

## Solution of Homework 2

### Social Networks

**Exercise 4.4** Let  $A$  be a square  $n \times n$  matrix whose rows are orthonormal. Prove that the columns of  $A$  are orthonormal.

**Solution:** Let  $A$  be  $\begin{bmatrix} a_{11} & \dots & a_{1n} \\ \dots & \dots & \dots \\ a_{n1} & \dots & a_{nn} \end{bmatrix}$ , the rows are orthonormal so  $r_i \cdot r_j = 1$  if  $i =$

$j$  and 0 otherwise, where  $r_i$  is the  $i$ -th row of  $A$ .

The means  $AA^T = A^T A = I$  since  $A$  is  $n \times n$  matrix.

Therefore we can get  $c_i \cdot c_j = 1$  if  $i = j$  and 0 otherwise, where  $c_i$  is the  $i$ -th column of  $A$ . Thus the columns are also orthonormal.

**Exercise 4.6** Prove that the left singular vectors of  $A$  are the right singular vectors of  $A^T$ .

**Solution:** Let  $A = UDV^T$  by SVD where  $U$  is composed of the left singular values of  $A$  and  $V$  is composed of the right singular values of  $A$ . Then  $A^T = (UDV^T)^T = VDU^T$ , so the left singular vectors of  $A$  are the right singular vectors of  $A^T$ .

### Exercise 4.31

1. Consider the pairwise distance matrix for twenty US cities given below. Use the algorithm of Exercise 2 to place the cities on a map of the US.
2. Suppose you had airline distances for 50 cities around the world. Could you use these distances to construct a world map?

#### Solution:

1. In order to put the cities on a map, we would compute the rank 2 approximation of the matrix of distance. This gives us a projection of the rows of the original matrix onto a two-dimensional subspace spanned by the first 2 singular vectors of the original matrix.
2. Yes, map  $M$  to a three-dimensional subspace. Do a rank 3 approximation of the distance matrix to get an approximate map of the world in three dimensions.

# Networks Homework 2 Solution

**F Rizvi**



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