SSR Algorithms for OFDM Systems: Theory to Practice

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Overview

Abstract

- Channel estimation plays a vital role in OFDM systems.
- Wireless channel is approximately sparse in lag domain.
- Bayesian based Sparse Signal Recovery methods have been proved very promising in the literature.

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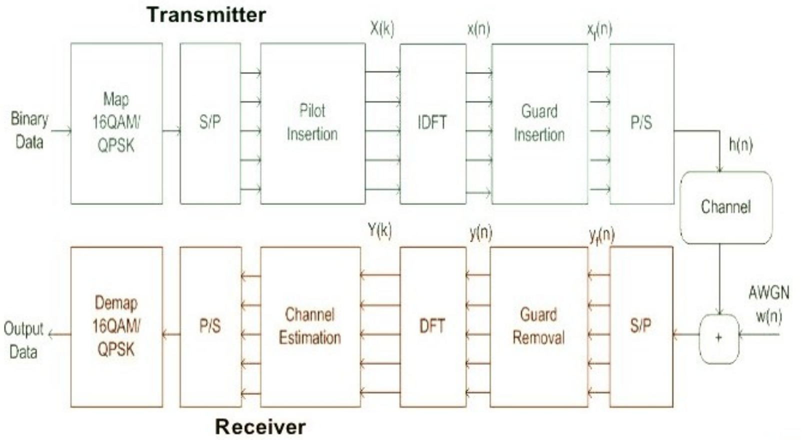
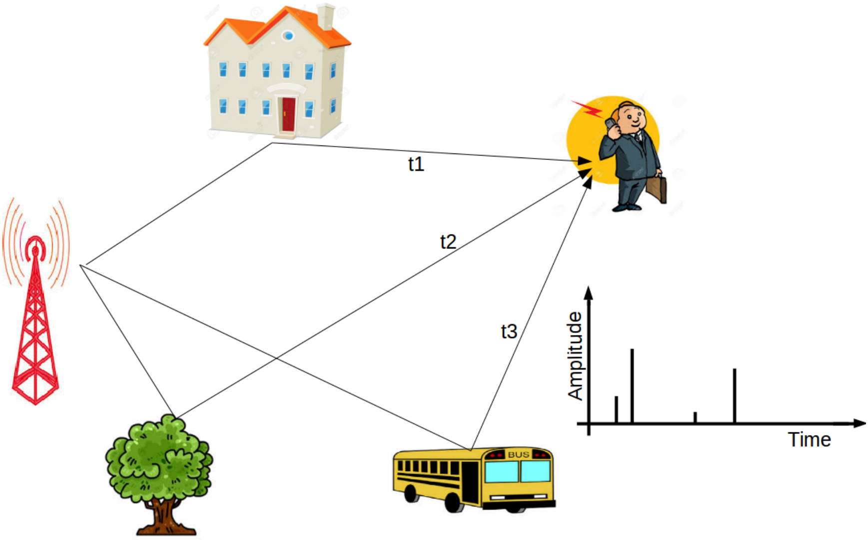
- Channel estimation plays a vital role in OFDM systems.
- Wireless channel is approximately sparse in lag domain.
- Bayesian based Sparse Signal Recovery methods have been proved very promising in the literature.
- However, there is a void of practical implementation!

OFDM System Architecture

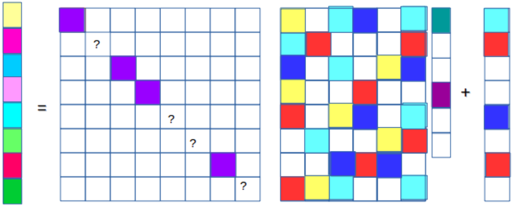


Wireless Communication Channel



Channel Model

$$Y = X\ F\ h + n$$



- Pilot based estimation :

$$Y_p = X_p F_p h + n$$

Sparse Bayesian Learning

- By applying SBL to channel estimation problem, we get :

$$P1: \quad \hat{h} = \underset{h,\gamma \epsilon R^{Lx1}}{\arg\min} \frac{\| Y_p - X_p F_p h\|_2^2}{\sigma^2} + log \mid \Gamma \mid + h^H \Gamma^{-1} h$$

$$P2: \quad \hat{h}, \hat{X} = \underset{h,\gamma \epsilon R^{Lx1}, X \epsilon S}{\arg\min} \frac{\| Y - XFh\|_2^2}{\sigma^2} + log \mid \Gamma \mid + h^H \Gamma^{-1} h$$

where, h $\sim \mathcal{CN}(0, \Gamma)$

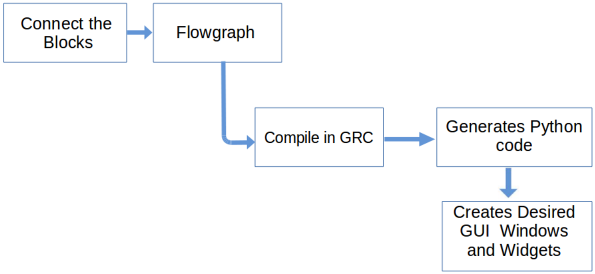
$\Gamma = diag(\gamma(1), \gamma(2).....\gamma(L))$

GNU Radio

- Open-source software developement toolkit.
- All kinds of signal processing blocks are available.
- Drag and Drop blocks using GUI.
- Blocks are written in C++ or Python.
- It can be used :
  With external RF hardware to create software-defined radios.
  Without hardware in a simulation-like environment.
- A platform for quick prototyping.

GNU Radio Companion

- The front-end to the GNU Radio libraries.



- Each block does one signal processing operation, such as filtering, adding signals, transforming, decoding, hardware access or many others.

- Data passes between blocks through edges in various formats, complex or real integers, floats or basically of any kind.

Demo

- Bit Error rate in AWGN Channel.
- OFDM Modulation and Demodulation.
- FM radio with USRP.
- Data Tx and Rx using OFDM with USRPs.

Block Structure

The work function:

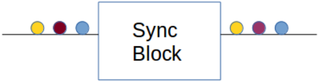
- Reads inputs, processes, and writes outputs.
- Arguments to the function
  1. **noutput items:** num of items in each output buffer.
  2. **ninput items:** vector desc the each input buffer len.
  3. **input items:** vector of input buffers for each input port.
  4. **output items:** vector of output buffers

IO Signatures:

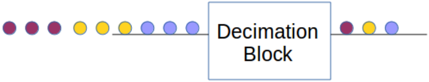
- Defines number of input, output ports and item size of each port.
- Two IO Signatures : Input and Output.

Types of Blocks

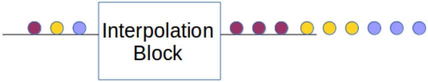
- Synchronous Blocks (1:1)



- Decimation Blocks (N:1)



- Interpolation Blocks (1:M)



- General Blocks (N:M), Hierarchical Blocks, Top Blocks.

Basic Files for a block

- Public Header File : Basic Structure
- Implementation Header File : Adds functinality
- Implementation Source File : Describes working
- Test File : Tests functionality

Stream Tags :

- A tag decorates a stream with metadata.
- Associated with a particular item in a stream.

USRP

USRP : Universal Software Radio Peripheral

- Driver : USRP Hardware Driver(UHD)
- Works as the RF Front-End.
- USRP N210 has one Rx and one Tx/RX antenna.
- FPGA Board for down-converting and up-converting.
- ADC and DAC with high resolution.
- 2x2 MIMO configuration is available.

Experimental setup

- Need to create static interface on the system.
- Make sure that Ethernet Port supports 1Gbps speed.
- Use USRP Source and Sinc in the flowgraph.
- Specify Antenna, Frequency, Device IP address etc...
- Run the flowgraph and data is on air.

GOAL

- Channel Estimation Block with Sparse Bayesian Learning methods.
- Simulate in loop back mode with controlled channel in between.
- Verify for the natural channel through USRP.
- Compare the SSR algorithms for channel estimation.

THANK YOU