Maths for ML

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3. For a scalar s

$$s = s^T$$

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5. If A is a row-vector ($1 \times n$ matrix).
   and θ is a column-vector ($n \times 1$) matrix.
   and $A\theta$ is a scalar.

Example

$$\theta = \begin{bmatrix} \theta_1 \\ \theta_2 \end{bmatrix}_{2\times 1}$$

$$A = \begin{bmatrix} A_1 & A_2 \end{bmatrix}_{1\times 2}$$

$$A\theta_{1\times 1} = A_1\theta_1 + A_2\theta_2$$

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$$\frac{\partial A\theta}{\partial \theta} = \begin{bmatrix} \frac{\partial}{\partial \theta_1}(A_1\theta_1 + A_2\theta_2) \\ \frac{\partial}{\partial \theta_2}(A_1\theta_1 + A_2\theta_2) \end{bmatrix} = \begin{bmatrix} A_1 \\ A_2 \end{bmatrix}_{2\times 1} = A^T$$

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Z has a property $Z_{ij} = Z_{ji} \implies Z^T = Z$

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$$\theta^T Z\theta = e\theta_1^2 + 2f\theta_1\theta_2 + g\theta_2^2$$

The term $\theta^T Z\theta$ is a scalar.

$$\frac{\partial}{\partial \theta}\theta^T Z\theta = \frac{\partial}{\partial \theta}(e\theta_1^2 + 2f\theta_1\theta_2 + g\theta_2^2)$$

$$= \begin{bmatrix} \frac{\partial}{\partial \theta_1}(e\theta_1^2 + 2f\theta_1\theta_2 + g\theta_2^2) \\ \frac{\partial}{\partial \theta_2}(e\theta_1^2 + 2f\theta_1\theta_2 + g\theta_2^2) \end{bmatrix}$$

$$= \begin{bmatrix} 2e\theta_1 + 2f\theta_2 \\ 2f\theta_1 + 2g\theta_2 \end{bmatrix} = 2\begin{bmatrix} e & f \\ f & g \end{bmatrix}\begin{bmatrix} \theta_1 \\ \theta_1 \end{bmatrix}$$

$$= 2Z\theta = 2Z^T\theta$$

Maths for ML: Matrix Rank[1]

- An *rxc* matrix as a set of *r* row vectors, each having *c* elements; or you can think of it as a set of *c* column vectors, each having *r* elements.

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- If *r* is greater than *c*, then the maximum rank of the matrix is *c*.

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- $r = c =$. Thus, rank is $<= 3$
- Row 3 can be written as: 3 times Row 1 + 2 times Row 1. Thus, Row 3 is linearly dependent on Row 1 and 2. Thus, rank(A)=2

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What is the rank of

$$X = \begin{bmatrix} 1 & 2 & 4 & 4 \\ 3 & 4 & 8 & 0 \end{bmatrix}$$

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Since X has fewer rows than columns, its maximum rank is equal to the maximum number of linearly independent rows. And because neither row is linearly dependent on the other row, the matrix has 2 linearly independent rows; so its rank is 2.

Maths for ML: Matrix Inverse

Suppose A is an $n \times n$ matrix. The inverse of A is another $n \times n$ matrix, denoted A^{-1}, that satisfies the following conditions.

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Below, with an example, we illustrate the relationship between a matrix and its inverse.

$$\begin{bmatrix} 2 & 1 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} 0.8 & -0.2 \\ -0.6 & 0.4 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

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A square matrix that has an inverse is said to be nonsingular or invertible; a square matrix that does not have an inverse is said to be singular.
Not every square matrix has an inverse; but if a matrix does have an inverse, it is unique.