Week 10 — Frontiers

Stochastic Optimisation, ML & Beyond

Dr Juan Zurita

Optimisation & Mathematical Methods for Economics
The University of Edinburgh · School of Economics

Stochastic Dynamic Programming

Real economies face uncertainty: $V(k,z) = \max_c \{u(c) + \beta\, \mathbb{E}[V(k',z')|z]\}$

z follows a Markov process (e.g. productivity shocks).

Discretise with Tauchen or Rouwenhorst methods; solve with VFI over the joint (k,z) grid.

Stochastic Gradient Descent

In machine learning: $\min_\theta \frac{1}{N} \sum_i \ell(\theta; x_i, y_i)$

SGD uses a random **mini-batch** instead of all N samples:
$\theta_{t+1} = \theta_t - \alpha_t \nabla \ell(\theta_t; x_{i_t}, y_{i_t})$

Variants: momentum, Adam, RMSProp — foundations of deep learning.

Course Summary

Weeks	Topic
1	Mathematical foundations
2–3	Unconstrained optimisation
4–5	Constrained (Lagrange, KKT)
6	Convex optimisation
7	Linear programming
8–9	Dynamic optimisation
10	Frontiers

These tools underpin virtually every model in modern economics.

Where to Go Next

- **PNM:** implement these methods computationally
- **Deep Learning for Macro:** neural nets meet DSGE models
- **Research:** heterogeneous agents, high-dimensional problems

References: Boyd & Vandenberghe, Sundaram, Stokey–Lucas–Prescott, Bertsekas

Thank you and good luck!