Modified Matching Pursuit Based Channel Estimation for ISDB-T

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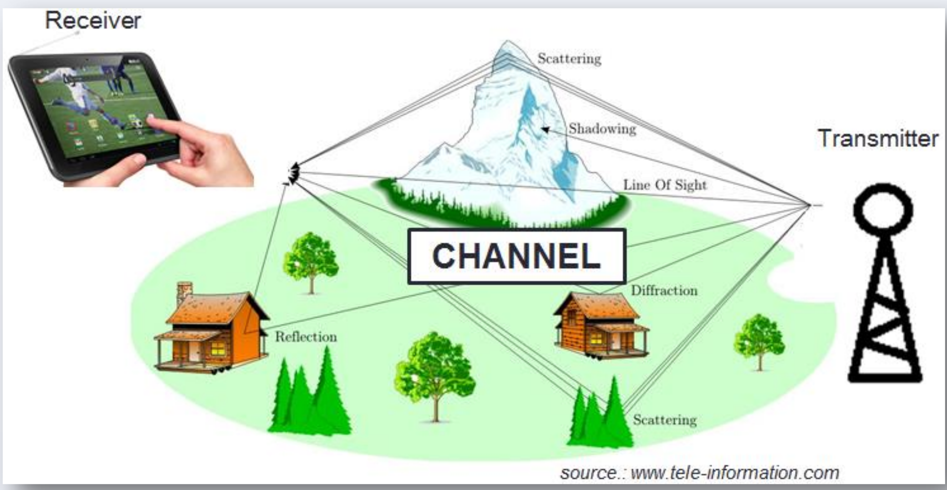
I. ABSTRACT

This research demonstrates a new approach in reliable Channel Estimation for Integrated Services Digital Broadcasting Terrestrial (ISDB-T) using Modified Matching Pursuit Algorithm (MMP). MMP will reduce the computational cost in estimating the sparse channel. MMP is an attractive substitute to the conventional MP since MMP is faster and easier to implement.

II. INTRODUCTION

Channel Estimation (CE) is a process of describing the channel properties of a wireless communication link.



Problem

- CE requires higher computational cost
- CE requires higher cost in hardware requirements.

Objective

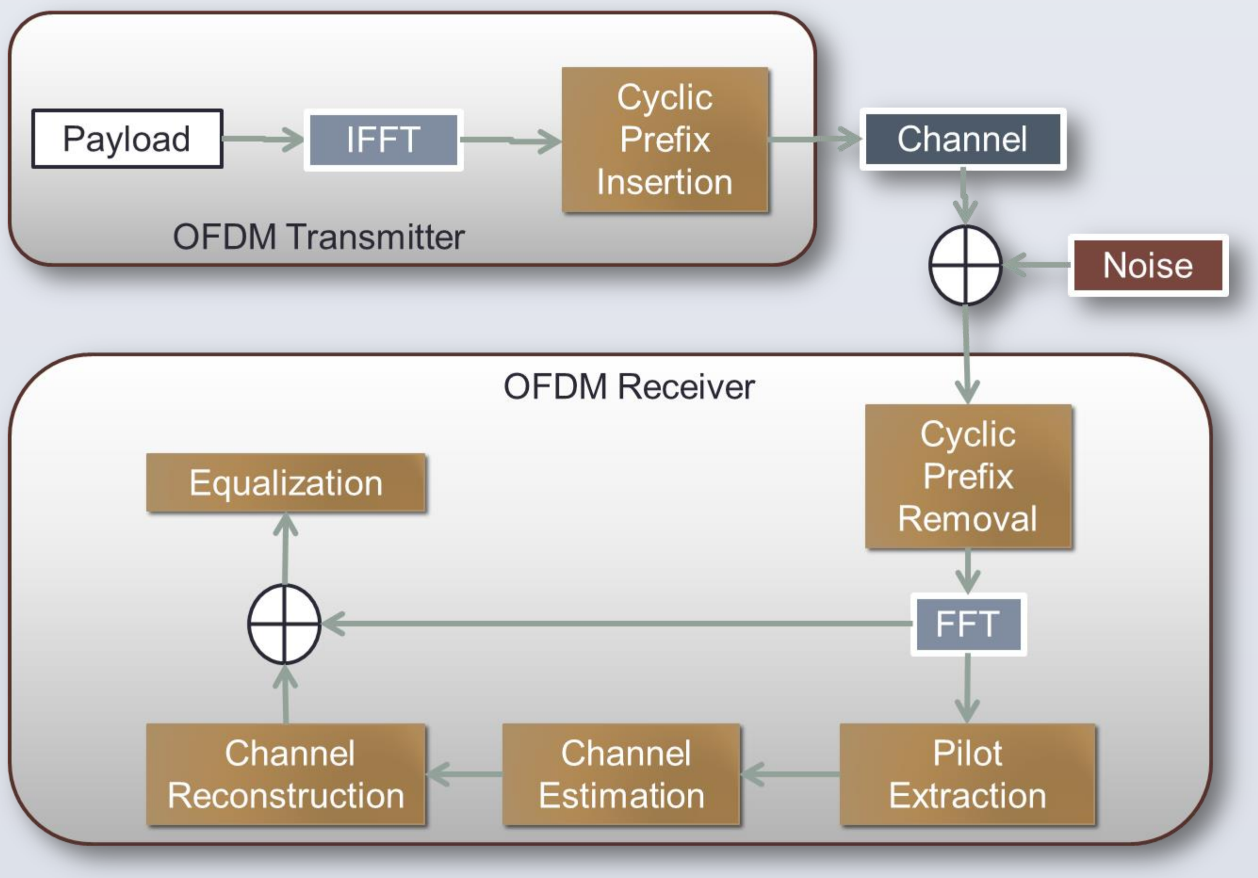
- Reduce the computational cost for Channel Estimation in ISDB-T using Modified Matching Pursuit Algorithm

III. SYSTEM MODEL

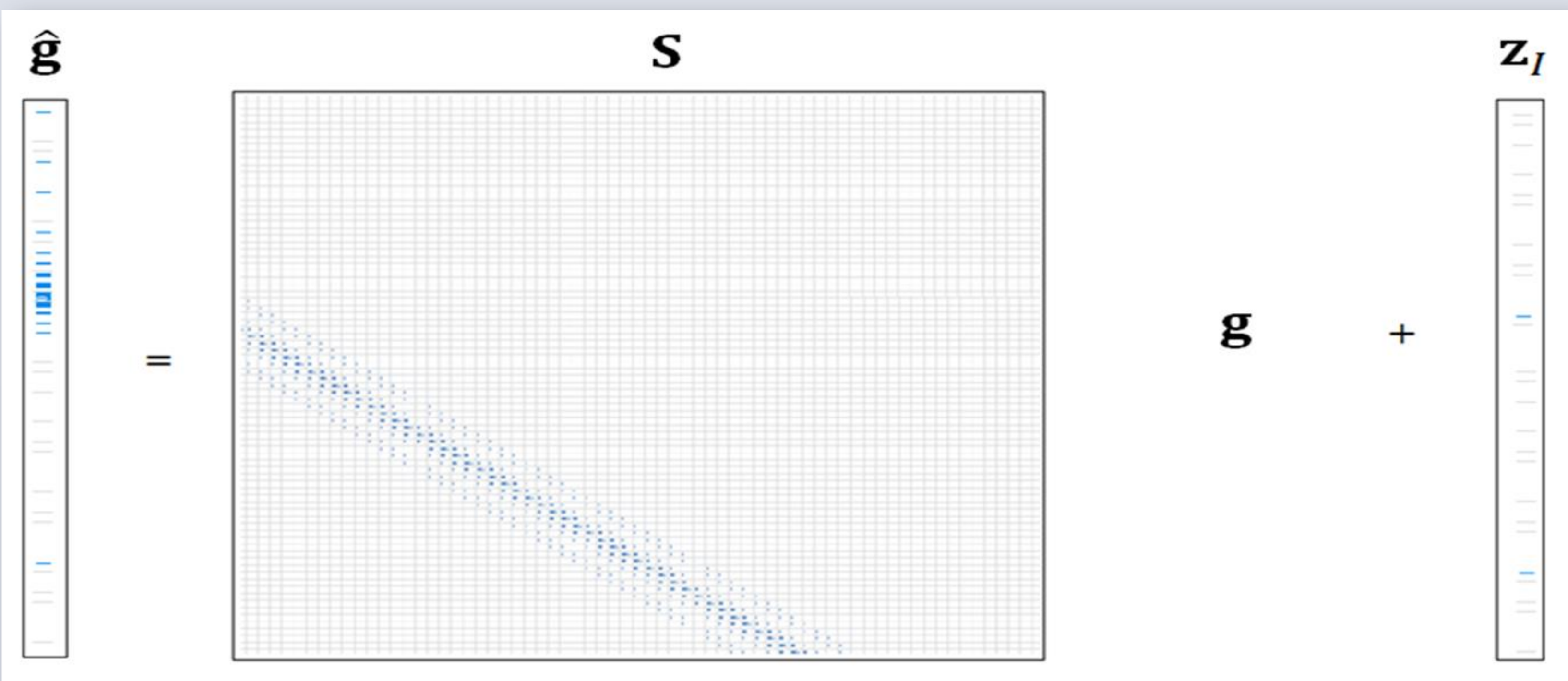
Orthogonal Frequency Division Multiplexing (OFDM) is implemented in ISDB-T.

Features

- Robust against multipath interference
- Robust against co-channel interference



Impulse Response Calculation is needed for Channel Estimation.



$$\hat{g} = S \, g + z_l$$

$$\hat{g} = Q_M \, F^{-1} \, Q \, Q_S \, Q^T \, F \, g + z_l$$

g = Impulse Response

z_l = Noise

$\hat{g}$ = Observed Impulse Response

(Pilot Pattern Matrix) $Q_s = \mathrm{diag}([q_0, q_1, \cdots, q_{K-1}]^T)$

(Fourier Transform Matrix) $F = \left[\exp\left(-j\frac{2\pi kn}{N}\right)\right]_{\substack{0\le k<N \\ 0\le n<N}}$

(Mask Matrix) $Q_M = \left[\begin{array}{cc|c} O_{N_T, N_{GI}-N_T} & I_{N_T} & O_{N_{GI}, N_A} \\ I_{N_{GI}-N_T} & O_{N_{GI}-N_T, N_T} & \end{array}\right]$

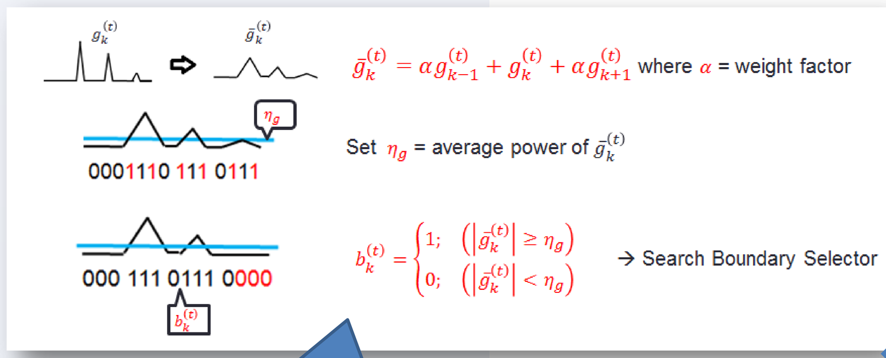
N, N_{GI}, N_T, and $N_A = N - N_{GI}$ are the FFT window size, the GI interval, the number of tail samples, and the size of masked samples, respectively

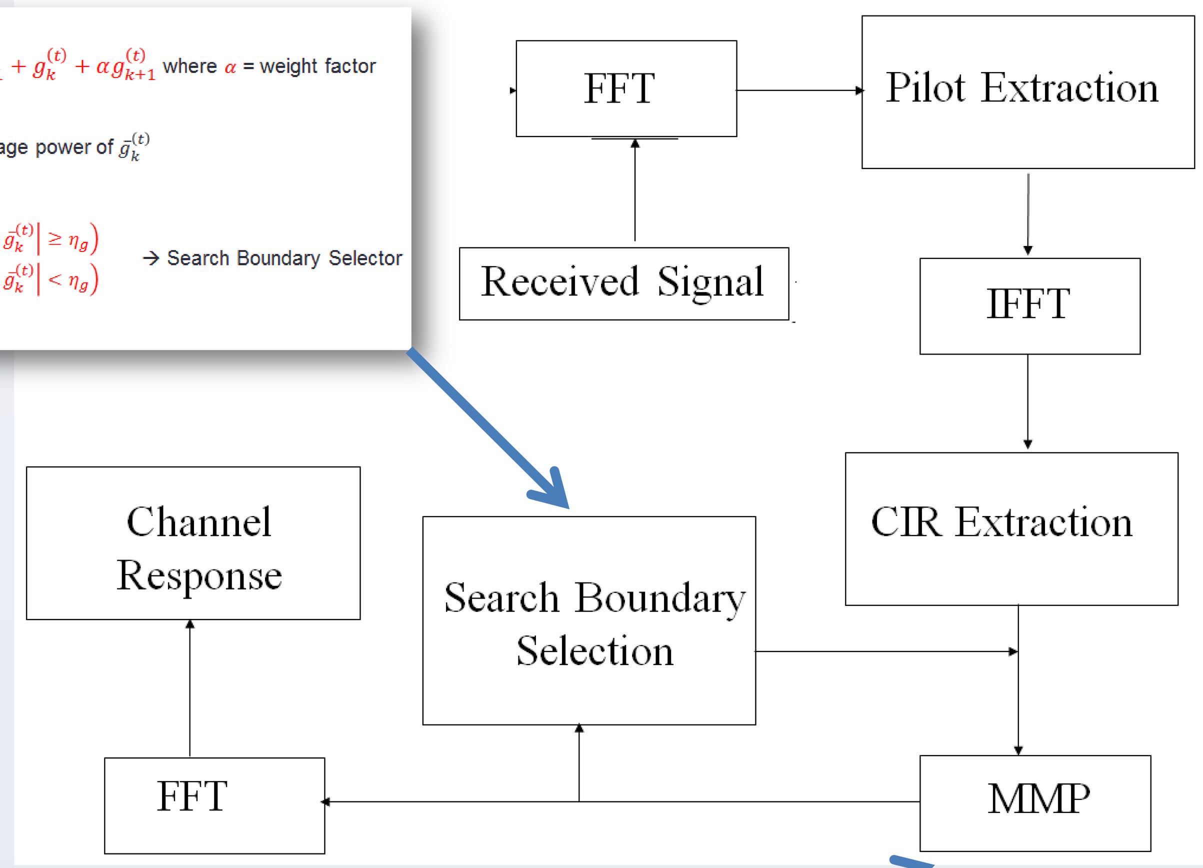
(Re-ordering Matrix) $Q = \begin{bmatrix} O_{K_P,K_N} & I_{K_P} \\ O_{N-K,K_N} & O_{N-K,K_P} \\ I_{K_N} & O_{K_N,K_P} \end{bmatrix}$

K_P and K_N are the numbers of positive and negative frequency subcarriers, respectively.

IV. PROPOSED METHOD

The Impulse Response can obtained with few pilots since the channel is sparse. The Modified Matching Pursuit Algorithm will determine the best matching projection of the Impulse Response from the Measurement Matrix (S).





The Search Boundary Selector will determine which columns of the Matrix S has the best projection. The computational cost will be reduced since not all columns of matrix S will be utilized.

The idea is to use Matching Pursuit for the first symbol arrival. And then Modified Matching Pursuit will be used for succeeding symbols.

1. Let $\mathbf{r}_0 = \hat{\mathbf{g}}$ → residual, $\Lambda_0 = \phi$ → index set, $X_0 = [\,]$ → chosen atom, and $i = 1$ → iteration counter, η_r = threshold, $\mathbf{s}_k$ = columns of measurement Matrix S.
2. $\lambda_i = \arg \max_{\{k | b_k^{(t)} = 1\}} |\mathbf{r}_{i-1}^H \mathbf{s}_k|$ → modified inner product
3. $\Lambda_i = \Lambda_{i-1} \cup \{\lambda_i\}$ $\quad \mathbf{X}_i = [\mathbf{X}_{i-1}, \mathbf{s}_{\lambda_i}]$ → augmentation
4. $\mathbf{w}_i = \arg \min_{\mathbf{w}} \| \hat{\mathbf{g}} - \mathbf{X}_i \mathbf{w} \|^2$ → solve using least square
5. $\mathbf{r}_i = \hat{\mathbf{g}} - \mathbf{X}_i \mathbf{w}_i$ → residual update
6. Increment the iteration counter i until the $\| r_i \|_2 < \eta_r^{mmp}$ modified threshold
7. $\mathbf{g}^{mmp} = [\boldsymbol{i}_{\lambda_0}, \boldsymbol{i}_{\lambda_1}, \cdots, \boldsymbol{i}_{\lambda_{m-1}}] \mathbf{w}_m$ where $\boldsymbol{i}_k = [\overbrace{0, \cdots, 0}^{k}, 1, 0, \cdots, 0]^T$

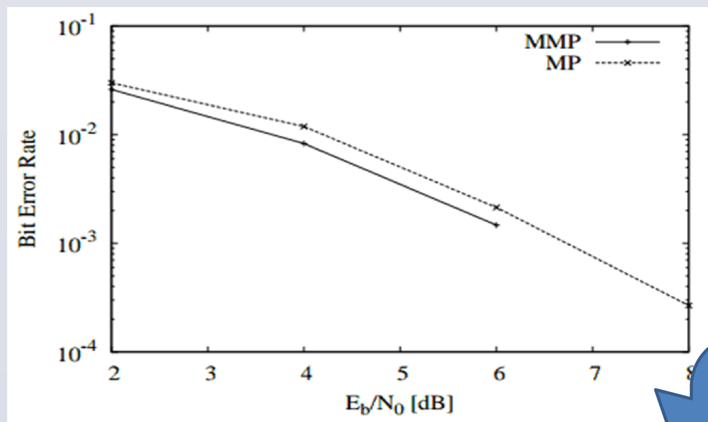
V. SIMULATION

The system was evaluation in terms of Bit-Error-Rate (BER) Performance.

Simulation Parameters

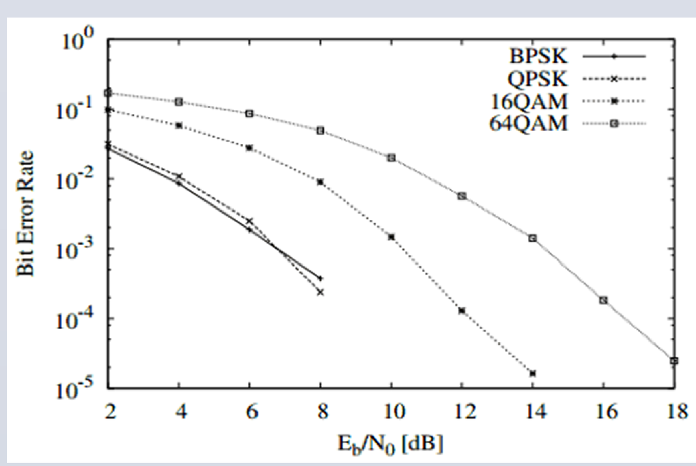
System Model	ISDB-T mode 3
Noise Type	AWGN
Modulation Type	QPSK
Data Subcarrier	3744
Pilot Subcarrier	1872
FFT size	8192
GI ratio	1/8
Path Model	δ(t) + 1/2δ(t-1)

BER Performance for MMP and MP

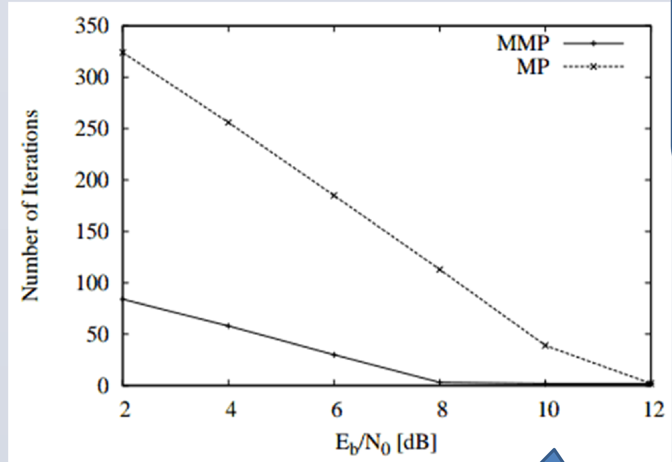


The BER Performance for both methods are almost the same

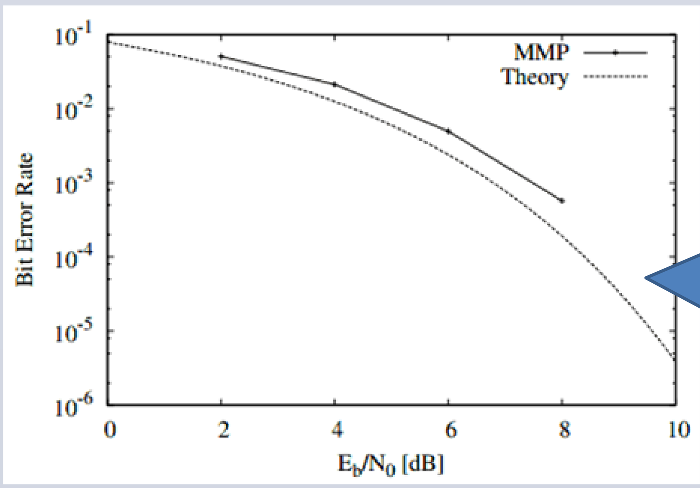
BER Performance for Different Modulation Type



Iteration Count for MMP and MP



The MMP has lower iteration count which means that MMP has lower computational cost.



The BER Performance of the proposed algorithm agrees with the theoretical curve.

CONCLUSION

- The proposed algorithm was able to validate the channel estimation capability based on the BER Performance.
- The MMP and MP have almost the same BER Performance. The difference is that MMP has lower computational cost than MP.