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# Notes On Matrix Calculus

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(Slightly Advanced)

*Lecture 4: Linear algebra (cont), matrix calculus, MATLAB*

~~Derivative of a Matrix~~

~~: Data Science Basics~~

The Matrix Calculus

You Need for Deep

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**Deep Learning**

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**Made Easy!** ~~Intro to~~

~~Matrices FEA 04:~~

~~Matrix Algebra~~

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~~Calculus~~ Linear

Algebra Done Right  
Book Review 15.

**Matrices  $A(t)$**

**Depending on  $t$ ,**  
**Derivative =  $dA/dt$**

**Lec 74 - Matrix**  
**Calculus**

*Eigenvectors and*  
*eigenvalues |*

*Essence of linear*  
*algebra, chapter 14*

The Map of  
Mathematics *Books*

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*for Learning Physics*

~~What does it feel like  
to invent math?~~

~~Three-dimensional  
linear transformations~~

~~| Essence of linear  
algebra, chapter 5~~

The Jacobian matrix

Introduction to

Calculus (1 of 2:

Seeing the big

picture) **Tensor**

**Calculus For**

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### **Diagonalizing 2nd Rank Tensors**

Calculus/Linear

~~Algebra: How to Find the Derivative of a~~

~~Matrix. [HD] How To Multiply Matrices - Quick \u0026 Easy!~~

*Gradient*

---

The determinant |  
Essence of linear algebra, chapter 6

**Matrix**

**Differentiation -**

*Page 7/36*

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**Derivatives With  
Respect to Scalars  
Schaum's Guide  
Math Book Review**

*Mathematical  
Methods for Physics  
and Engineering:  
Review Learn  
Calculus, linear  
algebra, statistics*

**Taylor series |  
Essence of calculus,  
chapter 11** *How to  
differentiate with*



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~~Calculus~~ *respect to a vector -*

*part 1* Books for

Learning Mathematics

Tensor Calculus For

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Vector

Transformations and

Vectors as Matrices

~~Notes On Matrix~~

~~Calculus~~

The field of calculus

for this is the most

general, namely

matrix calculus. To

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recap,  $f(x)$  is a scalar function of a scalar variable (use simple derivative rules),  $f(x)$  is a scalar function of vector variable  $x$  (use vector calculus rules) and  $f(x)$  is a vector of many scalar valued functions, with each function depending on a vector of inputs  $x$  (use matrix calculus rules).

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~~Notes on Matrix  
Calculus for Deep  
Learning | by Nikhil B~~

...

Notes on Matrix  
Calculus Paul L.  
Fackler? North  
Carolina State  
University September  
27, 2005 Matrix  
calculus is concerned  
with rules for  
operating on functions

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## Notes On Matrix Calculus

of matrices. For example, suppose that an  $m \times n$  matrix  $X$  is mapped into a  $p \times q$  matrix  $Y$ . We are interested in obtaining expressions for derivatives

~~Notes on Matrix  
Calculus~~

Matrix Calculus -  
Notes on the  
Derivative of a Trace.

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Johannes Traa. This write-up elucidates the rules of matrix calculus for expressions involving the trace of a function of a matrix  $X$ :  $f(\text{tr}(g(X)))$ . (1) We would like to take the derivative of  $f$  with respect to  $X$ :  $\frac{\partial f}{\partial X}$ . (2) One strategy is to write the trace expression as a scalar using index

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notation, take the derivative, and re-write in matrix form.

~~Matrix Calculus~~  
~~Notes on the~~  
~~Derivative of a Trace~~  
The field of calculus for this is the most general, namely matrix calculus. To recap,  $f(x)$  is a scalar function of a scalar variable (use simple

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## Notes On Matrix

derivative rules),  $f(x)$  is a scalar function of vector variable  $x$  (use vector calculus rules) and  $f(x)$  is a vector of many scalar valued functions, with each function depending on a vector of inputs  $x$  (use matrix calculus rules).

~~Notes on Matrix~~  
~~Calculus for Deep~~

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### Calculus

~~Learning - mc.ai~~

#### Appendix D: MATRIX CALCULUS D-6

which is the conventional chain rule of calculus. Note, however, that when we are dealing with vectors, the chain of matrices builds “toward the left.” For example, if  $w$  is a function of  $z$ , which is a function of  $y$ , which



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## Notes On Matrix

is a function of  $x$ ,  $w$   
 $\frac{\partial x}{\partial y} \frac{\partial y}{\partial z} \frac{\partial z}{\partial w}$   
 $\frac{\partial x}{\partial z} \frac{\partial z}{\partial w} \frac{\partial w}{\partial x}$ .(D.25)

~~Matrix Calculus—Rice~~  
~~University~~

Welcome to matrix calculus! Note that there are multiple ways to represent the Jacobian. We are using the so-called numerator layout but many papers and

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Calculus will use the denominator layout. This is just transpose of the numerator layout Jacobian (flip it around its diagonal):

~~The matrix calculus you need for deep learning~~

Matrix calculus refers to a number of different notations that use matrices and

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Vectors to collect the derivative of each component of the dependent variable with respect to each component of the independent variable. In general, the independent variable can be a scalar, a vector, or a matrix while the dependent variable can be any of these as well.

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~~Matrix calculus—  
WikiMili, The Best  
Wikipedia Reader  
(2071) Because  
gradient of the  
product (2068)  
requires total change  
with respect to  
change in each entry  
of matrix  $X$ , the  $Xb$   
vector must make an  
inner product with  
each vector in that~~

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Second dimension of  
the cubix indicated by  
dotted line segments;  
 $X(X^T a) X b = ? ? ? ?$   
 $a_{10} \ 0 \ a_1 \ a_{20} \ 0 \ a_2 \ ? \ ?$   
 $? \ ? \cdot b \ X_{11} + b_2 X_{12}$   
 $b_1 X_{21} + b_2 X_{22}$

~~Matrix Calculus~~  
~~CGRMA~~

Matrix Calculus[3] is a  
very useful tool in  
many engineering  
prob-lems. Basic rules

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Calculus

of matrix calculus are nothing more than ordinary calculus rules covered in undergraduate courses. However, using ma-trix calculus, the derivation process is more compact. This document is adapted from the notes of a course the author recently attends. It

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~~Matrix Calculus:~~

~~Derivation and Simple Application~~

Application: Di

erentiating Quadratic

Form  $x^T A x = x_1 \dots x_n$

$\begin{pmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{pmatrix}$

$\begin{pmatrix} x_1 & \dots & x_n \end{pmatrix}$

$= (a_{11}x_1 + \dots + a_{n1}x_n)$

$(a_{1n}x_1 + \dots + a_{nn}x_n)$

$\sum_{i=1}^n a_{i1}x_i + \dots + \sum_{i=1}^n a_{in}x_i$

$= x_1 \sum_{i=1}^n a_{i1} + \dots + x_n \sum_{i=1}^n a_{in}$

$= \sum_{i=1}^n a_{i1}x_i + \dots + \sum_{i=1}^n a_{in}x_i$

$= \sum_{i=1}^n a_{i1}x_i + \dots + \sum_{i=1}^n a_{in}x_i$

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$\sum_{i=1}^n a_{ij} x_i$   $\sum_{j=1}^n x_j$   $\sum_{i=1}^n a_{ij} x_i$   $\sum_{j=1}^n a_{ij} x_j$  H. K. Chen  
(SFU) Review of  
Simple Matrix  
Derivatives Oct 30,  
2014 3 / 8

~~Review of Simple  
Matrix Derivatives~~

0)) is one polar  
representation of  $z$ .

Write the non-zero  
complex number  $z$  as



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$$z = |z|(\cos(\theta) + i\sin(\theta)),$$

and note that the angle  $\theta$  then satisfies  $\tan(\theta) = \frac{\text{Im}(z)}{\text{Re}(z)}$  provided  $\text{Re}(z) \neq 0$ . However, because  $\theta$  is determined only up to multiples of  $2\pi$  but  $\tan(x)$  is determined up to multiples of  $\pi$ , we see that  $\theta = \tan^{-1} \frac{\text{Im}(z)}{\text{Re}(z)}$ .

~~MATH1056 Calculus~~  
Welcome to my math

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Calculus site. Contained in this site are the notes (free and downloadable) that I use to teach Algebra, Calculus (I, II and III) as well as Differential Equations at Lamar University. The notes contain the usual topics that are taught in those courses as well as a few extra topics that I decided

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Calculus  
to include just  
because I wanted to.

~~Pauls Online Math  
Notes~~

Matrix calculus When we move from derivatives of one function to derivatives of many functions, we move from the world of vector calculus to matrix calculus. Let us bring one more

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### Calculus

function  $g(x,y)$ ...

~~The Matrix Calculus  
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~~...~~

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Calculus Notes On  
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On Matrix Calculus  
The field of calculus  
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Calculus recap,  $f(x)$  is a scalar function of a scalar variable (use simple derivative rules),  $f(x)$  is a scalar Page 1/22.  
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THESE NOTES ARE  
NOT A SUBSTITUTE  
FOR ATTENDING  
CLASS!! Using these

*Page 29/36*

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Calculus notes as a substitute for class is liable to get you in trouble. As already noted not everything in these notes is covered in class and often material or insights not in these notes is covered in class.

~~Calculus I - Pauls  
Online Math Notes~~  
Such a matrix is

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called the Jacobian matrix of the transformation  $(\cdot)$ .

Notice that if  $x$  is actually a scalar in Convention 3 then the resulting Jacobian matrix is a  $m \times 1$  matrix; that is, a single column (a vector).

~~Matrix Differentiation~~  
~~Department of~~  
~~Atmospheric Sciences~~

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### Notes on Matrix

Calculus for Deep Learning – mc.ai Here is a set of notes used by Paul Dawkins to teach his Calculus I course at Lamar University. Included are detailed discussions of Limits (Properties, Computing, One-sided, Limits at Infinity, Continuity),



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~~Calculus~~ (Basic Formulas, Product/Quotient/Chain Rules, L'Hospital's Rule,

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~~Calculus~~

~~nsaidalliance.com~~

Linear Algebra, Rank of a matrix-echelon form, Diagonalization of a square matrix of order two. Click the below link to

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Linear Algebra . M-1

M-2 M-3 M-4 M-5.

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~~and Linear Algebra~~  
~~Notes - VTUPulse~~  
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