Machine Learning Foundations

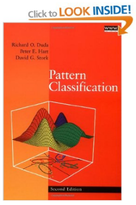
Mahesan Niranjan

School of Electronics and Computer Science
University of Southampton

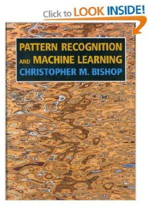
Summer School 2020

Good Books

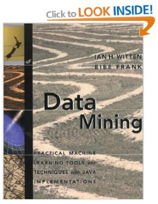
Well worth investing in books if you want to do more in this subject



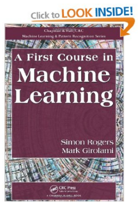
R.O.Duda, P.E.Hart & D.G.Stork
Pattern Classification



C.M. Bishop
Pattern Recognition and Machine Learning



I.H. Witten & E. Frank
Data Mining



S. Rogers & M. Girolami
A First Course in Machine Learning

"There is nothing to be learnt from a professor, which is not to be met with in books"
- David Hume (1711-1776)

(**WikiPedia:** "Hume had little respect for the professors of his time [...] He did not graduate")

Machine Learning as Data-driven Modelling

Single-slide overview of the subject and challenging questions

Data	$\{\boldsymbol{x}_n,\ \boldsymbol{y}_n\}_{n=1}^{N}$ $\quad\quad$ $\{\boldsymbol{x}_n\}_{n=1}^{N}$
Function Approximator	$\boldsymbol{y} \ = \ f\left(\boldsymbol{x},\,\boldsymbol{\theta}\right) \ + \ v$
Parameter Estimation	$E_0 \ = \ \sum_{n=1}^{N} \left\{\lvert\lvert\, \boldsymbol{y}_n \ - \ f\left(\boldsymbol{x}_n;\ \boldsymbol{\theta}\right)\ \rvert\rvert\right\}^2$
Prediction	$\hat{\boldsymbol{y}}_{N+1} \ = \ f\left(\boldsymbol{x}_{N+1},\ \hat{\boldsymbol{\theta}}\right)$
Regularization	$E_1 \ = \ \sum_{n=1}^{N} \left\{\lvert\lvert\, \boldsymbol{y}_n \ - \ f\left(\boldsymbol{x}_n\right)\ \rvert\rvert\right\}^2 \ + \ g\left(\lvert\lvert\boldsymbol{\theta}\rvert\rvert\right)$
Modelling Uncertainty	$p\left(\boldsymbol{\theta} \vert \left\{\boldsymbol{x}_n, \boldsymbol{y}_n\right\}_{n=1}^{N}\right)$
Probabilistic Inference	$\boldsymbol{E}\left[g\left(\boldsymbol{\theta}\right)\right] = \int g\left(\boldsymbol{\theta}\right) p\left(\boldsymbol{\theta}\right) d\boldsymbol{\theta} \ = \frac{1}{N_s} \sum_{n=1}^{N_s} g\left(\boldsymbol{\theta}^{(n)}\right)$
Sequential Estimation	$\boldsymbol{\theta}\left(n-1 \vert n-1\right) \longrightarrow \boldsymbol{\theta}\left(n \vert n-1\right) \longrightarrow \boldsymbol{\theta}\left(n \vert n\right)$ Kalman & Particle Filters; Reinforcement Learning