Neural Predictor-Corrector: Solving Homotopy Problems with Reinforcement Learning
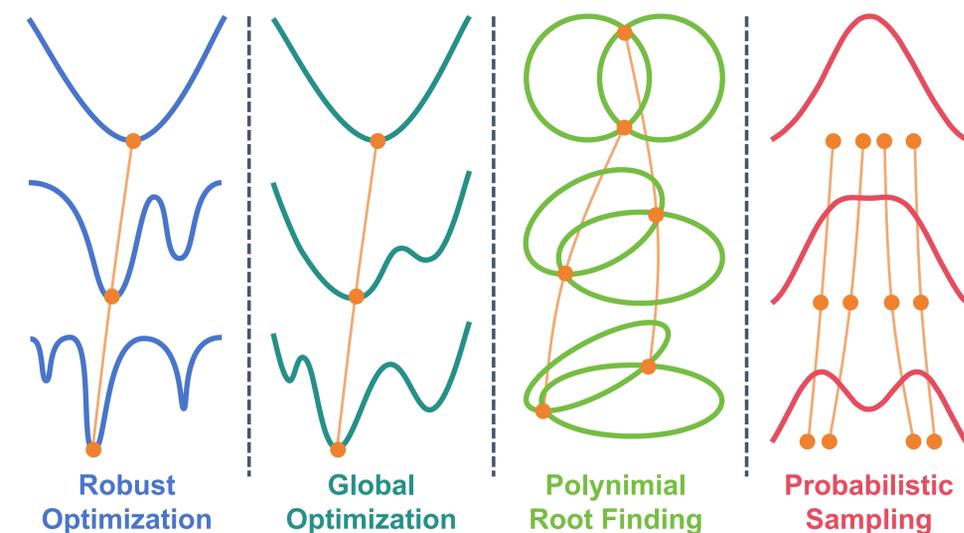
Jiayao Mai[1*], Bangyan Liao[2*], Zhenjun Zhao[3], Yingping Zeng[1], Haoang Li[4], Javier Civera[3], Tailin Wu[2], Yi Zhou[1†], Peidong Liu[2†]
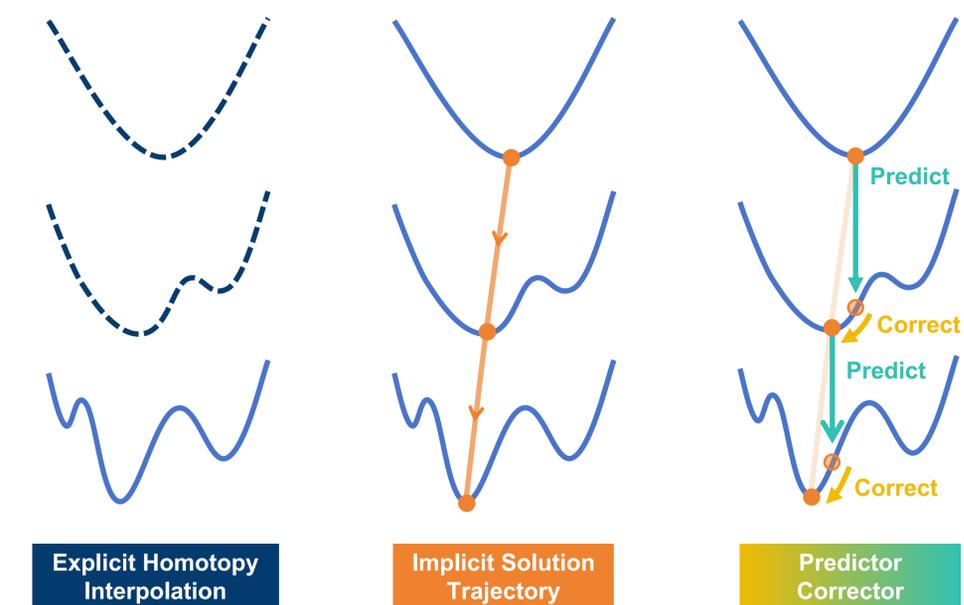
Homotopy Problems

Robust Optimization | **Global Optimization** | **Polynimial Root Finding** | **Probabilistic Sampling**

Many problems can be viewed as homotopy problem

Homotopy Paradigm

Predict
Correct
Predict
Correct

Explicit Homotopy Interpolation | **Implicit Solution Trajectory** | **Predictor Corrector**

Classical PC relies on hand-crafted heuristics

Neural Predictor-Corrector

External Action: Predictor's Next Level
Internal Action: Corrector's Tolerance

NPC ⟷ **Environment**

Reward: Accuracy + Efficiency Bonus

State:
1. Predictor's Homotopy Level
2. Corrector Statistics (Tolerance, Iteration)
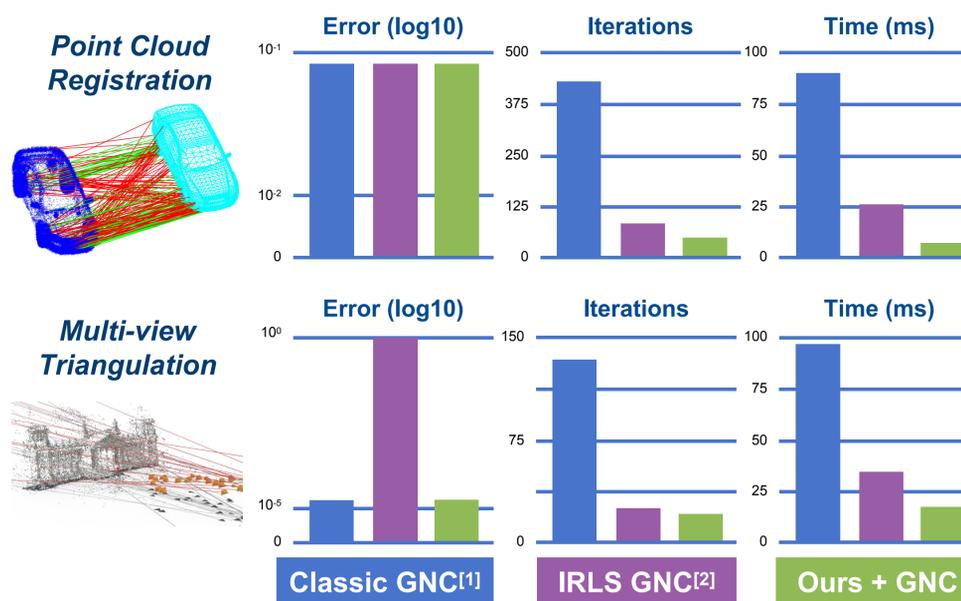3. Convergence Velocity

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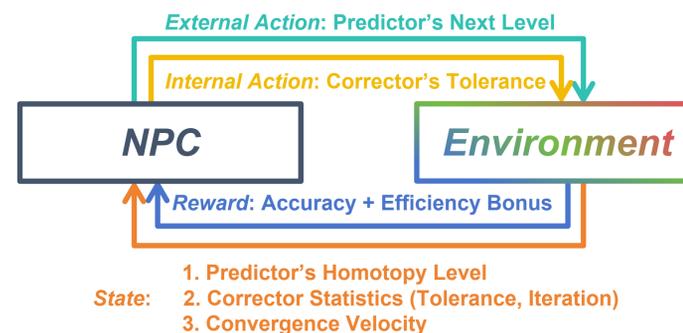
Neural Predictor-Corrector
while $t_n < T$ **do**
  NPC: $\{\Delta t_n, \epsilon_n\} = \mathbf{NN}(t_{n-1}, \epsilon_{n-1}, \tau_{n-1})$
  Predictor: Predict next level $t_n = t_{n-1} + \Delta t_n$
  Predictor: Predict $\mathbf{x}_{t_n}$
  While $H(\mathbf{x}_{t_n}, t_n) \leq \epsilon_n$ **do**
    Corrector: Correct $\mathbf{x}_{t_n}$
  end
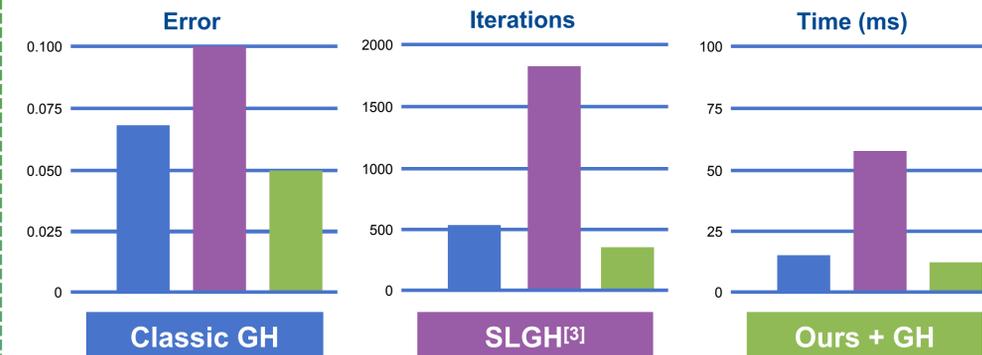 Collect corrector statistics ϵ_n and convergence velocity τ_n
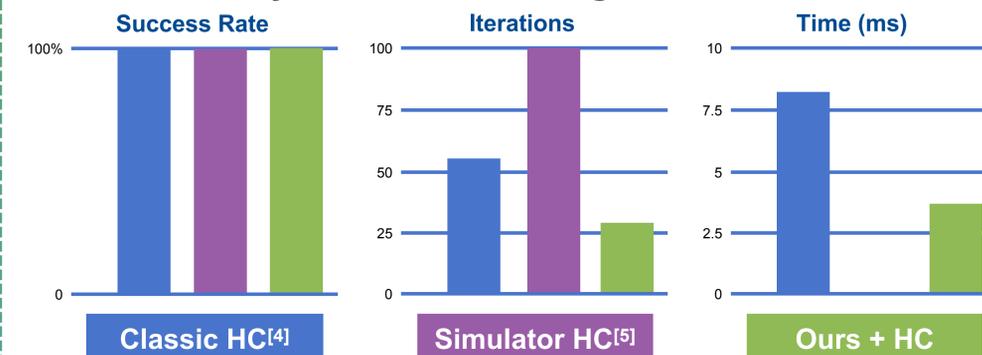**end**

Neural PC find the optimal policy with RL

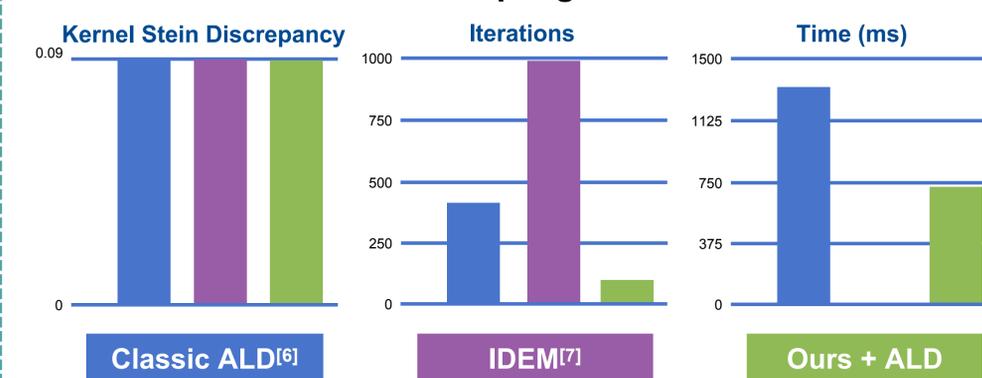## Experiments

Problem 1 : Robust Optimization via GNC

Point Cloud Registration

Error (log10) | Iterations | Time (ms)

Multi-view Triangulation

Error (log10) | Iterations | Time (ms)

Classic GNC[1] | **IRLS GNC[2]** | **Ours + GNC**

Problem 2 : Global Optimization via GH

Error | Iterations | Time (ms)

Classic GH | **SLGH[3]** | **Ours + GH**

Problem 3 : Polynomial Root-Finding via HC

Success Rate | Iterations | Time (ms)

Classic HC[4] | **Simulator HC[5]** | **Ours + HC**

Problem 4 : Probabilistic Sampling via ALD

Kernel Stein Discrepancy | Iterations | Time (ms)

Classic ALD[6] | **IDEM[7]** | **Ours + ALD**

Same Performance, Less Iterations, Unified Framework

References

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