A New Channel Estimation Technique for 5G MIMO Communication Systems

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***Abstract*—Internet of things (IoT) in health care is one of the major areas which ease the usage of many transmitters on board, leading to the usage of Multiple Input Multiple Output (MIMO) systems for better communications. Employing 5G MIMO systems suitable for IoT applications with quality of performance (QoP) is a challenge. This paper defines a channel estimation method based on training symbol for 5G MIMO wireless communication systems for IoT applications is proposed and analyzed. An M-estimator is suggested for optimizing the proposed channel estimator. The proposed technique performance is evaluated based on the comparison of Simulation results with Least Squares (LS) channel estimation with and without Discrete Fourier Transform (DFT). From simulation results, it is seen that the proposed method of channel estimation closely approximates that of true channel estimation.**

Keywords—channel estimation; discrete Fourier transform; influence function; least squares; M-estimator; penalty function.

I. Introduction

Rapid growing of mobile users and exponential growing demand of higher data rates force many practical challenges on existing cellular networks and their developments to provide a high network capacity with extensive area coverage to meet customer demands of upcoming 5G networks [1]. Major disadvantage of existing networks are low data rate, minimum quality of experience (QoE), low end-to-end performance, less indoor coverage, poor mobility performance etc. Similarly, network operators face difficulties in terms of providing satisfactory services e.g., high spectral efficiency, huge network capacity, large availability of spectrum, low latency, & lower energy consumption. In order for 5G MIMO communication systems to work for both the identified demands, plans for spectral efficiency improvement, scheduling for channel information, coding and adaptive modulation are required. All these techniques need an (CSI) i.e. accurate Channel State Information available at a transmitter end. An estimation of such CSI is crucial for high data throughput [2]-[5].

In [6], first algorithm is OMP i.e. orthogonal matching pursuit with lower complexity is used to identify the common support set followed by (LS) method i.e. least square for obtaining the channel estimation and it assumes perfect CSI measurement feedback from an User Equipment (UE) to Base Station (BS) which may not be possible in practice and alternate CSI measurement approaches need to be considered.

In [7], a new channel estimation technique was proposed with enhanced Kalman filter which operates to reduce the noise levels, improves the channel conditions and Quality of Service [QoS] over Wireless Communication environments.

In [8], channel estimation with minimum mean-squared-error (MMSE) criterion for orthogonal frequency division multiplexing (OFDM) systems was investigated. MMSE estimator was studied first which uses the correlation of a frequency response on different instant of time and frequency for a channel. This MMSE channel estimator may be a frequency domain filter with the help of the fast Fourier transform (FFT), and it is followed by a time-domain filters. Further, an estimator which is insensitive to a channel statistics was proposed and analyzed in [8]. A multiuser detector using *M*-estimator [9] was presented in [10]-[11] for non-Gaussian flat- fading channels.

Hence, in this paper, an *M*-estimator based channel estimation technique for 5G wireless communication channels is proposed and studied. The remaining paper is organized as follows: Section II refer to the system model. Section III describes the LS estimation, section IV describes proposed method and section V includes some simulation results. Finally, Section VI outlines some concluding remarks followed by acknowledgements and references.

II. System Model

One of the method for estimation of channel is using of a training symbols and for a given N subcarriers these symbols are represented by a diagonal matrix given in eq. 1(here all the subcarriers are orthogonal to each other (i.e., no ICI)).

$$X = \begin{bmatrix} X(0) & 0 & \cdots & 0 \\ 0 & X(1) & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & X(N-1) \end{bmatrix} \quad (1)$$

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where $X(k)$ represents a pilot tone at the k^{th} subscriber, zero mean and σ_x^2 gain (i.e., $H[k]$ for each sub carrier k). In a multi-user communications, users transmit their signals using same time and frequency slots. Thus, the received signal is the superimposed signal of all transmitting users and the training signal on receiver side, $Y[k]$, is expressed by

$$Y \triangleq \begin{bmatrix} Y[0] \\ Y[1] \\ \vdots \\ Y[N-1] \end{bmatrix} = \begin{bmatrix} X(0) & 0 & \cdots & 0 \\ 0 & X(1) & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & X(N-1) \end{bmatrix} \begin{bmatrix} H[0] \\ H[1] \\ \vdots \\ H[N-1] \end{bmatrix} + \begin{bmatrix} W[0] \\ W[1] \\ \vdots \\ W[N-1] \end{bmatrix} \tag{2}$$

or

$$Y = HX + W \tag{3}$$

where channel vector H is expressed as $H = [H[0], H[1], \cdots, H[N-1]]^T$ and W i.e. noise vector with zero mean and σ_w^2 variance is expressed by $W = [W[0], W[1], \cdots, W[N-1]]^T$.

III. Least Squares Estimation

In LS method the following equation is used for channel estimation

$$\hat{H}_{LS} = \left(X^H X\right)^{-1} X^H Y = X^{-1} Y \tag{4}$$

where estimate of H is $\hat{H}$.

IV. Proposed Method

A new method M-estimator [2] is proposed for robustifying training symbol based channel estimation for 5G wireless communications. Proposed estimator penalty and influence functions are given in eq. (4), eq. (5) & eq. (6) respectively (shown in Fig.1)

$$\rho_{PROPOSED}(x) = \begin{cases} \dfrac{x^2}{2} & for \quad |x| \le a \\ a^2 - a|x| & for \quad a < |x| \le b \\ \dfrac{-ab}{2} \exp\left(1 - \dfrac{x^2}{b^2}\right) + d & for \quad |x| > b \end{cases} \tag{5}$$

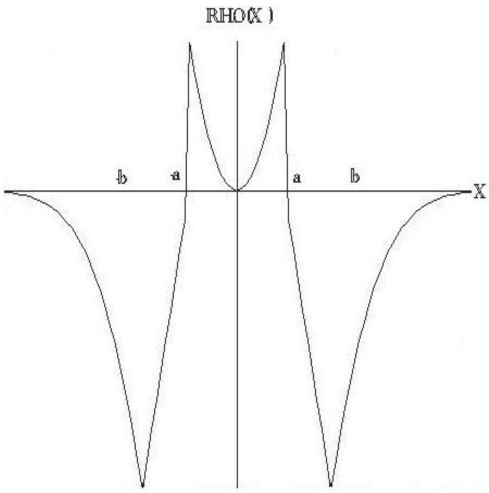
$$\psi_{PROPOSED}(x) = \begin{cases} x & for \quad |x| \le a \\ a\,sign(x) & for \quad a < |x| \le b \\ \dfrac{a}{b} x \exp\left(1 - \dfrac{x^2}{b^2}\right) & for \quad |x| > b \end{cases} \tag{6}$$

$$w_{PROPOSED}(x) = \begin{cases} 1, for \quad |x| \le a \\ \dfrac{a\,\mathrm{sgn}(x)}{x}, for \quad a < |x| \le b \\ \dfrac{a}{b} \exp\left(1 - \dfrac{x^2}{b^2}\right), for \quad |x| > b \end{cases} \tag{7}$$

where a and b are constants and x is any datum. From an influence function, robustness measures are derived and will fix the selection of constants a $\left(= kv^2\right)$ and b $\left(= 2kv^2\right)$, where k is any constant. M-estimators reduce the outcome of outliers, resulting $\min \sum_i \rho(x_i)$, where $\rho(.)$ is penalty function, $\psi(x) = \dfrac{d\rho(x)}{dx}$ is the influence function and $w(x) = \dfrac{\psi(x)}{x}$ is the weight function.

The proposed M-estimator based method finds the channels estimation parameters using

$$\hat{H}_{PROPOSED} = \left(X^H \psi(x) X\right)^{-1} X^H Y \tag{8}$$



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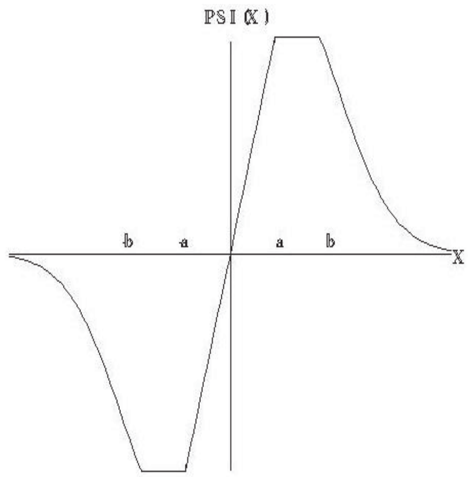

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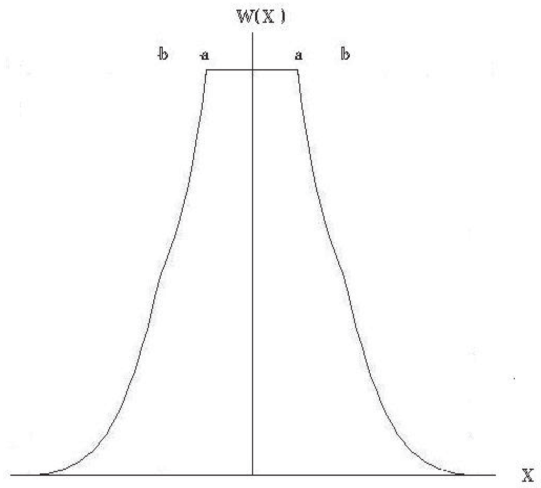
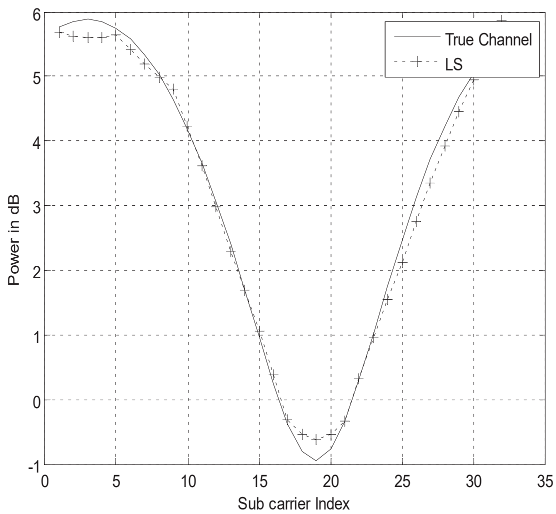


(c)

Figure 1. (a) Penalty function, (b) influence function, and (c) weight functions of the proposed *M*-estimator.

V. Simulation Results

In simulations, channel estimation using LS and Proposed *M*-estimator (with and without DFT) based techniques are compared and shown in Fig. 2. FFT size is 32 and pilot spacing is 4. For improving the performance of channel estimation technique a DFT-method is been developed by suppressing noise effect outside of the maximum channel delay which is shown in simulations. From the simulation results, an observation is done on the proposed method for channel estimation (with and without DFT) as closely approximation of true channel in both the cases.



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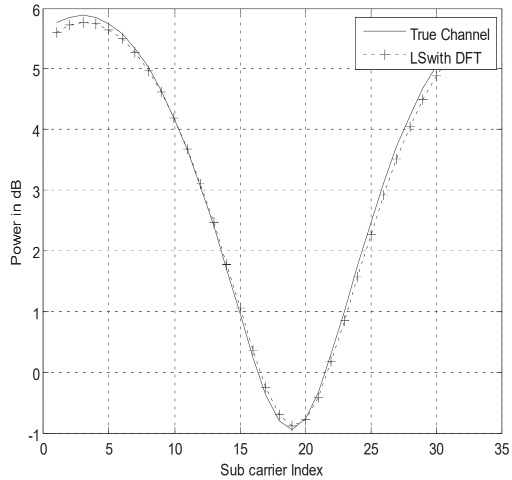

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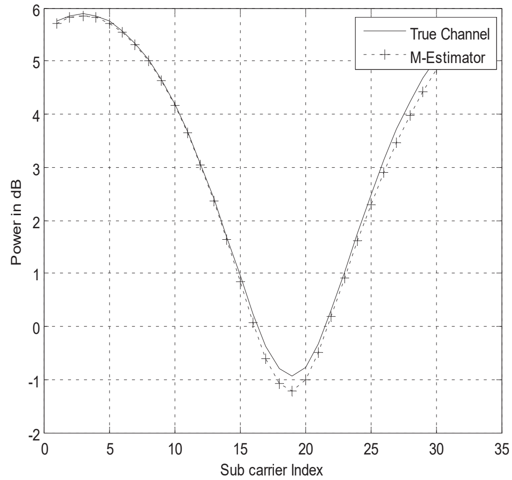

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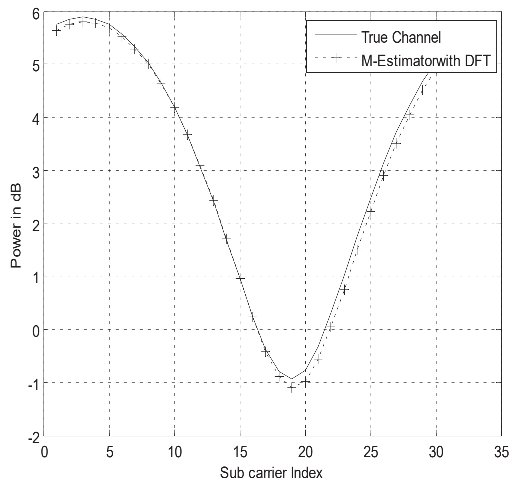

(d)

Figure 2. Channel estimation using (a) LS (b) LS with DFT (c) *M*-estimator and (d) *M*-estimator with DFT.

VI. Conclusions

Robust training symbol based channel estimation for 5G wireless communication systems using *M*-estimation is proposed and studied in this paper. An *M*-estimator is proposed and used for optimizing the channel estimation technique. Simulation results are also provided to support efficacy of the proposed study of channel estimation in 5G wireless communication systems with additive white Gaussian noise. From simulation results, it is concluded that the proposed technique closely approximates true channel estimation for 5G MIMO wireless communication system with and without DFT.

Acknowledgment

This research work is carried out under the scheme Teachers Associateship for Research Excellence, sponsored by Science and Engineering Research Board (SERB), Government of India. The authors would like to thank SERB, India for sponsoring this research work. The authors would also like to thank for NIT, Warangal and CMRIT, Hyderabad for encouraging this research work.

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