BagIt! An Adaptive Dual-Arm Manipulation of Fabric Bags for Object Bagging

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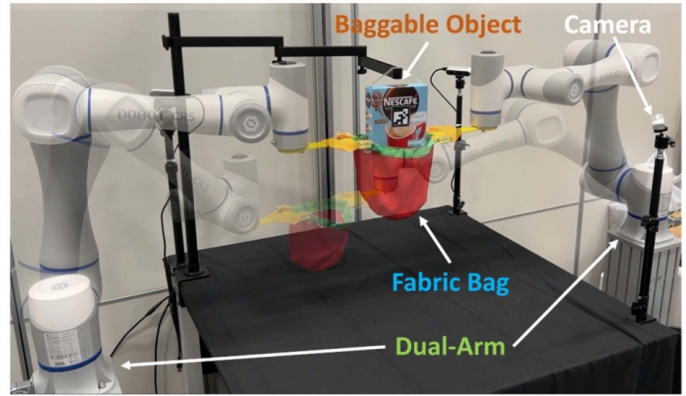Yizhou Chen and Zeqing Zhang* *Member, IEEE*

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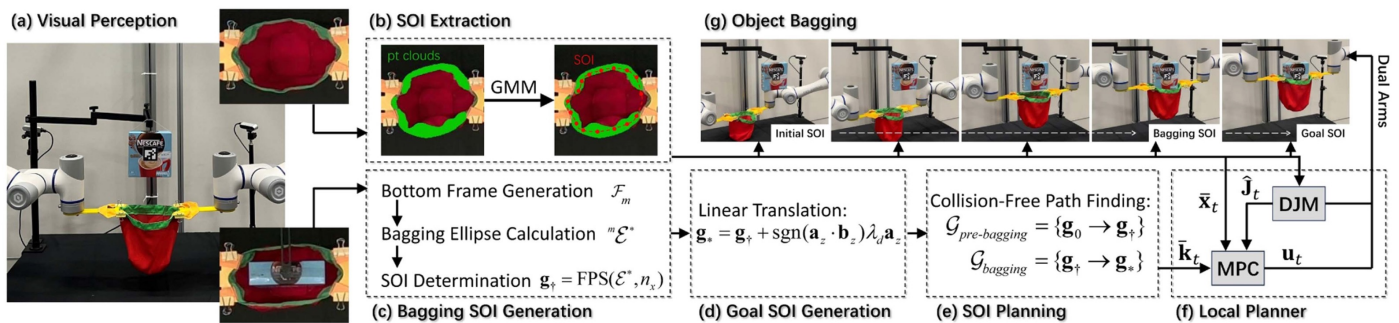
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Motivations

- ➤ Deformable fabric bags pose a complex challenge for industrial automation.
- ➤ Manipulation requires adaptive control for unpredictable shape changes.
- ➤ Existing approaches are slow or rely on pre-programmed material data.
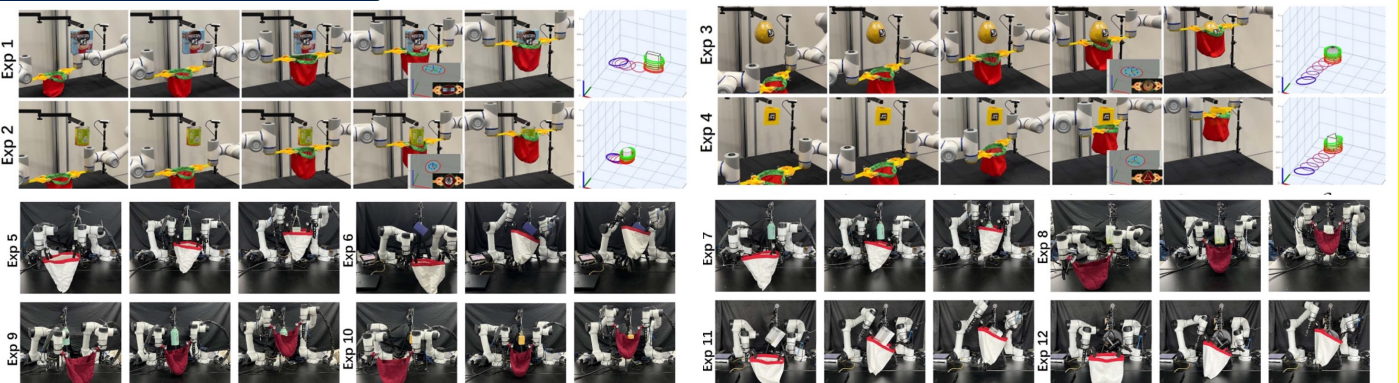
Need: Adaptive, vision-based automation without prior material knowledge.

Methodology

(a) Visual Perception
(b) SOI Extraction — GMM
(c) Bagging SOI Generation — Bottom Frame Generation $\mathcal{F}_m$; Bagging Ellipse Calculation $^m\mathcal{E}^*$; SOI Determination $\mathbf{g}_\dagger = \text{FPS}(\mathcal{E}^*, n_x)$
(d) Goal SOI Generation — Linear Translation: $\mathbf{g}_* = \mathbf{g}_\dagger + \text{sgn}(\mathbf{a}_z \cdot \mathbf{b}_z)\lambda_d\mathbf{a}_z$
(e) SOI Planning — Collision-Free Path Finding: $\mathcal{G}_{pre-bagging} = \{\mathbf{g}_0 \to \mathbf{g}_\dagger\}$; $\mathcal{G}_{bagging} = \{\mathbf{g}_\dagger \to \mathbf{g}_*\}$
(f) Local Planner
(g) Object Bagging — Initial SOI, Bagging SOI, Goal SOI

Experiment Result

Method	Coffee box (Exp 1)			Canned pineapple (Exp 2)			Grapefruit (Exp 3)			Triangular prism (Exp 4)			Tea caddy (Exp 5)		
	Planning S.R.	Planning time (s)	Manip. S.R.	Planning S.R.	Planning time (s)	Manip. S.R.	Planning S.R.	Planning time (s)	Manip. S.R.	Planning S.R.	Planning time (s)	Manip. S.R.	Planning S.R.	Planning time (s)	Manip. S.R.
FFG-RRT [23]	6/10	3.87 ± 1.97	8/8	8/10	2.37 ± 0.87	8/8	7/10	3.89 ± 1.18	8/8	6/10	3.58 ± 1.11	8/8	8/10	4.93 ± 1.23	7/8
TS-RRT [24]	7/10	6.32 ± 1.08	8/8	8/10	5.58 ± 1.13	8/8	9/10	6.85 ± 0.56	8/8	7/10	7.32 ± 1.34	8/8	8/10	7.46 ± 0.97	8/8
IBVS [25]	-	-	4/8	-	-	7/8	-	-	5/8	-	-	6/8	-	-	7/8
SSVS [26]	-	-	5/8	-	-	7/8	-	-	6/8	-	-	7/8	-	-	8/8
Ours	9/10	5.13 ± 1.26	8/8	10/10	4.21 ± 0.98	8/8	10/10	4.98 ± 1.93	8/8	9/10	5.32 ± 1.56	8/8	10/10	6.16 ± 1.58	8/8

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