## Programming Assignment 4

**Issued:** Tuesday 27$^{\text{th}}$ November, 2018      **Due:** Monday 3$^{\text{rd}}$ December, 2018

4.1. Suppose we are given a dataset $\{(x^{(i)}, y^{(i)}) : i = 1, 2, \ldots, N\}$. $x^{(i)}$ belongs to discreet finit set $\mathcal{X} = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$, $y^{(i)}$ belongs to discreet finit set $\mathcal{Y} = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14\}$.

  (a) (10 points) The given data num.npy is a $10 \times 15$ matrix, each entry of this matrix represents the number of corresponding pairs occur in the given dataset. i.e. num$(0, 1)$ is the number of pair $(x^{(i)} = 0, y^{(i)} = 1)$ occurs in the given dataset. Implement ACE algorithm to calculate $g(y)$ and second singular vector of B matrix in the given dataset, refer to your class notes for the defination of B matrix.



**Algorithm 2** ACE Algorithm with Finite Samples

**Require:** training samples $\{(x_i, y_i) : i = 1, \ldots, N\}$
  1. Initialize: randomly pick $g(y)$, $y \in \mathcal{Y}$
  **repeat:** pick a subset of $n$ samples
    2a. $f(x) \leftarrow \widehat{\mathbb{E}}_n[g(Y)|X = x]$, $\forall x \in \mathcal{X}$
    2b. $g(y) \leftarrow \widehat{\mathbb{E}}_n[f(X)|Y = y]$, $\forall y \in \mathcal{Y}$
    2c. Regularize: $g(y) \leftarrow g(y) - \widehat{\mathbb{E}}_n[g(Y)]$, $\forall y \in \mathcal{Y}$
                $g(y) \leftarrow g(y)/\sqrt{\widehat{\mathbb{E}}_n[g^2(Y)]}$, $\forall y \in \mathcal{Y}$
  **until** $\widehat{\mathbb{E}}_n[f(X)g(Y)]$ stops to increase

`Pa4_2018.py` will walk you through this exercise.

**Notice:**

- Submit your .py file only.

- Use whole dataset instead of a subset of n samples in this problem.

- np.linalg.svd(), np.linalg.eig() or other matrix decompose methods are forbidden.

- Using matrix manipulation and numpy broadcasting for efficiency.

- If your codes are right, the result will be like one of those: