

# Convex optimization in communications systems

2016 Warwick BT study group

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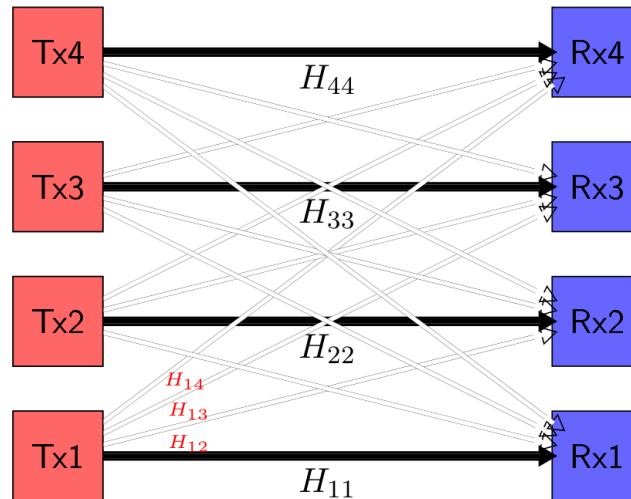
Academic convenor: Samuel Johnson

The aim of this study is to look at some applications of recently developed optimization methods to maximize the performance of certain communication systems. We aim here for a seamless integration of ideas from mathematics, engineering, numerical analysis, and software.

The steps are:

1. Get the free pdf file of the book *Convex Optimization* by Boyd and Vandenberghe from <http://stanford.edu/~boyd/cvxbook/> .
2. If necessary, study the paper [Luo03] cited on page 692, and any other required background material (it is not necessary to understand how the interior-point solvers work – they can be viewed as black-boxes).
3. Study these examples:
  - a) 4.20 on page 196
  - b) 4.57 on page 207
  - c) 4.62 on page 210
  - d) 5.2 on page 245
4. Write software to solve all these examples, using cvxpy from <http://www.cvxpy.org/en/latest/>. The aim is to have model code, which can be submitted to the cvxpy project to be added to the published examples (<http://www.cvxpy.org/en/latest/examples/index.html>). But at the same time, the codes should solve meaningful and useful cases; in other words, the physical parameters must be realistic (I can provide values for these). Note that the code will be pure python, but that the cvxpy library has been cleverly designed to make the expression of the optimization problem close to one which mathematicians are used to.
5. **Research challenge: multiuser beamforming.** Here we have  $n$  transmitter-receiver pairs, but each pair has  $m$  antennas on the transmitter and  $m$  on the receiver (see figure for an  $n=4$  example). In general we want a high signal-to-interference-plus-noise ratio (SINR) at each receiver, but of course increasing the power, and thus the signal, also increases interference. (a) Write down an optimization problem with

the objective of minimizing transmit power, while achieving at least some pre-set target SINR value at each receiver. Is this problem convex? If not, can it be relaxed or transformed into a convex problem? Thus, or otherwise, solve an example of this problem with cvxpy. (b) A related problem is to maximize the sum (or the minimum) of SINRs over all receivers, while not exceeding a specified maximum transmit power. Discuss, and solve an example of, this problem.



6. The write-up should emphasize the essential unity (achieved through the recognition of the convexity of the problems) of this approach, to the four examples.