1. Collaborative Filtering, Kernels, Linear Regression

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Homework due Oct 14, 2020 05:29 IST *Past Due*

In this question, we will use the alternating projections algorithm for low-rank matrix factorization, which aims to minimize

$$J(U,V) = \underbrace{\frac{1}{2}\sum_{(a,i)\in D}\left(Y_{ai} - [UV^T]_{ai}\right)^2}_{\text{Squared Error}} + \underbrace{\frac{\lambda}{2}\sum_{a=1}^{n}\sum_{j=1}^{k}U_{aj}^2 + \frac{\lambda}{2}\sum_{i=1}^{m}\sum_{j=1}^{k}V_{ij}^2}_{\text{Regularization}}.$$

In the following, we will call the first term the squared error term, and the two terms with λ the regularization terms.

Let Y be defined as

$$Y = \begin{bmatrix} 5 & ? & 7 \\ ? & 2 & ? \\ 4 & ? & ? \\ ? & 3 & 6 \end{bmatrix}$$

D is defined as the set of indices (a,i), where $Y_{a,i}$ is not missing. In this problem, we let $k = \lambda = 1$. Additionally, U and V are initialized as $U^{(0)} = [6,0,3,6]^T$, and $V^{(0)} = [4,2,1]^T$.

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1. (a)

1 point possible (graded)

Compute $X^{(0)}$, the matrix of predicted rankings UV^T given the initial values for $U^{(0)}$ and $V^{(0)}$.

(Enter your answer as a matrix, e.g., type **[[2,1],[1,0],[3,-1]]** for a 2×3 matrix $\begin{pmatrix} 2 & 1 \\ 1 & 0 \\ 3 & -1 \end{pmatrix}$. Note the square brackets, and commas as separators.)

24

Answer: [[24, 12, 6], [0, 0, 0], [12, 6, 3], [24, 12, 6]]

Solution:

- the predicted rankings should be the matrix product between U and V^T.

$$X = UV^T = \begin{bmatrix} 24 & 12 & 6 \\ 0 & 0 & 0 \\ 12 & 6 & 3 \\ 24 & 12 & 6 \end{bmatrix}$$

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Answers are displayed within the problem

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1. (b)

2 points possible (graded)

2 points possible (graded)

Compute the squared error term, and the regularization terms in for the current estimate X.

Enter the squared error term (including the factor $1/2$):

Answer: 255.5

Enter the regularization term (the sum of all the regularization terms):

Answer: 51

Solution:

$$\begin{aligned} J_{\text{square}} &= \sum_{i,j \in D} (Y_{ij} - X_{ij})^2/2 \\ &= \frac{1}{2}\left((5-24)^2 + (7-6)^2 + (2-0)^2 + (4-12)^2 + (3-12)^2 + (6-6)^2\right) = 255.5 \\ J_{\text{reg}} &= \frac{\lambda}{2}\|U\|_F^2 + \frac{\lambda}{2}\|V\|_F^2 \\ &= \frac{\lambda}{2}\sum_{a=1}^{n}(U_a)^2 + \frac{\lambda}{2}\sum_{i=1}^{m}(V_i)^2 = 51 \end{aligned}$$

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1. (c)

1 point possible (graded)

Suppose V is kept fixed. Run one step of the algorithm to find the new estimate $U^{(1)}$.

Enter the $U^{(1)}$ as a list of numbers, $[U_1^{(1)}, U_2^{(1)}, U_3^{(1)}, U_4^{(1)}]$:

Answer: [3/2, 4/5, 16/17, 2]

Solution:

With V fixed as $[4,2,1]^T$, we can represent prediction X as:

$$X = UV^T = \begin{bmatrix} 4U_1 & 2U_1 & 1U_1 \\ 4U_2 & 2U_2 & 1U_2 \\ 4U_3 & 2U_3 & 1U_3 \\ 4U_4 & 2U_4 & 1U_4 \end{bmatrix}$$

Let D be the set of index of observation, the estimate $U^{(1)}$ should be:

$$\begin{aligned} U^{(1)} &= \arg\min_U \; J(U) \\ &= \arg\min_U \; \sum_{(a,i)\in D} (Y_{ai} - (UV)_{ai})^2/2 + \sum_{a=1}^{4} \frac{\lambda}{2}\|U_a\|^2 \\ &= \arg\min_U \; [(5-4U_1)^2 + (7-U_1)^2 + (2-2U_2)^2 + (4-4U_3)^2 + (3-2U_4)^2 + (6-U_4)^2]/2 + \sum_{a=1}^{4}\frac{1}{2}U \end{aligned}$$

To minimize this loss, we take the gradient with respect to U and equate it to zero.

$$0 = \nabla J(U) = \begin{pmatrix} -4(5-4U_1)-(7-U_1)+U_1 \\ -2(2-2U_2)+U_2 \\ -4(4-4U_3)+U_3 \\ -2(3-2U_4)-(6-U_4)+U_4 \end{pmatrix} = \begin{pmatrix} -27+18U_1 \\ -4+5U_2 \\ -16+17U_3 \\ -12+6U_4 \end{pmatrix}$$

Hence,

$$U_1^{(1)} = \frac{3}{2}$$
$$U_2^{(1)} = \frac{4}{5}$$
$$U_3^{(1)} = \frac{16}{17}$$
$$U_4^{(1)} = 2$$

Submit You have used 0 of 3 attempts

Answers are displayed within the problem

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?	Got 1.c wrong even if my answer looks correct Hi, The official answer is **[3/2, 4/5, 16/17, 2]** and mine was **[1.5,0.8,0.95,2]**. After recalculating the whole thing several times ...	7
	[Staff] Will it be possible to extend some more time for this course deadlines????????? Hello!!!!I am an undergraduate student, so really liking the way it is teaching the concepts of ML. But my only concern is that will it be...	4
?	[Staff] Could not format HTML for problem. Contact course staff in the discussion forum for assistance. question 1a, please takes a look, I've spent more than an hour on this question	2
	Compute the squared error term For this question the X that we use is the one we got in the previous question? and correct me if I am wrong the answer would be do...	4
?	quant_18 Hi everyone, How can I show matrix in the answer box?? the 1st question is asking compute matrix, but how to show it in the box?? t...	3
	1.(c)- this may be helpful if some is struggling with this question. I did the answer right the first time. but I gave the answers in decimals like 1.5 in place of 27/18 (eg. U1). The second time, I got conf...	1
?	In case of question 1a, how to write matrix in box? question is related to 1. Collaborative Filtering, Kernels, Linear Regression First homework	4
?	[STAFF] General query Can I submit the homework after the due date? Someone please reply!!	3
?	Could you please hint for c? I fix V to (4,2,1) took the derivative and got each U1 to U4 like the previous lecture.And I put them list [U1, U2...]. But I got the wrong ...	6
	Need Hint/Approach for Question 1a) I Didn't exactly understand how to begin my approach, I would be more than Happy if someone Helps me out.Your One minitue of s...	2
	Qs on 1b , 2nd part	

Community TA 3

? Change Input Answer
Hi, Can you please change the input for the answer in (c), so that we have 4 different inputs, as in (b) for instance. My answer is mark... 5

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