

A Globally Optimal Data-driven Approach for Image Distortion Estimation

Yuandong Tian and Srinivasa G. Narasimhan, Carnegie Mellon University



Problem Statement



Distortion Model

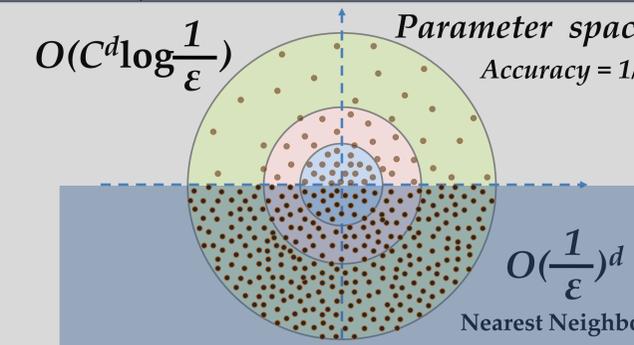
$$W(x; p) = x + B(x)p$$

Bases $B(x)$ → •Linear & Rigid
•Spatial nonlinearity
•Measurement-based
Parameters p → Fewer dimensions

| Previous Works | Generative | Discriminative |
|----------------|--------------|----------------------|
| Method | Optimization | Direct Mapping |
| Disadvantages | Local minima | Exponential #samples |

Contribution

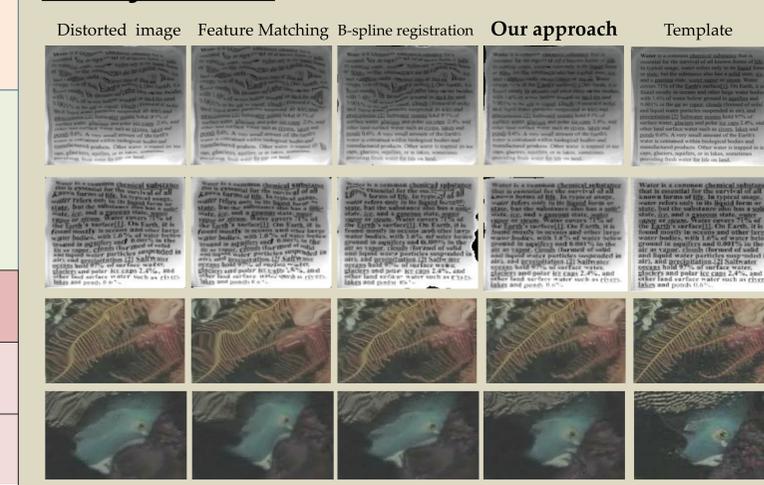
- Guaranteed worst-case convergence to the global optimum using only $O(C^d \log(1/\epsilon))$ samples.
- Decoupling accuracy $1/\epsilon$ from the dimension d of the parameter space.



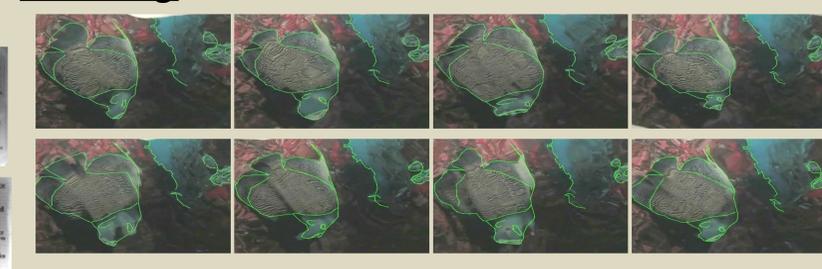
Experimental Result

More results on <http://www.cs.cmu.edu/~yuandong/>

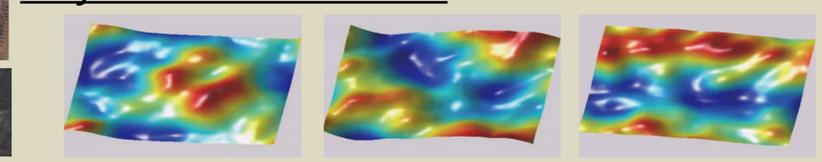
Rectification



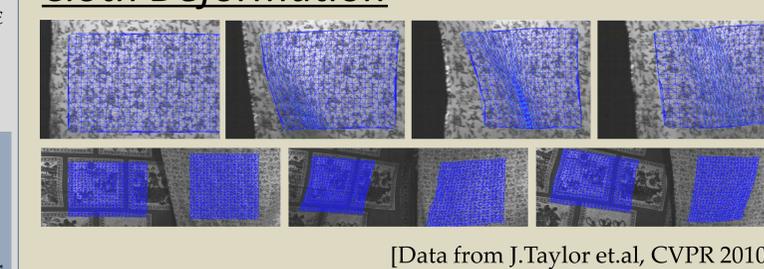
Tracking



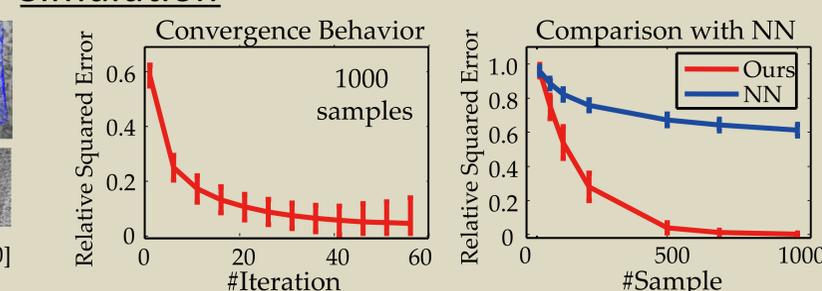
Surface Reconstruction



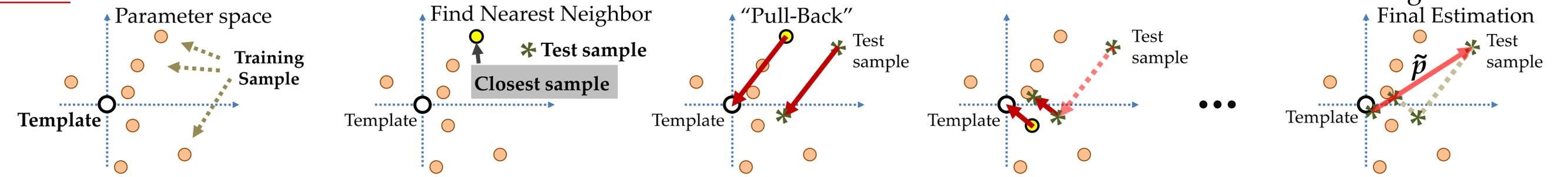
Cloth Deformation



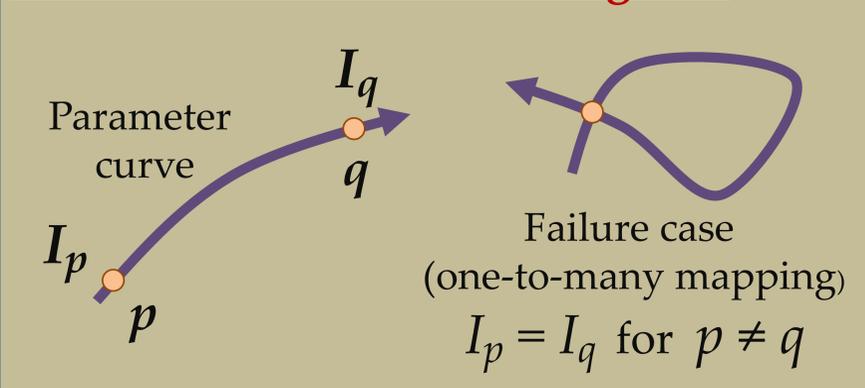
Simulation



The Algorithm



Effectiveness of Nearest Neighbor



Lipchitz Continuity:
 $L_1 \|I_p - I_q\| \leq \|p - q\| \leq L_2 \|I_p - I_q\|$

The Pull-back Operation

For invertible distortion (e.g. affine):
 $H(I_p, q) = \text{Inv}(I_p, q) = I_{p-q}$

For non-invertible distortion:
In the case of $W(x; p) = x + B(x)p$
We prove $\|I_{p-q} - H(I_p, q)\| \leq R \|p-q\|$

Failure case: Resampling artifacts. E.g. Aliasing

A constant related to $\max(\|\nabla B(x)\|, \|\nabla T\|)$

Sample Distribution

