Fig1: Teaser

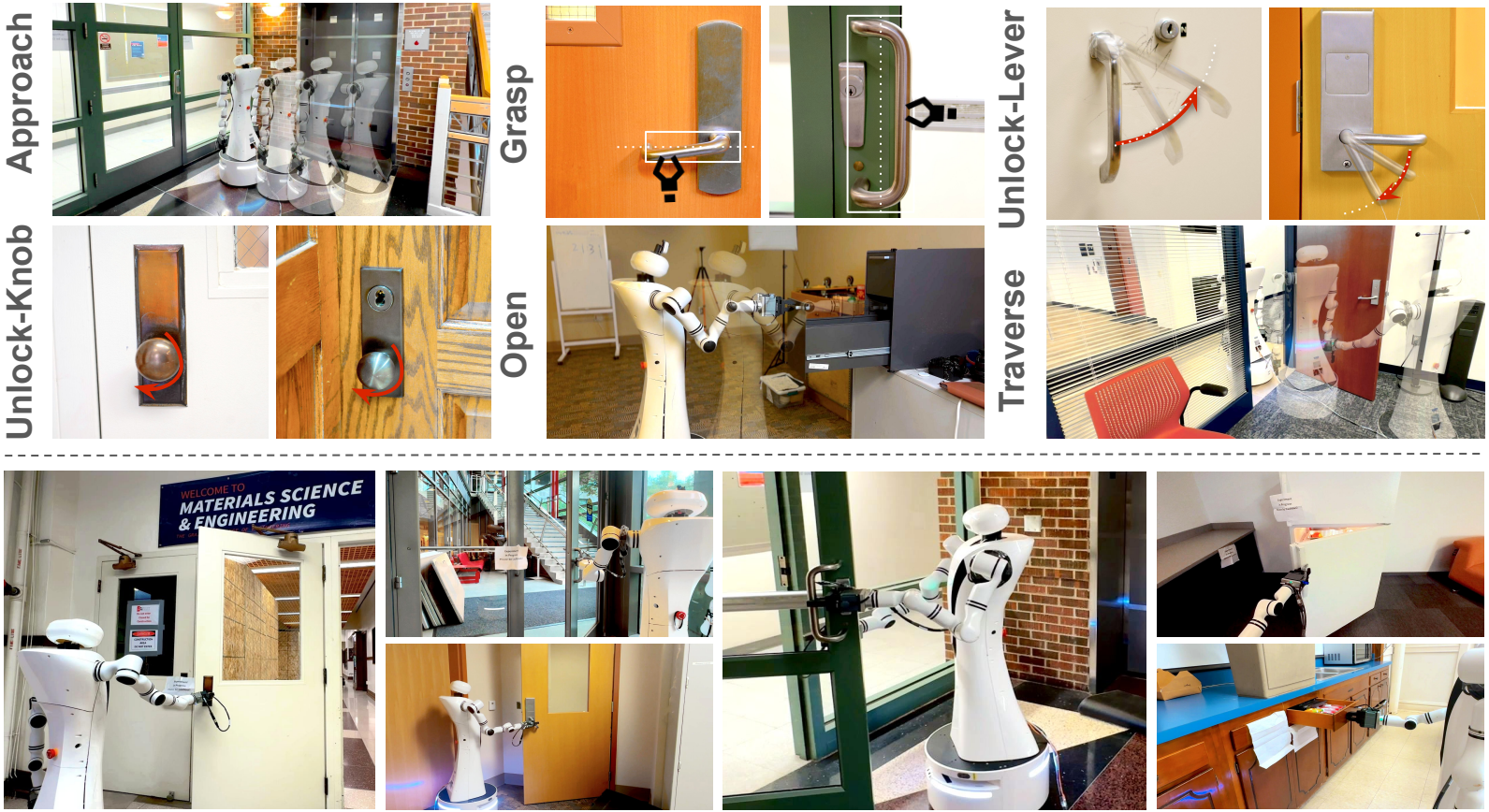
Approach
Unlock-Knob
Grasp
Open
Unlock-Lever
Traverse
WELCOME TO
MATERIALS SCIENCE
& ENGINEERING

Fig2: The visual appearance of our bimanual mobile robot.

Features

Dofs	7x2 (arms) + 2 (base) + 2 (head)
Weight	80kg
Size	53L * 209W * 152H
Payload	5kg (per arm), 60kg (base)
Arm Repeatability	0.05mm
Battery Life	11 hours

Components

Arms	2 x RealMan RM75-B
Mobile Base	Yunji Water2
Camera	Intel Realsense D435
Grippers	2 x DH PGI-140-80
Head	2 x LX-224HV

Fig3: System Architecture.

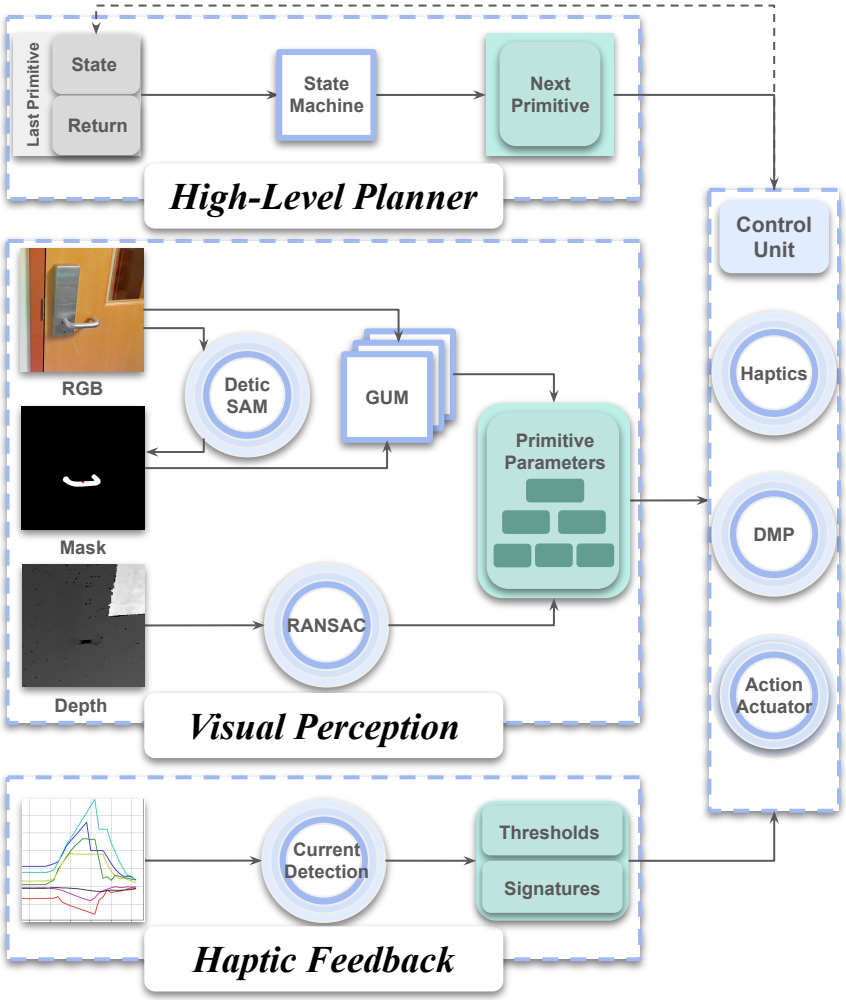

Fig4: State Machine.

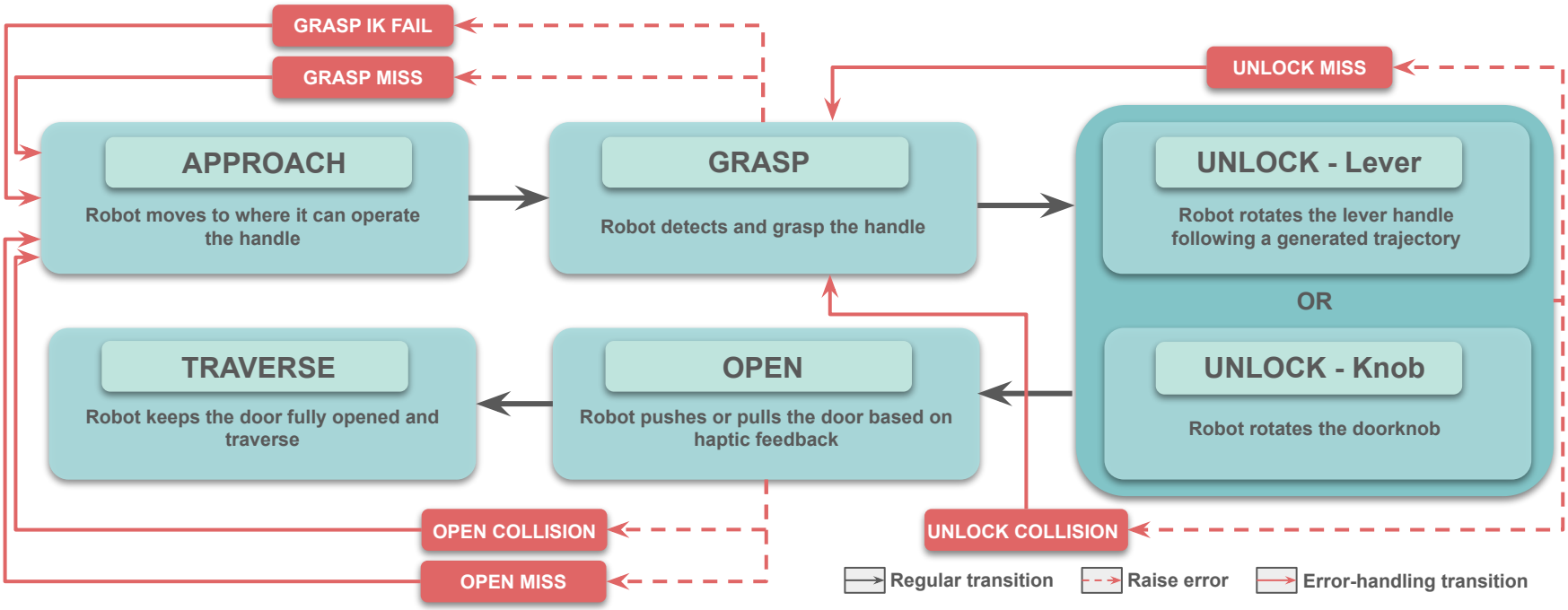

Fig5: GUM

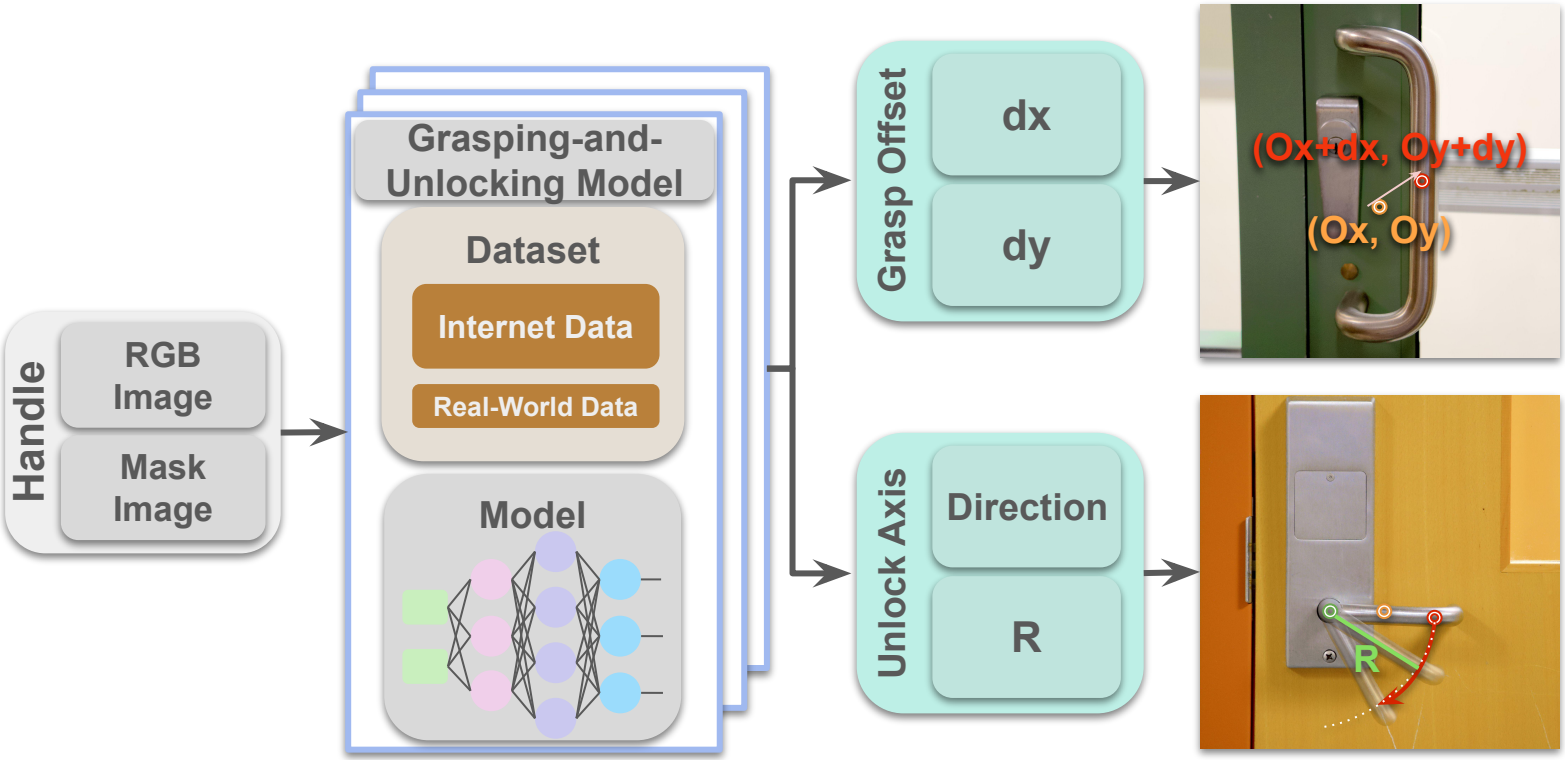
Handle
RGB Image
Mask Image
Grasping-and-Unlocking Model
Dataset
Internet Data
Real-World Data
Model
Grasp Offset
dx
dy
(Ox+dx, Oy+dy)
(Ox, Oy)
Unlock Axis
Direction
R
R

Fig6: GUM Internet Data

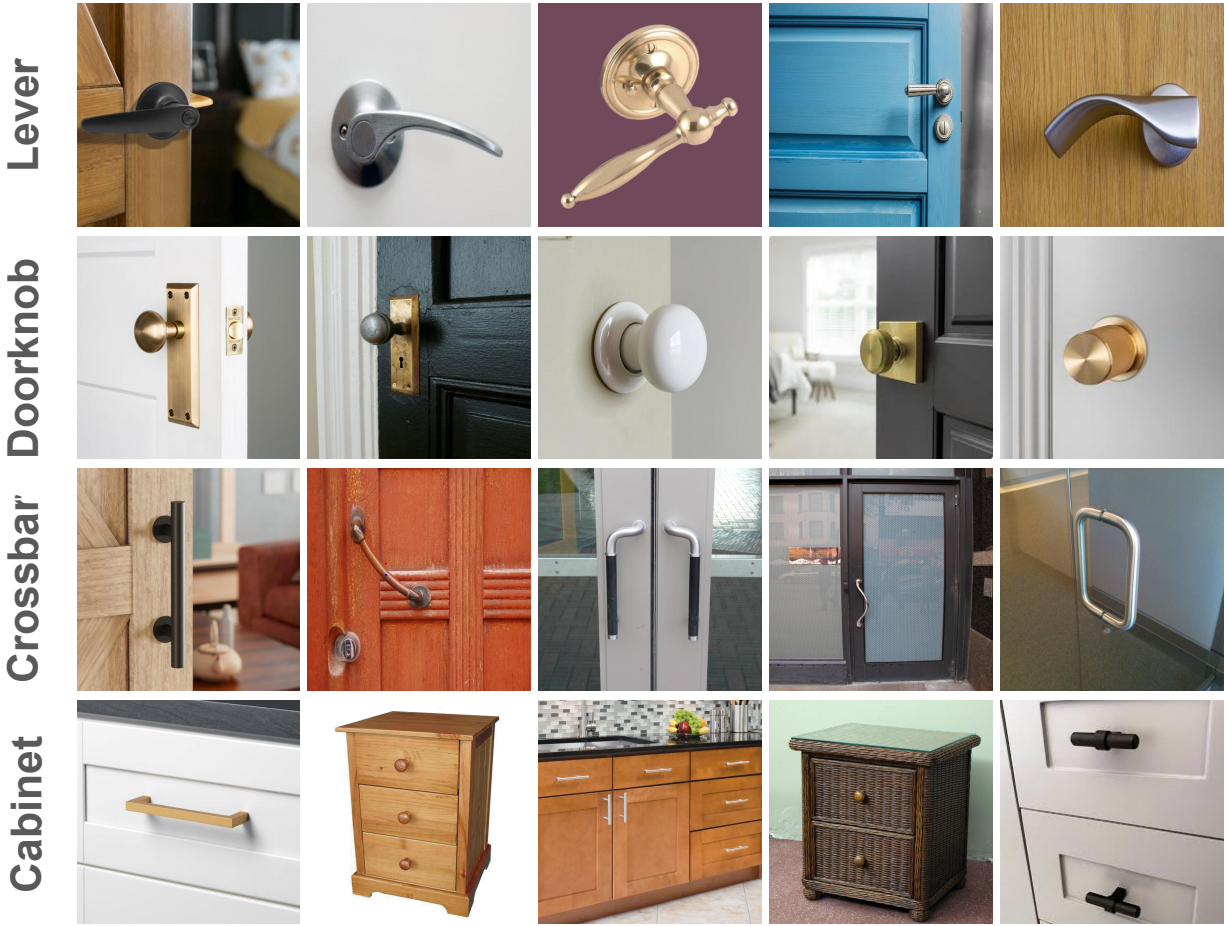

Fig7: Door handles in our experiments.

Fig8: Exp1

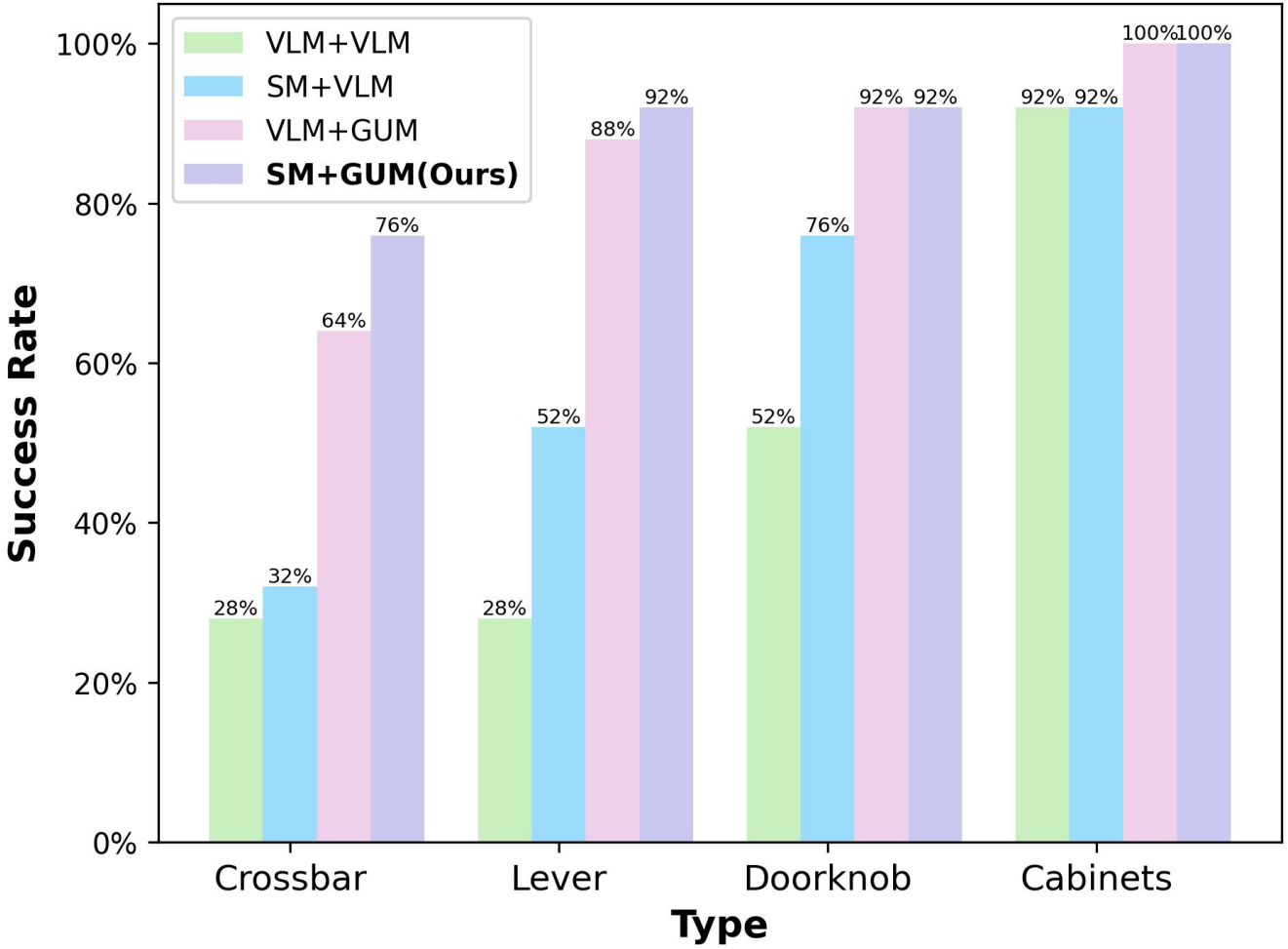
VLM+VLM
SM+VLM
VLM+GUM
SM+GUM(Ours)
Success Rate
100%
80%
60%
40%
20%
0%
28%
32%
64%
76%
28%
52%
88%
92%
52%
76%
92%
92%
92%
92%
100%
100%
Crossbar
Lever
Doorknob
Cabinets
Type

Fig9: Exp2

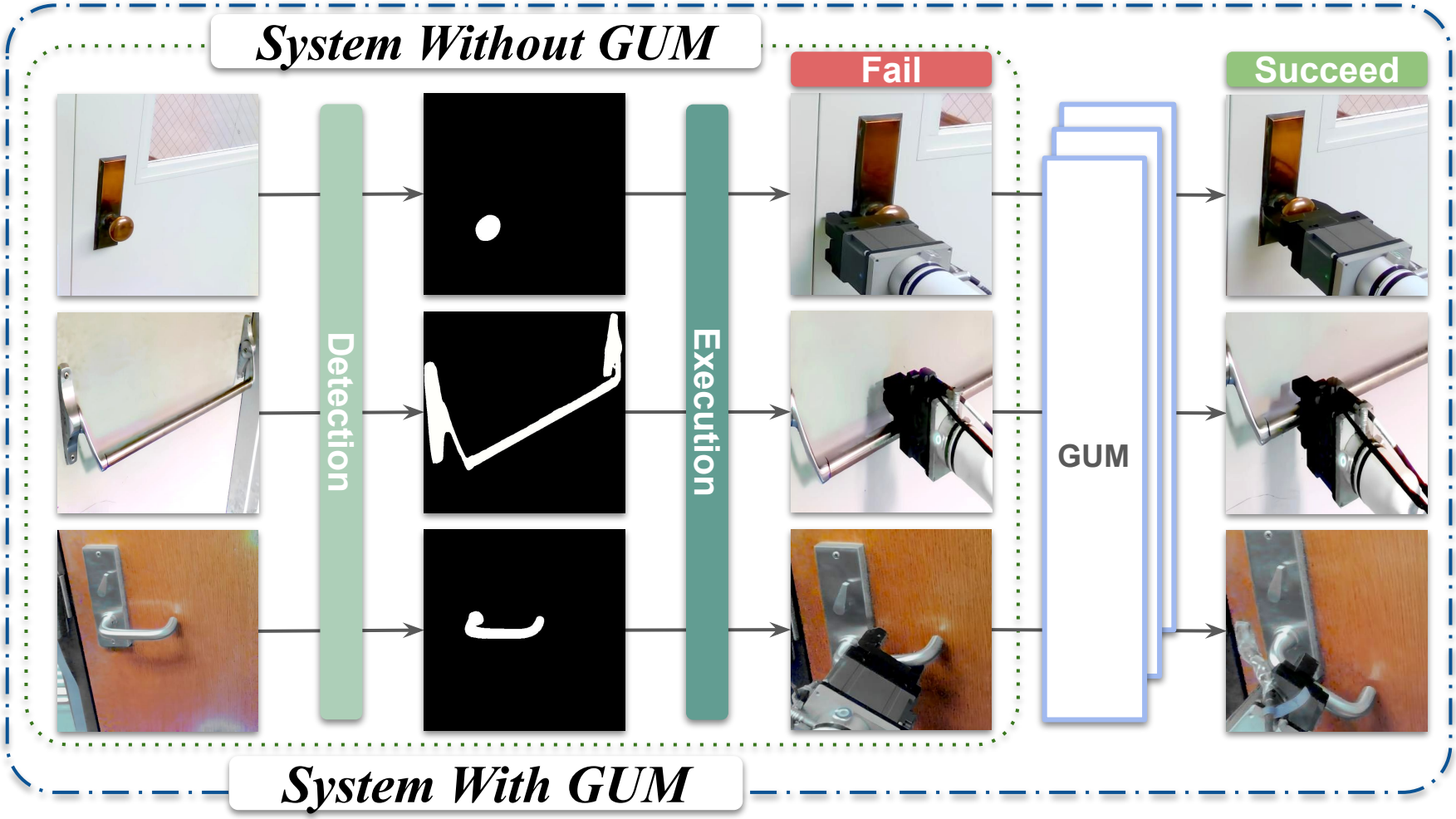
System Without GUM
Detection
Execution
Fail
Succeed
GUM
System With GUM

Fig10: Exp3

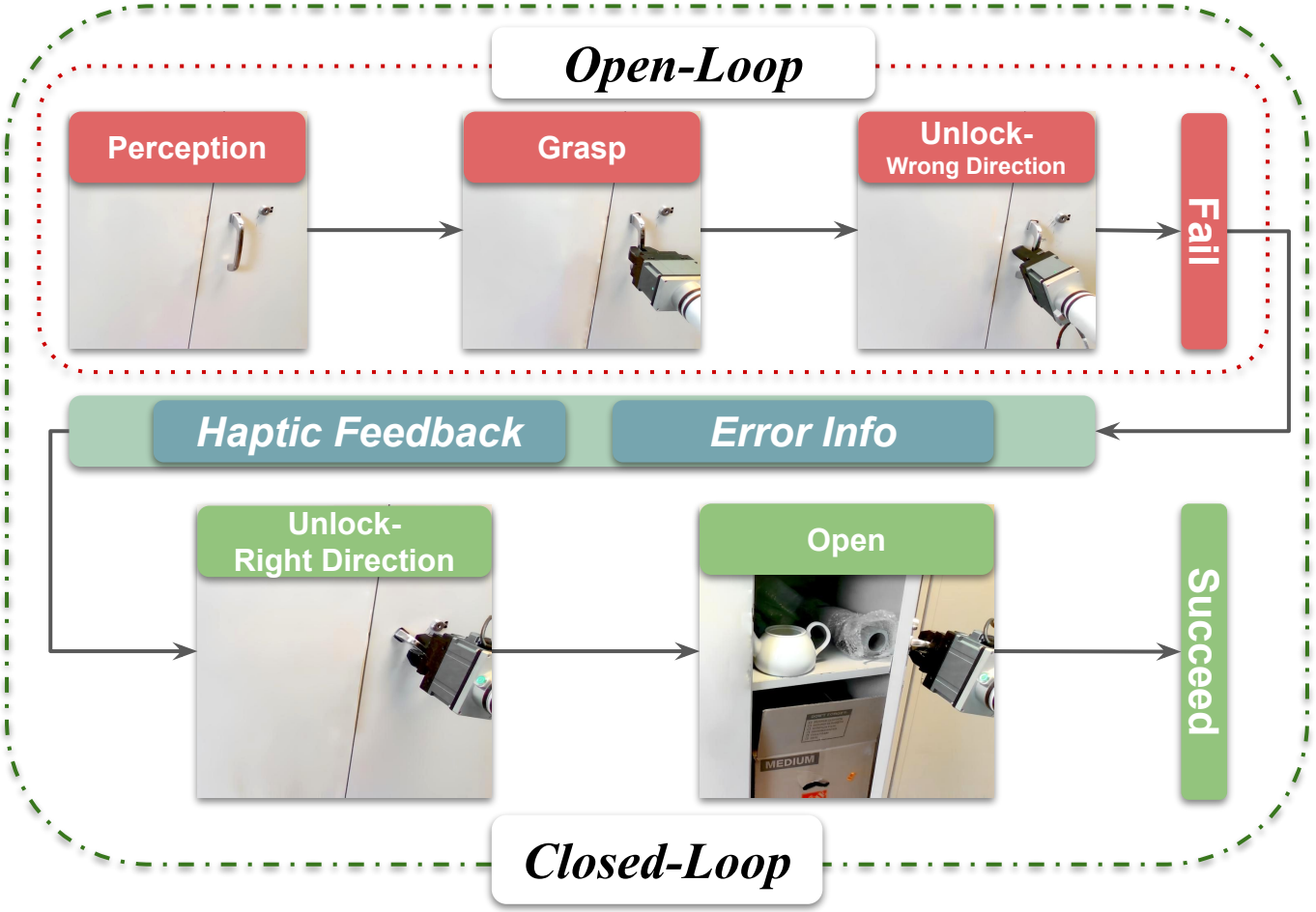
Open-Loop
Perception
Grasp
Unlock-
Wrong Direction
Fail
Haptic Feedback
Error Info
Unlock-
Right Direction
Open
Succeed
Closed-Loop

Fig11: Exp4

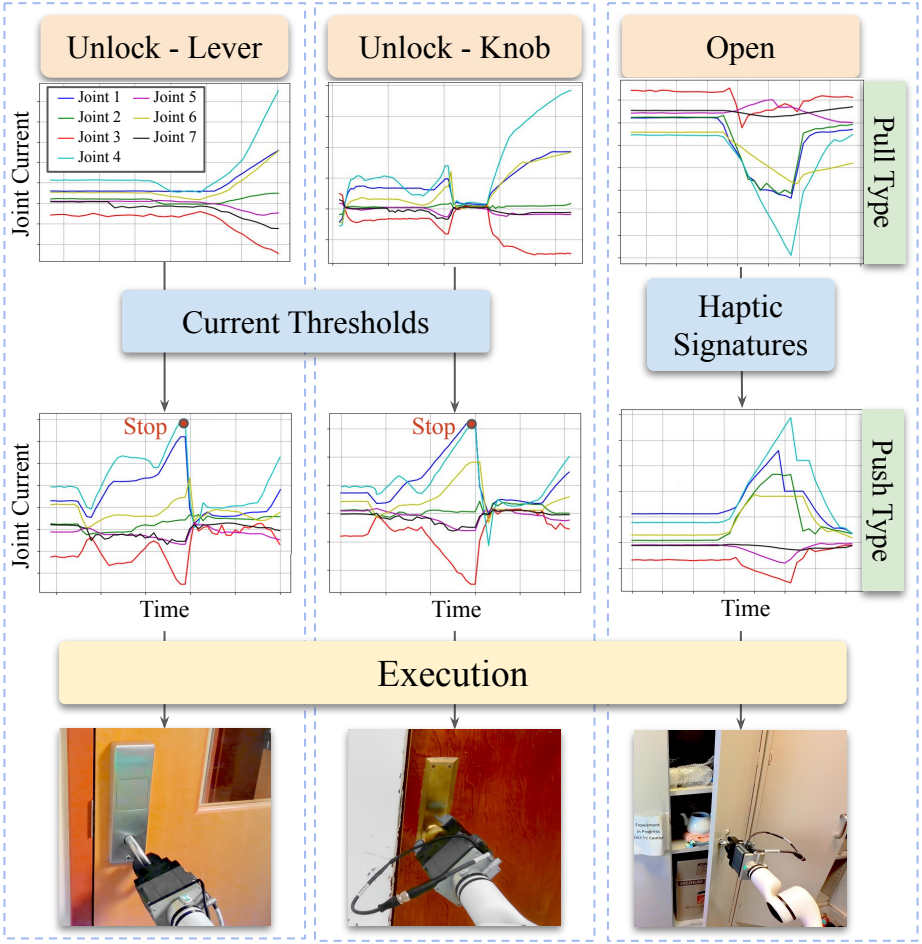
Unlock - Lever
Unlock - Knob
Open
Joint 1
Joint 2
Joint 3
Joint 4
Joint 5
Joint 6
Joint 7
Joint Current
Pull Type
Current Thresholds
Haptic Signatures
Stop
Stop
Joint Current
Push Type
Time
Time
Time
Execution

Fig12: UIUC Campus

Exp Data

Exp1

Method		Lever	Knob	Crossbar	Drawer	Sum
High-Level	Low-Level					
VLM	VLM	7/25	13/25	7/25	23/25	***50%***
Ours	VLM	7/25	19/25	8/25	23/25	***57%***
VLM	Ours	22/25	23/25	16/25	25/25	***86%***
Ours	Ours	23/25	23/25	19/25	25/25	***90%***

Exp2

Method	door1	door2	door2	door4	door5	sum
w/o HGUM	0/5	2/5	3/5	0/5	0/5	***20%***
HGUM (no RW)	4/5	5/5	5/5	5/5	5/5	***92%***
HGUM (RW)	5/5	5/5	5/5	5/5	5/5	***100%***

Exp3

Method	door1	door2	door2	door4	door5	sum
open-loop	3/5	1/5	2/5	1/5	3/5	***40%***
close-loop	5/5	5/5	5/5	5/5	5/5	***100%***

Exp4

Method	grasping				push or pull
	grasp	unlock	rotate	open	
clip	42.67%	33.33%	38.81%	15.79%	15.00%
gemini	29.63%	93.75%	86.36%	88.89%	65.00%
haptics	**100%**	**100%**	**100%**	**100%**	**100%**