**Petroleum Reservoir Production Optimization Based on Approximate Dynamic Programming**

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**Motivation**
- Shortage of energy resources calls for production optimization of petroleum reservoirs
- Petroleum reservoir production optimization is challenging
  - Large-scale nonlinear dynamic optimization problem
  - Complicated constraints on control
  - Current optimization techniques have various limitations
- We propose optimization algorithms based on Approximate Dynamic Programming (ADP) to solve this problem

**Dynamic Optimization Model**
- Petroleum reservoir can be modeled as a nonlinear dynamic system
- System dynamics are determined by:
  - Fluid dynamics in porous media
  - Mass balance equation
  - Geological model of the reservoir
- **Objective:** maximize the cumulative profit

**Brief Overview of ADP**
- Dynamic Programming (DP) potentially achieves the global optimum but suffers from "curse of dimensionality" when computing the value function $J^*$
- ADP tries to keep DP's merits but overcome the dimensionality curse

**Case 2 Continued**
- Result: Within 1% of the best local optimum
- 6% better than the worst local optimum

**Case 3: Black-Oil Model with General Constraints**
- 40x40 blocks, 2 producers and 2 injectors
- Constraints on control:
  - Bounded BHP
  - Minimum water cut at each production well
  - Maximum liquid injection/production rates
  - Minimum of production rate
- **Result:** 19% improvement over baseline

**Conclusion and Ongoing Work**
- Developed and successfully applied ADP for petroleum reservoir production optimization
- ADP appears to be a promising methodology for production optimization
- Ongoing works include:
  - Test ADP extensively for realistic 3D examples
  - Compare with other optimization techniques
  - Model uncertainty of geological parameters
  - Combine production optimization with well scheduling