# Wireless communications
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# Adaptive beamforming

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https://github.com/BernardoCama/WirelessCommunicationProject

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## Contents

## List of Figures

## Listings

# 1 Introduction

# 2 Project description

In this section, we describe the structure of out project with a brief description of the main points of all the parts composing our work.

## 2.1 Beamforming techniques

We have implemented 5 beamforming techniques:

1. **Simple beamforming** The phases are selected to steer the array in a particular direction.
2. **Null-steering beamforming** Used to cancel K ¡= N-2 plane waves arriving from known directions.
3. **Minimun variance distiortionless response (MVDR) beamforming** This beamformer minimizes the interference-plus- noise power at the output of the beamformer.
4. **Minimum mean square error (MMSE) beamforming** The weigths of the antennas are adjusted in a way that the MSE between the output of the beamformer and the reference signal is minimized.
5. **Least mean square (LMS) beamforming** This iterative algorithms adjust the weights by estimating the gradient of the MSE and moving them in the negative direction of the gradient at each iteration. We have implemented this iterative algorithm both in the time and in the frequency domain.

## 2.2 Channels

All the 5 beamformers have been tested on 3 different channel:

1. **LOS channel** A simple line of sigth channel with no reflections.
2. **Two-ray channel** For each signal, we consider a direct path (LOS) and a single reflection.
3. **Quadriga channel** Here, the scenario we have used is the *QuaDRiGa_UD2D_LOS*.

## 2.3 Signals

For all the beamformers and in all the channel, the bits we transmit are generated randomly and modulated fist with a 4QAM modulation (we have also tested the beamformers with a 16QAM); then, the QAM symbols are modulated with OFDM for transmission.

## 2.4 Reported results

In this report, we only describe the three most important simulations we have done:

1. Comparison between the SNR at the input and at the output of all the five beamformers in a LOS channel (section 3).

2. Comparison of the performance in terms of constellations revealed, weigths of the antennas and BER for all the
five beamformers considering different antenna arrays (section 4). This has been done in the quadriga channel
and using the LMS beamformer in the time domain.

3. Traking of two vehicles using LMS beamforming in the frequency domain (section 5).

All the other simulations we have done can be found on the *Github* repository of the project (link in title page).

## 3 SNR comparison

# 4 Antenna array comparison

# 5 Tracking

# 6 Conclusions

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