system utility, we can monitor and control the system easy.

VII. Recommendations

In order to achieve a high performance PV power plant, automatic data acquisition and monitoring technology is essential. This allows the plant to be monitored and faults can then be detected and rectified before they have an appreciable effect on production.

Some recommendations must be taken into consideration to get a good strategy facing islanding phenomenon as follow:

- Backup system for inverters to control the system long time as possible.

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- Coding and addressing of all system elements, and by a package of software, controlling the system could be easy.
- Using two inverters, especially in radial systems meeting the non detection zones in case of islanding occurrence.
- Replacing electromechanical relays by numerical relays makes control easier.

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A Comprehensive Survey on Various ICIC Schemes and Proposed 3G RF Interference Mitigation Techniques for OFDM Downlink on Cellular Networks

By Walid M. Raafat

Introduction- The demand for cellular communication services is expected to continue its rapid growth in the next decade, fuelled by new applications such as mobile web-browsing, video downloading, on-line gaming, and social networking. The commercial deployment of 3G. Cellular network technologies began with 3GPP UMTS/WCDMA in 2001 and has evolved into current UMTS/HSPA networks. To maintain the competitiveness of 3GPP UMTS networks, a well-planned and graceful evolution to 4G networks is considered essential [1]. LTE is an important step in this evolution, with technology demonstrations beginning in 2006. Commercial LTE network services started in Scandinavia in December

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2009 and it is expected that carriers worldwide will shortly be starting their upgrades. The main design goals behind LTE are higher user bit rates, lower delays, increased spectrum efficiency, reduced cost, and operational simplicity [2]. The first version of LTE, 3GPP Release 8, lists the following requirements:

(1) Peak rates of 100 Mbps (downlink) and 50Mbps (uplink); increased cell-edge bit rates.

(2) A radio-access network latency of less than 10ms.

(3) Two to four times the spectrum efficiency of 3GPP Release 6 (WCDMA/HSPA).

(4) Support of scalable bandwidths: 1.25, 2.5, 5, 10,15, and 20MHz; support for FDD and TDD modes; smooth operation with and economically viable transition from existing networks. In order to meet these demanding requirements, LTE makes use of multi-antenna techniques and inter-cell interference coordination.

A survey of radio resource scheduling and interference mitigation in LTE. Both are widely recognized as areas which can greatly affect the performance and spectrum efficiency of an LTE network. Inter Cell Interference (ICI) still poses a real challenge that limits the OFDMA system performance, especially for users located at the cell edge. A common Inter Cell Interference Coordination (ICIC) technique is interference avoidance in which the allocation of the various system resources (e.g., time, frequency, and power) to users is controlled to ensure that the ICI remains within acceptable limits. This section present surveys various ICIC avoidance schemes in the downlink of OFDMA based cellular networks and makes use of these classifications to categorize and review various static (frequency reuse (FR)-based) and dynamic (cell coordination-based) ICIC schemes.

A comprehensive survey that investigate such wide range in the area of ICIC as an attempt to resolve ambiguity by providing precise classification in the research community is also presented. For next generation of mobile communication systems; LTE is being standardized by the 3rd Generation Partnership Project (3GPP) ISO; some proposed 3G RF interference mitigation techniques is provided. The trend toward LTE commercial launch in Heterogeneous Network (HetNet) environment and the future plan for LTE - Advanced new releases is highlighted [1].

The next generation wireless systems are proposed for Intelligent Transportation System (ITS) and the applications of proposed ITS are intended to use for wideband digital communications such as: broadband wireless internet access digital television, audio broadcasting, and video conferencing, real-time video security, communication for high speed trains. One of the techniques which are proposed for new generation in wireless communication system is OFDM; which is used to transmit data over extremely hostile channel at a comparable low complexity with high data rates. Next generation cellular systems promise significantly higher cell throughput and improved spectral efficiency as compared to existing systems such as GSM, EDGE, and High Speed Packet Access R.7 (HSPA+). For example, system performance requirements for the 3GPP, LTE of UMTS and LTE-A target significant improvements in cell edge spectral efficiency and peak transmission rates that can reach, respectively, 0.04-0.06 bps/Hz/cell, 100 Mbps and beyond [2].

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In order to achieve these targets, dense frequency reuse of the scarce radio spectrum allocated to the system is needed. Efficient use of radio spectrum is also important from a cost of service point of view, where the number of served users is an important factor. However, as the frequency reuse increases, so does the interference caused by other users using the same channels. Therefore, interference becomes a decisive factor that limits the system capacity, and hence, the suppression of such interference becomes of a particular importance to the design of next generations cellular networks.

II. Problem Statement

As a result of several researches has been published, there is no existence to a comprehensive survey that investigates to the wide range of ICIC avoidance schemes. Moreover, there have been several confusions between the various ICI schemes; either in their naming conventions or their operational principles due to the large number of published work in this area. For example: some published work uses the notion of "Partial Frequency Reuse (PFR)" [2] while others use "Fractional Frequency Reuse with full isolation (FFR-FI)" [3] to refer to the same scheme. Also some published work refers to the well known "Reuse-3" scheme as "Hard frequency reuse" [3], the notion of "Soft Frequency Reuse (SFR)" was originally proposed in [2] with a particular definition, whereas in [4] a different scheme was introduced with the same name of "Software Frequency Reuse (SFR)". This raises the need to present a comprehensive coverage of this fast moving field. Also, wireless communications and mobile computing provides the research and development communities working in academic tele-communications and networking industries with a forum for sharing research and ideas. On the other hand, the 3G RF interference in HetNet environment as in Fig.1 and its mitigation techniques used become a hot research area now for multi-cell interference avoidance in OFDMA systems as no recent new techniques were proposed. The Small cells, Pico cells and femto cells represent a promising solution to enhance network performance with a pervasive coverage at low cost and energy consumption. Small cells stand for small size cells that can be deployed in indoor or outdoor environments and are based on existing or emerging cellular wireless network standards (such as WiMAX, UMTS and LTE). The convergence of wireless communications and mobile computing is bringing together two areas of immense growth and innovation.

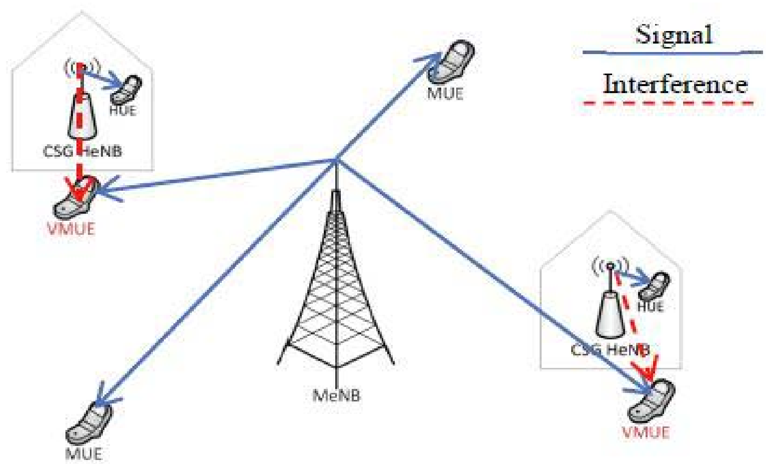


Figure 1 : HetNet Environment

III. Previous and Related Work

In this section, a brief review on the main previous survey published researches related to the interference avoidance schemes. In ref. [3] a performance of a Turbo coded OFDM wireless link is evaluated in the presence of Rayleigh fading for SISO, SIMO, MISO and MIMO system. Data are encoded using turbo encoder then modulated by QPSK or 16 QAM or 64 QAM and further encoded using STBC, and the encoded data are split into "n" streams which are modulated by OFDM and simultaneously transmitted using "n" transmit antennas and the results showed the coded MIMO-OFDM has a significant difference over un-coded schemes, in ref. [4], the channel allocation schemes has been classified to three categories: Fixed Channel Allocation (FCA), Dynamic Channel Allocation (DCA) and Hybrid Channel Allocation (HCA).

A summary of the three categories descriptions of channel allocation schemes are:

FCA: A set of nominal channels are permanently allocated to each cell for its exclusive use. Where channels can be allocated to cells either uniformly (equal shares) or non-uniformly (based on expected traffic loads) with the option of allowing cells to borrow channels from one another.

DCA: A set of nominal channels are permanently allocated to each cell for its exclusive use. Where channels can be allocated to cells either uniformly (equal shares) or non-uniformly (based on expected traffic loads) with the option of allowing cells to borrow channels from one another.

HCA: Presents a mixture between FCA and DCA where the total number of channels available is divided into fixed and dynamic sets. The fixed set is assigned as in the FCA schemes while the dynamic set is shared by all cells.

While in ref. [4] four categories are proposed for interference avoidance schemes based on how much it adapts the network to Static Schemes (SS), Low Level Dynamic Schemes (LLDS), Intermediate Level Dynamic Schemes (ILDS) and High Level Dynamic Schemes (HLDS). The results showed that as the degrees of freedom increases the total throughput and 10% throughput increase. A summary of the different categories between interference avoidance schemes.

SS: The best values for the different parameters (power ratio allocated to each user class, number of sub-bands allocated to each user class, frequency allocated to each cell) are determined based on full traffic load scenarios and then these values are kept fixed.

LLDS: As the best values for the different parameters may not always be "best" with different traffic loads, several pre-planned sets of best values for the different traffic loads and varied distributions of users. Given that BSs can know the total number of user and there are reliable and efficient connections between BSs, a scheme can switch based on the traffic load between two or more sets of best values each optimized for a certain traffic load.

ILDS: Given the serving user's quantity in each cell and locations of users in its own cell data available to the BSs, BSs calculates the best values for the different parameters to escape the limitation of using one of the pre-planned best value sets in LLDS.

HLDS: Require the availability of the channel condition information. It works similarly to ILDS to calculate the best values for power ratio, the sub-band number and allocation of frequency but it also calculates the number of sub-channel to be allocated to each user based on its channel condition.

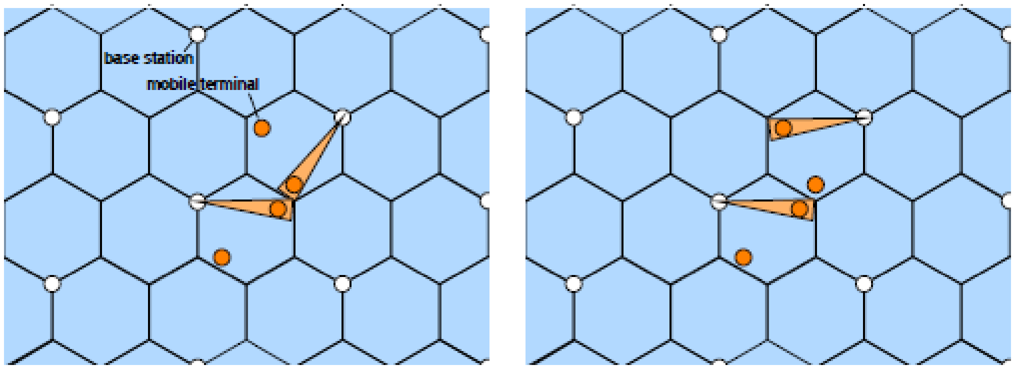
In ref. [5], a survey on resource allocation algorithm for downlink of multi-user OFDM system is presented, however a single cell was assumed, thus ICI and ICIC for the downlink were not discussed.

In DCA and based on information used for channel assignment, DCA schemes can be classified either as call-by-call (use only current channel usage conditions) or adaptive (use previous as well as current channel usage conditions), while based on the type of control employed, schemes can be classified either as centralized (a centralized controller assigns channels to users) or distributed (base stations assigns channels to users). Distributed DCA schemes can be either cell based (base stations use local information collected from users and the exchanged information from other base stations) or adaptive (base stations rely only on the signal strength measurements collected locally from its users). Although many claims have been made about the relative performance of each DCA scheme to one or more alternative schemes, the trade-off and their range of achievable capacity gains are still unclear, and questions remain unanswered: How does each dynamic scheme produce its gain? What are the basic trades-off? Why do some schemes work only under certain traffic patterns? Can different schemes be combined? What is the value of additional status information of the nearby cells? What is the best possible use of the bandwidth [2].

IV. Proposed System Model Interference Coordination in Spatial Domain

The channel throughput is determined based on the used Modulation and Coding Scheme (MCS) for a channel (selected based on the Channel Quality Indicator (CQI) reported from the user) as a method for computing and transmitting channel quality information in a multi-carrier communications system which is mapped to the Transport Block Size (TBS) that can be used by using the mapping tables, in a method to perform link adaptation at the radio interfaces. Since different users perceive different channel qualities, a "bad" channel (due to deep fading and narrowband interference) for one user may still be favorable to other users. Thus, OFDMA exploits the multi-user diversity by avoiding assigning "bad" channels, which is an important feature in OFDMA. In OFDMA systems, ICI is caused by the collision between resource blocks. With such collision model, the overall system performance is determined by the

collision probabilities and the impact of a given collision on the Signal to Interference and Noise Ratio (SINR) associated with the colliding resource blocks. ICIC mechanisms aim at reducing the collision probabilities and at mitigating the SINR degradation that such collisions may cause in order to improve the system performance and increase the overall bit rates of the cell and its cell edge users. Generally, ICIC techniques can be classified into mitigation and avoidance techniques. In interference mitigation, techniques are employed to reduce the impact of interference during the transmission or after the reception of the signal [5]. In order to achieve the goal of coordinating transmissions in neighboring cells, IFCO is a powerful tool to solve the problem of ICI in cellular networks and may control over various different resources and variables in the cellular network based on various common input parameters and controllable resources, such as Position of Mobile Terminals, Direction of Arrival (DoA), Signal Measurements and Channel Quality. The controllable resources and variables can be time, frequency, and code resources, Space Transmit power and MCS. Fig. 2 (a) shows a case where two transmissions in neighboring cells cause high interference on one another as it may occur in an uncoordinated system. In contrast, the transmissions are coordinated in Fig. 2 (b) in order to minimize interference. The coordination in the spatial domain may leverage all degrees of freedom that the installed beam-forming systems allow such as placing nulls or arbitrarily shaping the radiation pattern.



(a) Uncoordinated (b) Coordinated operation

Figure 2 : Illustration of IFCO in Spatial.

V. Interference Avoidance Schemes Classifications

A wide range of techniques are presented in order to improve the throughput of the cell-edge users by reducing or suppressing the ICI.

Interference mitigation techniques includes:

(1) Interference randomization (where some cell-specific scrambling, interleaving, or frequency-hopping (spread spectrum)).

(2) Interference cancelation (where the interference signals are detected and subtracted from the desired received signal, or if multiple antenna system is employed, the receiver can select the best quality signal among the various received signals) [6].

(3) Adaptive beam-forming (where the antenna can dynamically change its radiation pattern depending on the interference levels). Interference avoidance schemes represent the frequency reuse planning algorithms used by the network elements to restrict or allocate certain resources (in both frequency and time domains) and power levels among users in different cells. The objective of these frequency reuse planning algorithms is to increase the SINR, and hence, allow the system to support as many users as possible. These frequency reuse planning algorithms must satisfy the power constraint in each cell by ensuring that the allocated transmission power of an Enhanced NodeB (eNB) does not exceed the maximum allowable power. A fundamental concept common to most interference avoidance schemes is to classify users in the cell based on their average SINR to a number of users' classes (also known as "cell regions"). Interference avoidance schemes then apply different reuse factors to the frequency band used by the different classes of users (i.e, to different cell regions). Fig. 3 depicts the various types of interference avoidance schemes.

VI. Fractional Frequency Reuse

One of the fundamental techniques to deal with the ICI problem is to control the use of frequencies over the various channels in the network. Frequency reuse-based schemes include: conventional frequency planning schemes (Reuse-1 and Reuse-3), FFR, PFR, SFR. Despite their differences, all frequency reuse-based schemes need to specify the followings:

(1) The set of channels (sub-bands) that will be used in each sector/cell.

(2) The power at which each channel is operating.

(3) The region of the sector/cell in which this set of channels are used (e.g., cell-centre or cell-edge) [7].

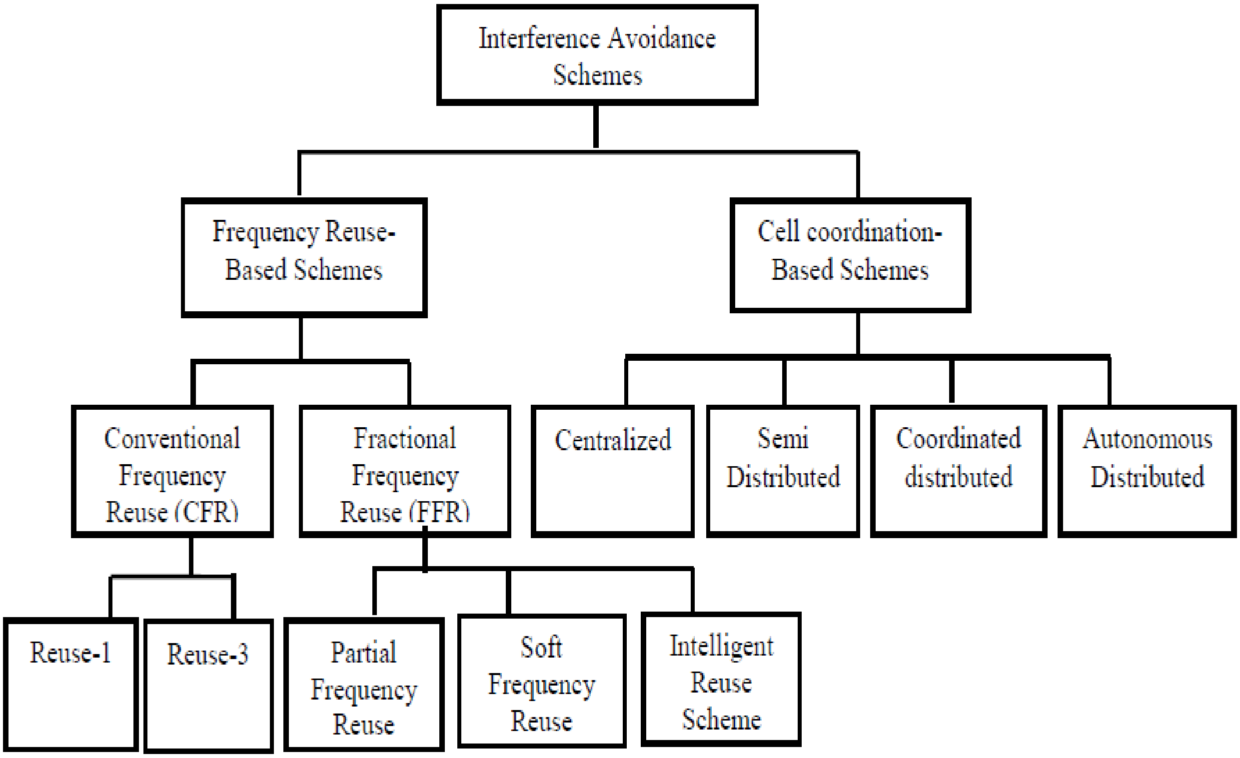


Figure 3 : ICI Avoidance Schemes Classifications [5]

Different schemes define different values and approaches for these various parameters. Accordingly, an identification of a unified structured description for any frequency reuse-based scheme. Such structured description will not only simplify the expression of various schemes, but it will also reduce ambiguity in understanding some of the subtle schemes. In the following section, an introduction of a new classification model that can use to explain some of the key frequencies reuse based schemes. The assignment of mobile terminals to the different reuse partitions can be done based on various criteria. Typically, those terminals that are close to the base station experience good Signal to Interference Ratio (SIR) conditions and are therefore assigned to partitions with a small reuse factor. Vice versa, mobile terminals close to the cell edge are usually assigned to partitions with a large reuse factor as illustrated in Fig. 4.

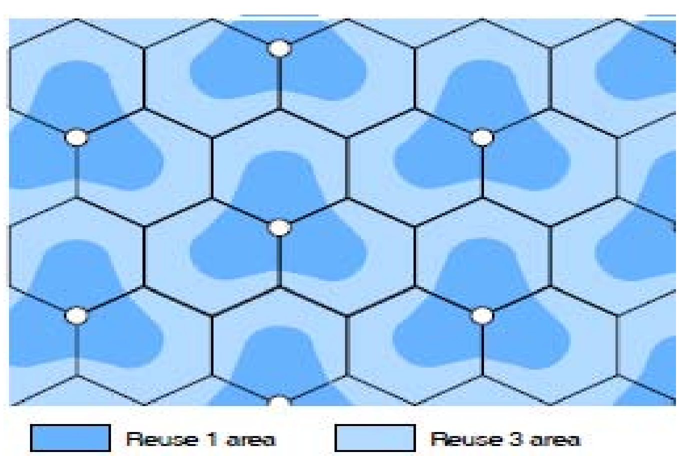


Figure 4 : Illustration of Fractional Frequency Reuse with two Reuse

To avoid the shortcomings of the conventional frequency reuse schemes, the FFR scheme is introduced to achieve a FRF between 1 and 3. FFR divides the whole available resources into two subsets or groups, namely, the major group and the minor group. The former is used to serve the cell-edge users, while the latter is used to cover the cell-center users [8].

VII. Fractional Frequency Reuse Main Classes

The FFR scheme can be divided into three main classes:

PFR: A common frequency band is used in all sectors (i.e., with a frequency reuse-1) with equal power, while the power allocation of the remaining sub-bands is coordinated among the neighboring cells in order to create one sub-band with low inter cell interference level in each sector.

SFR: Each sector transmits in the whole frequency band. However, the sector uses full power in some frequency sub bands while reduced power is used in the rest of the frequency band.

IRS: In Intelligent Reuse Schemes (IRS), band allocated to different sectors expands and dilates based on the existing workloads. These schemes start with a reuse-3 like configuration at low workloads which can be changed with the increase of workloads to become PFR, SFR or even reuse-1.

In Fig. 5, represents the FFR based frequency allocation for a typical femto cell system. Total frequency is divided by four frequency sub-bands, a f is allocated for cell - center and f B (f B1, f B2, f B3) is allocated for three sectors in an orthogonal fashion in order to avoid the interference between macro and femto cells. For example, OFDMA in IEEE 802.16m can be considered which allocate Physical Resource Unit (PRU) for macro and femto cell. PRU is composed of 18 subcarriers and 6 symbols, the total number of PRU of OFDMA with 10 MHz bandwidth Will be 48 including Cyclic Prefix (CP).

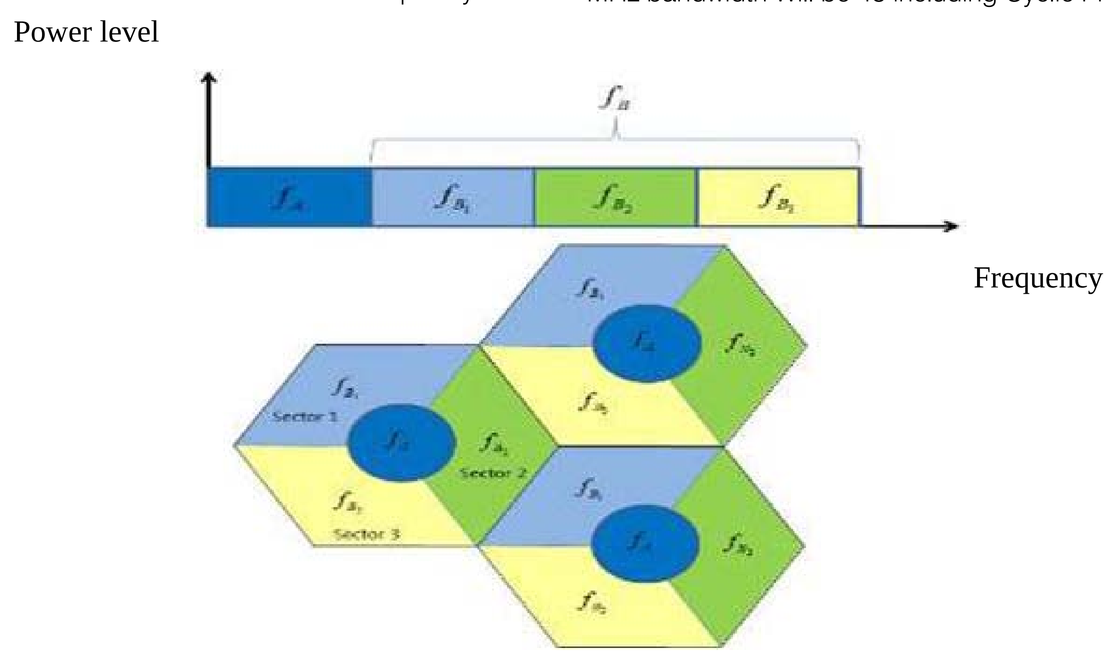


Figure 5 : FFR based Frequency Allocation Scheme [9]

In order to evaluate the total cell throughput, the Shannon's Formula is
used as [9]:

$$R = BW\log_2(1+SNR) \tag{1}$$

Where, R is the cell throughput and BW is the bandwidth of PRU for each user and SINR for each user can be applied By:

$$SINR = \frac{Pi \times hi}{\sum_{j=1}^{M} Pj \times hi + n_0} \tag{2}$$

Where Pi is the received power from macro cell and femto cell, hi is the channel gain of MS received from macro cell and femto cell, Pj is the interference power from macro cell or femto cell which use a same PRU and hj is the channel gain of Mobile Station (MS) received from macro cell and femto cell which use a same PRU and n0 is the AWGN for each user.

A conventional interference cancellation scheme between macro and femto and the throughput increased based on FFR environment.

Femto Base Station (BS) is allocates different frequency bandwidth according to existence macro MS around the femto BS, and the femto BS is interfered other femto BS. SINR performance has been decreased than eased than dynamic FFR, but 90% of MS throughput has been increased.

In general, frequency reuse schemes are suitable for networks with a static even distribution of loads; however, they lead to significant performance degradation in terms of cell and user throughput when used due to the natural dynamic nature of cellular systems, where there is an unevenly distributed dynamically changing load. Therefore, dynamic frequency allocations are needed in order to cope with the continuous load changes in cells. In cell coordination, interference reduction is realized by real time coordination among all involved cells to avoid that two cell edge UEs in neighboring cells use the same sub-carriers.

Adaptive algorithms are developed in order to efficiently manage the resource utilization among cells without a priori resource partitioning. Coordination between cells can be performed in either a centralized, semi- distributed or distributed fashion. Dynamic ICIC schemes reported in the literature are mostly either semi-distributed or distributed via coordination. A limited number of autonomous distributed ICIC schemes have been proposed, and accordingly, more research efforts are needed in order to develop autonomous schemes that can cope with the nature and needs of the emerging OFDMA-based cellular networks with highly mobile users.

Fig. 6 shows an orthogonal FA scheme. The frequency bands for Macro BS and femto BS can be allocated in an orthogonal fashion in order to avoid the mutual interference between macro and femto BSs. Though macro BS cannot use the full frequency band, orthogonal FA scheme can avoid the co-channel interferences between macro BS and femto BSs.

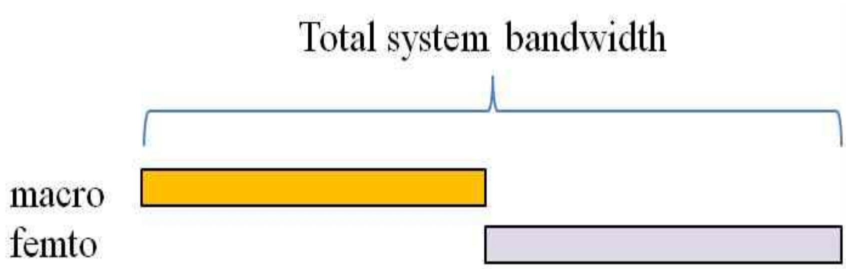


Figure 6 : Orthogonal frequency allocation scheme

VIII. LTE Commercialization Trend

Wireless mobile communications are continuously evolving to respond to increasing needs of quality of service, data rates and diversity of the offered services. Meeting the ever expanding requirements; require innovations in architectures, protocols, spectrum sharing techniques, and interoperability between HetNet networks. This is reflected throughout the research by strongly focusing on new trends, developments, emerging technologies and new industrial standards, providing leading edge coverage of the opportunities and challenges driving the research and development of mobile communication systems.

IX. Universal Mobile Access (UMA) Femto Cells

Mobile operators have been searching for licensed indoor coverage solutions since the beginning of wireless networks. Unfortunately, the bulk of this opportunity (i.e. residential environments) has been beyond the addressable market for cost and operational reasons. To be successful, a residential licensed access point (i.e. femto cell) solution must include low cost femto cells, a reasonable approach for managing RF interference, and a standard, scalable, IP-based approach for core network integration. Femto cells are important because mobile operators need to seize residential minutes from fixed providers, and respond to emerging VoIP and WiFi offerings. Fig. 7, shows the services provided to operator and subscribers. For operator, benefits will be:

(1) Reduce churn with high quality 3G coverage.
(2) Avoid capital expense by off loading the macro 3G network.

On the other hand, subscriber benefits will be:

(1) High performance 3G.
(2) Coverage at home.

Femto cell system is promising to provide cost effective strategy for high data traffic and high spectral efficient services in future wireless cellular system environment. However, the cochannel operation with current Macro networks occurs some severe interference between Macro and Femto cells. Hence, the interference cancellation or management schemes are imperative between Macro and Fem to cells in order to avoid the decrease of total cell throughput. First, we briefly investigate the conventional resource allocation and interference cancellation scheme between Macro and Fem to cells.

Then, a proposal on adaptive resource allocation scheme based on the distribution of Fem to cell traffic in order to increase the cell throughput and also maximize the spectral efficiency over the FFR (Fractional Frequency Reuse) based conventional resource allocation schemes.

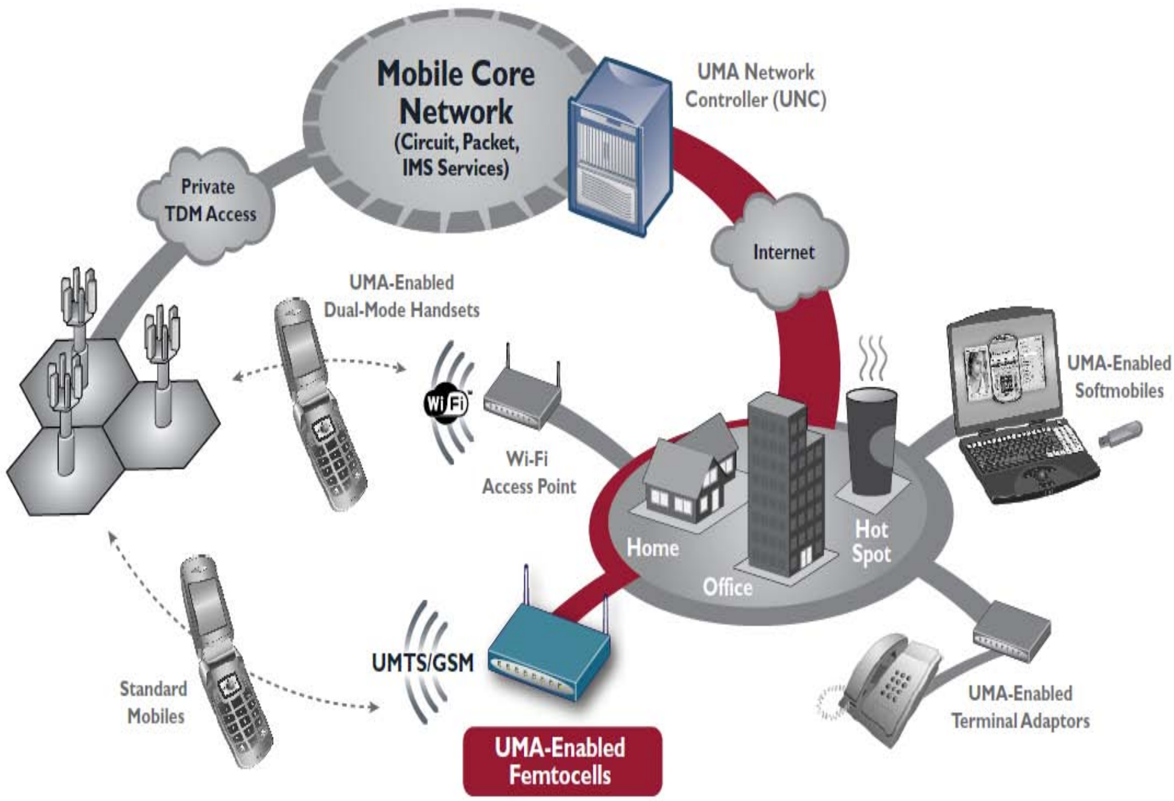


Figure 7 : UMA the 3GPP Standard for Convergence Provides High Performance Mobile Coverage at Home

One of the main concerns for 4G wireless networks is to provide ubiquitous and high speed connectivity to mobile users. Indeed, one notorious limitations regarding wireless coverage is that it is difficult to provide high signal strength for indoor traffic since wireless signals generally have a difficulty in penetrating through many walls. Femto BS devices appeared as a promising solution to complement and enhance traditional macro BS coverage in specially indoor environment.

Moreover, the dense deployment of these femto cells can provide the higher capacity through increased spatial reuse. However, the overlapping of femto BSs and macro BSs in a same operator license band can occur some critical problems linked mainly to interference management. Recent developments from silicon and femto cell access point vendors promise to address the cost and interference issues over the next several years; a solution for core network integration has remained a challenge, as UMA provides standard, secure, scalable and cost effective IP-based access into core mobile service networks, it is now being leveraged to address this challenge. LTE technology is a basic mobile communication standard presented in late 2009 by ITU-T. Nowadays, 4th Generation of Mobile communication systems are launched known as LTE-A. The main targets of LTE system are to support high data transfer, low latency, increased bandwidth (capacity), and improve QoS. However these benefits face a lot of challenges. Among these challenges are high path loss and greater signal attenuation due to higher frequencies, transmit power controls, and the problem of interfering signals from neighbor cells (ICI). ICI results from the motion of user from cell center to cell edge resulting in power reduction of the signal transmitted from the cell center while interference signals from neighbor cells is increased. ICI randomization, cancellation, and coordination/avoidance are three general approaches for ICI mitigation approaches [8].

Frequency reuse is one of the most commonly used interference coordination technique, where the whole frequency band is divided into several sub-bands and wisely allocated to a specific area so as to improve signal status at cell edge. Frequency reuse is a common approach to increase data rate of point to multipoint systems.

X. From LTE-A to 4G Future

In ref. [4], LTE and LTE-A have undeniably provided a major step forward in mobile communication capability, enabling mobile service provisioning to approach for the first time that available from fixed-line connections. However, market demands typically do not evolve simply in discrete steps; therefore, the future evolution of LTE-A will be a story of continuous enhancement, on one hand, taking advantage of the advancing capabilities of technology, while on the other aiming to keep pace with the expectations and needs of the end users. The likely directions of this continuing enhancement are discussed, and some areas where further technical advancement will be required are identified. In particular, potential measures to enhance the efficiency of spectrum utilization by joint multi-cell optimization, dynamic adaptation of the network to traffic characteristics and load levels, and support for new applications are highlighted. The limited availability of suitable radio spectrum will increasingly impact the future evolution of LTE-A. This is already evident in the carrier aggregation features provided by LTE-A, and it is inevitable that the range of band combinations that have to be supported will continue to increase. Techniques to enhance dynamic load management between carriers according to traffic demand will also become an increasingly valuable tool for ensuring full and efficient use of scarce spectrum resources. Such dynamic techniques are likely in due course to evolve in the direction of cognitive radio solutions, with increasing utilization of spectrum sharing and white space detection as spectrum becomes ever more crowded.

XI. 3G RF Interference Mitigation Techniques - self Optimization Network (SON) and WCDMA Hetnets

In mobile radio networks with several operators covering the same geographic area, interferences between the frequency channels of the model used in 3G to evaluate the interference between operators is relined so that the simulation results reflect the parameters used for path to reduce the interference between the operators by radiation pattern design of the antennas at the base stations [9]. The following are proposed techniques can be used to mitigate it.

a) Automatic Carrier Selection

In this technique, a frequency list is provided by supervision system named by SCMS, the small cell selects the appropriate frequency for operation during auto-configuration, i.e., once every 24 hrs, that has least interference using Network Listen Measurements (NLM). A suitable hysteresis is added to prevent toggling between carriers and applicable to non-group deployments only. This proposed technique is mainly suitable for the home segment, which removes the need for manual provisioning of carrier frequency and has better coverage and capacity due to the selection of less interfered channel.

b) Up link Interference Management

The worst case of Uplink (UL) interference occurs when a small cell mobile handset (UE) comes close to the border of the neighboring small cell macro cell and there is also another UE on the border with both UEs transmitting at high uplink data rates. Aim of this feature is to control small cell UE maximum, UL transmitted Power based on; estimated pathloss between small cell UE and its neighboring Small Cell/Macro cell based upon UE Common Pilot Channel (CPICH) protocol measurements and the neighbor's CPICH transmit power. UL UE maximum transmitted power is updated through Radio Resource Control (RRC) signaling protocol. The mechanism is activated only when following events occur; UL Received Total Wideband Power (RTWP) - checking the uplink interference - is above a threshold of uplink enhanced Dedicated Channel (E-DCH) or high UL data rate is configured on the small cell UE. An Operation & Maintenance defined maximum level of interference that the small cell UE can create into a neighbor cell is implemented. This technique is suitable for all segments and any carrier deployment scenario.

c) Continuous Coverage Self-Optimization Based on Admission

In closed access mode, too many Location Area Update (LAU) and Routing Area Update (RAU) attempts from public UEs will trigger a reduction in the pilot power, SON technique to adapt the coverage of the closed access mode Shared Carrier (SC) based on how often non registered UEs are trying to camp on femto or rate at which registered users are performing outgoing handovers. This technique is particularly useful for a SC placed in a sub-optimal location, e.g., next to a window, the technique algorithm runs continuously and can adapt to local traffic variations [10].

One of the proposed features of this technique is it configurable thresholds for camping rate and handover rate can be targeted and is applicable mainly to home and enterprise segments in shared carrier deployments to minimize impact of downlink RF leakage on non-registered/public users and to minimize signaling resulting from frequents camping requests from non-registered users.

d) Outdoor Metro Cell Deployments Challenges

Deployment of small cells in realistic environments poses significant challenges. It is crucial to address these challenges for enabling large scale adoption of small cells in the future.

The myriad of challenges include co-existence schemes with neighboring cells (including small and macro cells), interference management mechanisms (to ensure continuity of service over neighboring small and macro cells), self organizing and self management issues (crucial for efficient deployment of small cells) and optimal network architectures (related to the host radio access technology).

Fig. 8, shows an example of outdoor metro cell deployment [11].

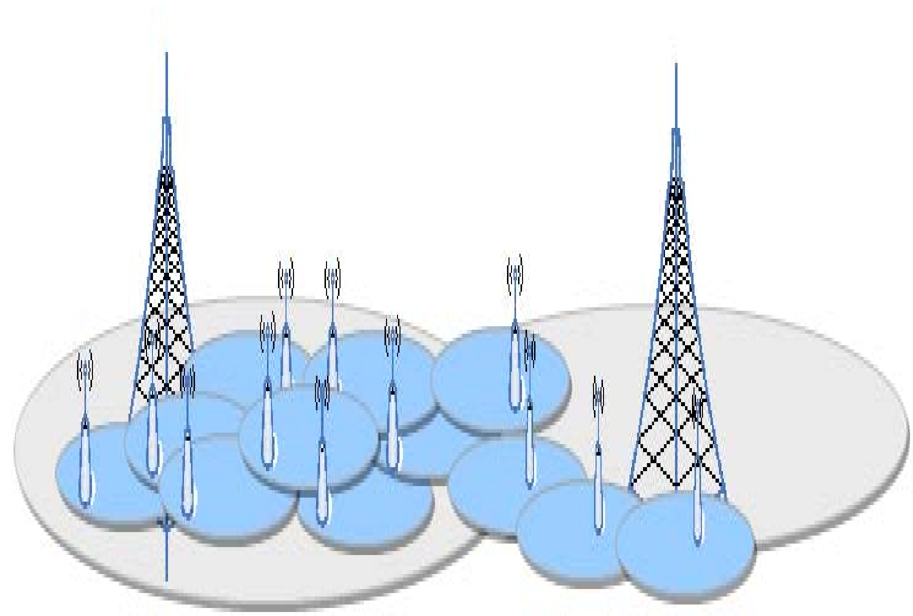


Figure 8 : Outdoor Metro Cell Deployments.

Metro Cells can provide additional data capacity in areas of high traffic density in dense urban outdoor areas as macro RF signal levels are generally very high in operator areas deployment of interfaces based outdoor metro cells under an existing interface based macro layer is challenging. Based on simulations and field experience macro cell coverage area can be divided into three zones (red, yellow and green) in terms of suitability for deploying outdoor metro cells on shared carrier, as shown in

Fig. 9, metro cells can be deployed in the Green and Yellow zones, but deployment guidelines need to be followed in order to get good trade-off between performance improvement and interference impacts. Implementation of traffic segmentation is recommended in the Yellow zone in order to maintain Key Performance Indicators (KPIs). Similarly, multiple metro cells deployed in close proximity and configured in a group can offload more users and improve business case in comparison to isolated metro cell deployments Hierarchal Cell Structure (HCS) high mobility detection feature can be implemented on the macro to minimize camping of fast moving idle mode UEs on metro cells Exclusion zone – interference is significant, small cell off load potential is low due to reduced small cell size. Intermediate zone – interference is still significant, but benefits of small cell offload starts to come into play Safe zone – effect of interference is not significant, benefits of small cell offload is maximized.

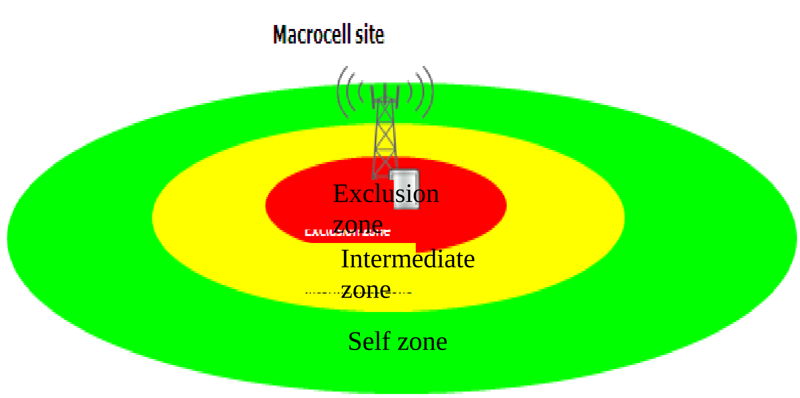


Figure 9 : Metro Deployment Zones.

Identification and some challenges related to the design and analysis of ICIC scheme that make interesting future research directions.

- *Evaluation Framework and Benchmark*

Due to the complexity of the dynamic ICIC problem, most of the performance evaluations are based on simulation models. A principal problem with simulation evaluations during comparing different schemes is the lack of common context, scenarios and evaluation metrics. Accordingly, an evaluation framework and a benchmark are needed to allow researchers to develop and evaluate their ICIC schemes in a sound manner. Such an effort will provide researchers with data sets for unified realistic scenarios (similar to those provided by the European Momentum project for Berlin and Lisbon) that define common realistic conditions, such as: cells layout, number of channels, propagation data, and traffic intensity.

The evaluation framework should provide a unified set of metrics that can be used to evaluate and benchmark various ICIC schemes.

- *Wireless Network Cloud (WNC)*

Recently, with the emergence of the cloud-computing technology and other technologies related to wireless infrastructure including software radio technology and remote radio head technology, Wireless Network Cloud (WNC) with Base Station Pooling (BSP) is becoming an interesting alternative network architecture where all eNBs computational resources (enabled by Software Radio) are pooled in a central location and connected via fiber to simple radio-front ends (Remote Radio heads) mounted on remote cell-towers.

WNC provides all the necessary transmission and processing resources for a wireless access network to operate in a central fashion. A promising research direction is to re-think the way ICIC centralized schemes are structured by exploiting the transmission and processing resources of the WNC.

- Heuristics algorithms

An important line of work is to formulate the ICIC problem as an optimization task whose objective is to maximize the multi-cell throughput subject to: power constraints, inter-cell signaling limitations, fairness objectives, and/or minimum bit rate requirements. The problem of resource allocation with dynamic demand is known to be NP-hard. Using an exact method is computationally inefficient as the problem involves extremely large search spaces with correspondingly large number of potential solutions. While optimization models give an insight into the upper bounds of achievable ICIC gains, actually implementing these near optimal mechanisms can be economically and/or technologically infeasible. Thus, various lower complexity heuristics algorithms should be investigated as they have the power of obtaining good suboptimal solutions in a computationally efficient way.

- *Autonomous schemes*

Static schemes suffer from the limitation of being unable to adapt to inhomogeneous traffic load and varying user group distribution within each cell. Centralized and semi-distributed schemes are often too heavy for implementations in reality as all the interference information on all RBs has to be gathered at a central controller, which is prohibitively large. Coordinated distributed schemes realization has remained limited largely due to constraints on inter-eNB communication and the latencies involved in information exchange for distributed eNBs. Self-organization is a key factor for the future evolution of mobile networks, due to their increasing complexity and required management efforts. Thus, with the current network architecture and large number of cells, it appears that the future is for autonomous schemes as they can achieve a good ICIC level with no signaling overheads [12].

Moreover, they open the way for a more flexible and adapted cell topology as well as for new energy saving methods. Not much research efforts have been reported in developing autonomous distributed ICIC schemes, which makes it an interesting research direction that is worth further investigation.

The demand for cellular communication services is expected to continue its rapid growth in the next decade, fuelled by new applications such as mobile web-browsing, video downloading, on-line gaming, and social networking. The commercial deployment of 3G. Cellular network technologies began with 3GPP UMTS/WCDMA in 2001 and has evolved into current UMTS/HSPA networks. To maintain the competitiveness of 3GPP UMTS networks, a well-planned and graceful evolution to 4G networks is considered essential. LTE is an important step in this evolution, with technology demonstrations beginning in 2006. Commercial LTE network services started in Scandinavia in December 2009 and it is expected that carriers worldwide will shortly be starting their upgrades. A high-level survey of works on resource scheduling and interference mitigation in 3GPP LTE was presented. These two functions will be key to the success of LTE. The next step in the evolution of LTE is LTE-A, a 4G system which promises peak data rates in the Gbps range and improved cell-edge performance. Important scheduling/interference mitigation related technical issues which require further exploration include:

(1) use of relaying techniques which can provide a relatively inexpensive way of increasing spectral efficiency, system capacity, and area coverage.
(2) DL and UL coordinated multipoint transmission/ reception to improve high data rate coverage and

cell-edge throughput. For DL, this refers to coordination in scheduling transmissions from multiple geographically separated transmission points.

(3) For UL, this involves different types of coordination in reception at multiple geographically separated points.

(4) support for UL spatial multiplexing of up to four layers and DL spatial multiplexing of up to eight layers to increase bit rates.

Another general area deserving attention is the design of low-complexity scheduling/interference mitigation schemes which provide near optimal performance.

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Simulation of the Stochastic Resonance Effect in a Nonlinear Device

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Abstract- The possibility to separate a useful signal from the realization of the random process representing the sum of the harmonic signal and Gaussian noise, using the method of stochastic resonance, is shown. The results of calculation of the signal-to-noise ratio at the output of a nonlinear device, creating an effect of stochastic resonance, are given. It is shown that the nonlinear device, described by the equation of stochastic resonance, operates as a stochastic low-pass filter. A simulation model of a non-linear device possessing effect of SR is constructed.

Keywords: stochastic resonance (SR), nonlinear device, signal-to-noise ratio (SNR), filter.

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Simulation of the Stochastic Resonance Effect in a Nonlinear Device

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Abstract- **The possibility to separate a useful signal from the realization of the random process representing the sum of the harmonic signal and Gaussian noise, using the method of stochastic resonance, is shown. The results of calculation of the signal-to-noise ratio at the output of a nonlinear device, creating an effect of stochastic resonance, are given. It is shown that the nonlinear device, described by the equation of stochastic resonance, operates as a stochastic low-pass filter. A simulation model of a non-linear device possessing effect of SR is constructed.**

Keywords: stochastic resonance (SR), nonlinear device, signal-to-noise ratio (SNR), filter.

I. Introduction

It is considered that noise in a system is a negative factor and the fight against noise is one of actual problems of radio engineering systems. Low-noise devices and methods of noise reduction are developed, noiseproof codes, digital communication, signals with the necessary correlation properties are created.

However, research conducted recently in the field of theoretical and experimental physics has shown that in some cases an input weak signal can be amplified and optimized with the assistance of noise (Anishchenko *et al*, 1999;, Geraschenko, 2003). The integral characteristics of the process at the system output, such as the spectral power amplification (SPA), the signal-to-noise ratio (SNR) have a well-marked maximum at a certain optimal noise level.

The notion of stochastic resonance (SR) determines a group of phenomena wherein the response of a nonlinear system to a weak input signal can be significantly increased by appropriate tuning of the noise intensity. SR refers to a generic physical phenomenon typical for nonlinear systems.

This article discusses the simulation of the effect of SR in the case of additive sum of a harmonic signal and Gaussian noise at the nonlinear device input.

II. Characterization of Stochastic Resonance

A weak input signal significantly increases with increasing intensity of noise and reaches its maximum at a certain noise level in nonlinear systems in which SR occurs.

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Consider the equation describing the model of nonlinear systems in which SR occurs (Anishchenko *et al*, 1999;, Kharchenko*et al*, 2015):

$$d\dot{\eta}/dt = \eta(t) - \eta^3(t) + x(t)\,, \qquad (1)$$

where $x(t)$ – input signal;

$\eta(t)$ – output signal.

This formulais Abel's equation of the first kind and has no analytical solution(Kamke, 1961). It is also impossible to find two-dimensional probability density of the output signal by using the exact solution of the Fokker – Planck equation even in the absence of an input harmonic signal (Middleton, 1996).

Therefore, the signal correlation functions and spectral density at the nonlinear system output can't be defined exactly. Naturally, there are additional difficulties in the analytical description of actual effects, if there is an additive sum of harmonic signal and Gaussian noise.

III. Signal-to-Noise Ratio at the Nonlinear System Output

Unlike linear systems, in which the energy spectrum at the output follows input energy, output spectrum of the non linear system has amore complicated structure (Levin, 1969, Volochuk, 2005). Signal and noise are independent in ali near system. The output of the non linear device forms new spectral components due to the interaction of the components of the input process.

Moreover, the type of non-linear transformation and the statistical characteristics of the input signal determine the type and intensity of the additional component.

If the input processisan additivesum of the unmodulated carrier and noise, there are three main parts in the output power spectrum of the non linear device:

$F_{SxS}(\omega)$ – corresponds to the beats between the components of the signal and its harmonics (a discrete part of the spectrum);

$F_{NxN}(\omega)$ – is formed by beats of noise components (continuous component of the spectrum);

$F_{SxN}(\omega)$ – is formed by mutual beats of signal components and noise(continuous component of the spectrum).

The discrete part of the spectrum is complemented by the spectrallineat zero frequency, representing the DC component at the output, which is also determined by the beats of the signal components and noise. Consequently, the energy spectrum of the output of the nonlinear device is determined as (Levin, 1969, Voloshchuk, 2005):

$$F(\omega) = F_{SxS}(\omega) + F_{SxN}(\omega) + F_{NxN}(\omega).$$

Practically the most convenient power indicator of the output signal is the signal–to–noise ratio (SNR). Since the output process is an in separable mixture of an input signal and noise, it is impossible to specify components, which would depend only on the signal and, accordingly, only on noise.

In order to evaluate the SNR at the output of the nonlinear system, it is necessary to determine the portion of the spectrum $F_{SxN}(\omega)$.

We can calculate SRN at the output ofthe nonlinear system in two ways as:

a) if the beats between signal components and noise are attributed to noise:

$$SNR = \frac{\int_0^\infty F_{SxS}(\omega)d\omega}{\int_0^\infty [F_{SxN0}(\omega) + F_{NxN}(\omega)]d\omega},$$

b) if the beats between signal components and noise are attributed to signal:

$$SNR = \frac{\int_0^\infty [F_{SxS}(\omega) + F_{SxN}(\omega)]d\omega}{\int_0^\infty F_{NxN}(\omega)d\omega}.$$

SNR is calculated using the last formula in case of the SR, as a high valueof this parameter is predetermined by the component $F_{SxN}(\omega)$, i.e. by the interaction between signal and noise.

IV. SNRat the Output of the NonlinearDevicehas the Effect ofSR

Consider the case where the input signal of the nonlinear device is an additivesum of the sinusoidal signal and Gaussian noise

$$\dot{d\eta}/dt = \eta(t) - \eta^3(t) + A\cos(2\pi ft + \varphi) + \xi(t) \quad (2)$$

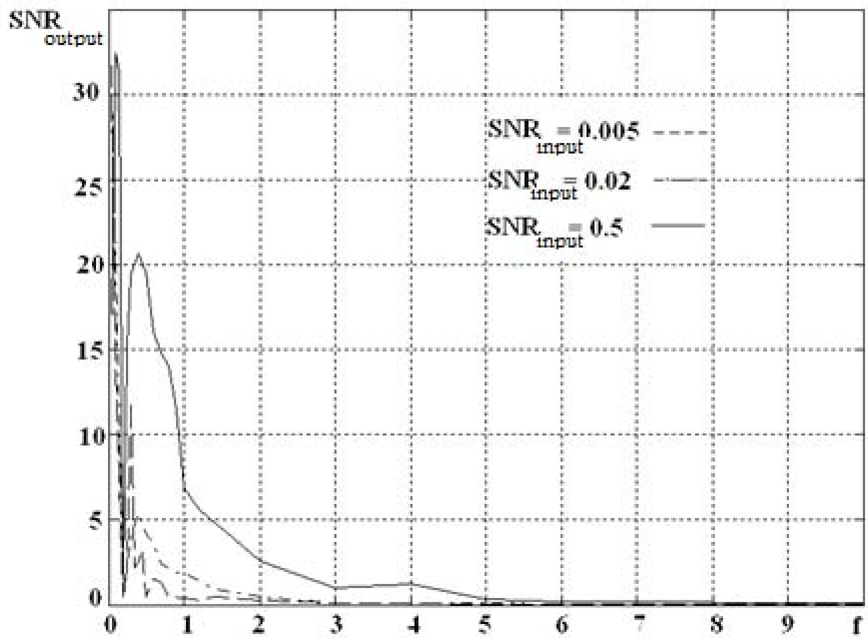
where $\xi(t)$ – Gaussian noise with a zero average and variance D,

$\eta(t)$ – the process at the nonlinear device output.

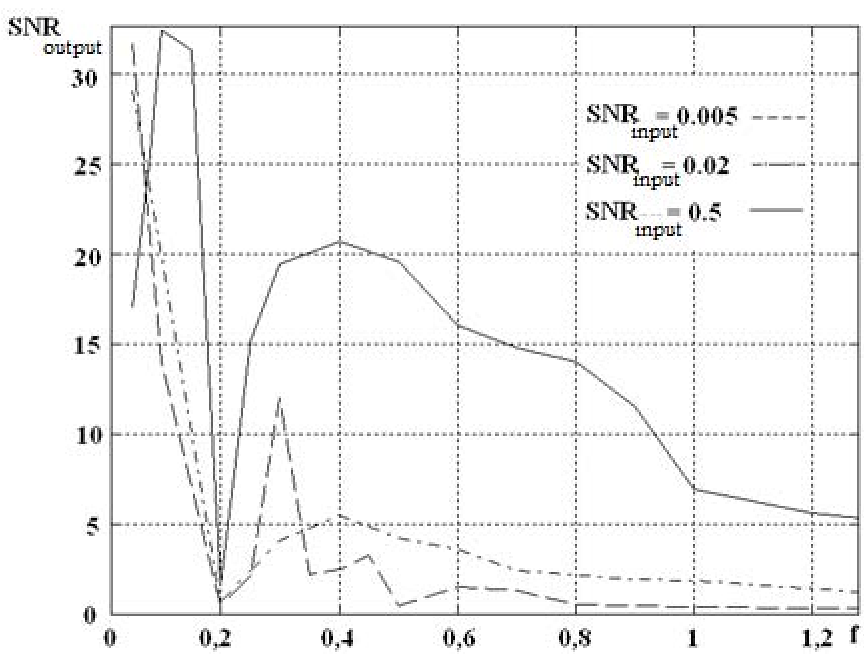
Having solvede quation (2) numerically, let'sde fine the SNR at the output of the nonlinear device (SNR_{output})as a function of frequency and SNR at the input (SNR_{input}). We can calculate SNR_{input}as

$$SNR_{input} = A^2/2D.$$

The frequency is set in the range of 0.05÷10Hz. Power SNR at the input is consideredequal, respectively: 0.005; 0.02; 0.5. The calculation result sare shown in Fig. 1a and1b. Fig. 1bshowsthelowfrequencyin moredetail.



a)



b)

Figure 1 : The SNR dependence of the output of the nonlinear device(SNR_{output})on the frequency of the periodic input signal for various values of the SNR at the input(SNR_{input})

The figures show that the phenomenon of SR is best expresse dat low frequencies, thus a nonlinear device having the effect of SR, is astochasticlow-pass filter. In addition, there is a minimum SNR at the outputat a frequency of $f = 0.2$ Hz, and this effect is observedat any SNR at the input. SNR at the output is a nonlinear function of the external noise and the input harmonic signal. You can then make three-dimensional SNR graphs of the input noise power and harmonic signal amplitude. It should be noted that the numerical simulations were performed by summing the dataon limited time intervals (up to 50periods of frequency).Naturally, the time delay affects the results of (Middleton, 1996).

V. Model of the Nonline Device Having the Effect of CR

Let's create a simulation model of the nonlinear device according to the graphical programming environment SIMULINK (intfig.2egrated with MATLAB), described by equation (2). This system has the SR effect. An additive mixture of the harmonic signal and Gaussian noise is sent to the input. Output signal stakes from the oscilloscope. This scheme can be the basis for practical implementation of the nonlinear filter (fig.2).

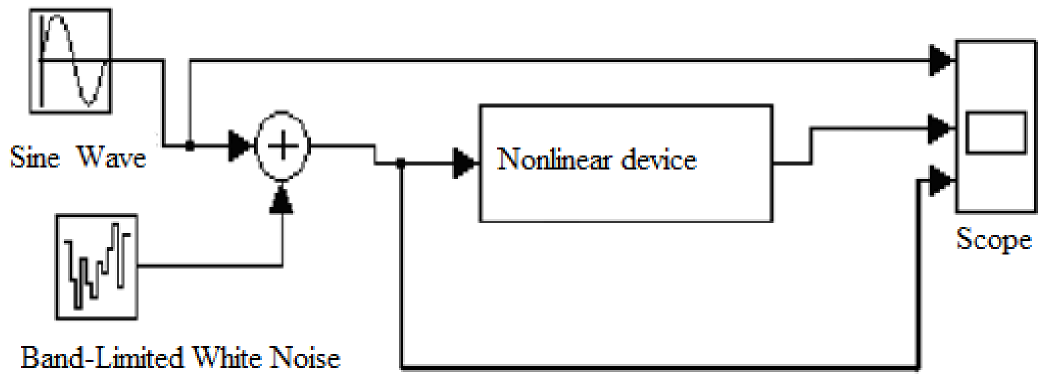
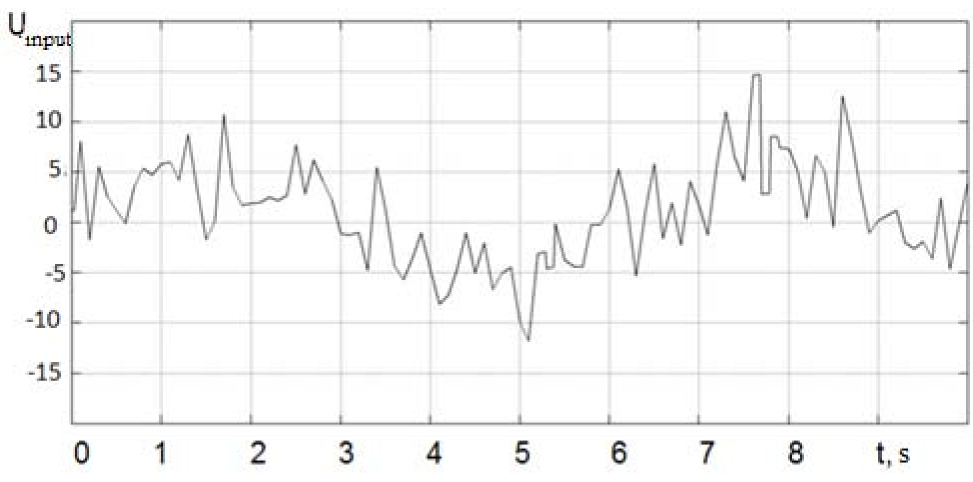


Figure 2 : The simulation model of the nonlinear device.

Fig. 3 shows the signals taken from the oscilloscope. It can be seen clearly that the dispersion in Fig. 3ais much less than the dispersion in Fig. 3b. Thus, this model shows the increase in the SNR at the output of the nonlinear device having the effect of SR. In addition, the harmonic nature of the output signal is retained.



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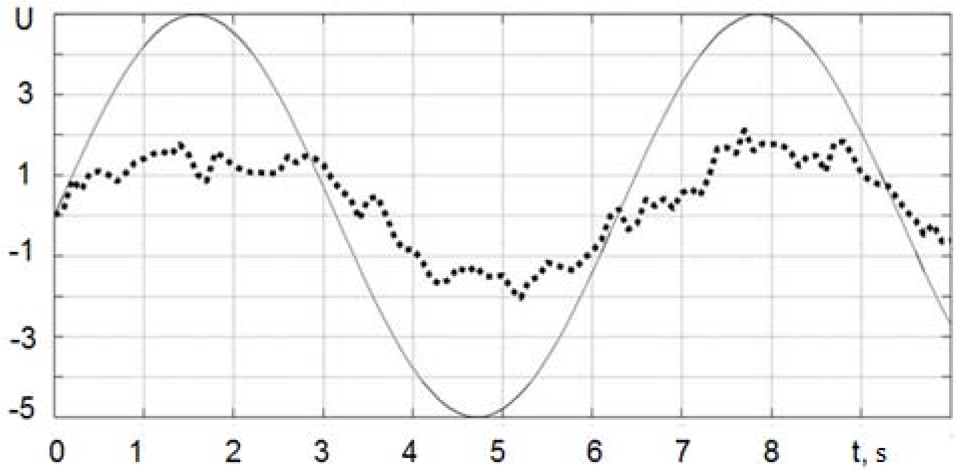

b)

Figure 3 : The input signal of the nonlinear device(a);time dependences of input of a harmonic signal (solid line) and the output signal of the nonlinear device (points) (b)

The response of the nonlinear system on a weak external signal in case of SR noticeably increases with the height of the noise intensity in the system and arrives at a certain maximum at some level.

VI. Conclusions

In this paper we discuss the work of the non-linear device having the effect of SR at the input of the additive mixture of the harmonic signal and the white noise of short duration. The results make it clear that the device works as a stochastic low-pass filter. In addition, numerical analysis of the equation describing the effect of SR showed that the SNR at the output of the nonlinear device under certain conditions exceeds the SNR at the input. Hence, the nonlinear device operates as an amplifier.

In this paper we can build a simulation model of the nonlinear device, described by equation SR. We have used an additive mixture of the harmonic signal and noise with a duration of 10 s at the input of the nonlinear device. We have used the graphical programming environment SIMULINK (integrated with MATLAB) for building a simulation model.

These results demonstrate that the signal obtainedat the output of the nonlinear device has a lower noise level as compared with the input signal.

Prospects of development schemes of nonlinear filter based on the designed model are indicated.

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On the ICI Mitigation Techniques in High Mobility MIMO-OFDM Systems with Parallel ICI Cancellation Under Various Normalized Doppler Spreads

By Walid M. Raafat

Introduction- The signals of LF and VLF are rapidly alternated by the earth's surface; and there are various propagation models currently used by the wireless industry for signal transmission within the frequency range 150-1800 MHz. Hata-Okumura two rays model are one of them. The problem of Inter Carrier Interference (ICI) arising from the Doppler shift caused by the high mobility in areas covered by OFDM based systems via High Altitude Platforms (HAPs). The proposed scheme presented is for Doppler assisted channel estimation with the parallel interference cancellation with decision statistical combining scheme (PIC-DSC) for high mobility MIMO-OFDM systems to improve the ICI cancellation which is essential in enhancing the BER performance which induces a large frequency offset error.

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Strictly as per the compliance and regulations of :

On the ICI Mitigation Techniques in High Mobility MIMO-OFDM Systems with Parallel ICI Cancellation Under Various Normalized Doppler Spreads

Walid M. Raafat

I. Introduction

The signals of LF and VLF are rapidly alternated by the earth's surface; and there are various propagation models currently used by the wireless industry for signal transmission within the frequency range 150-1800 MHz. Hata-Okumura two rays model are one of them. The problem of Inter Carrier Interference (ICI) arising from the Doppler shift caused by the high mobility in areas covered by OFDM based systems via High Altitude Platforms (HAPs). The proposed scheme presented is for Doppler assisted channel estimation with the parallel interference cancellation with decision statistical combining scheme (PIC-DSC) for high mobility MIMO-OFDM systems to improve the ICI cancellation which is essential in enhancing the BER performance which induces a large frequency offset error. The simulation results shows that the outperforms convergence characteristic of channel estimation with the PIC-DSC interference cancellation scheme - under various normalized Doppler spreads (e.g., normalized Doppler spread of 0.1 and 0.025) at SNR 20dB and 30dB - has better symbol error rate (SER). The algorithm is efficiently mitigates ICI under Quadrature Phase Shift Keying (QPSK) modulation showing Bit Error Rate (BER) performance analysis and compared with other existing schemes. One of the most common models for signal prediction in large urban macro-cells is Okumura's model.

This model is applicable over distances of 1-100 Km and frequency ranges of 150-1500 MHz. The Okumura model for urban areas is a radio propagation model that was built using the data collected in the city of Tokyo, Japan. The model is ideal for using in cities with many urban structures but not many tall blocking structures. The model served as a base for the Hata model. It was built into three modes (urban, suburban and rural areas), the model for urban areas was built first and used as the base for others, it is more frequently used for estimating cell radius usually 50-60% path loss is accepted for urban areas. On the other hand; it is 70-75% for rural areas as in [13].

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In this phase; the analysis will be extended to the case of mobile users (Doppler shift) co-existing with randomly distributed but stationary users in co-channel cells. A specific system model will be put forward in order to evaluate system dependent parameters, e.g. Bit Error Rate (BER) - as a function of the Signal to Interference plus Noise Ratio (SINR) and the normalized Doppler shift. The model will also rely on semi-analytical techniques as well as some theoretical aspect as possible. The research methodology that characterizes this phase is the iterative convergence towards the results by extensive simulations as in [14]. Ref. [15] is recommended to start firstly to this phase by a brief review and re-implementation of the results we have previously; for the average link capacity in a multi cell MIMO system covered by HAP. As the results confirms that the use of MIMO system will greatly increase the achievable rate (capacity) on Rayleigh fading channels with certain degree of correlation and shows that multi cell MIMO systems covered by HAP outperforms conventional terrestial in terms of the per user link capacity as the performance metric of interest.

II. Problem Statement

OFDM by itself has the advantage of turning the frequency response of a frequency selective channel into a flat nonselective fading channel. However, in fading channels with very high mobility, the time variation of the channel envelope over an MIMO-OFDM symbol period results in a loss of the sub carrier orthogonality which leads to inter-channel interference (ICI) due to power leakage among MIMO-OFDM subcarriers.

III. Synchronization Error

It can be assumed that most of the wireless receivers cannot make perfect frequency synchronization, in fact, practical oscillators for synchronization are usually unstable, which introduce frequency offset (FO). Although this small offset is negligible in traditional communication system; but for OFDM system it is a severe problem. In most situations, the oscillator frequency offset varies from 20parts per

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million (ppm) to 100ppm. Provided an OFDM system operates at 5GHz, the maximum offset would be 100kHz to 500kHz (20-100ppm.). However, the subcarriers frequency spacing is only 312.5 kHz. Hence; the frequency offset could not be ignored, but it can be normalized by the reciprocal of symbol duration. For example, if a system has a bandwidth of 10MHz, and the number of subcarriers is 128, then the subcarrier frequency spacing would be 78kHz. If the normalized frequency offset is larger than 1, only the decimal part needs to be considered as in [16].

IV. Signal and Channel Models

The block diagram of a MIMO-OFDM system transmitter is shown in Fig. 10(a) - considering MIMO-OFDM system with MT transmit and MR receive antennas. At the transmitter side, a serial bit stream is mapped to a symbol stream by a modulator, then; this serial symbol stream is converted into parallel sub-streams. Next pilot symbols for the channel estimation are inserted into these parallel sub-streams in the frequency domain prior to the OFDM modulation.

The OFDM modulation is then implemented by performing inverse discrete Fourier transform (DFT), each transmit antenna sends independent OFDM symbols.

Let Xp(k) denote the information symbol sent by transmit antenna p at subcarrier k, the OFDM symbols transmitted by MT transmit antennas can then be presented as:

$$X = [X1, . . . ,Xp, . . . ,XMT]\ T \qquad (1)$$

Where, Xp = [Xp(0), . . . , Xp(N − 1)] T is the OFDM symbol transmitted from the pth transmit antenna, and N is the number of subcarriers for one OFDM symbol. After performing inverse DFT (IDFT) on each transmit antenna, the time-domain modulated signal on the pth transmit antenna can be expressed as

$$xp = FHXp = [xp(0), . . . , xp(N − 1)]\ T \qquad (2)$$

Where, F is the N × N DFT matrix with its element at row n and column k, which is defined as wn, k= e(−j2πnk/N) for n, k = 0, . . . , N−1. To avoid inter-symbol interference (ISI) due to a multipath delay spread, a cyclic prefix of length equal or greater than the expected maximum time delay of the channel is inserted in each OFDM symbol prior to transmission. This prefix serves as guard interval (GI) between OFDM symbols.

Finally, the symbol streams are converted from a parallel to a serial form and allocated to corresponding transmitters for transmission. The block diagram of a MIMO-OFDM system receiver is shown in Fig. 10(b) as in [16].

At the receiver side, once the GI is removed, the received signal at the *q*th receive antenna and time *n* can be represented as

$$rq(n) = \sum_{p=1}^{MT} (h\ pq(l,n) \otimes xp(m))\omega q(n) \qquad (4)$$

$$= \sum_{p=1}^{MT} \sum_{l=0}^{L-1} (h\ pq(l,n) xp(n-l) + \omega q(n) \qquad (5)$$

Where $\otimes$ is the cyclic convolution, *wq*(*n*) is the additive white Gaussian noise (AWGN), and *hp,q* (*l, n*) is the impulse response of the *l th* channel tap between the *p*th transmit antenna and the *q*th receive antenna at time *n*. From the model introduced about that; the expression of the received signal must generally include a possible phase error.

However, the ICI effects may or may not be mitigated effectively without the original phase error information.

This is done either by assuming a perfect synchronization of the receiver's local oscillator with the incoming RF carrier or the ICI mitigation technique may not require information about the phase error at all.

V. ICI Cancellation Technique

ICI cancellation techniques are essential in improving the Bit Error Rate (BER) performance of OFDM systems in an environment which induces a large frequency offset error.

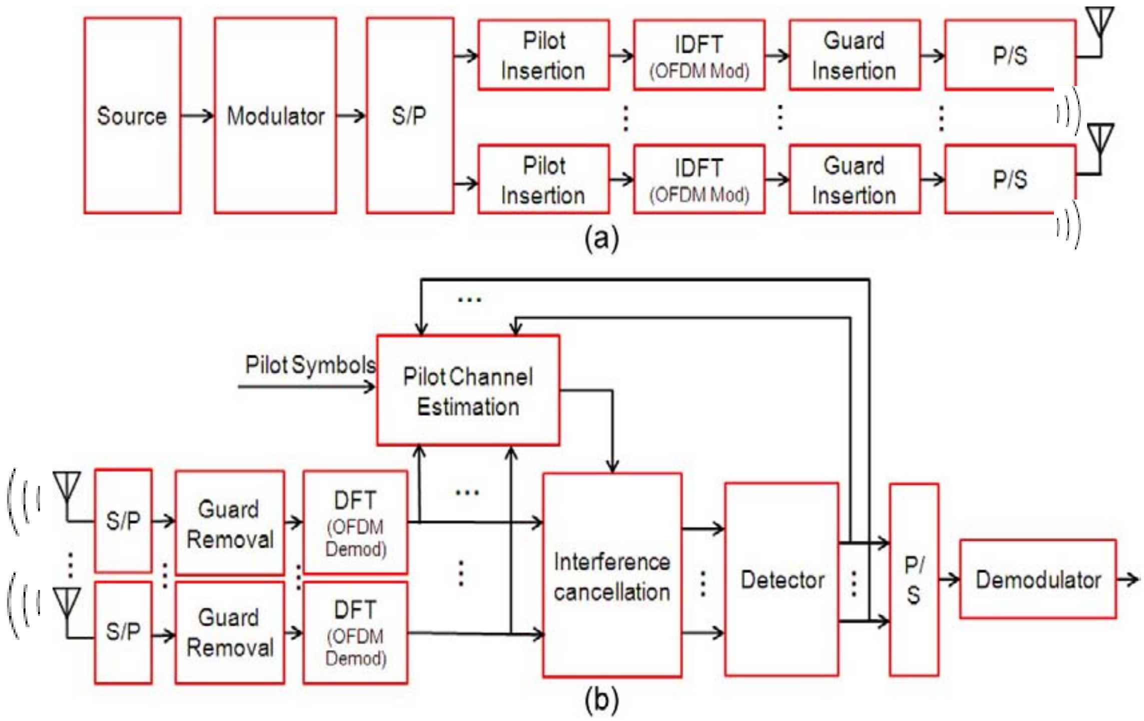

Figure 10 : Block diagram of the OFDM system (a) Transmitter (b) Receiver

A lot of ICI mitigation methods have been extensively investigated to combat the ICI, including the following:

1. Channel Estimation with Frequency-Domain Equalization (CE-FDE).
2. Time-domain windowing filters.
3. Self-cancellation schemes.
4. Frequency offset estimation and tracking techniques.

VI. Channel Estimation with Frequency Domain Equalization

The advantages of OFDM of viewing the channel as a single tap channel, thus; a simple one tap equalizer is needed to estimate the channel and recover the data. The techniques for equalization in high mobility channels are generally classified as linear equalization: a zero-forcing (ZF) equalizer or the Minimum Mean Squared Error (MMSE) equalizer in frequency domain was proposed by ignoring the ICI terms which have insignificant influence on the desired signal.

While nonlinear equalization is classified by: Decision Feedback Equalizers (DFE), after MMSE; the complexity and performance trade-off become better. Its complexity grows linearly with the number of transmit antennas and transmission rate and the effect of the AWGN is eliminated as in [17]. The following scheme is presenting the parallel interference cancellation with decision statistical combining (PIC-DSC):

In the first stage (soft decision), the received signal at each time slot is given by:

$$r_t = Hx_t + n_t \tag{5}$$

Where, rt is received signals across the nr receive antennas, xt is the transmitted signals and nt is the AWGN noise signals from the receive antennas,

$$yt = wHi\ r \tag{6}$$

Where, w is an nr× nt matrix of linear combination coefficients given by:

$$w^H = [H^H H + \sigma^2 I_{nt}]^{-1} H^H \tag{7}$$

Where, σ 2 is the noise variance.

In the second stage (hard decision), min E {(x − w H r) 2 }

$$x\wedge_i^t = q(y_i^t) \tag{8}$$

In the algorithm - with interference suppression only - the detector calculates the hard decisions estimates by using the above equation for all transmit antennas. In interference suppression and interference cancellation, a soft decision is given by:

$$y_i^t = w_i^H r \tag{9}$$

Where, i is the transmitting antenna number and hard decisions:

$$x\wedge_i^t = q(y_i^t) \quad (10)$$

$$r^{i-1} = r^i - x\wedge_i^t h_i \quad (11)$$

Where, hi is the ith column in the channel matrix H. One of the disadvantages of the MMSE scheme with successive interference cancellation is that the first desired detected signal to be processed sees all the interference from the remaining (nT −1) signals, whereas each antenna signal to be processed later sees less and less interference as the cancellation progresses as shown in Fig. 11, the ZF versus MMSE equalizers for QPSK. This problem can be alleviated either by ordering the layers to be processed in the decreasing signal power or by assigning power to the transmitted signals according to the processing order as in [10].

MMSE and ZF equalizer performance for QPSK for Rayleigh channel +AWGN response.

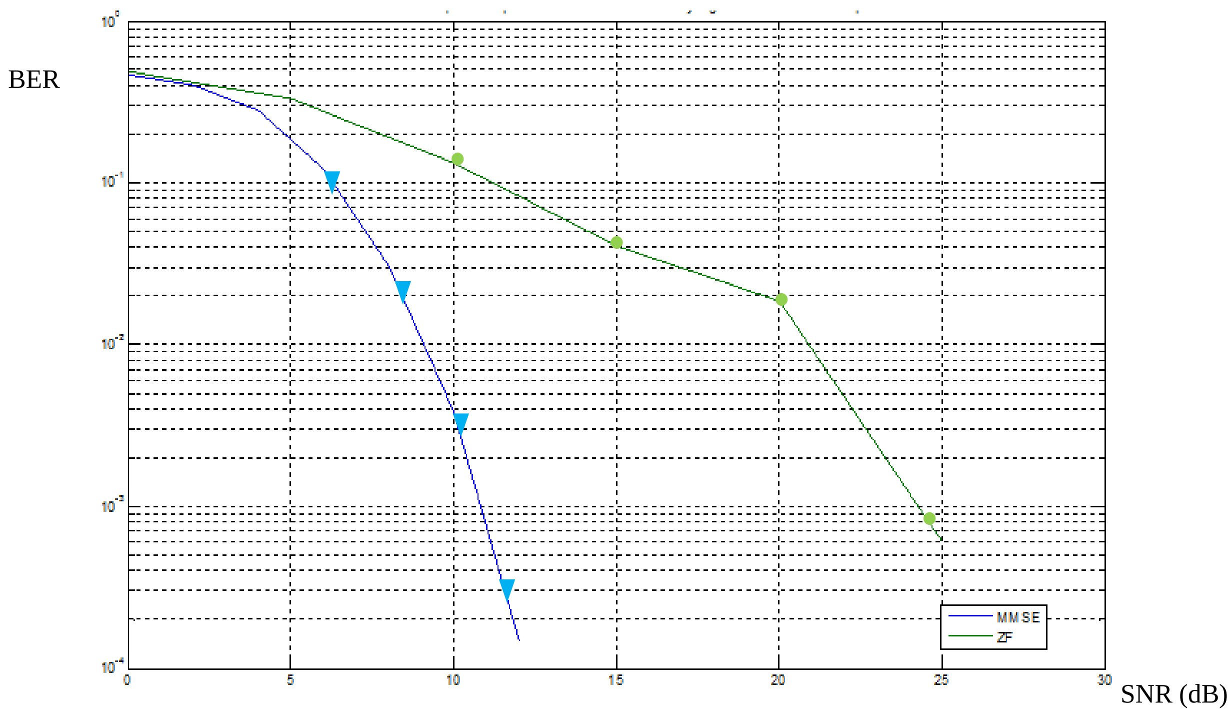

Figure 11 : ZF versus MMSE Equalizers in MIMO multiplexing systems for QPSK modulation

VII. Comparison Between ZF Versus MMSE Equalizers in MIMO Multiplexing

Nonlinear equalizers generally outperform linear approaches; however, linear equalizers still preserve their importance mainly because they are less complex. But, since the number of subcarriers is usually very large, may reach about 8,096 in high speed wideband wireless standards, even linear equalizers demand very high computational load. Fig.12 shows the ZF versus MMSE for 16QAM. The main factor that affects the rate of fading is the mobility of the receiver relative to transmitter - as the receiver moves with some velocity relative to the transmitter and the phase shifts of the received signal changes (Doppler shift). The specific structure of the Doppler induced ICI matrix in OFDM systems operating over highly mobile channels is a distinctive feature of each proposed receiver. On the other hand, the recent work on the separate equalization and estimation for OFDM systems in a highly mobile environment can be summarized as in the following section.

MMSE and ZF equalizer performance for 16 QAM modulation

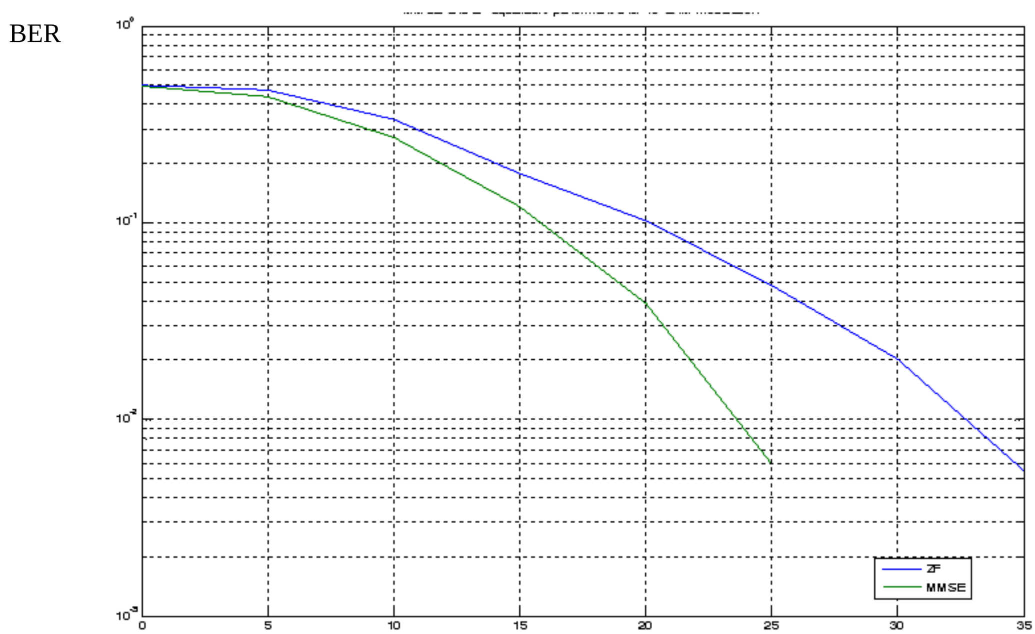

Figure 12 : ZF versus MMSE Equalizers in MIMO Multiplexing Systems for 16QAM Modulation

For a rapidly time varying Doppler channel, the time domain channel estimation method proposed in is a potential candidate for the channel estimator in order to mitigate the ICI. This technique estimates the fading channel by exploiting the time-varying nature of the channel as a provider of time diversity and reduces the computational complexity using the singular-value decomposition (SVD) method. However, the linear MMSE successive detection with optimal ordering proposed in along with channel estimation demand very high computation, since the number of subcarriers is usually very large; thus it may not be feasible in practical systems.

VIII. Complexity Reduction in Complex Exponential/Equalization

Most of the complexity reduction techniques depend on a finite power series expansion for the time varying frequency response is used and channel acquisition and ICI removal are accomplished in the frequency domain. This is instead of assuming that the channel is banded as in low mobility environments complex exponentials.

a) Time Domain Windowing Filters

Time windowing methods have the advantages that they reduce the required SNR to achieve the BER than that do not use time domain windowing. Fig. 13, shows the BER of an OFDM system versus SNR (dB) QPSK modulation.

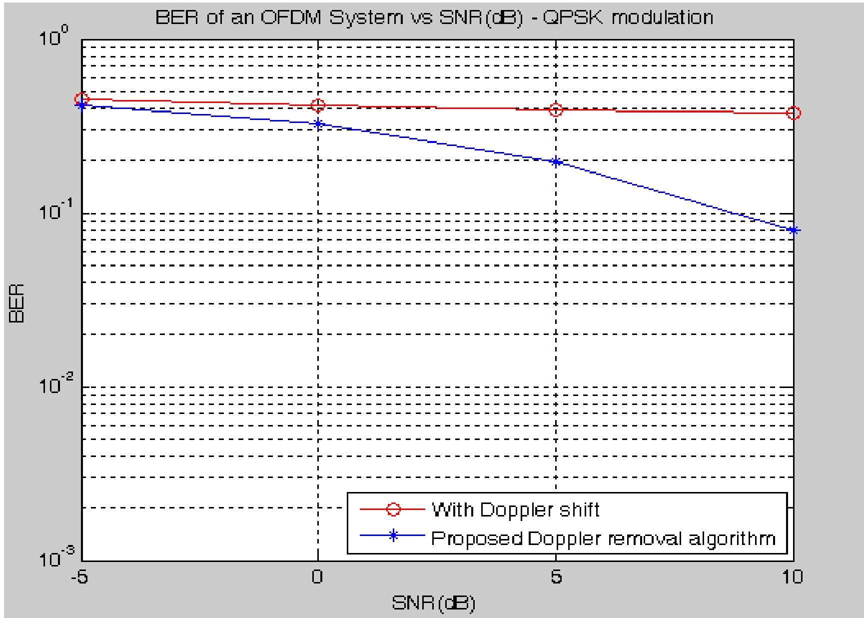

Figure 13 : BER of an OFDM system versus SNR (dB) - QPSK modulation

They need redundant information, performance of the windowing methods degrade significantly with the increase of frequency offset. The BER performance levels off with increasing the SNR and is not a monotonically decreasing function of the SNR.

b) Self Cancellation Schemes

Among the methods, the ICI self cancellation method is a simple way to suppress ICI that uses redundant modulation. Several self-cancellation methods have been exploited, including data conversion, data conjugate and symmetric data-conversion/conjugate methods. The advantage is gain with high accuracy, but the performances of the self-cancellation methods degrade significantly with the increase of frequency offset, and the data low efficiency which increase system high computational complexity.

c) Frequency Offset Tracking by Kalman Filter (KF)

Several of algorithms have been developed for Carrier Frequency Offset (CFO) estimation in OFDM. KF algorithms belong to the frequency offset estimation and compensation methods. Fig. 14, shows the FO tracking by KF, in this method; the received signal is divided into real and imaginary parts.

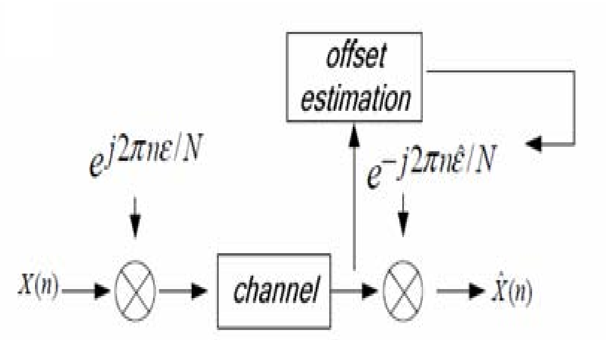

Figure 14 : Frequency Offset Tracking by Kalman Filter (KF)

With some relationship between the real and imaginary parts, the KF is used to estimate the frequency offset regardless of the estimate of original phase of carrier. KF is an adaptive one and hence; the Doppler frequency drift information can be updated at each step to get a more accurate result [17].

d) Extended Kalman Filter (EKF)

The EKF which is based on Taylor series linear approximation of the received signal model. The main disadvantage is that the Doppler Effect with noise is actually a non-linear Gaussian process, so the approximation is not very accurate, in addition to calculating the Jacobean matrices, may increase the computation complexity such that the system runs out of real time applications. This lead to proposing what is called Unscented Kalman filter (UKF), which is based on is unscented transformation of the joint distribution and has the advantages that; UKF performances better at capturing the higher order moments caused by the non-linear transform and the computation of Jacobean matrices is not needed, so the estimation procedure is in general easier and less subject to errors.

On the other hand it the estimated value by this algorithm is not accurate when Doppler shift is larger. From what was presented, the performances of the time domain windowing methods and the self cancellation methods is degraded significantly with the increase of frequency offset. Also, KF algorithms belong to the frequency offset estimation and compensation methods, but its implementation is more complex than self cancellation methods. From Fig. 15, It can see that the proposed scheme outperforms convergence characteristic of channel estimation with the PIC-DSC interference cancellation scheme - under various normalized Doppler spreads (0.1 and 0.025) at SNR 20dB and 30dB - has better symbol error rate (SER).

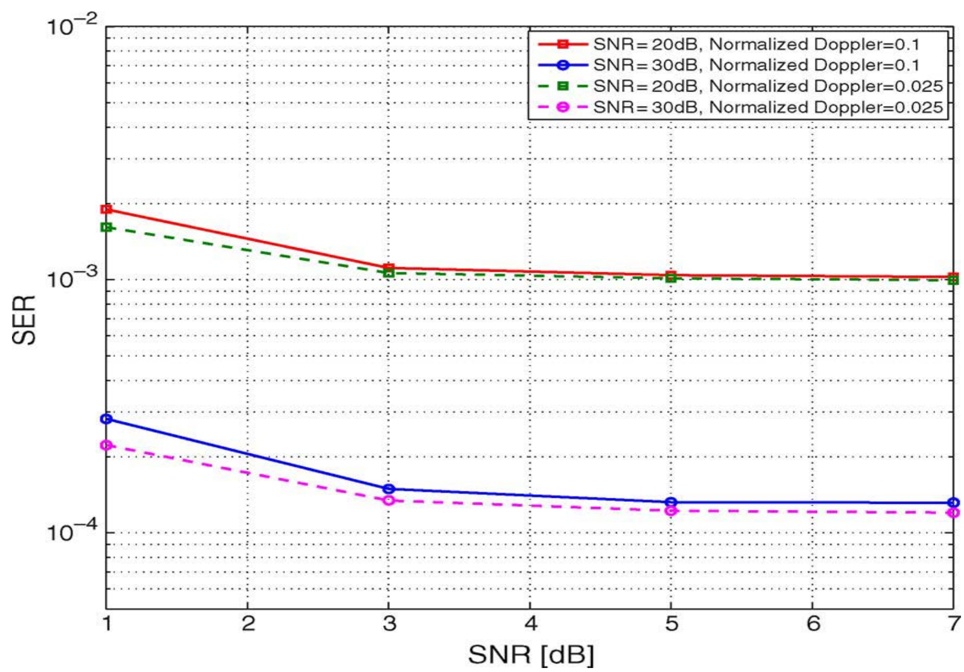

Figure 15 : Convergence characteristic of the proposed channel estimation with The PIC-DSC interference cancellation scheme under various normalized Doppler spreads

IX. Beam-forming Techniques

Another category to avoid complicated channel estimation and equalization is by some pre-processing method at the transmitter or receiver - such as frequency domain pre-coding. MIMO-OFDM symbol detection requires channel state information (CSI) estimation at the transmitter. The reliability of symbol detection depends on the accuracy of the channel estimation at the receiver. To accurately estimate the wireless channel, a number of subcarriers in an OFDM symbol are used as pilots, the remaining subcarriers are then either employed to transmit data symbols or set as unused carrier.

In Water-Filling algorithm and SVD the case that the transmitter and receiver know the CSI matrix H, the capacity can be further enhanced by using a type of beam forming technique in which we assign unequal powers among the transmitter ports. The optimal power distribution method that can be used is known as the water filling algorithm. In such algorithm, the MIMO transmitter array is assumed to virtually divide the channel into independent decoupled sub-channels and beam forming of the radiated transmitted signal is performed to send information among these virtually decoupled sub-channels, in such a way that the best Eigen modes of the propagation channel, that is, the sub-channels with highest gain are selected. Thus; water filling is an optimal method of power distribution among spatial MIMO sub-channels created using beam-forming techniques, in which weaker channels are - in general - not used. In linear algebra, the SVD is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. Formally, the SVD of an m×n real or complex matrix M is a factorization of the form [18]:

$$M = U \Sigma V^* \quad (12)$$

Where *U* is an m×m real or complex, *Σ* is an *m×n* rectangular diagonal matrix with non-negative real numbers on the diagonal, and *V** (the conjugate transpose of V) is an *n×n* real or complex unitary matrix. The diagonal entries *Σi,i* of *Σ* are known as the singular values of *M*. The m columns of *U* and the *n* columns of *V* are called the left singular vectors and right singular vectors of *M*, respectively. The singular value decomposition and the Eigen decomposition are closely related. Namely: The left singular vectors of *M* are eigenvectors of MM^* and the right singular vectors of *M* are eigenvectors of M^*M .The non-zero singular values of *M* (found on the diagonal entries of *Σ*) are the square roots of the non-zero eigen values of both M^*M and MM^*.

Applications which employ the SVD include computing the pseudo inverse, least squares fitting of data, matrix approximation, and determining the rank, range and null space of a matrix as in. If we assume the SVD of the CSI matrix H is given by the following equation [18]:

$$\mathbf{H} = \mathbf{U}\Lambda\mathbf{V}^{\mathbf{H}} \quad (13)$$

With U and V are the left and right singular vectors respectively. $(.)^H$ is the Hermitian operator and Λ is a diagonal matrix whose elements are the singular values λ_i of the CSI matrix *H*.

These singular values are given by :

$$\Lambda = \mathbf{U}^{\mathbf{H}}\mathbf{H}\mathbf{V} \quad (14)$$

Where, Λ : is the uppercase notation of λ and the Hermitian operator $(.)^{\mathrm{H}}$ is just the conjugate of the transpose of a complex matrix, that is, $(.)^{\mathrm{H}} = \left((.)^*\right)^T$.

The Power Distribution Function (PDF) of the matrix and elements (landas), the average allocation and water – filling allocation depends on rank of the channel matrix H and by applying SVD in the statistical behavior of MIMO channels.

The following two figures, (Fig. 16 and Fig. 17) are showing the PDF of elements in matrix landa in SVD decomposition of matrix H of nt x nr and the capacity of a MIMO channel with nt x nr nr antenna varying from 1 to 8 respectively. Recently, spatial diversity has attracted a lot of attention due to its capability to mitigate fading in wireless channels.

Some techniques show that beam forming can alleviate the time variance.

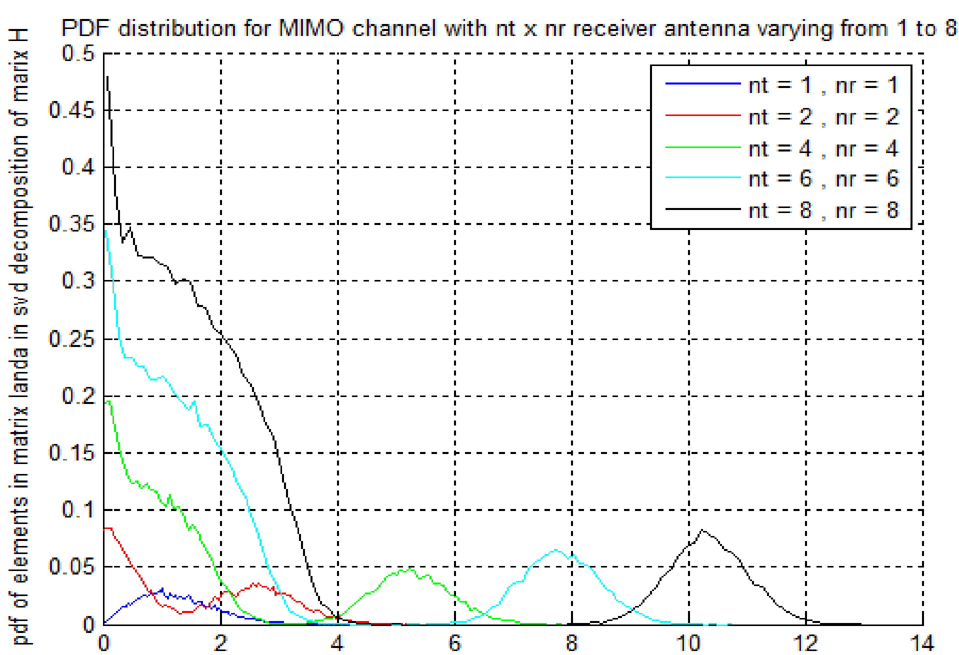

Figure 16 : PDF Distribution for MIMO Channel with nt x nr Receiver Antenna Varying from 1 to 8

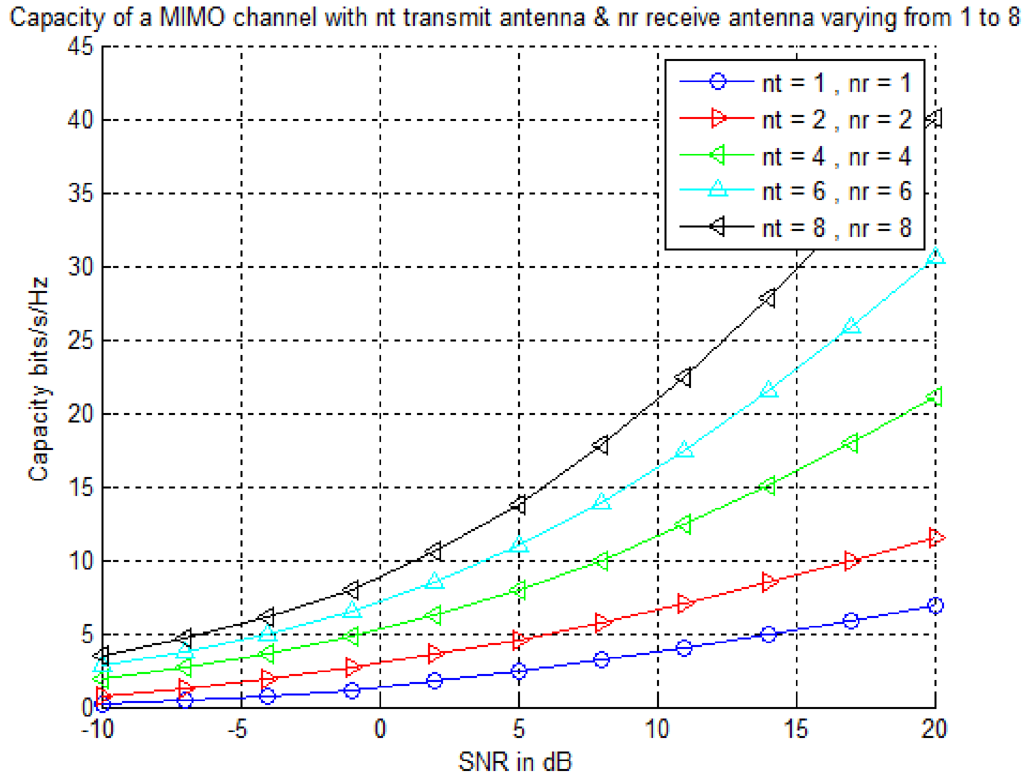

Figure 17 : Capacity of a MIMO Channel with nt x nr Receive Antenna Varying from 1 to 8.

By using ideal directional antennas and sectorized antennas the ICI to be investigated. These works reveal that the ICI can be partially compensated by regarding the Doppler spread as an equivalent frequency shift in a certain sector. In many cases, the space is divided usually into three sections according to the strength of ICI, which were processed respectively by dual antenna. These schemes can narrow the Doppler spreading by ideal sectors and have low complexity increase in the baseband. The receiver can form ideal patterns in certain angles-of-arrival (AoA), it can focus on these AoA, and correct their Doppler shifts via a frequency shift and sum up again to compensate the Doppler spreading. The multiple directional paths after Doppler compensation are finally combined for extra performance gains. No remarkable advantages can be stated - since it is an alternative equivalent to the channel estimation and equalization techniques, the disadvantages is the perfect CSI is not always available at the transmitter site and needs a reverse link, hence low spectral utilization.

X. Conclusion

Throughout this study, a highly scattered mobility environment is considered for the capacity of a MIMO channel with nt x nr is analyzed, the power in parallel channel (after decomposition) is distributed as water-filling algorithm of a PDF of the matrix lanada elements is depicted too. The algorithm is proposed to remove the Doppler shift arising from high mobility corresponding to a normalized Doppler shift of 0.2 or a speed of 120 km/hr. In this study, the proposed scheme for Doppler assisted channel estimation with the parallel interference cancellation with decision statistical combining scheme (PIC-DSC) for high mobility MIMO-OFDM systems improve the ICI cancellation which is essential in enhancing the BER performance which induces a large frequency offset error. The wireless channel has been estimated by using the Doppler spread information; the simulation results show that the proposed scheme outperforms convergence characteristic of channel estimation with the PIC-DSC interference cancellation scheme - under various normalized Doppler spreads (0.1 and 0.025) at SNR 20dB and 30dB - has better symbol error rate (SER). Note that the normalized Doppler spread of 0.1 is equivalent to an LTE user moving at the speed of 324 km/h and operating in the 5GHz band with a sampling frequency of 7.68MHz.

XI. Future Works

For future work, it would be interesting to study the performance of STBC-OFDM in fast fading channels, and to compare the advantages and disadvantages of both STBC-OFDM and other potential modulation techniques to be used for the future 4G wireless communication systems such as WiMax (IEEE 802.16m) and LTE advanced. Also, an STBC-OFDM system will

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suffer from two kinds of interference in time varying channels. One of them is the ICI caused by variation of the received subcarrier multipath channels within an OFDM symbol; it would be interest for research to study the effect of ICI and how it will significantly degrades the system performance under high mobility, and to focus on the computation complexity.

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Models and Techniques Analysis of Border Intrusion Detection Systems

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MODELSANDTECHNIQUESANALYSISOFBORDERINTRUSIONDETECTIONSYSTEMS

Strictly as per the compliance and regulations of :

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Mosad Alkhathami [α], Lubna Alazzawi [σ] & Ali Elkateeb [ρ]

Abstract- This research paper sets out to explore various border intrusion detection systems but with emphasis on wireless sensor detection method. The system described in this paper relates to the detection of human beings in particular but also offers ways of detecting non-human intruders such as objects and animals. Thus, the study aims at ascertaining the intruder crossing a specified border or perimeter under surveillance before raising an alarm. It also looks forward to provide intrusion detection mechanisms for other forms of objects that are considered to be intruding to a specified perimeter. The application is being developed for border intrusion detection problems that are mainly focused on human and any other intruder. As such, the system will focus on all forms of intrusion including objects. There is also need for an intrusion detection system to ascertain the identity of the intruder. There is need for the system to distinguish between animal intrusion, human intrusion and any other object that may be used to detect the intruder. Since this paper is meant particularly for human intrusion, it will focus on the human and while also explaining the capability available for detecting animal and object intrusion. Most of the low-cost surveillance systems lack the capability of discerning the intrusion of animals from humans. The study proposed in this paper will make use of shape to train the neural networks. A series of theories that explain the development of the system has been provided in the paper. The discussion has also included recent intrusion detection techniquesand the mathematical derivation of recommended intrusion detection technique.

Keywords: intrusion detection techniques, wireless sensor network, detection models,dma, neural network, border security, network deployment.

I. Introduction

Borders of all nations in this world are at danger and, because of their vast sizes, cannot in any way, shape, be observed in their whole by individuals at extremely inconvenient times of the day. Security is considered to be the primary concern of most of the countries in the world today. The increase in terror and other related crime activities have raised the need to develop and implement intrusion detection system that can raise an alarm whenever there is danger. There are many applications of intrusion detection mechanisms. The primary concern in this paper is the human and object intrusion mechanism. The study will focus on the development of the intrusion detection that will detect the activities of human beings, as well as, other intruders.

Most of the intrusion detection systems have employed wireless sensor networks to facilitate the communication[1]. Wireless sensor networks are considered to provide not only easy implementation procedures but also rapid alternatives for building the network. Depending on the mode of deployment, the coordinates of the sensor devices can follow a given distribution pattern. The mode of distribution of the sensor devices will depend on the nature of the perimeter under surveillance. The analysis of the distribution mode will can be solved using a three dimensional field models and also analysis of non-uniform deployment[2]. Deterministic deployment can also work for plain and easily accessible fields.The system will be deployed in sensitive areas that are expected to have suspicious activities by human beings. The model developed here will make use of wireless sensor networks that will be controlled from a central point. The wireless sensor networks will work to track the detection signals that are obtained from each individual sensor.This paper is organized as follows: Section 2 presents the intrusion detection system architectural design. Section 3 briefly describes different types of sensors that used intrusion detection. Section 4gives the Network Model for WSN. Section 5 presents the intrusion detection systemtechniques. Section 6the recommended technique for Intrusion detection system. Finally, this paper is concluded in Section7.

II. Intrusion Detection System Architectural Design

The design of a successful intrusion system will have to incorporate a given perimeter that will be defined by the monitoring system. Typical intrusion systems are normally developed to monitor a given perimeter which in most cases is defined by an object. The entire security perimeter of the border is coordinated from a central base station [3]. Any detection segment is sent to the central base station. It should be also mentioned the activity of such systems must be supported 24/7. The system should be allowed to run throughout its life. This ensures continuous monitoring of the defined region. Additionally, the deployment of the sensors should be made in such a

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way that the perimeter is entirely covered without any unattended spaces in between the nodes. This requires accurate and effective orientation and positioning of the sensor devices [4]. It can also be said that such system require a design where intruders are less likely to notice the location of the sensors. There is also need for the sensor devices to communicate to each other. This can only be accomplished through the use of line topology where the sensor devices are placed in a straight line of a semi-straight. This implies that routing will be very important in deriving the communication protocols for the sensors [5].

III. Intrusion Detection Sensors

The decision on the location and distribution of the sensors is considered to largely contribute tothe success of the system. Human intrusion can be detected using many sensor modalities that do not emit a signal and sense how targets modify it. Magnetic sensors accept that the trespasser, for instance a person carrying weapons, has material that is magnetically sensitive [6]. Ferromagnetic material generates a particular magnetic signature, which can be sensed by means of a magnetometer. Footsteps of humans and animals, birds flapping their wings, etc., correspondingly make sound over and above the entity's voiced sound. Sensors designed to take measurements of sound are fundamentally hydrophones and microphones. Conversely, vibration-based motion sensors sense displacement, velocity, and acceleration using ismometers/geophones, velometers, and accelerometers, respectively. Additionally, in the case of heavy vehicles there might be coupling between the acoustic noise and ground vibrations [7]. The acoustic waves travel at different speeds and their amplitudes decrease at different rates with distance or get absorbed at different rates. This helps in distinguishing the type of intruding vehicle or other noise source. Table below shows a comparison between different types of sensors when used in detecting intrusions such as human beings, animals, or objects.

Table 1 : Comparison of the existing intrusion detection sensors [12]

Sensor	Low Power	Reliability	Cost
Infrared(Thermal)	Yes	Medium	Low
Ultrasound	No	High	High
Accelerometer(Seismic)	Yes	Low	High

Table above shows a comparison between different types of sensors used in detecting intrusion such ashuman beings, animals, or objects. Infrared, ultrasound and accelerometer are most common intrusion detection sensors. Comparing the infrared and accelerometer sensors, the infrared sensor has better movement detection properties [8]. In addition, an infrared sensor requires low energy and has an analogue output signal that gives the direction of an object's movement. Ultrasound sensors are used to locate objects such as human beings using the high frequency acoustic waves reflected from an object. The delay between transmission of the ultrasound pulse and the echo return helps determine the distance of the object. Accelerometer is a low power dynamic sensor used to determine the position and velocity, orientation or tilt and impact or vibration and shock.

IV. Intrusion Detection Sensor Models

An intrusion detection sensor model is a model of a real time intrusion detection system that is capable of detecting penetrations, break-ins and other forms of abuse. An intrusion detection sensor model helps discover distinct pattern that describes an abnormal or intrusion activity. The discovered distinct pattern is used to train the detection model to recognize abnormalities and intrusion. The models are built using low cost sensors that send sound and light data to help the model make an automated decision and report an abnormality or intrusion activity. Each model of the network can monitor the local region and then communicate through the wireless channels with the other nodes for the collaborative production of a high-level representing on the state of the environment [9].There are many different types of sensor models that can be employed in intrusion detection systems. Depending on the area to be covered and the type of space, different kinds of WSN can be deployed. Most of the outdoor applications are known to make use of microwaves, infrared, ultrasonic and radar sensor systems. The effectiveness of these models will depend on the target to sensor distance, environment, propagation characteristics, size and motion pattern of the target, amount of energy emitted, capability of the sensor etc[6].Below are the detailed descriptions about the most common detection sensor models.

a) Probabilistic Model

Probabilistic sensing model is an accurate sensing model adopted in the analysis of the quality of coverage of WSN. A probabilistic sensing model takes into account the detection probabilities of the sending device, which decay with factors such as distance, hardware configuration and environmental conditions [10]. The probabilistic sensing model helps develop intrusion detection systems whose sensors are deployed and distributed in a manner that meets the system requirements and minimizes cost. Probabilistic sensor model relies on the threshold distance within which an intruder can be detected wirelessly. This implies that the threshold distance is governed by the perimeter of the space within which the detection should occur. In relation to Elfes' model the detection probability can be described by such physical parameters of the sensors that are accommodated by the generic model parameters. If the target sensor distance is abbreviated d, the detection probability is an exponentially decaying function of *d*. The rate of decay is determined by two parameters; *y* and *B* which reflect the sensor characteristics [11]. In general the probability that a sensor will detect a target can be found using the following relation.

$$P_d = \begin{cases} 1 \\ e^{-\lambda}(d - d_t^1)^{\beta} \\ 0 \end{cases}$$

According to the formula above, the probabilistic sensing model sensor detects a target object with a probability of 1 if the distance between the target and the sensor *d* is below the threshold distance d_t. This is a simplified formula using *d* alone that can be deployed indoors where the light of sight is ensured. According to the following, the following conditions holds:

If $d<d^1_t$ then $P_d =$ 0. However, the detection probability used if target object lies in a range of $d^1_t<d<d^2_t$, then an exponentially decaying function is deployed, using the parameters β and λ. The parameters β, λ, d^1_t *and* d^2_t are adjusted based on the physical characteristics of a sensor. Different detection models can be illustrated using the following figure. The figure shows three common detection models that are governed by different technical parameters.

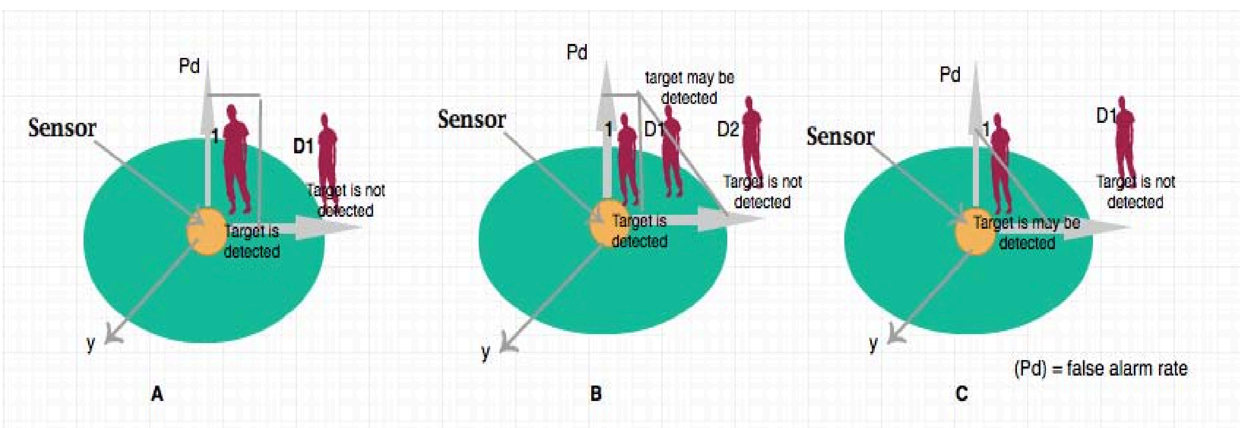

Figure 1 : a) Binary Detector b) Elfes's Detector, c) Neyman-Pearson detector

The probabilistic model is founded on the concept that the sensors will operate in the presence of additive white Gaussian noise. It is also assumed that the signal will undergo path loss. There are two hypotheses that represent the presence and absence of a target setup. The NP detector serves to compute the likelihood ratio which is used to compare the detection results against a threshold false alarm constraint [12]. The formulation of NP is provided below where Gaussian noise and path loss are assumed.

$$pd = 1 - \Phi(\Phi - 1(1-\alpha) - \sqrt{\gamma 9d})$$

The above relation incorporates both target distance and the cumulative distribution function of zero mean unit variance Gaussian random variable at the point x. If the standard bounds are introduced into the system, then the probability can be computed as below. In the above formulation, *γ(d)* is a signal to noise ratio at the sensor, when a target is at a distance *d*. *Φ(x)* represents the cumulative function of the zero mean and unit variance Gaussian variable at a point *x*. The equation uses the proportionality $\gamma(d) \sim d^{-\eta}$. The formula below is derived using the standard bounds on *Φ(x)*.

$$pd \approx A(\gamma(d).\eta.\alpha)exp\{\Phi - 1(1-\alpha) - \sqrt{\gamma(d)}$$

Where A(ϒ(d)) is the signal to noise ratio level. It can be emphasized that the above model has demonstrated an exponentially decaying factors that is governed by the sensor-target distance [13].

b) Exposure-Based Sensor Model

The second model that is commonly used in the intrusion detection systems is the exposure-based sensor models. This model is based on the fact that the received energy level provides a clue on the observability. The expected level of observability within the monitored space is referred to as exposure. The total amount of energy that is received by the sensors at different points on the breath path is normally defined as the path of exposure[14]. The level of detection energy can be expressed as shown below.

$$Si(d) = \frac{k}{dk}$$

From the above formulation, *Si(d)* represents the signal energy of the target. The signal energy for the target is a measure from an *i*th sensor, and the distance between the target and the sensor is *d*. Where k is barrier coverage or the decay factor of the energy and dk is detection energy. *k* is a nonnegative constant that satisfies the condition $2<k<5$ [15]. A multiplicative factor can be included in the system to cater for the effects of obstacles and other sources of errors. The most essential designing factor is the fusion of exposure levels where different types of sensor devices are deployed [16]. Using the preceding sensing and exposure model and knowing the threshold energy, can detect any kind of target. Finally the advantage of exposure-based coverage assessment is the inclusion of a practical object detection probability that is based on signal processing, signal distortion, as applicable to specific sensor types.

c) Shape Based Intrusion Detection Models

There is need for an intrusion detection system to ascertain the identity of the intruder. There is need for the system to distinguish between animal intrusion, human intrusion and any other object that may be used to intrude any object. Since this paper is meant for human and object intrusion detection mechanism, the algorithm developed will focus on the human and other object detection mechanisms. Most of the low-cost surveillance systems lack the capability of discerning the intrusion of animals from humans. The shape of a human being and the intruding objects are simplified through removal of the redundant points that connect short and straight line segments. The technique can be employed to search for best matched contour within the database in order to distinguish humans from other objects using different viewing angles and distances [17].

This methodology makes use of differential motion analysis which detects the scene change within perimeter of the surveyed region. The object contour is extracted by getting the difference between a reference and the test image. The differential motion analysis method eliminates illumination variations through subtraction. The polygon approximation technique integrated into the system to extract contour in order to remove the noise and as such eliminate redundant data points. This makes the shape to be represented using a fixed number of points. The shapes are described in a way that makes them invariant to rotation, scaling and translation using shape representation techniques such as turn angle and bend angle function. The shape features that are collected are used to measure similarity between the test contour and those contained in the database. The following Figure shows the basic steps that can be used to extract the shape of a human being.

An intrusion detection system under this model has a database composed of different shape features of possible objects through training. The database thus contains shape features of images taken from different times, locations, angles and distances. The new shape features of a target object is calculated from the contour and compared with a reference shape feature in the system database. The target and reference shape are matched based on either a similarity or a dissimilarity measure. A best shape match for a target object is one with a high similarity measure or a minimum dissimilarity measure with a reference shape feature. The matching helps determine the intrusion object.

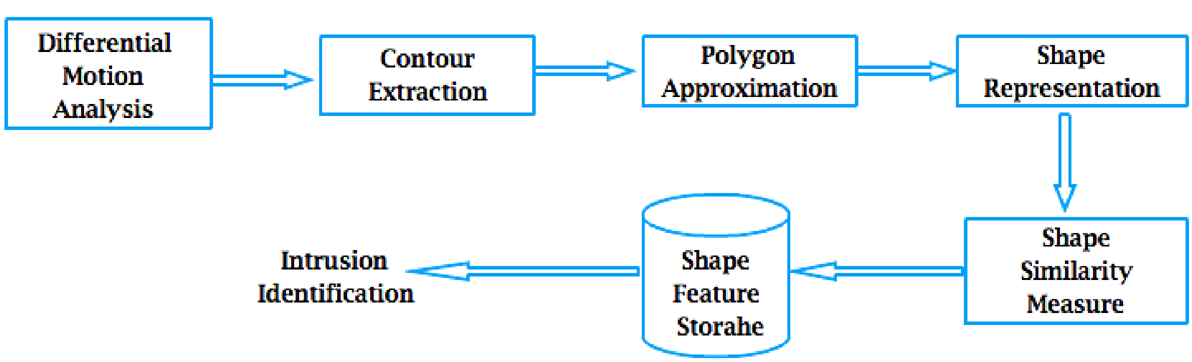

Figure 2 : Basic steps used to extract shape of human being

d) Barrier Coverage Intrusion Detection Models

Any kind of movement or crossing could be detected by the barrier coverage model. The purpose of barrier coverage is to detect intruders who attempt to cross from one side to the other side of the border area that you want to detect. Barrier coverage model is a technique whose goal is to minimize the probability of an undetected intrusion through a sensor network or a barrier. S But sometimes in some situations, it is not necessary for detecting both direction of crossing the belt. Therefore, barrier coverage is not suitable model since it may not differentiate the illegal intruders from the

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legal [18]. The barrier coverage can be considered as the coverage with the goal of minimizing the probability of undetected penetration through the barrier. Figure 3 shows the general of the barrier coverage problem where start and end points of the path are selected from bottom and top of the area. The selection of the path depends on the objective.

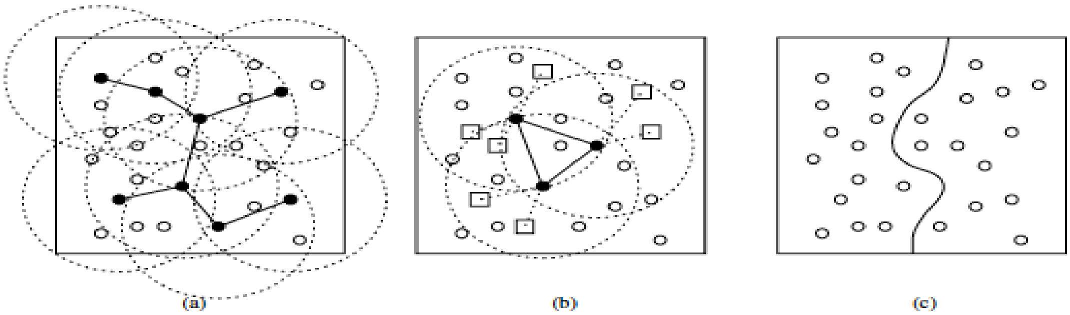


Figure 3 : (a) Random sensor deployment for square-shaped area; (b) random sensor deployment to cover set of points; (c) general barrier coverage problem [18]

Figure 3 represents a sample of random deployment of sensors to cover the perimeter of a square shaped area. The active sensors are represented by the set of connected black nodes through a scheduling mechanism inside the square shaped area.

V. Intrusion Detection Systemtechniques

Intrusion involves an activity that violates the security policy of a protected area or system, while intrusion detection is the process of identifying an intrusion. Monitoring illegal movement across a border is a challenging task. WSN is an emerging technology that is expected to provide new ways of energy and cost efficient border intrusion detection. An intrusion detection system technique is usually deployed as a line of defense to protect a border. Intrusion detection system techniques include the cost effective techniques deployed for monitoring critical applications ranging from border monitoring to industrial control. Intrusion detection techniques provide accurate detection and tracking of intrusion with minimal human intervention [19, 20]. Some of the existing intrusion detection techniques include dynamic mechanical analysis, infrared intrusion, neural network, and image processing detection systemare described below.

a) *Dynamic Mechanical Analysis Detection System*

Dynamic Mechanical Analysis (DMA)system considered to be a powerful technique that can be used to process the shape of a human being. The processing helps to distinguish the human beings from animals. It also helps the system to differentiate humans from other objects. The following Figure illustrates the working mechanism of DMA.

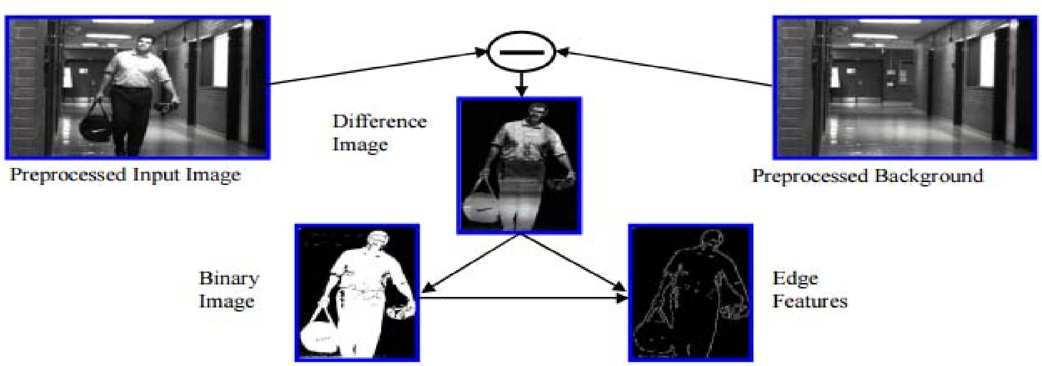


Figure 4 : Differential motion analysis using a reference background [2]

In Figure 4 the selected reference image was subtracted from the input image to provide the difference image. Also a linear threshold can be selected to binarize the difference image.It should be noted that shape descriptors and classification algorithms ought to be invariant to rotation, translation, scaling since the objects can be viewed from different angles, locations at different sizes. The following expression can be used to compute the data point reduction[17].

$$K(S1,S2) = \frac{|\beta(S1,S2) - 180|(S1)(S2)}{|(S1) + |S2)}$$

The formula above is a curve evolution technique that compares the relevance measures of the vertices on the contours. K is the relevance measure for the curve evolution method. K is modified to eliminate the redundant points while maintaining the significance of the contours. In the formula above, β is the turn angle on the vertex between the line segments s_1 and s_2. $l(s_1)$ and $l(s_2)$ represents the normalized lengths from a vertex to the two adjacent vertices. Applying the formula of the modified curve evolution reduces the short and straight line segments that provide little information about an overall shape of an object. This method easily measures shape similarity as it preserves a fixed number of data points and preserves detail shape information unlike other techniques that may lose data points containing critical shape information. This can be illustrated in the following series of figures which outline the distinguishing feature of animals against those of a human being.

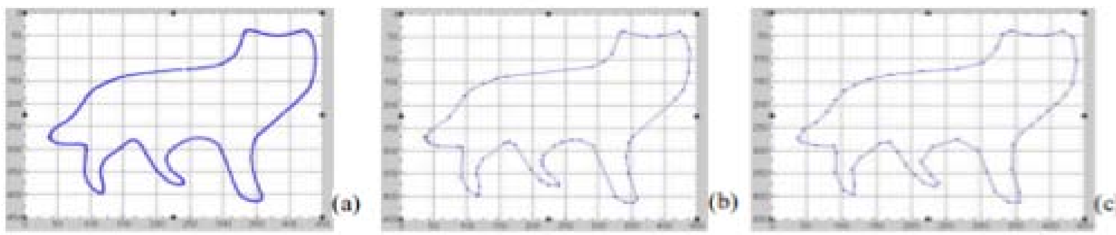
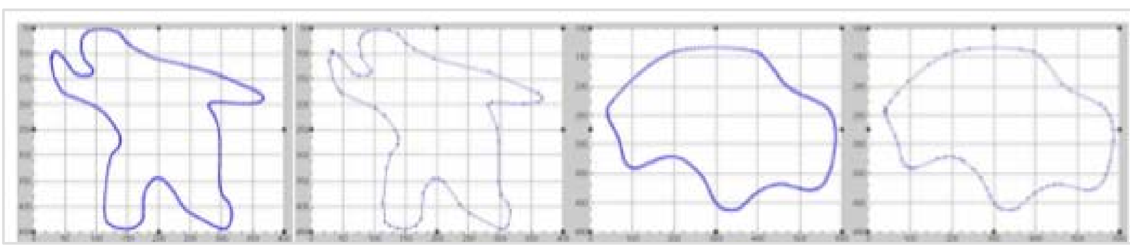


Figure 5 : (a) Original data set, (b) reduced to 60 points using Equation 5, (c) equal space sampling



(a) (b) (c) (d)

Figure 6 : Distinguishing features of animals against those of human beings [1]

In the above figure, 5(a) and 6(a) represents the original data set of a dog and human respectively. The data set is obtained through the use of contour extraction algorithm. Applying the equation above helps reduce the data set to obtain figure (b). The 60 data points contribute to the shape, and figure (c) is produced by equal space sampling of the data points. As we can see from the figure above, the bend angle have been reduced using the Fourier descriptors [21]. The any given bend angle function; the similarity of the two shapes can be established through Fourier expansion as shown below.

$$\Theta(1) = \mu 0 + \sum_{n=1}^{\infty} (an \ \cos nl + bn \ \sin nl)$$

The Fourier descriptors derived above is used to measure the similarity between two shapes [22]. *An* and*Bn* are the coefficients for each frequency component. The below formulation shows how the coefficients can be derived considering that ϴ*(l)* is a step function.

$$\mu 0 = -\pi - \frac{1}{l} \sum_{k-1}^{\infty} \lambda k \ \theta k$$

$$An = -\frac{1}{n\pi} \sum_{k=1}^{m} \theta k \sin \frac{2m\lambda}{L} \quad Bn = \frac{1}{n\pi} \sum_{k=1}^{m} \theta k \cos \frac{2m\lambda}{L}$$

$$Where \ \lambda k \sum_{i=1}^{k} |, \ AND \ L = \sum_{i=1}^{\infty} |, = the \ total \ lenght$$

b) Infrared Intrusion Detection System

Infrared is one of thetechniques that can be employed to detect presence of intruders. In this system valuable information can be obtained from the human such as the location and the other necessary signal that will confirm presence of a human being. The system is known to make use of the rate of the heartbeat to detect human beings. The system makes use of infrared sensor that comprises of a light emitting diode which is adjacent to a phototransistor. The infrared sensor is used to measure the distance between the detector and the intruder. The infrared sensor consists of infrared LED and a pair of silicon phototransistors. The high intensity and long range infrared distance sensors can be used to determine the presence of an intruder accurately and precisely [23].

This technology makes use of infrared light that is absorbed well in blood and weakly in human tissue.

As such, if light that is reflected back from the skin of an intruder on account of blood passages is captured by the detector. The reflected light consists of intensity variations that occur as a result of variations in the blood volume in the tissue which give rise to variations in output voltages of the detector. The voltage variations are used to detect the heart rate. When the voltage variations are found to match those of the heart rate, positive results of the detection are assumed.

c) Neural Network Intrusion Detection System

A neural network is essentially a network of computational units that jointly implement complex mapping functions.Also it is a systems mainly focus on the face to detect the presence of an intruder. There are two main stages that are involved in the detection process; application of a set of neural network-based filters to the image and arbitration of the filter outputs. Cameras of high resolution are used to take live images which are processed by the system. The images taken are first introduced to a set of filters which look for the location that might contain the face. Once the face has been located, the arbitrator is used to merge the detections from the individual filters and hence eliminate the overlapping detections.

The first component of the system involves receiving the image at a specified pixel by the filter. The filter processes the image to given an output that signifies the presence or absence of the face. The following figure can be used to illustrate the algorithm of the underlying process.

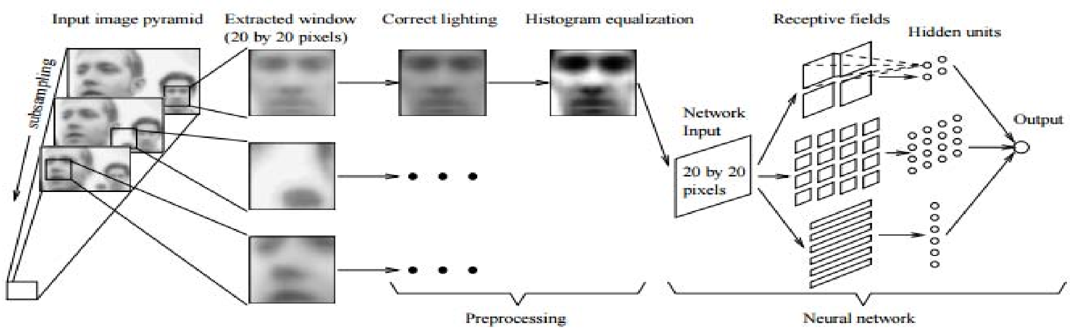


Figure 7 : Basic algorithm that is used to detect the presence of an intruder

The filter is normally applied at every location of the image in order to detect the face. Faces that may be larger than the window size are normally subsampled by a factor of 1.2 and the filter applied to each scale. The processed window is passed through a system of neural networks which determine the presence of the face. The neural network is normally trained prior to the detection on the general features of a face. This implies that neural networks are relied upon in confirming the presence of a face and therefore the presence of an intruder. It should also be noted that a minimum threshold on the number of detections is set in order to eliminate false detections [23]. The idea of using neural network is to discover patterns that describe an intrusion activity and train the neural network to discover them. The neural network system uses a set of 32 MicaZ sensor nodes. The nodes distributed along a perimeter to detect single and group intrusion.

d) Image Processing Detection System

The forthtechnique of intruder observation framework is image processing-based human intruder identification framework. It is by method for utilizing image to follow out whether there is a presence of trespasser/human intruder or not. Image processing-based human intruder location framework is broadly supported by numerous professionals when contrasted with robber alert frameworks and radar-based human intruder recognition, principally because of these four reasons: [24]

a. It helps catch pictures. The connected security camera is an extraordinary device to catch a photo of the robber/terrorist when they are attempting to break into a precluded domain.
b. More probability of the robbers/terrorists being caught. Control rooms have the capacity to view the photos from the cameras to distinguish intruders for easier arrests.
c. Security cameras are extraordinary aversion instruments. Robbers/terrorists are known for dodging region that has great security, particularly those fitted with security cameras.
d. Security cameras can secure defenseless ranges. At the point when control is inside the foundation's edge and needs to see what is going on outside of the adjacent building for security, security cameras are the most ideal approach for this objective securely.

In general, the image processing-based trespasser detection system could be a divided to two main categories: first is night vision/IR spectrum image processing-based human intruder detection system which can divide to digital video surveillance and analog video surveillance. The second one is vision spectrum image processing-based human intruder detection system which can known as type of video recording system applying digital technology.

VI. Recommended Technique for Intrusion Detection System

There are many techniques that are associated with intrusion detection systems. The DMA is considered to be the most powerful technique that can be used to process the shape of a human being. This process helps to distinguish the human beings from animals. It also helps the system to differentiate humans from other objects.Using DMA on the fact that is has capability of discerning human beings from animals and vehicles. The use of DMA is considered to be cost effective. It does not involve a lot of costs and time of installation. DMA is also known to consume less amount of energy as compared to other methods that were considered in the paper. Its processing time is also considered to be the least in considerations to other techniques mentioned in this paper.

VII. Conclusion

Wireless sensor networks have attracted lots of attention in recent years due to their potential in many applications such as border intrusion detection systems. The field of intrusion detection has been, and will continue to, develop rapidly. A number of models and techniques found in current systems are outlined in this paper. The paper relates the detection of human beings and other intrusion objects. Detection of intrusion for threat assessment and intruder identification requires the capability of distinguishing whether the intrusion object is a human, animal or other object. The techniques discussed in this paper uses simple electronic motion detection sensors that monitor the motion, or location of an object within a secured perimeter. This paper found out some Techniquesuch as DMA is the most suitable for various reasons. First, it can detect humans and non-human intruders. Second, it is not as expensive as other conventional methods. Third, it is easily scalable. Using, DMA the contours of an intruding object can be extracted for shape feature analysis. The paper highlighted how contour points are simplified by removing the redundant points that connect short and straight line segments. The intrusion detection techniques have been developed to best match contour feature in a database and that of a target to distinguish a human from an animal or other objects. The matching process of a target and database shape feature can be done from different angles and distances. The paper covers barrier and sensor coverage which is an important element in WSN. Future research can study communication issues and breach path problems.

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An Estimation Technique using FFT for Heart Rate Derived from PPG Signal

By Jayadevappa B.M & Mallikarjun S. Holi

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ANESTIMATIONTECHNIQUEUSINGFFTFORHEARTRATEDERIVEDFROMPPGSIGNAL

Strictly as per the compliance and regulations of :

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Jayadevappa B.M [α] & Mallikarjun S. Holi [σ]

Abstract- Heart rate (HR) observation by using photoplethysmography (PPG) signals during intense physical activity is a crucial task because of the fact that PPG signals are affected by the noise due to movement artifacts by the user's hand movements. This paper addresses the discriminating assessment of a novel encapsulation for wearable PPG sensor during the severe physical activity. In this work, we plan the HR estimation issue, and utilization of proposed algorithm to find high-determination power spectra of PPG signals, from which heart rates are evaluated by selecting and comparing the peaks. The proposed system was applied on PPG recordings obtained from 10 subjects who were quick runners at the top velocity of 15km/hour on a treadmill. Utilizing correlation and HR investigation with the assistance of peak detection, we assessed the simulation of the proposed framework against the existing works. The outcome demonstrated that the average absolute estimation error achieved using proposed method is lesser contrasted with ground truth heart rates obtained at the same time through the recording of electrocardiogram (ECG).

I. Introduction

The heart rate (HR) is a major physical sign amongst the many physical parameters that are identified with human health. Heart Rate (HR) of the patients is frequently need to be observed in the clinical environment by the doctor to provide appropriate diagnosis. Observing the HR is important for the patients as well as advantage for common man to know their health condition. In recent years, automatic detection of HR during exercise has enabled new type of health assessment and wearable tools used for such purpose will help in monitoring of health in real time. Heart Rate (HR) exhibits various characteristics in different physical activities. Recent technological advances have made it possible to build wearable products that can capture and process bio-signals generated by the human body. In terms of HR monitoring, two essential innovations are accessible for gadget producers: ECG and PPG. ECG is a standard signal that is utilized by healthcare providers for the assessment of health of an individual based on their cardiac activity. In the other hand PPG sensors use ECG signal as a reference for HR comparison.

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PPG signals are weak to motion artifacts, which is critical to heart rate checking during exercise. Numerous signal processing strategies have been proposed to remove movement artifacts (MA) from raw PPG signals. PPG signals can be obtained from fingertip, earlobe, wrist etc. Contrasting with fingertip and earlobe, wrist can bring about much more complex MA because of expansive adaptability of wrist and free interface between heartbeat oximeter and skin. However, recording PPG from wrist enormously encourages configuration of wearable gadgets and expands user experience. Thus, assessing HR from wrist type PPG signals turns into a mainstream highlight in smart-watch type gadgets. In this regard, developing high-performance HR observation and analysis algorithms for wrist-sort PPG signs is of great value.The current study focuses on HR analysis utilizing wrist-type PPG signals when the wearer performs severe physical exercises. A novel system is proposed which comprises of four key parts, specifically: preprocessing, denoising, heart rate estimation and the optimization of the heart rate estimation. The aim of the decomposition of signal is to remove MA in a raw PPG signal and sparsifies its range. Periodogram estimation plans to ascertain a high-resolution range of the PPG signal, which is strong to noise and is profitable over conventional nonparametric range estimation calculations and model-based sparse signal estimation algorithms. Heart rate estimation using peak detectionis a vital part of the proposed structure, which looks for the peak relating to HR. To further overcome solid obstruction from MA and supplement the peak determination approach, some decision systems are intended to check the selected spectral peak. The proposed technique is applied on PPG recordings of 10 subjects who were quick running at the top velocity at 15 km/hour on a treadmill. The results of the proposed method shows that its estimation performance is high compare to other works. The rest of this paper is organized as follows: Section II provides the related work in this field, Section III presents the proposed framework, Section IV describes recorded datasets, experiment settings, and experimental results and conclusions are given in the last section.

II. Literature Survey

Tamura et al [1] utilized the PPG innovative idea to develop small, wearable, heartbeat rate sensors.

These gadgets comprising of infrared light-emanating diodes (LEDs) and photodetectors offer a basic, dependable, ease method for observing the beat rate noninvasively. In this survey, authors present the historical backdrop of PPG and late advancements in wearable heartbeat rate sensors with green LEDs and the use of wearable heartbeat rate screens.

Yousefi et al [2] proposed a novel real-time adaptive calculation for the accurate movement tolerant extraction of HR and oxygen saturation (SpO2) from wearable PPG biosensors. The proposed algorithm overcomes the motion artifacts arising from different sources including tissue impact and venous blood changes during body movements and gives commotion free PPG waveforms. A two-stage normalized least mean square adaptive noise canceler is designed and validated using a novel synthetic reference signal at each stage.

Ram et al [3] proposed a basic and effective methodology based on adaptive step-measure least mean squares (AS-LMS) adaptive channel for minimizing MA in undermined PPG signals. The proposed technique is an expansion to our earlier work to use it efficiently for reducing of MA in PPG signals. The novelty of the method lies in the fact that a synthetic noise reference signal for an adaptive filtering process, representing MA noise, is generated internally from the MA-corrupted PPG signal itself instead of using any additional hardware such as accelerometer or source-detector pair for acquiring noise reference signal.

Chia-Ching Chou et al [4] presented a compelling PPG gaining and signal handling framework taking into account square wave modulation. Through modulating the achieved signal on different frequency square waves, it is effective to get PPG signals with high SNR by utilizing basic transporter wave generators and diminishing the harmonic load and force. The proposed framework incorporates a wonderful and wearable three way PPG front-end sensor for procuring PPG signals, a FPGA-based DSP for signal modulation.

Ucar et al [5] presented a technique for the diagnosis of obstructive sleep apnea syndrome based on respiratory scoring process. To examine the patient's condition, four signals are required according to this method. For analysis and diagnosis PPG (during normal sleep) signal are considered in this work. Changes occurring in PPG signal during respiratory events were examined.

Lin and Kunpeng [6] presented a new method to calculate the pulse wave quality index using a quality evaluation function. By using the pulse quality index, the reliability of PPG feature point selection can be calculated.

Verma et al [7] proposed a framework for the heart rate variability (HRV) spectra from the PPG and ECG signals. In this work, first of all the signals were interpolated to a common sampling frequency then to remove the lower frequencies, IIR filter has been used. Next step to remove the high band frequencies by using undecimated wavelet transform. To detect the peak, the filtered signal is squared and peaks are extracted from the signal. Once peaks are detected HRV signal was determined using cubic spline interpolation to create a signal at a very low sampling rate of 1-4 Hz.

Fukushima et al [8] proposed the algorithm to estimate HR for the wrist-type PPG sensor. The accuracy of heart rate estimation is affected by motion artifacts. This study uses accelerometer built in the wrist-type sensor to improve the accuracy of heart rate estimation. Two main components are presented in this work. One is removing artifacts with the power spectrum's difference between PPG and acceleration obtained by frequency analysis. The other is the reliability of heart rate estimation, defined by the acceleration.

III. Proposed System

This section describes our proposed approach to estimating the heart rate. We have considered the input signal and then it is getting divided into time series and again that time series is getting decomposed into oscillatory components and noise. Let $P^u \triangleq [P^u{}_1, \ldots, P^u{}_m]^T$ represent the raw PPG signals of length m aquired.

According to the proposed method the first step is to perform preprocessing on the signal which is for removing the partial noise and performing the bandpass filtering. Next step is denoising of the signal, in this first of all the filtered signal is converted into multidimensional signal which is used for creating trajectory matrix, then this matrix is decomposed in singular values to get the eigen vectors.

Once the signal is decomposed, next step is estimation of heart rate using first and second order frequency difference. Finally, we perform the optimization of the detected heart rate based on peak frequency and their harmonics. The proposed method is described below:

a) Preprocessing

This is the first stage of proposed framework. At this stage the P^u signal is processed and filter in order to remove the motion artifacts. According to this framework, in a given time window, the recorded raw PPG signal and the acceleration sign are first band-pass shifted with the cut-off recurrence of 0.4 Hz and 7 Hz. This pre-processing evacuates bunches of noise and MA outside of the recurrence band of interest. This can facilitate sparsifies the range coefficients when utilizing the frequency strategy. Let P represent the filtered or preprocessed signal. The preprocessing step can be defined as

$$P = f_{bp}(P^u, f_l, f_u) \quad (1)$$

Where f_l and f_u represent the lower and upper cutoff frequencies of the bandpass filter f_{bp}

b) Denoising

The preprocessed motion artifact removed signal is passed for the denoising stage. Preprocessed signal P is one dimensional, to perform the signal denoising, we convert the signal to multidimensional. This conversion process is defined as

$$P_d = (P_{i-1}, \ldots\ldots P_{i+m-2}), 1 \leq i \leq K \quad (2)$$

$$K = N - m + 1$$

Where P_d multidimensional signal, N is length of the signal, m is window length

This signal P_d can be written into a trajectory matrix. In this step a time series $P \triangleq [P_1 \ldots P_M]^T$ is mapped into $M_1 \times M_2$ matrix($M_2 = M - M_1 + 1, M_1 < M/2$, called $M1$-trajectory matrix.

$$D \triangleq \begin{bmatrix} P_1 & P_2 & \cdots & P_{M_2} \\ P_2 & P_3 & \cdots & P_{M_2+1} \\ \vdots & \vdots & \ddots & \vdots \\ P_{M_1} & P_{M_1+1} & \cdots & P_M \end{bmatrix} \quad (3)$$

In the *signal decomposition step*, the M_1-trajectory matrix is decomposed by decomposition method as follows,

$$D = \sum_{i=1}^{d} D_i, d \triangleq min\{M_1, M_2\} \quad (4)$$

Where $D_i = \sigma_i u_i V_i^T$ and σ_i, u_i ,v_i are the ith singular value, the corresponding left-singular vector and the corresponding right-singular vector, respectively.

This gives us a decomposed signal which contains the eigen values.

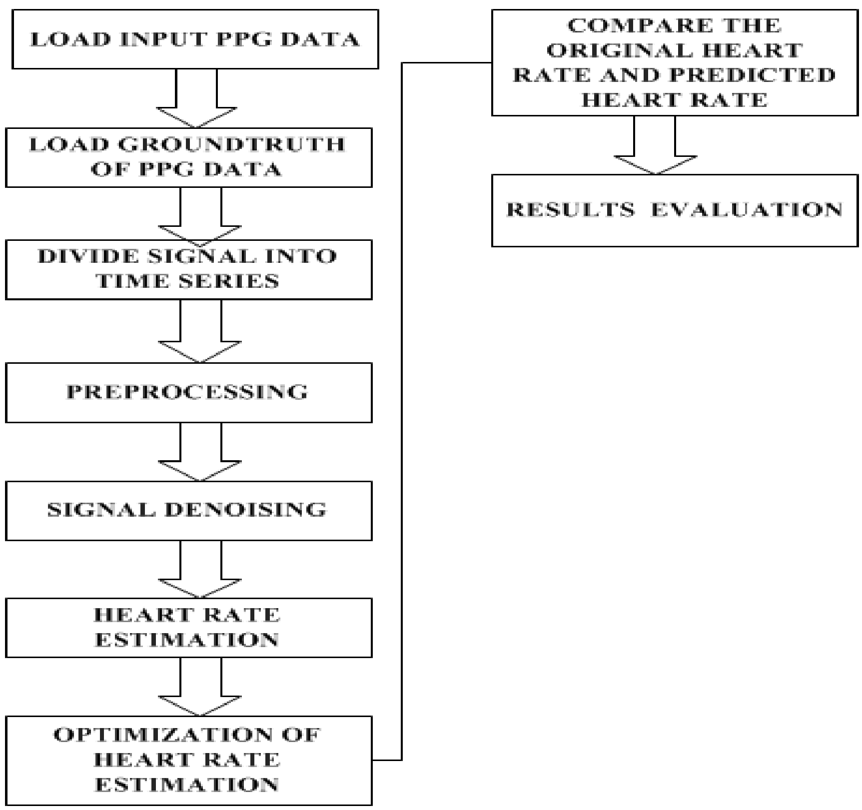

Figure 1 : Flow chart of the proposed framework

c) Reconstruction

Once the decomposed signal D is achieved, the next step is to perform reconstruction of the signal. In this step the d rank-one matrixD_i is assigned into G groups namely the set of indices$\{1, \ldots, d\}$ is portioned into G disjoint subsets $\{I_1, \ldots, I_G\}(G \leq d)$ and

$$Y = \sum_{p=1}^{G} D_{I_p} \quad (5)$$

With $\sum_{t \in I_p} D_t$ .The rank-one matrices in each groupD_{I_p} generally satisfy some common characteristics (such as their corresponding oscillatory components after reconstruction have the same frequency or exhibit harmonic relation).

In the *Averaging based Reconstruction Step*, each D_{I_p} is used to reconstruct a time series$\widetilde{P_p}$with the length M by a so called diagonal averaging procedure.

Thus the original signal p is composed into g time series, i.e.

$$P_{AR} = \sum_{p=1}^{G} \widetilde{P}_p. \qquad (6)$$

P_{AR} = averaging based reconstructed signal

IV. Heart Rate Estimation

After reconstruction of the signal, reconstructed signal P_{AR} is achieved. By utilizing the spectrum method heart rate of this signal can be achieved. This signal is in periodic time series so for a periodic time series $S = [S(1), S(2), \ldots, S(M)]$ with the fundamental frequency $freq_0$, its first-order difference, defined as $S' \triangleq [S(2) - S(1), S(3) - S(2), \ldots, S(M) - S(M-1)]$, maintains the fundamental frequency and the harmonic frequencies. The second-order difference of h, i.e. the first-order difference ofS', also maintains the fundamental frequency and the harmonic frequencies. As long as k is not large, the spectrum of the $k-th$ difference of the periodic time series always significantly exhibits the fundamental frequency and its harmonic frequencies. In contrast, this is not observed from a non-periodic time series. Note that an artifact free PPG signal is approximately periodic in short time, while motion artifact is generally non-periodic (except to the situation when only hand swing occurs). Therefore, we calculate the $k-th$ difference of the cleaned PPG signal. In our experiments we calculated the second-order difference. The resulting time series of difference is denoted by p_{diff}. After this step, the spectrum peak corresponding to the HR and harmonic spectrum peaks are more prominent in the spectrum.

V. Optimiz Ation of Heart Rate Estimation

The above section discusses about the heart rate estimation by calculating the first and second order difference of the periodic time series signal but this method sometimes can wrongly track the spectral heart rate associated with MA or spectral fluctuations. Thus, an optimization stage is necessary. This optimization to estimate the heart rate is discussed in this section.

Corresponding to the estimated HR the frequency is denoted by $freq_{old}$ in the previous time window. We set a search range for the fundamental frequency in the signal s which is $R_0 = [freq_{old} - \Delta, \ldots, freq_{old} + \Delta]$. Another search range is$R_1 = [2(freq_{old} - \Delta - 1) + 1, \ldots, 2(freq_{old} + \Delta - 1) + 1]$. In the spectrum, we select at most two highest peaks in each search range. Denote the frequency bin indexes of the two peaks in $R0$ by $freq_0^1$and $freq_0^2$, the frequency bin indexes of the two peaks in R1 by $freq_1^1$ and $freq_1^2$

If there exists a peak-pair $(freq_i^0, freq_j^1)(i \in \{1,2\}, j \in \{1,2\})$ which holds a harmonic relation, then $freq_i^0$ corresponds to the heart rate. If there is no such peak-pair (presence of strong motion artifacts), we select $\widehat{freq} \leftarrow \arg \underset{freq}{min} \{|freq - freq_{old}|\}$

Where $freq \in \{freq_1^0, freq_2^0, \frac{freq_1^1 - 1}{2} + 1, \frac{freq_2^1 - 1}{2} + 1$

and$\widehat{freq}$ corresponds to the heart rate

VI. Results and Discussion

a) Dataset

To show the performance of our proposed algorithm we had considered the PPG signal, we have taken the wrist-type PPG signals from 10 male subjects having age in the range of 18 to 33 years. For each user data has been recorded while performing physical exercise on the treadmill. The treadmill exercise is executed with different speed consideration wherein initially subject walked at the speed of 2 km/hour for 1 minute, then at 4 km/hour for 1 minute, and then ran at the speed of 10 km/hour for 1 minute, next fast ran at the speed of 15 - 17km/hour for 1 to 1.5 minutes, and then again ran at the speed of 10 km/hour for 1 minute, and finally walked at the speed of 4 km/hour for 1 minute. While performing the exercise each subject has been asked to use the hand with the wrist-band to pull clothes, wipe sweat on forehead, and push buttons on the treadmill, in addition to freely swing. This is done to incorporate for the motion artifacts. These PPG signals are having three-axis acceleration. These signals are recorded from user's wrist by using a PPG system with LED as light source having wavelength of 609 nm. For simulating these recorded PPG signals we have sampled all the data at 125 Hz. The ground-truth of the each PPG signal is recorded at the same time.

b) Simulation Parameters

In our proposed system we set its execution parameters as input PPG signal grid parameter = 2048, the regularization parameter = 0.1. For filtering the PPG signal the window distance is considered uniform distance and Gaussian distance, the size of the window is taken 15. To calculate the HR the number of cardiac cycles Q and time duration T (seconds) then heart rate is given by 60Q/T beats per minute (BPM).

c) Performance Measurement Parameters

For the recorded PPG signal to measure the performance of our proposed system in terms of BPM we have measured the average absolute error. The original heart rate of the user can be achieved using the ground truth, now in order to show our proposed system measurement accuracy we have achieved the HR for the each user. The accuracy of the system is represented in the terms of average absolute error and percentage error. The HR estimated from the groundtruth is denoted by BPM_{true} and the calculated heart rate using our system is demoted as BPM_{est}

To calculate the average absolute error

$$Error1 = \frac{1}{W}\sum_{i=1}^{W}|BPM_{est}(i) - BPM_{true}(i)|$$

where W is the total number of time windows.

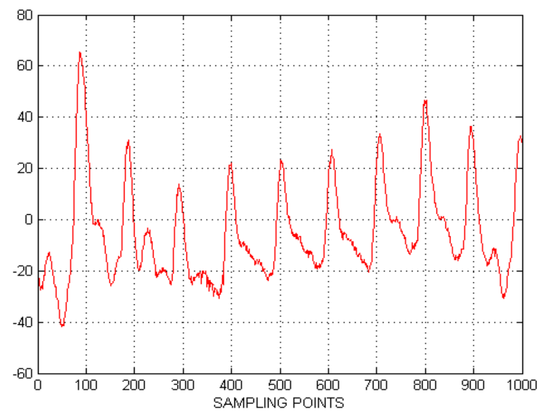

Fig 2(a) Raw PPG Signal

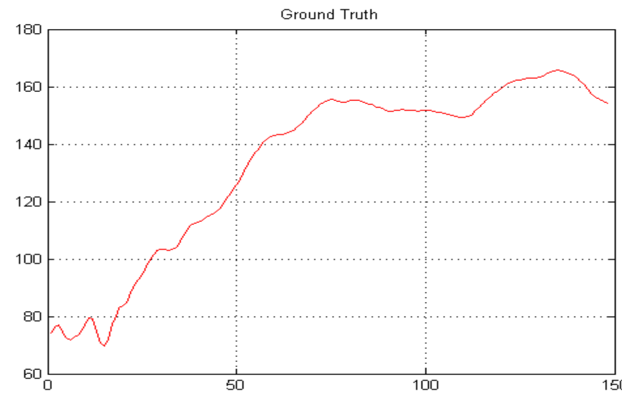

Fig 2(b) Ground Truth of the PPG Signal

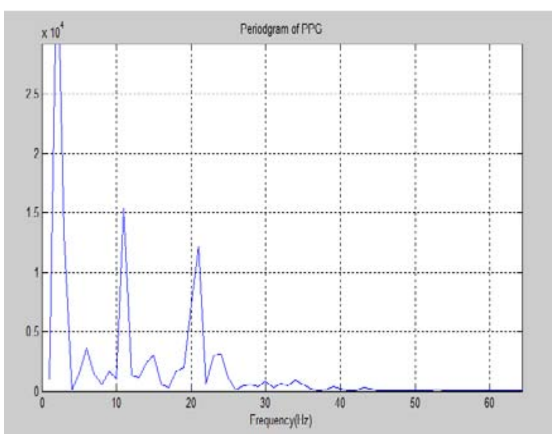

Fig 2(c) Periodogram of PPG Signal

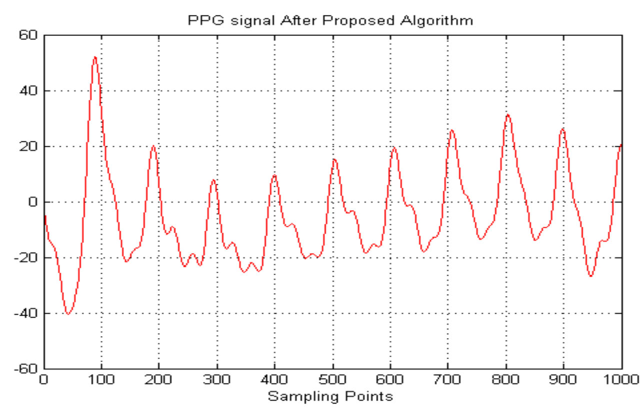

Fig 2(d)PPG signal After Proposed Algorithm

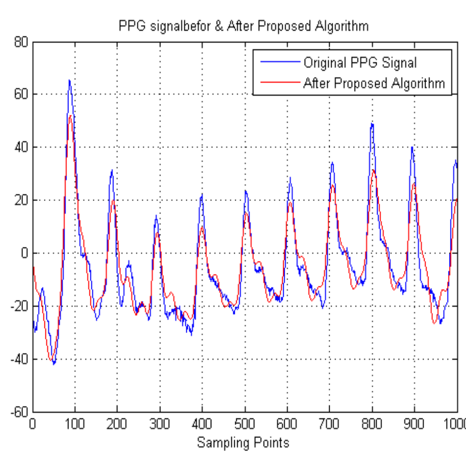

Fig 2(e) Combined Representation of the signal

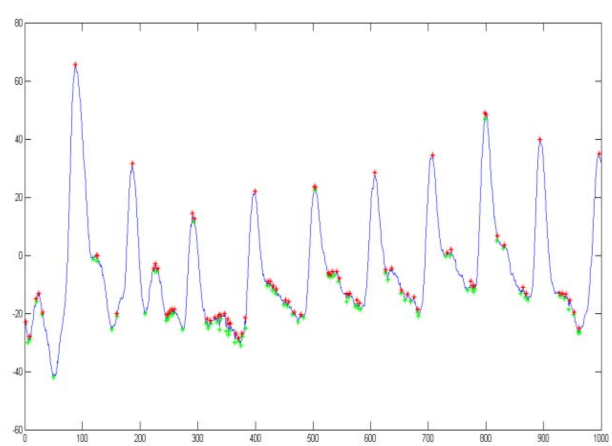

Fig 2 (f) Peak Detected

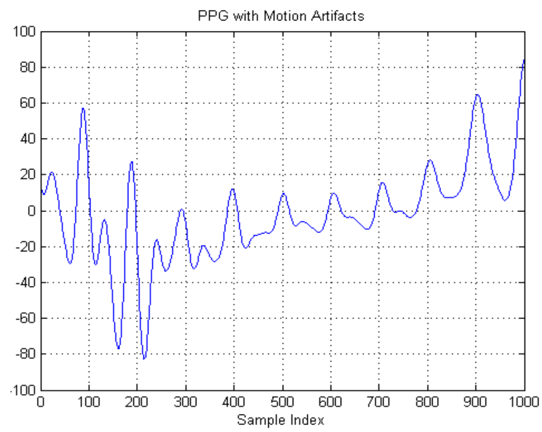

Fig 2 (g) PPG with Motion artifacts

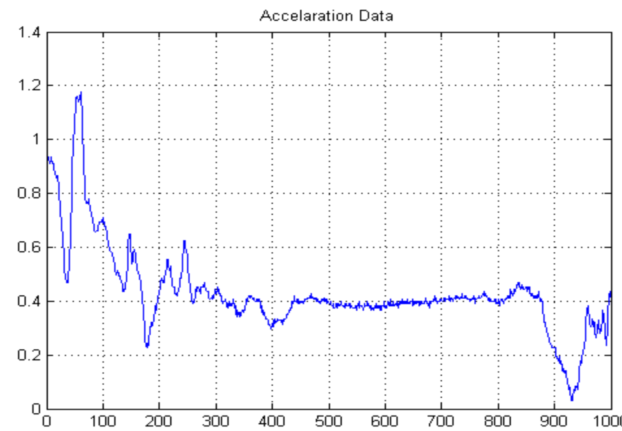

Fig 2 (h) PPG Accelaration

In the above given figure fig2 (a) is the representation of the Raw PPG signal. Fig2 (b) is the ground truth of the original PPG signal. Groundtruth is the actual heart rate of the user. Fig2(c) is the Periodogram of the PPG signal. Fig 2(d) is the signal achieved after passing through proposed algorithm which gives peaks associated with Heart rate. . Fig 2(e) is the combined representation of the original signal and after passing through the proposed algorithm for the peak detection. Fig2 (f) shows the detected peaks in the PPG signal

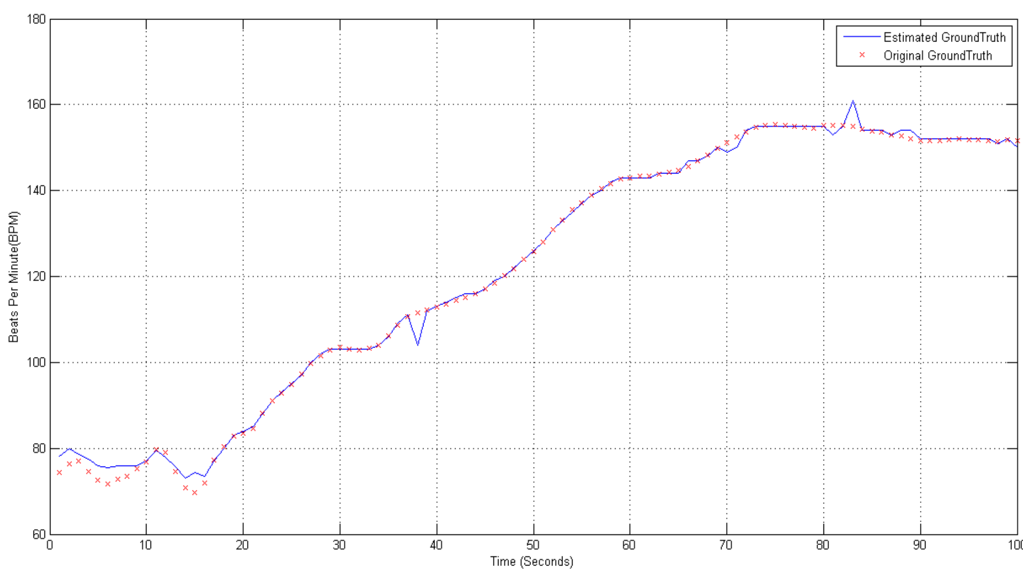

Figure 3 : Estimation result on recordings of user 5

Fig. 3 shows the result on recordings of user 5 as an example when processed using our proposed algorithm. The estimated HR was very close to the ground truth, and every small change in the ground truth was estimated with high fidelity.To better see the benefit of proposed algorithm to partially remove MAs, we carried out an experiment using a raw PPG segment and a simultaneous ECG segment (see Fig. 2(a) and (g), respectively).

In contrast, after proposed algorithm, the spectrum of the cleansed PPG signal [see Fig. 2(d)] clearly presents the spectral peak associated with the HR, as shown in Fig. 2(f). This result shows that proposed algorithm can remove MAs in PPG and make more significant the spectral peak associated with HR.

	USER 1	USER 2	USER 3	USER 4	USER 5	USER 6	USER 7	USER 8	USER 9	USER 10
ERROR1(BPM) ES	3.09	1.37	2.51	3.58	7.19	2.21	1.60	1.22	1.11	1.79
ERROR1(BPM) PS	1.790	2.04	1.58	1.33	1.16	1.06	1.03	1.15	1.12	1.23

Comparing to other works on heart rate monitoring during running, our proposed algorithm showed competitive or superior performance.

VII. Conclusion

In this work, we proposed a general framework for HR estimation using wrist-type PPG signals when the user is performing intensive physical exercise. The novelty of the method lies in removing the noise efficiently, generated during intensive physical exercise and optimization of the heart rate estimation. The proposed method consists of four divisions: preprocessing of the signal, denoising of the signal, heart rate estimation and optimization of heart rate estimation. Experimental results on recordings from 10 subjects showed that the proposed algorithm has high estimation accuracy. The proposed algorithm removes motion artifact due to body movements during intensive exercise and provides noise-free PPG waveforms for further feature extraction.

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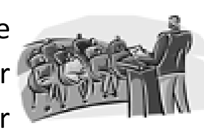

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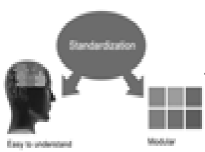

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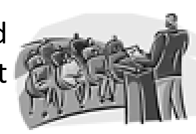

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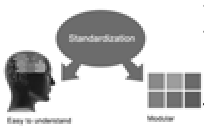

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21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments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

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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.

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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.

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Final Points:

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- Significant conclusions or questions that track from the research(es)

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- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
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Approach:

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- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

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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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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
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