

Chapter 1

Matrix calculations - Quadratic placement by GR633

1.1 a) Explain how to find the positions of the free cells that minimize the total wire length

The total square wire length is given by Equation (1.1).

$$J_K = \sum_{k=1}^K \left[(x_{I(k)} - x_{J(k)})^2 + (y_{I(k)} - y_{J(k)})^2 \right] \quad (1.1)$$

where $x_{I(K)}$ is the position where the wire start and $x_{J(K)}$ is the position where the wire ends. Likewise with y .

By defining the position of the free cells, x_{free} , as $[x_1, x_2, \dots, x_n]^T$ and the fixed cells, x_{fixed} , as $[x_{n+1}, \dots, x_N]^T$, x can be defined as $[x_{\text{free}}^T, x_{\text{fixed}}^T]^T$ and similarly with y .

The matrix, A , describes which wire connects the start cell, $I(k)$, to the end cell, $J(k)$. It can then be shown that

$$x_{I(k)} - x_{J(k)} = A_k x$$

as A_{kj} is -1 if wire k goes from cell j , 1 if wire k goes to cell j or 0 otherwise.

A simple example can be seen in Equation (1.2).

$$\begin{aligned} A_1 &= [-1, 0, 0, 1], x = [x_1, x_2, x_3, x_4]^T, \text{ from cell 1 to cell 4} \\ A_1 x &= x_4 - x_1 \end{aligned} \quad (1.2)$$

To get the same expression as Equation (1.1) the term needs to be squared. This is similar to squaring the norm of Ax . The cost function can thus be rewritten to be

Equation (1.3).

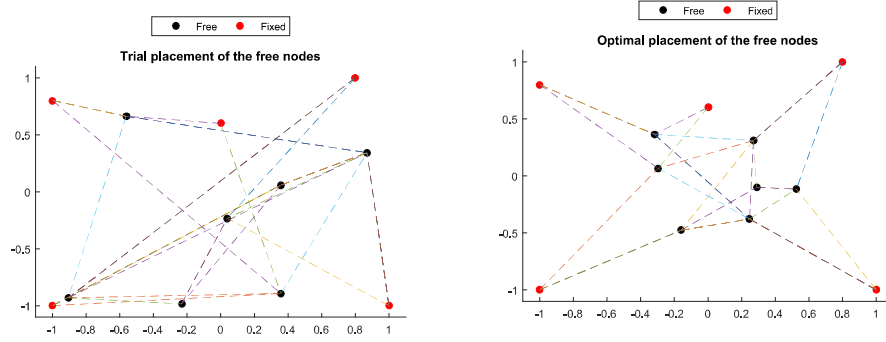
$$J_K = \left(\|Ax\|_2^2 + \|Ay\|_2^2 \right)$$

$$J_K = \left(\|A[x_{\text{free}}^T, x_{\text{fixed}}^T]^T\|_2^2 + \|A[y_{\text{free}}^T, y_{\text{fixed}}^T]^T\|_2^2 \right) \quad (1.3)$$

The cost function is similar to the least square approximation as the function needs to be minimized by selecting x_{free} and y_{free} that gives the least squares.

1.2 b) Determine the optimal quadratic placement for a specific set of cells and interconnect topology.

Equation (1.3) is minimized using the CVX toolbox in matlab c.f. matrix_hw_GR633.m except the norm isn't squared in the matlab program as it gave an error with the CVX toolbox. This isn't an issue as the minimizer will be the same.



(a) Plot of randomly selected free cells. (b) Plot of free cells selected by minimizing Equation (1.3).

Figure 1.1: Plot of the fixed and free cells incl. their wiring.

On Figure 1.1 the fixed and free cells are seen where they're randomly selected or optimized. Since they're connected to each other and/or the fixed cells it makes sense that the optimized cells are closer to the center of the fixed cells than when randomly selected.