Active Perception for Grasp Detection via Neural Graspness Field

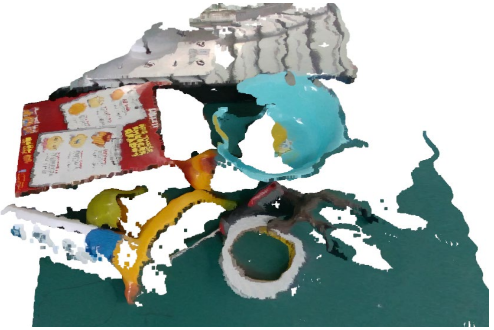
Haoxiang Ma[1], Modi Shi[1], Boyang Gao[2] and Di Huang[1*]

[1]Beihang University [2]Geometry Robotics

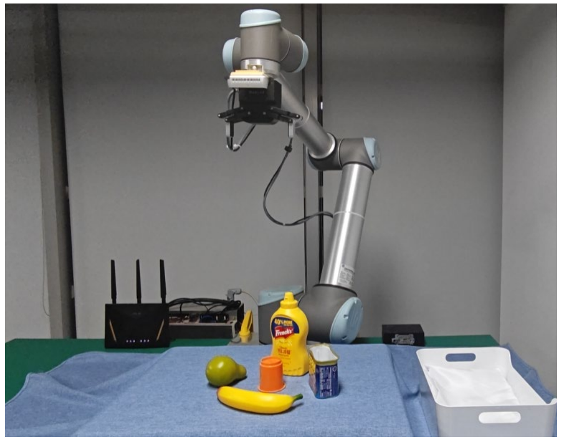
Problem

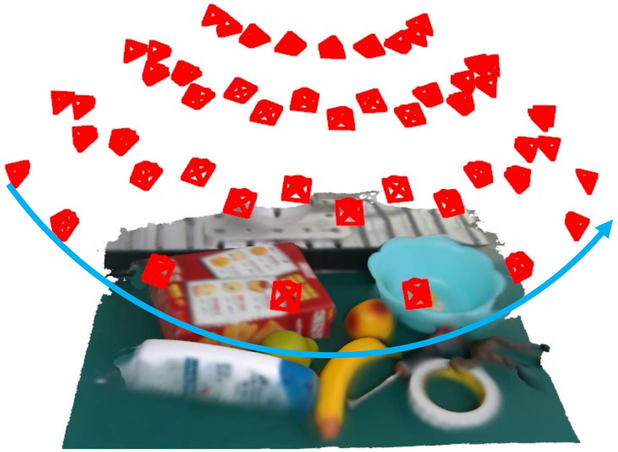
- Observing from multi-view is crucial for grasp detection
- Moving the camera to scanning the whole scene can increase the time cost

Single-view



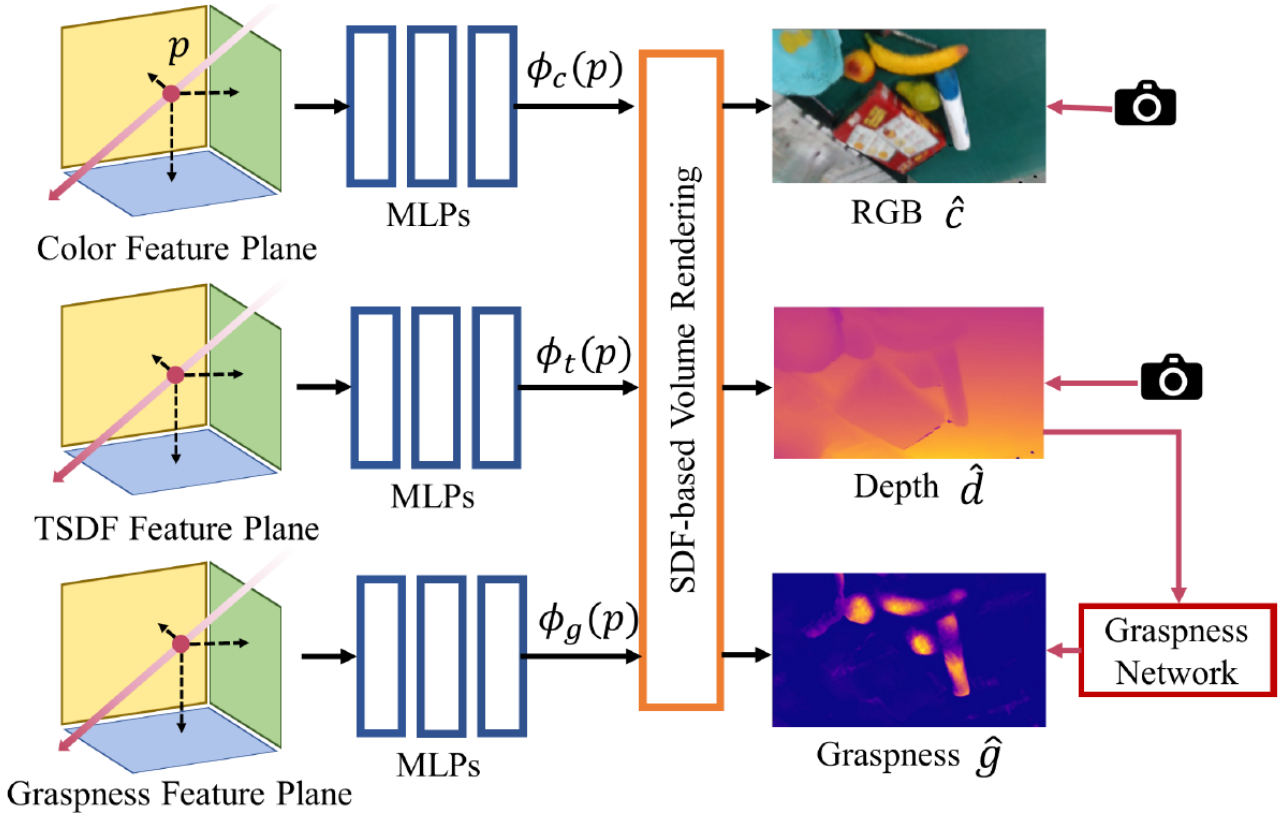
Multi-view
Reconstruction





- Active perception to achieve the trade-off between time cost and accuracy

Neural Graspness Field (NGF)

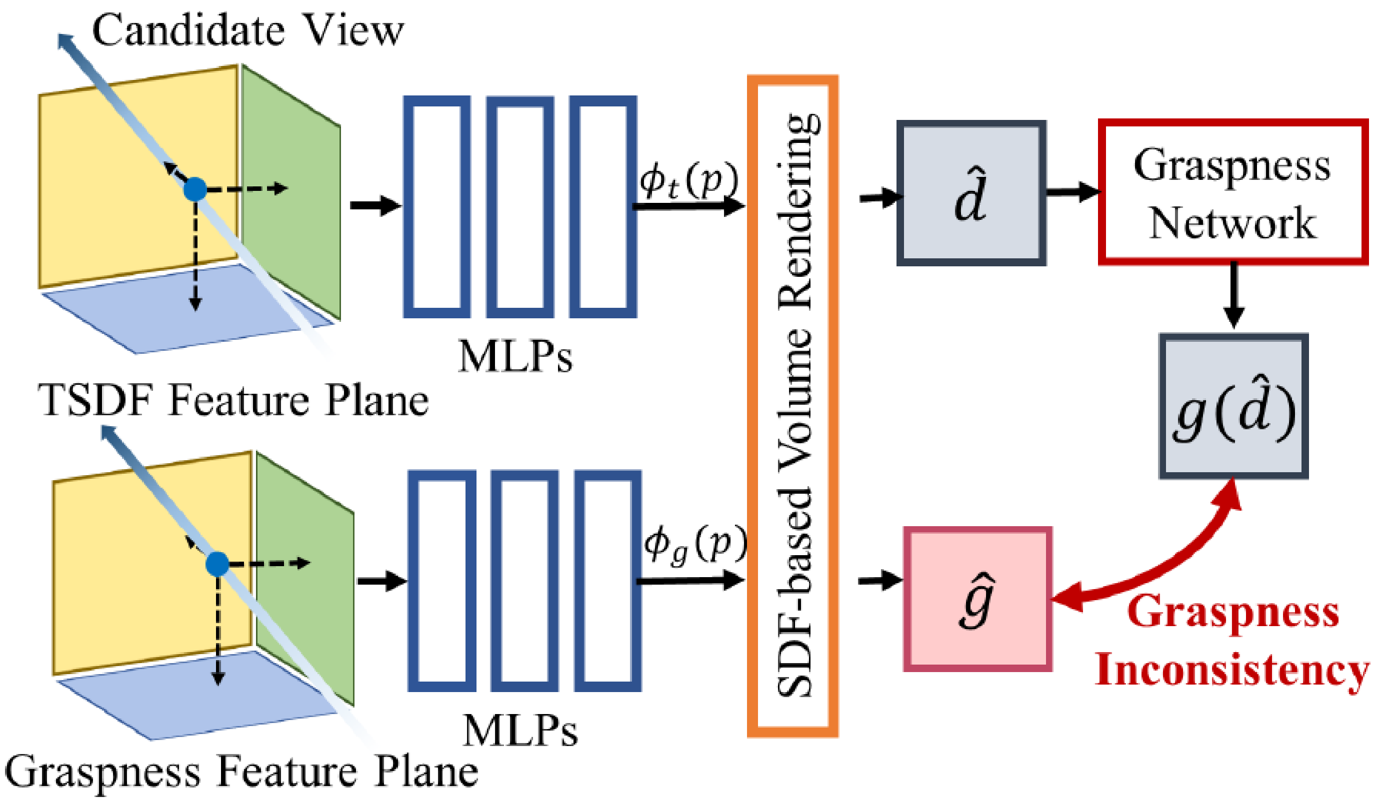


Graspness Definition:

$$\widetilde{g}_p = \frac{\sum_{k=1}^{L} \mathbf{1}(q_k > t) \cdot \mathbf{1}(c_k)}{|G_p|}$$

- **Employ the NeRF-based mapping system to render the grasp distribution**

Next-Best-View Planning



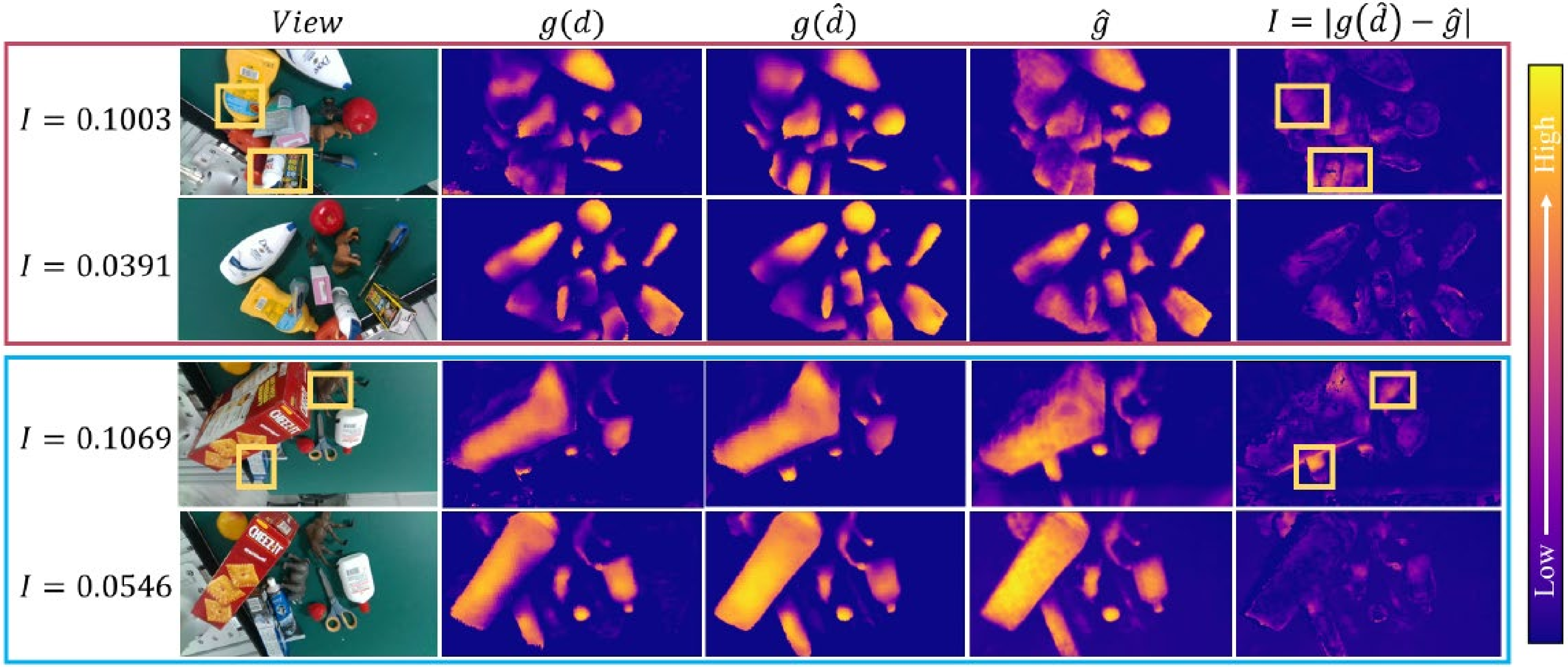
NBV Problem:

$$s^* = \underset{s \in S}{argmax} \sum_{n=1}^{N} I(v_n)$$

View Uncertainty:

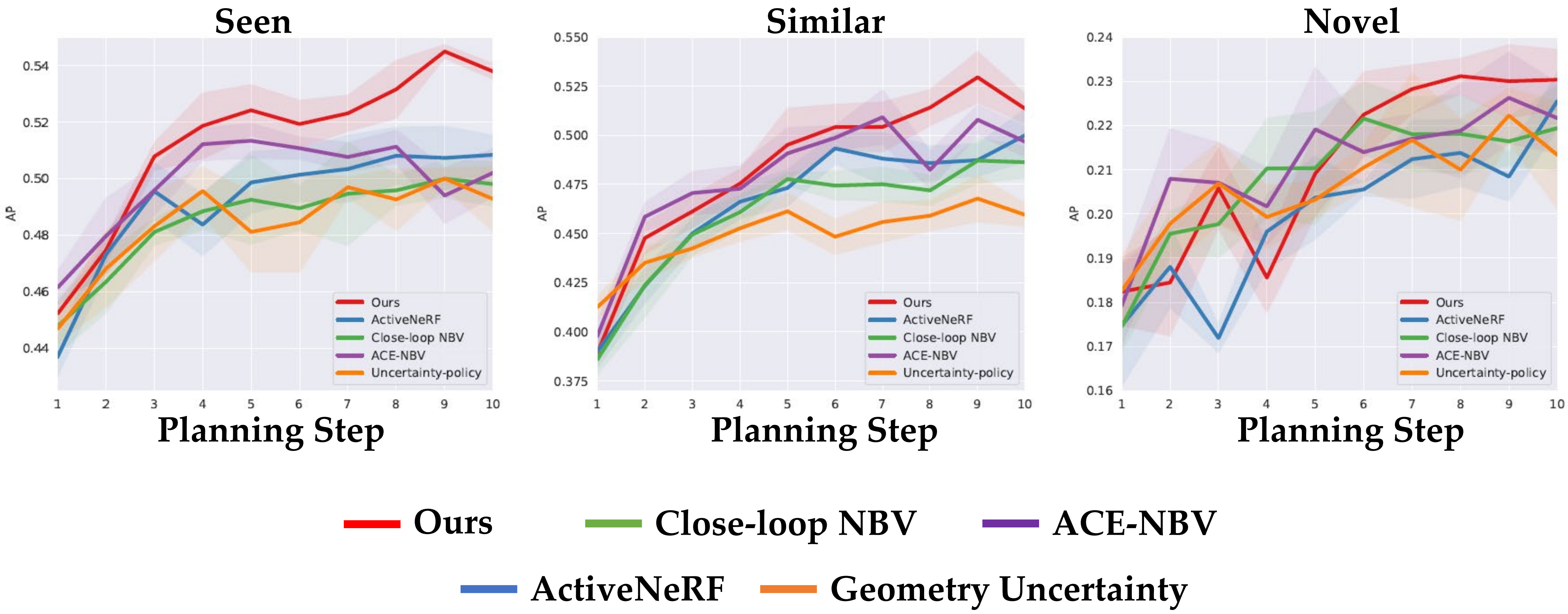
$$I(v) = \left| \sum_{r \in v} \hat{g}(r) - g(\hat{d}) \right|$$

Next-Best-View Planning



Experiments

- **Comparison on different NBV policies**



Experiments

- **Overall Performance**

Methods	Seen			Similar			Novel		
	AP	**AP$_{0.8}$**	**AP$_{0.4}$**	**AP**	**AP$_{0.8}$**	**AP$_{0.4}$**	**AP**	**AP$_{0.8}$**	**AP$_{0.4}$**
Close-loop [5]	43.84	53.95	34.18	42.17	51.51	34.02	19.54	23.96	9.49
ACE-NBV [32]	46.74	56.17	38.13	46.14	55.42	38.86	21.76	26.89	12.16
Ours	55.12	65.07	48.88	52.85	62.63	46.49	24.74	30.21	12.00
All views	63.75	73.30	58.38	61.54	71.17	55.94	24.89	30.18	13.95

Table: Overall results compared to the state-of-the-art active grasp detection methods.

- **Runtime Analysis**

Overall	NBV Planning	Mapping	Grasp Detection	Robot Execution
3.44s	1.00s (29.07%)	0.45s (13.08%)	0.23s (6.69%)	1.76s (51.16%)

Table: Runtime analysis of the proposed method.

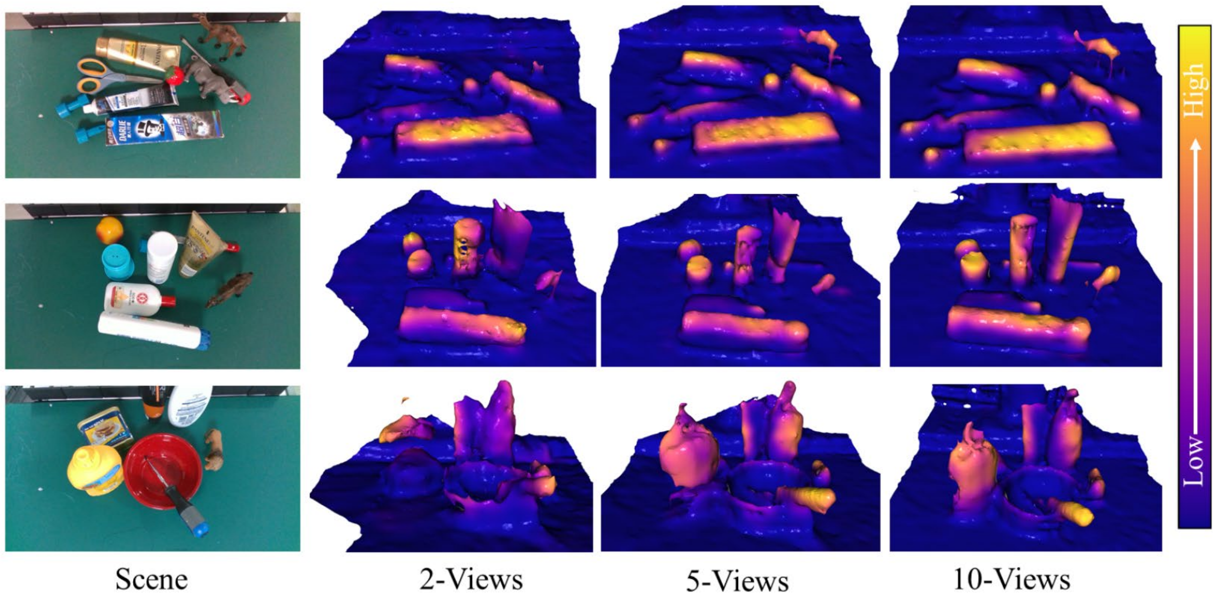
Real-world Experiments

- **Physical Setting**

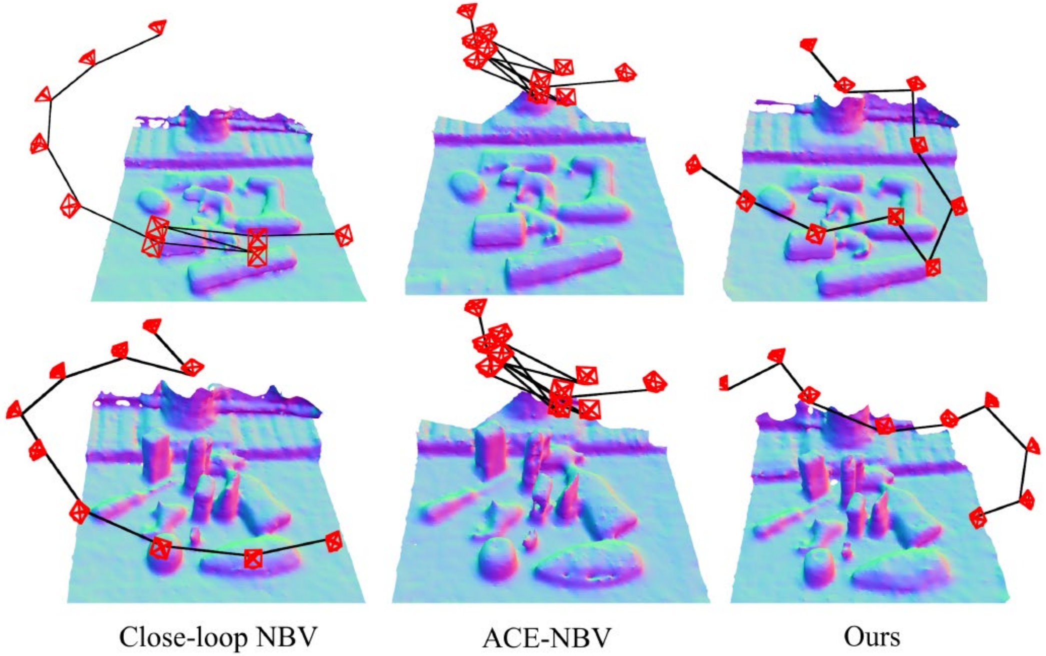
Model	Success Rate (%)
Close-loop [5]	70.67 (53/75)
ACE-NBV [32]	62.67 (47/75)
Ours	74.67 (56/75)

Visualization

- **NGF from different steps**



- **Planned Camera Trajectories**



Thanks!

IRIP laboratory http://irip.buaa.edu.cn/

GitHub: http://github.com/mahaoxiang822/ActiveNGF

Contact: mahaoxiang822@buaa.edu.cn