${\bf Contents}$

1	Abo	About					
2	Not	Notation					
3 Linear Algebra							
	3.1	Vector spaces	6				
		3.1.1 Euclidean space	6				
		3.1.2 Subspaces	7				
	3.2	Linear maps	7				
		3.2.1 The matrix of a linear map	8				
		3.2.2 Nullspace, range	9				
	3.3	Metric spaces	9				
	3.4	Normed spaces	9				
	3.5	Inner product spaces	10				
		3.5.1 Pythagorean Theorem	11				
		3.5.2 Cauchy-Schwarz inequality	11				
		3.5.3 Orthogonal complements and projections	12				
	3.6	Eigenthings	15				
	3.7	Trace	15				
	3.8						
	3.9						
	3.10	Symmetric matrices	17				
		3.10.1 Rayleigh quotients	17				
	3.11	Positive (semi-)definite matrices	18				
		3.11.1 The geometry of positive definite quadratic forms	19				
	3.12	Singular value decomposition	20				
	3.13	Fundamental Theorem of Linear Algebra	21				
	3.14	Operator and matrix norms	22				
		Low-rank approximation	24				
	3.16	Pseudoinverses	25				
	3.17	Some useful matrix identities	26				
		3.17.1 Matrix-vector product as linear combination of matrix columns	26				
		3.17.2 Sum of outer products as matrix-matrix product	26				
		3.17.3 Quadratic forms	26				
4	Calo	culus and Optimization	27				

	4.1	Extrema	27
	4.2	Gradients	27
	4.3	The Jacobian	27
	4.4	The Hessian	28
	4.5	Matrix calculus	28
		4.5.1 The chain rule	28
	4.6	Taylor's theorem	29
	4.7	Conditions for local minima	29
	4.8	Convexity	31
		4.8.1 Convex sets	31
		4.8.2 Basics of convex functions	31
		4.8.3 Consequences of convexity	32
		4.8.4 Showing that a function is convex	33
		4.8.5 Examples	36
5	Pro	bability	37
9	5.1		37
	0.1	5.1.1 Conditional probability	38
		5.1.2 Chain rule	38
		5.1.3 Bayes' rule	38
	5.2	Random variables	39
	0.2	5.2.1 The cumulative distribution function	39
		5.2.2 Discrete random variables	40
		5.2.3 Continuous random variables	40
			40
	5.3		41
	0.0		41
		5.3.2 Marginal distributions	41
	5.4		41
	0.1	5.4.1 Properties of expected value	42
	5.5	Variance	42
	0.0	5.5.1 Properties of variance	42
		5.5.2 Standard deviation	42
	5.6	Covariance	43
	5.0	5.6.1 Correlation	43
	5.7	Random vactors	43

References							
	5.9.1	The geometry of multivariate Gaussians	45				
5.9	The C	Gaussian distribution	45				
	5.8.2	Maximum a posteriori estimation	45				
	5.8.1	Maximum likelihood estimation	44				
5.8	Estim	ation of Parameters	44				