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Classification of optimization algorithms for reservoir operation – workflow case study

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- We have created a problem driven classification system for optimization algorithms used in reservoir operation optimization to enable easy understanding and selection of suitable algorithms.
- We demonstrate a workflow on the Wessex Water spine main.

1) Most commonly we aim to optimize *operation policies*

Operation policy: function returning release decisions dependent on state variables, demonstrated in Fig. 1.

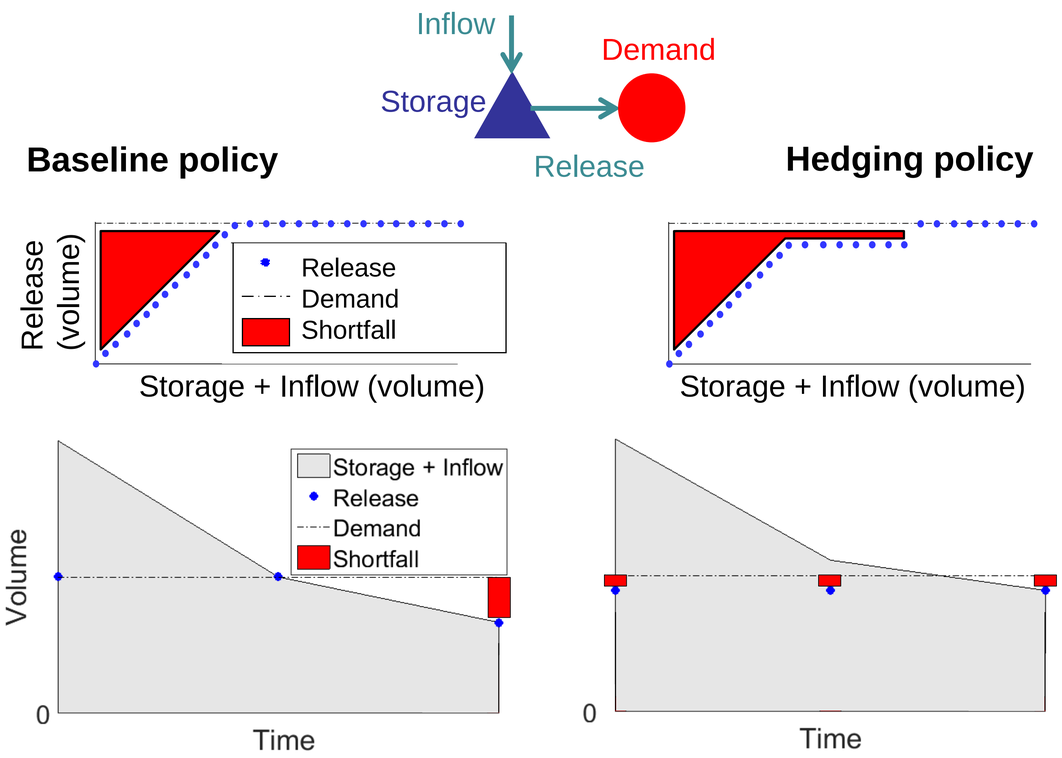

Fig. 1, Baseline (top left) and hedging (top right) policies for a system (top middle) over a time-series of inflows (bottom left and right)

2) We wish to optimize a policy for a network, Fig. 2

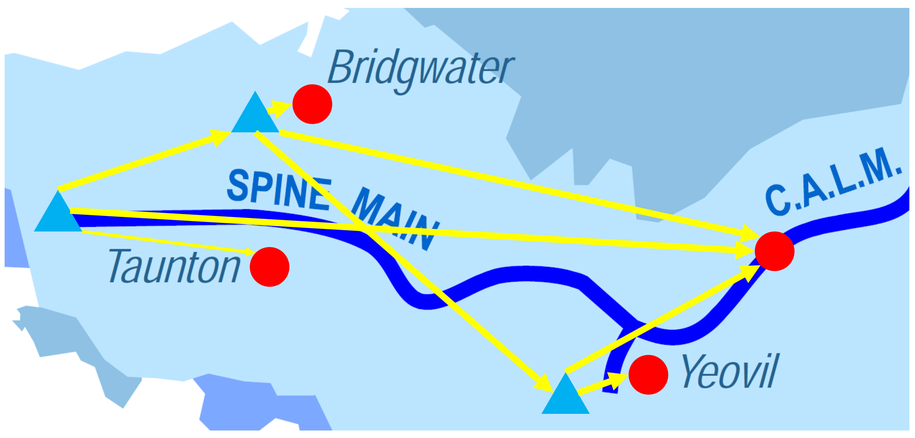

Fig. 2. Our estimated model to describe the Wessex Spine main network

3) The classification system, Fig. 3, sorts algorithms by contexts, and branches

Context: the context in which optimization occurs; the context of *policy optimization* optimizes operation policy's parameters

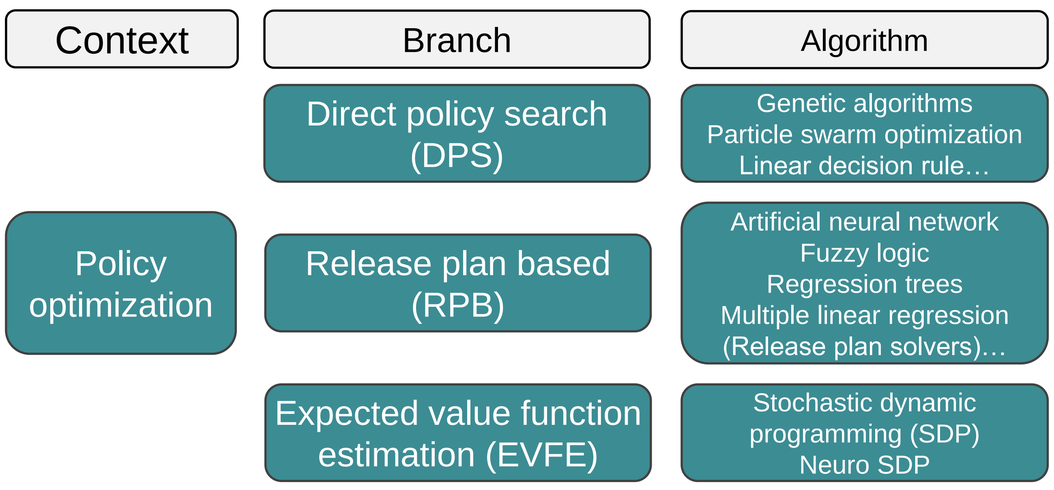

Fig. 3, The 'policy optimization' context of our classification system

Branch: algorithms within a context can be sorted into branches based on their formulation meta-characteristics

4) Branches are suitable to different system traits. The Wessex network traits are used to find an appropriate branch, Fig. 4

Branch	RPB-CP	RPB-VFE	DPS	EVFE
Refined and converged algorithms	M	M	N	Y
Multiple objectives (typically >3)	N	N	Y	N
Non-linearity	N	Y	Y	Y
Time non-separable objective	M	N	Y	N
Multiple reservoirs (typically >3)	Y	M	M	N
Flow regime with long memory	Y	Y	Y	N

Fig. 4, The selection pressures for branches in the context of policy optimization

5) The direct policy search branch will be used, Fig. 5

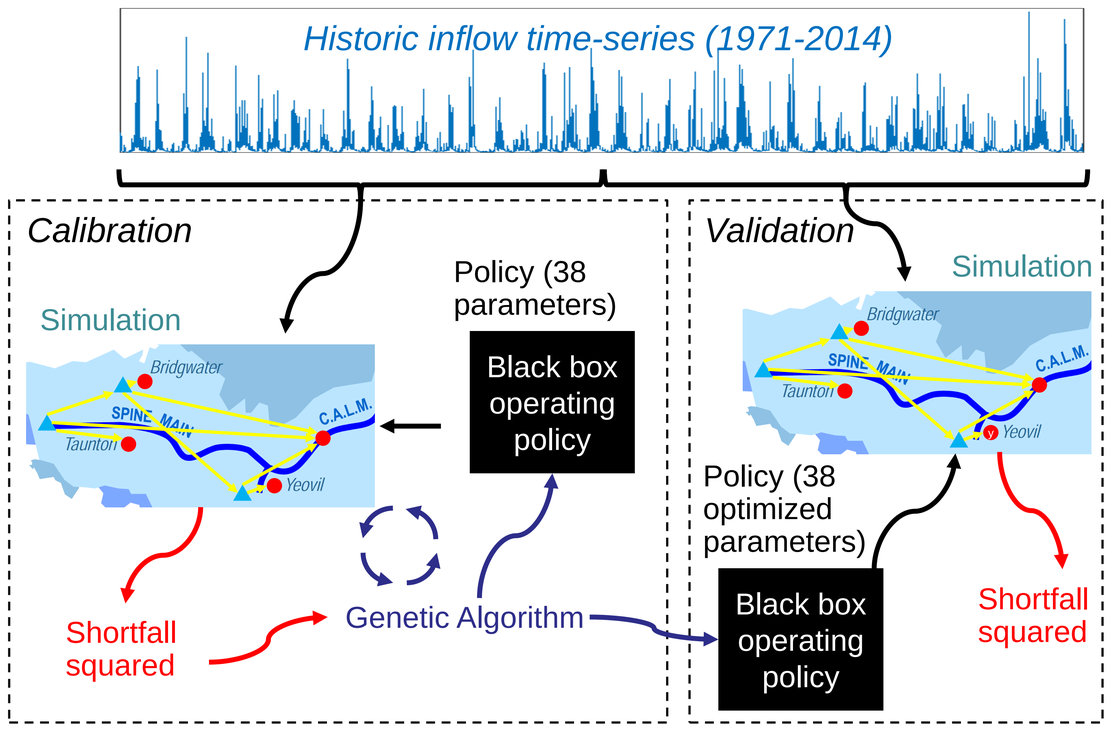

Fig. 5, The optimization and validation process for a direct policy search algorithm

6) The optimized policy changed the distribution of shortfalls by reducing the frequency at greater magnitudes, Fig. 6

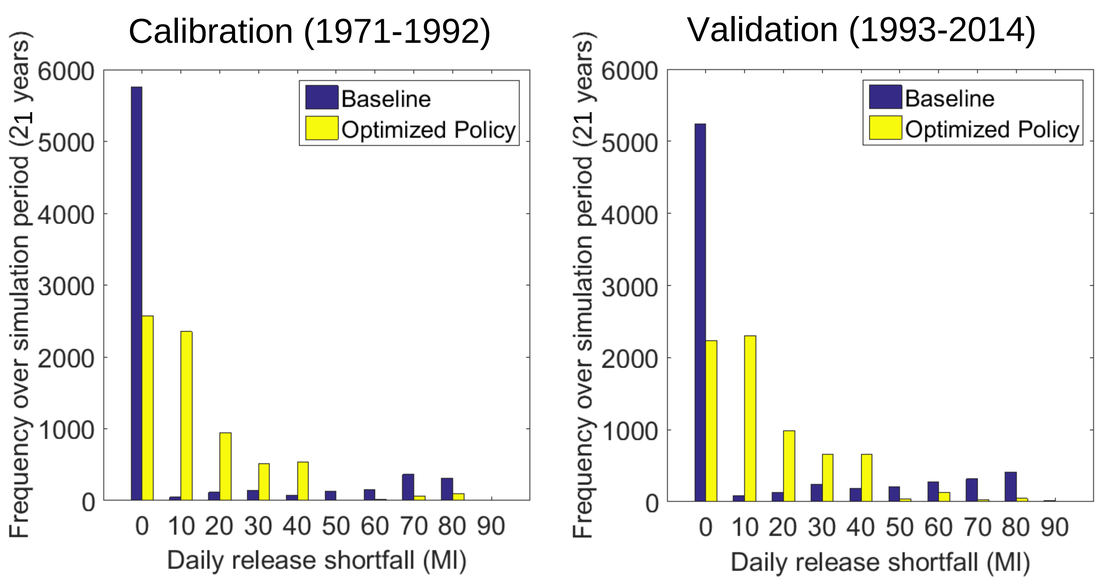

Fig. 6, The results over the calibration and validation period

7) Implications of this case study

- Optimization works
- Optimization works without supercomputers (on a medium performance desktop):
  - Total optimization time = 20 minutes
  - Average simulation time = 0.03 seconds
  - Total simulations in optimization = 60,000

Acknowledgements

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