SceneWeaver: All-in-One 3D Scene Synthesis with an Extensible and Self-Reflective Agent

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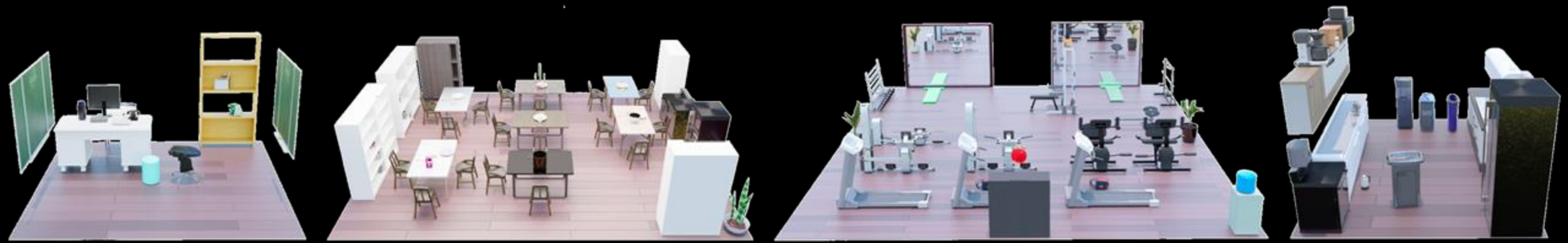
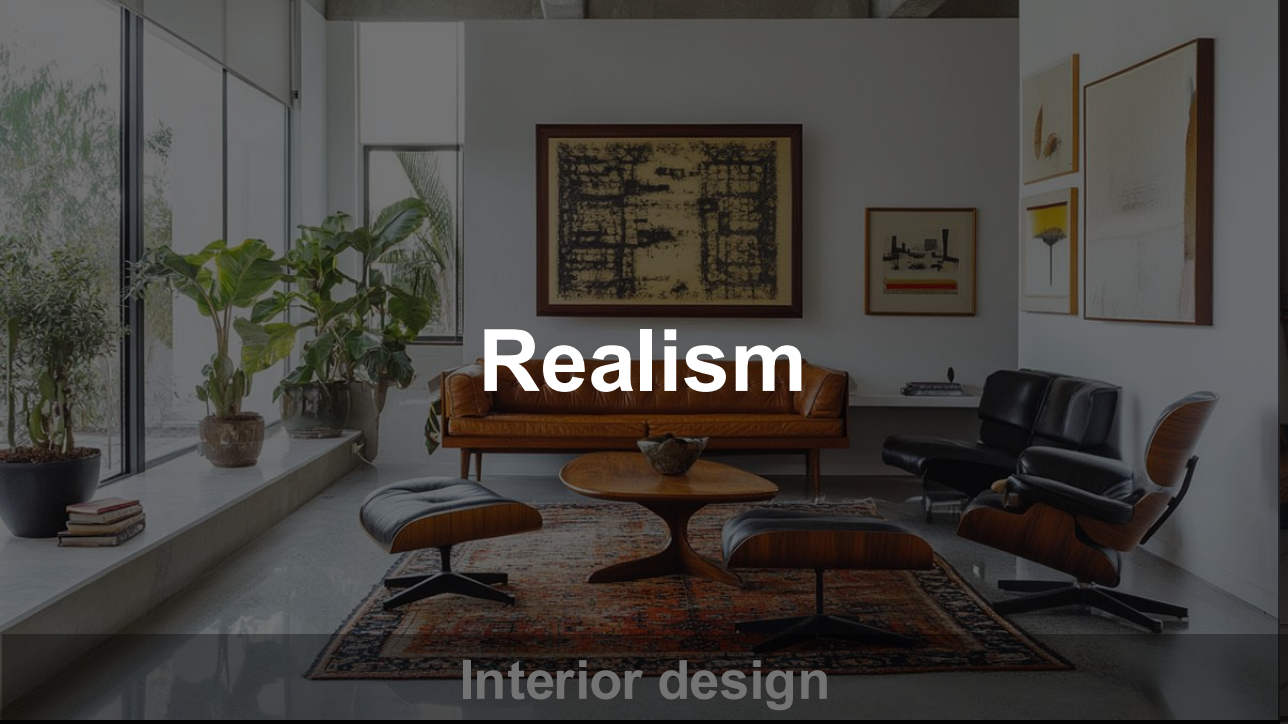
[1]State Key Laboratory of General Artificial Intelligence, BIGAI [2]Tsinghua University

*Equal contribution. ✉Corresponding Authors

https://scene-weaver.github.io





Realism

Interior design

Diversity

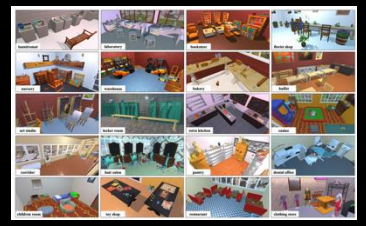
Gaming asset creation

Physical plausibility

Controllability

Physical Plausibility

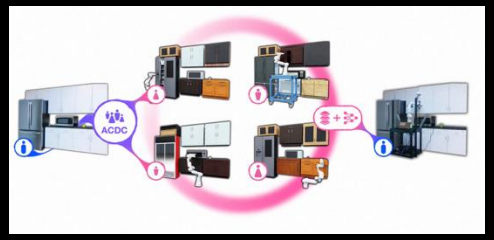
RoomCraft



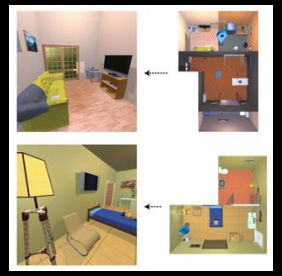
Holodeck

Infinigen

Physcene



ACDC



ProcTHor

ATISS

MetaScenes

Architect

LayoutVLM

Realism

LayoutGPT

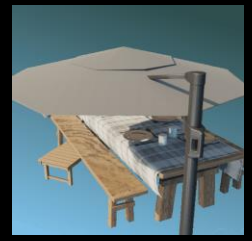
AnyHome

I-Design

InstructScene

ArtiScene

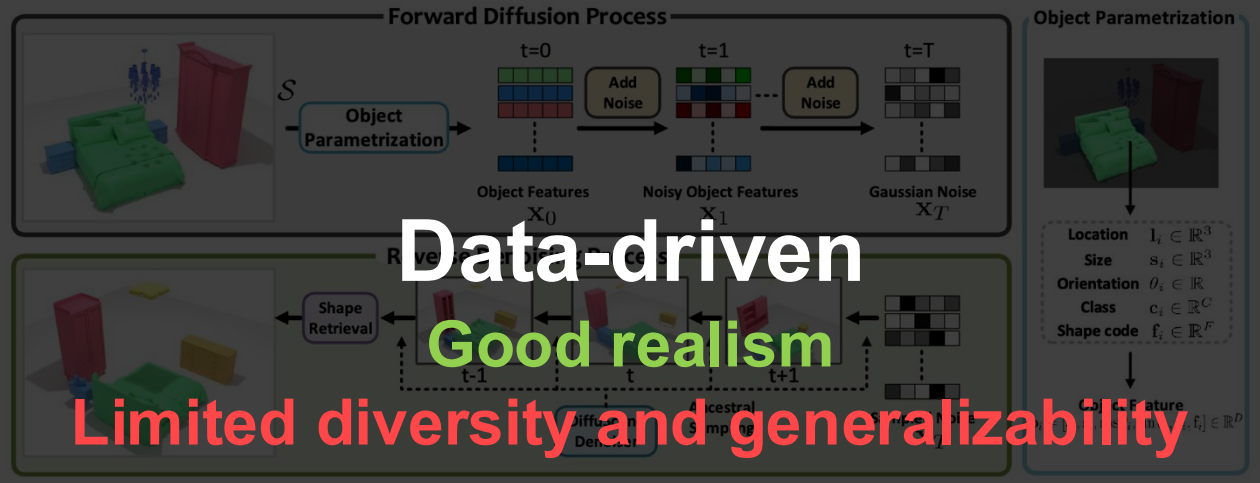
Scenethesis



Lay-A-Scene

SceneGen

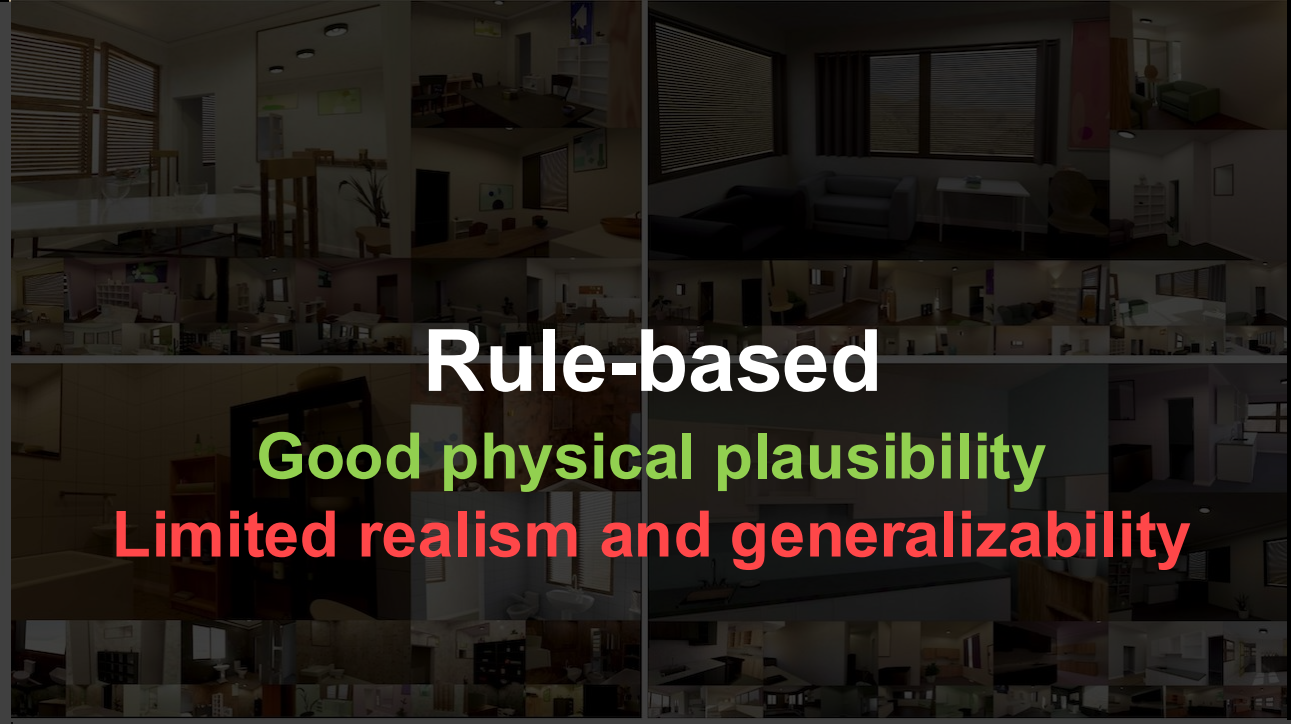
Controllability



Data-driven

Good realism

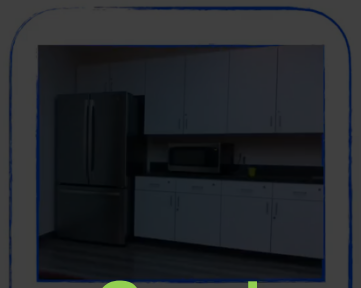
Limited diversity and generalizability



Rule-based

Good physical plausibility

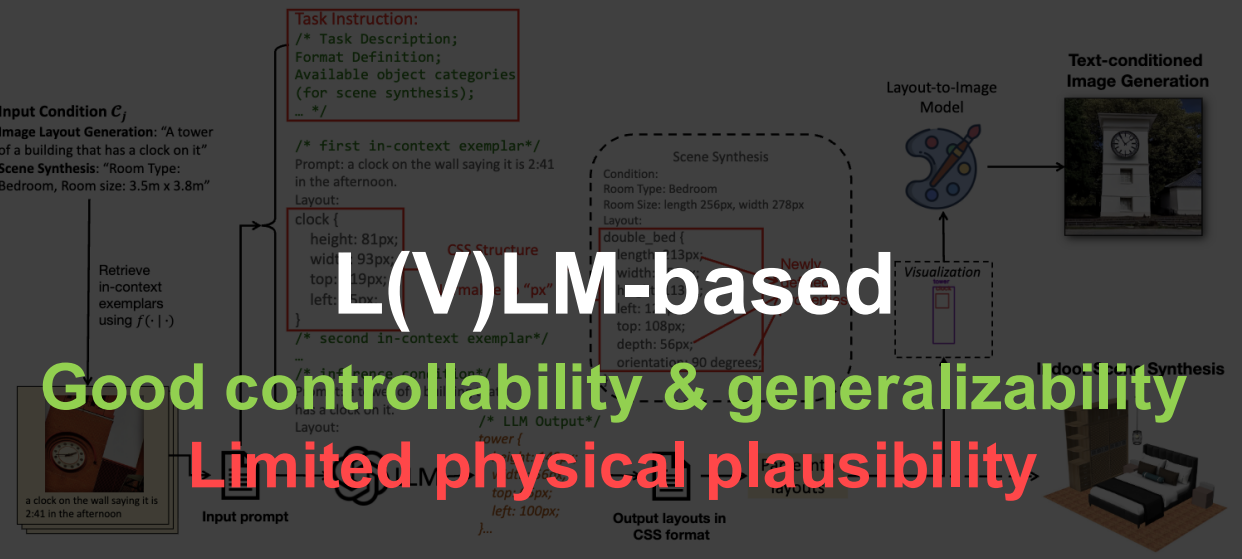
Limited realism and generalizability



Real2Sim

Good realism & generalizability

Limited controllability



L(V)LM-based

Good controllability & generalizability

Limited physical plausibility

Agentic framework

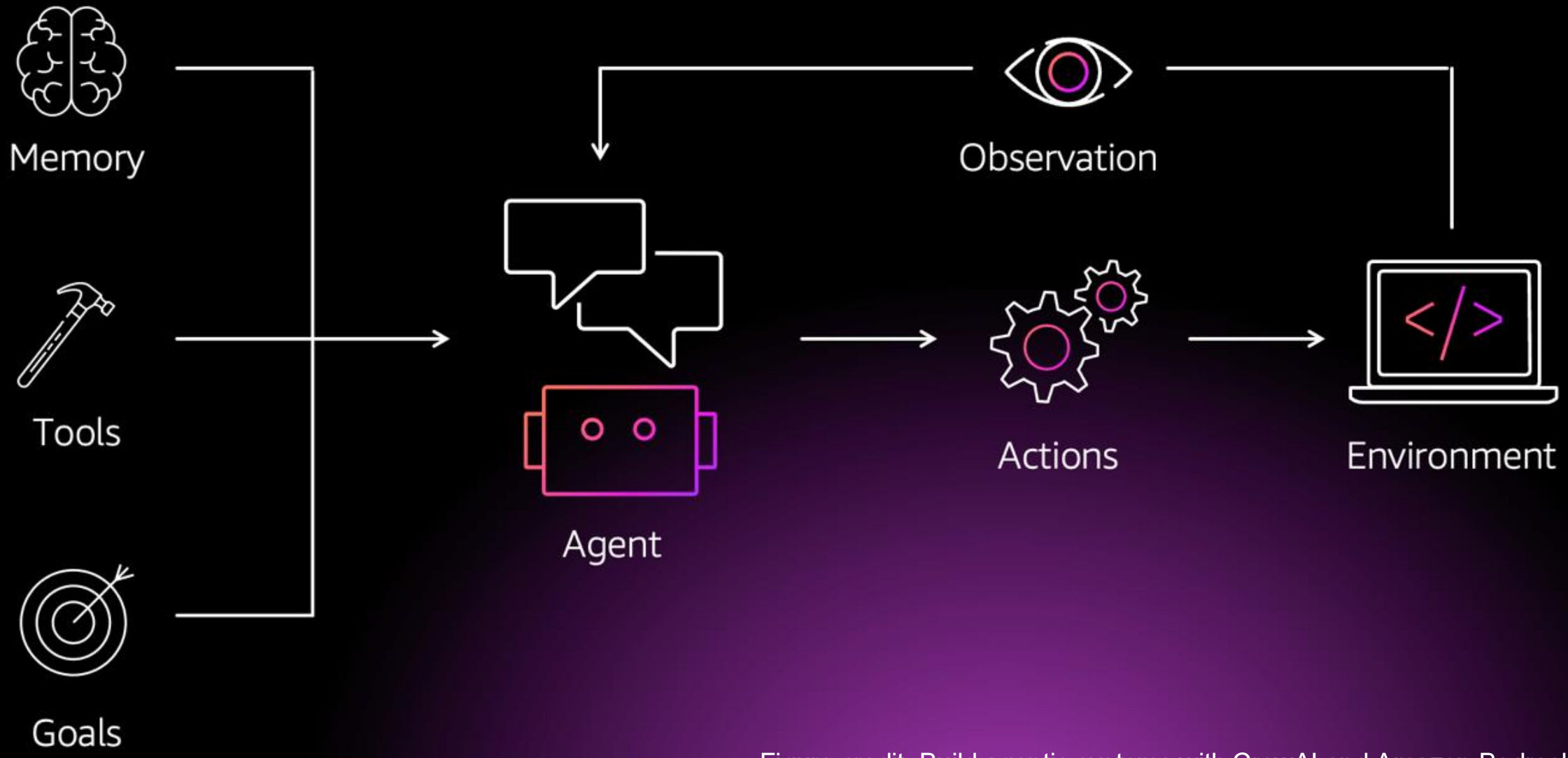


Figure credit: Build agentic systems with CrewAI and Amazon Bedrock, Amazon

Tool Cards

Initializer

Tool #1: MetaScenes

Tool #2: PhyScene

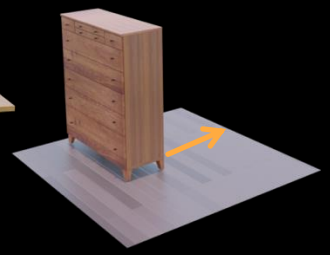
Implementer

Tool #1: ACDC

Tool #2: LLM

Refiner

Tool #1: VLM
Update Rotation



Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Query

STOP

Planner

Think

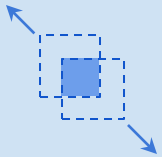
Reflection

Action

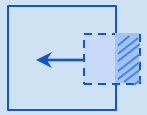
Feedback

Executor

+Physical optimize



Collision



Out of bound

Relation

Final Scene

Assets

3D FUTURE

MetaScene

Objaverse

Infinigen

Tool Cards

Initializer

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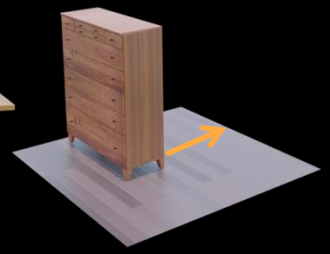
Update Rotation



Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Initializer

Tool #1: MetaScenes

Real World Scan

Interactive 3D Scene

Initializer Tool #1: MetaScenes

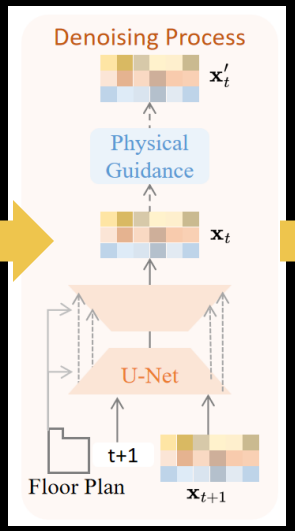
Yu et al., MetaScenes: Towards Automatic Replica Creation for Real-world 3D Scans, CVPR 2025

Initializer

Tool #1: MetaScenes

Tool #2: PhyScene

Training Dataset



Neural Network

Generated Scene

Initializer Tool #2: PhyScene

Yang et al., PhyScene: Physically Interactable 3D Scene Synthesis for Embodied AI, CVPR 2024

Initializer

Tool #1: MetaScenes

Tool #2: PhyScene

Implementer

Tool #1: ACDC

2D Image

3D Micro Scene

Implementer Tool #1: ACDC

Dai et al., Automated Creation of Digital Cousins for Robust Policy Learning, CoRL 2024

Initializer

Tool #1: MetaScenes

Room Type
Room Size
3D Layout
Relation
Assets

Tool #2: PhyScene

Implementer

Tool #1: ACDC

GPT: Add objects on / inside supporter.

Tool #2: LLM

GPT: Add objects on / inside supporter.

Implementer Tool #2: LLM

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Tool #1: MetaScenes

Room Type
Room Size
3D Layout
Relation
Assets

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Implementer

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Refiner

Tool #1: VLM
Update Rotation

Refiner Tool #1: VLM
Update Rotation

Initializer

Tool #1: MetaScenes

Tool #2: PhyScene

Implementer

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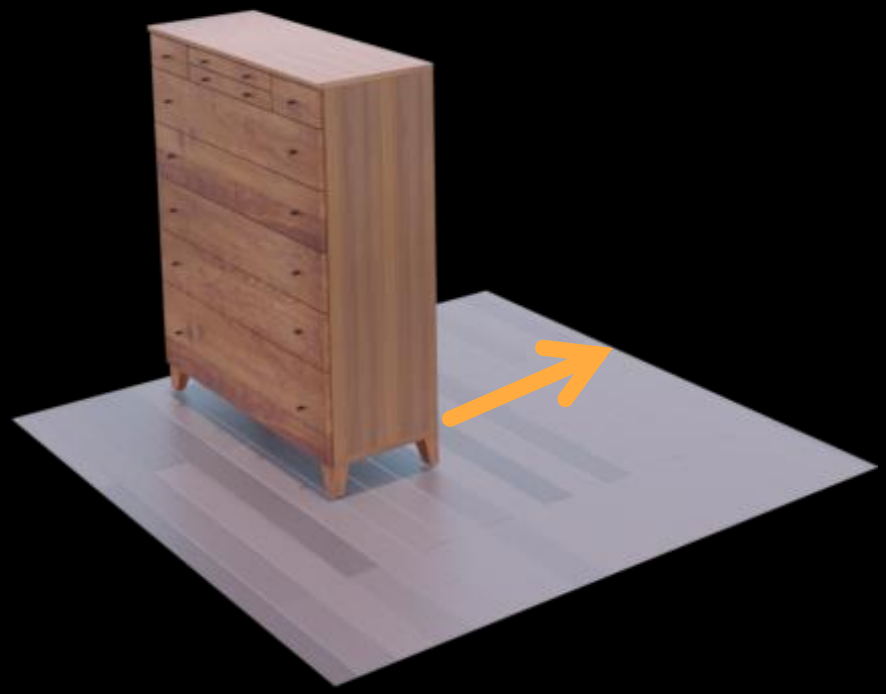
GPT: Add objects on / inside supporter.

Tool #2: LLM

Refiner

Tool #1: VLM
Update Rotation

Tool #2: Rule
Add Relation



Refiner Tool #2: Rule
Add Relation

Initializer

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Implementer

Tool #1: ACDC

GPT: Add objects on / inside supporter.

Tool #2: LLM

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Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Refiner Tool #3: LLM
Remove Object

Tool Cards

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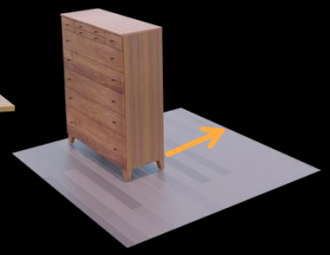
Tool #1: VLM
Update Rotation



Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Query

SceneWeaver

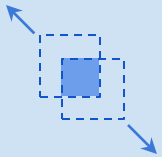
Planner

Think

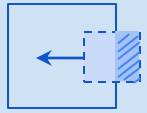
Action

Executor

+Physical optimize



Collision

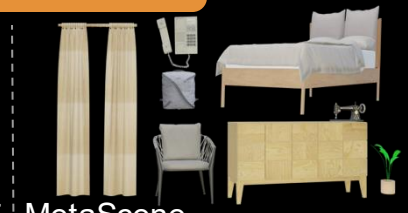


Out of bound

Relation

Assets

3D FUTURE



MetaScene

Objaverse

Infinigen

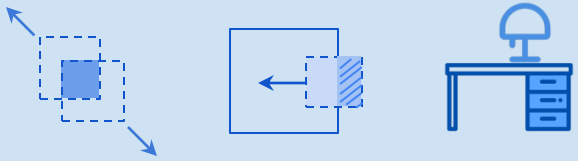
Collision

Out of Bound

Relation constraints

Executor

+Physical optimize



Tool Cards

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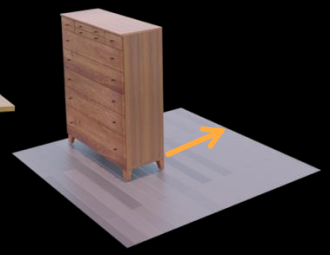
Refiner

Tool #1: VLM
Update Rotation



Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Query

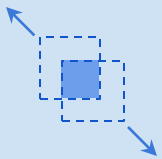
SceneWeaver

Planner

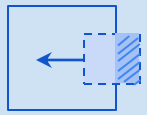
Think → Action → Feedback → Reflection

Executor

+Physical optimize



Collision



Out of bound

Relation

Query: Design me a laundry room.

Step t-1:

Plan:

Correct the rotation of washing machine.

Tool Selection:

Refiner: VLM - Update Rotation.

Feedback & Reflection:

Object number: 8, Collision: 0, Out of room: 0.
Real: 8, Functional: 7, Layout: 8, Completion: 5.
The lack of decoration or daily supplies makes the room feel unfinished.

Tool Cards

Initializer

Tool #1: MetaScenes

Tool #2: PhyScene

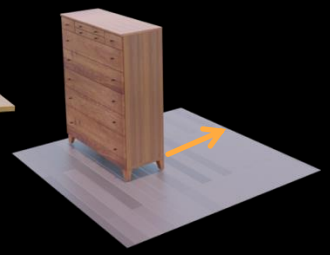
Implementer

Tool #1: ACDC

Tool #2: LLM

Refiner

Tool #1: VLM
Update Rotation



Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Query

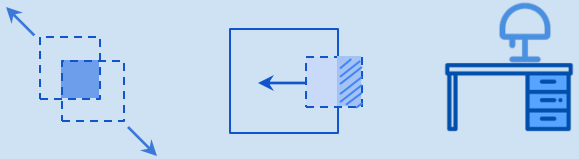
SceneWeaver

Planner

Think → Action → Feedback → Reflection

Executor

+Physical optimize



Collision | Out of bound | Relation

Query: Design me a laundry room

Memory of Step t-1

Step t :

Plan for step t:

1. Find the most serious problem to solve in this step.
The completion score is low, missing small objects. Add more laundry objects in the shelf.

2. List appropriate tools with 0-1 **confidence score** and **choose one tool** for this step.
Use Implementer: LLM: GPT to add objects.

3. Explain the **expectation** and suggest next steps:
Objects should be added into the shelf. If success, proceed to finer adjustments. If not, try another strategy with a different tool.

Tool Cards

Initializer

Tool #1: MetaScenes

Tool #2: PhyScene

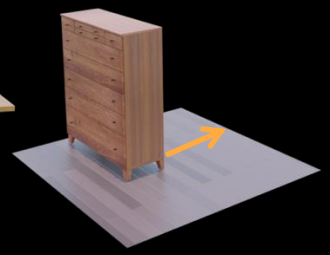
Implementer

Tool #1: ACDC

Tool #2: LLM

Refiner

Tool #1: VLM
Update Rotation



Tool #2: Rule
Add Relation

Tool #3: LLM
Remove Object

Query

SceneWeaver

STOP

Planner

Think

Reflection

Action

Feedback

Executor

+Physical optimize

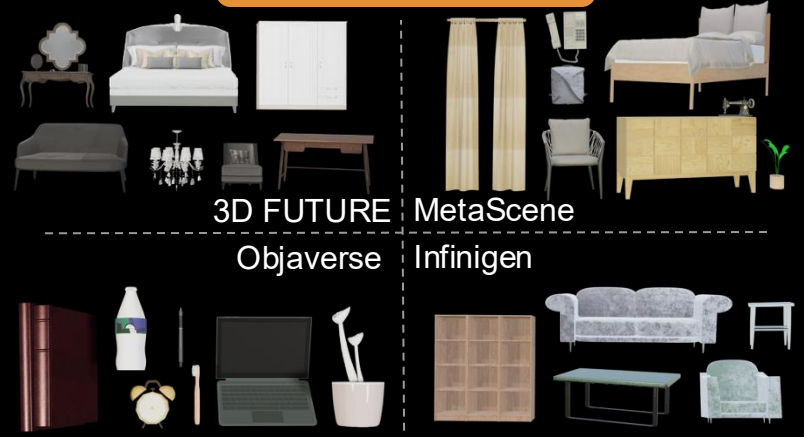
Collision

Out of bound

Relation

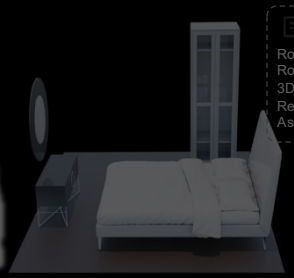
Final Scene

Assets



Initializer | Implementer | Refiner


Tool #1: MetaScenes


Tool #2: PhyScene


Tool #1: ACDC

GPT: Add objects on / inside supporter.


Tool #2: LLM


Tool #1: VLM
Update Rotation

Tool #2: Rule
Add Relation


Tool #3: LLM
Remove Object

Query: Design me a restaurant.

SceneWeaver

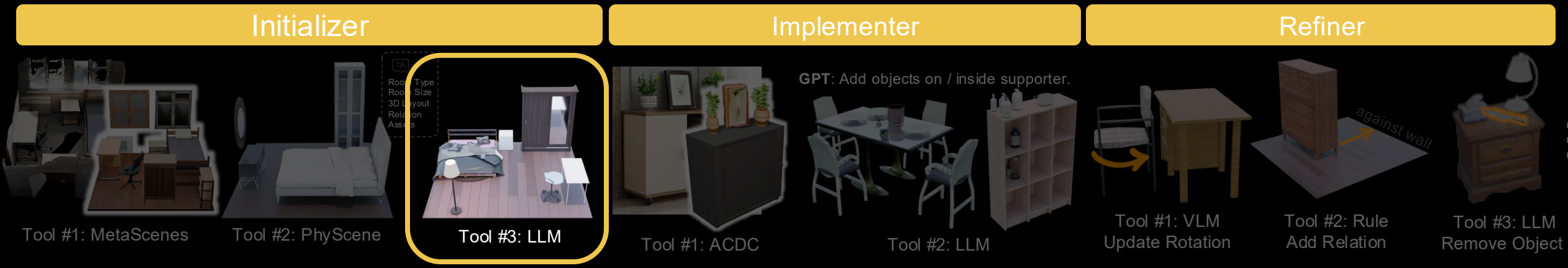
Step 1:

Planner: Initialize a basic restaurant.

Tool: Initializer-LLM

Executor: Update scene with physical optimization

Feedback:
Real: 6, Functional: 6, Layout: 5, Complete: 4



Query: Design me a restaurant.

SceneWeaver

Step 1:

Planner: Initialize a basic restaurant.

Tool: Initializer-LLM

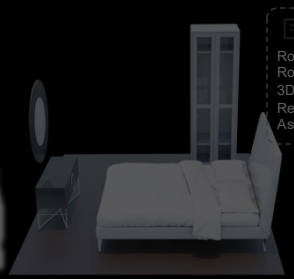
Executor: Update scene with physical optimization

Feedback:
Real: 6, Functional: 6, Layout: 5, Complete: 4

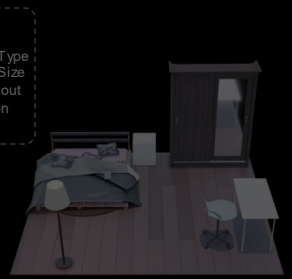
Reflection:
The scene is real, but the shelves are empty.

Initializer | Implementer | Refiner


Tool #1: MetaScenes



Tool #2: PhyScene


Tool #3: LLM


Tool #1: ACDC

Tool #2: LLM


Tool #1: VLM
Update Rotation

Tool #2: Rule
Add Relation


Tool #3: LLM
Remove Object

Query: Design me a restaurant.

SceneWeaver

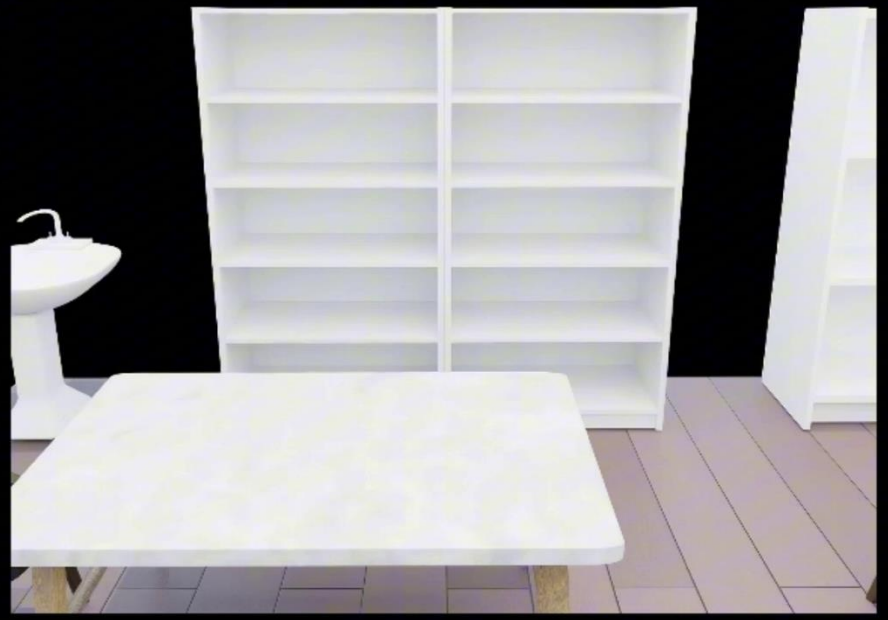
Step 2:

Planner: Add objects in the shelf.

Tool: Implementer-LLM

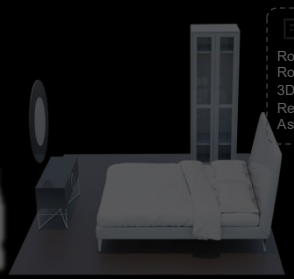
Executor: Update scene with physical optimization

Feedback:
Real: 6, Functional: 6, Layout: 5 Complete: 6

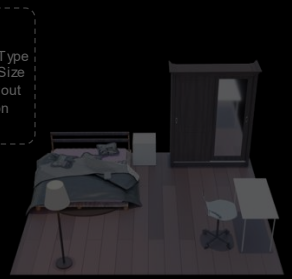


Initializer | Implementer | Refiner


Tool #1: MetaScenes



Tool #2: PhyScene


Tool #3: LLM


Tool #1: ACDC

Tool #2: LLM


Tool #1: VLM
Update Rotation

Tool #2: Rule
Add Relation


Tool #3: LLM
Remove Object

Query: Design me a restaurant.

SceneWeaver

Step 2:

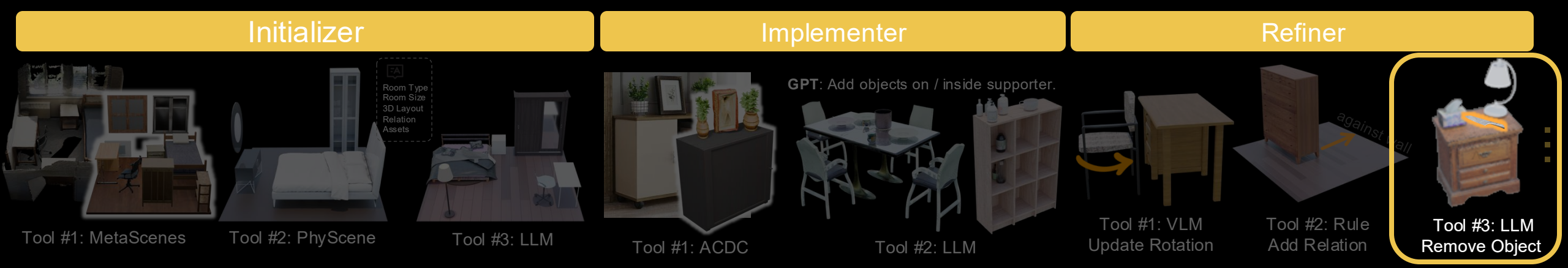
Planner: Add objects in the shelf.

Tool: Implementer-LLM

Executor: Update scene with physical optimization

Feedback:
Real: 6, Functional: 6, Layout: 5 Complete: 6

Reflection:
Objects have been placed in the shelves.
The bathroom sink seems improper.



Query: Design me a restaurant.

SceneWeaver

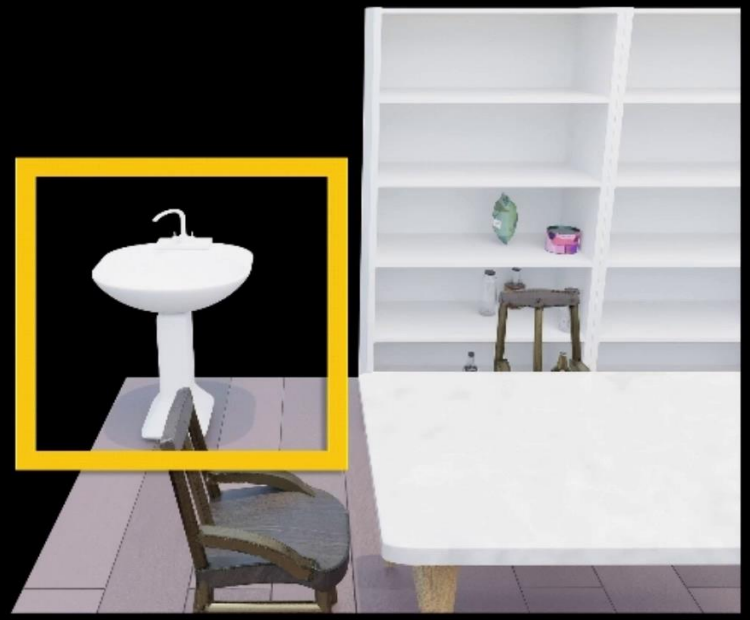
Step 3:

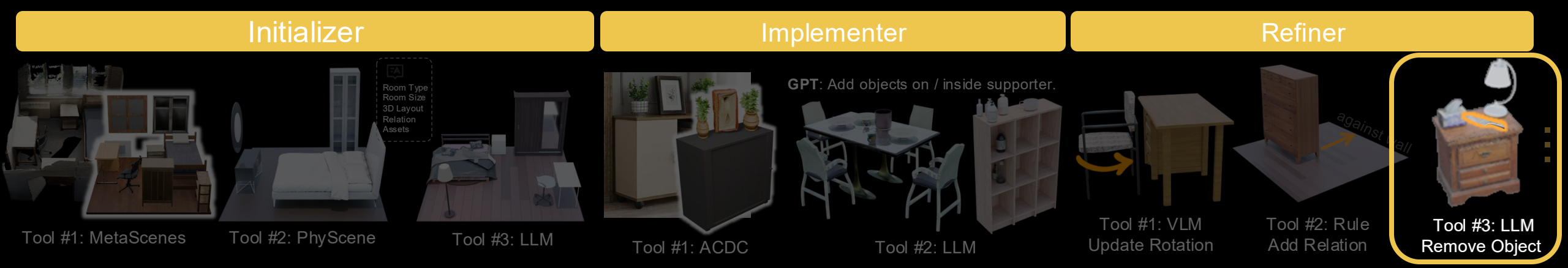
Planner: Remove the bathroom sink

Tool: Refiner-Remove Object

Executor: Update scene with physical optimization

Feedback:
Real: 8, Functional: 7, Layout: 6 Complete: 6





Query: Design me a restaurant.

SceneWeaver

Step 3:

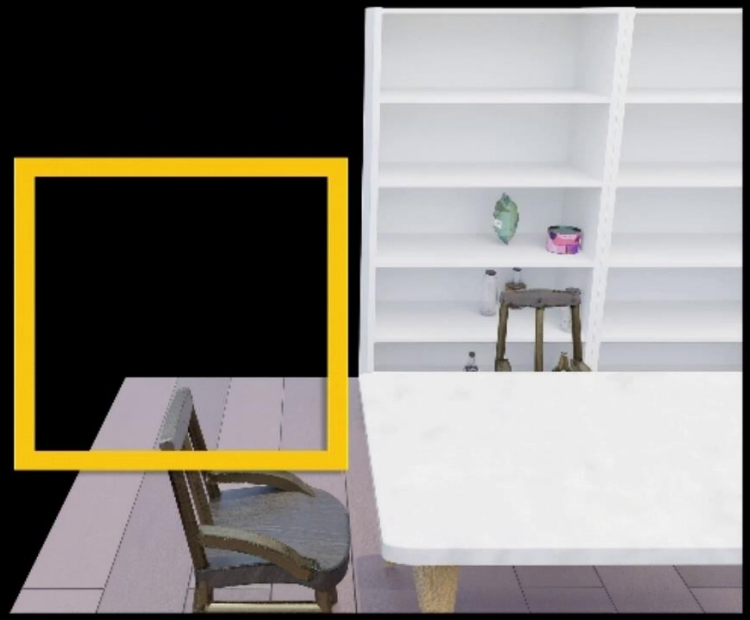
Planner: Remove the bathroom sink

Tool: Refiner-Remove Object

Executor: Update scene with physical optimization

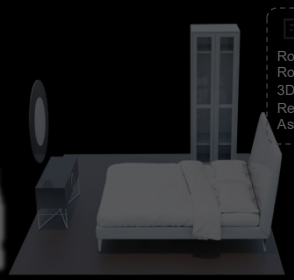
Feedback:
Real: 8, Functional: 7, Layout: 6 Complete: 6

Reflection:
Bathroom sink has been removed. The tables in the center seems crowded.

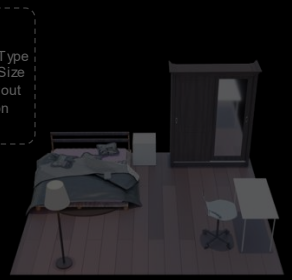


Initializer | Implementer | Refiner


Tool #1: MetaScenes



Tool #2: PhyScene


Tool #3: LLM


Tool #1: ACDC

GPT: Add objects on / inside supporter


Tool #2: LLM


Tool #1: VLM
Update Rotation

Tool #2: Rule
Add Relation


Tool #3: LLM
Remove Object

Query: Design me a restaurant.

Step 4:

Planner: Rotate the tables in the center.

Tool: Refiner-Update Rotation

Executor: Update scene with physical optimization

Feedback:
Real: 8, Functional: 7, Layout: 8, Complete: 6

Query: Design me a restaurant.

Step 4:

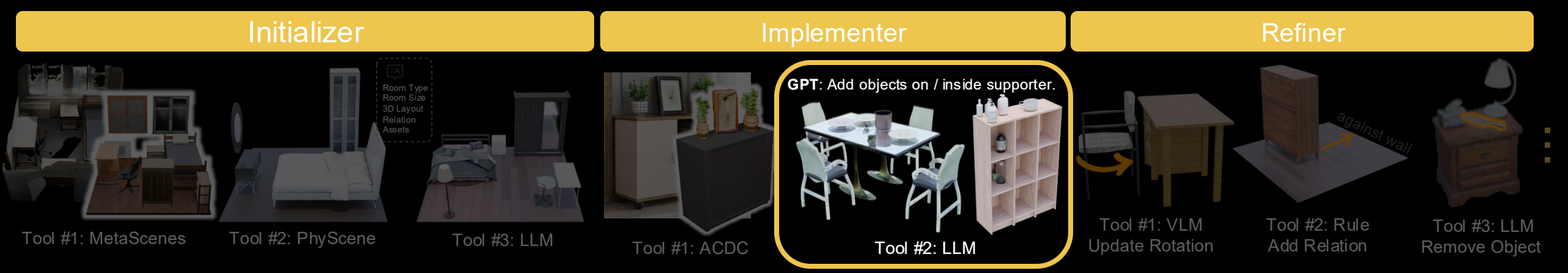
Planner: Rotate the tables in the center.

Tool: Refiner-Update Rotation

Executor: Update scene with physical optimization

Verifier:
Real: 8, Functional: 7, Layout: 8, Complete: 6

Reflection:
The space seems less crowded after rotation. But the tabletop is empty.



Query: Design me a restaurant.

SceneWeaver

Step 5:

Planner: Add objects on each table.

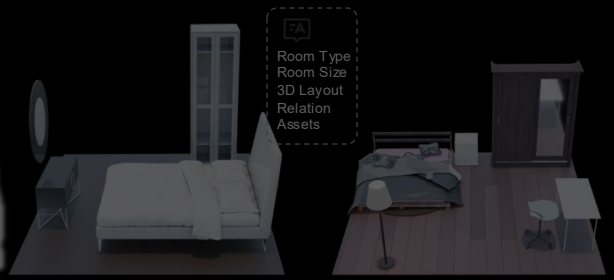
Tool: Implementer-LLM

Executor: Update scene with physical optimization.

Feedback:
Real: 8, Functional: 7, Layout: 8, Complete: 8

Initializer | Implementer | Refiner


Tool #1: MetaScenes



Tool #2: PhyScene

Tool #3: LLM


Tool #1: ACDC

Tool #2: LLM


Tool #1: VLM
Update Rotation

Tool #2: Rule
Add Relation


Tool #3: LLM
Remove Object

Query: Design me a restaurant.

SceneWeaver

Step 5:

Planner: Add objects on each table.

Tool: Implementer-LLM

Executor: Update scene with physical optimization.

Verifier:
Real: 8, Functional: 7, Layout: 8, Complete: 8

Reflection:
Each table has objects on the top now. And no physical problem exists.
The scene is well developed. Finish!

Iterative refinement with complex user queries

1 **Initializer**: Init a basic scene.

2 **Implementer**: Add objects on the shelf.

3 **Refiner**: Resize objects on the shelf.

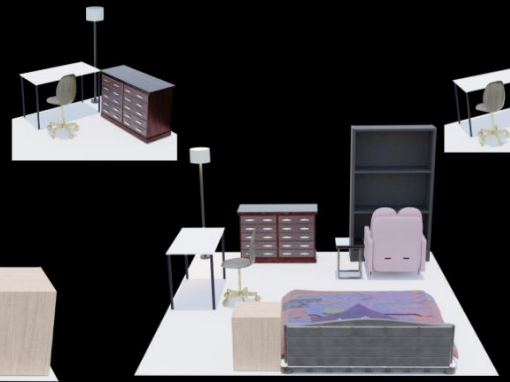
4 **Refiner**: Add objects in the shelf.

5 **Implementer**: Add objects on the washing machine.

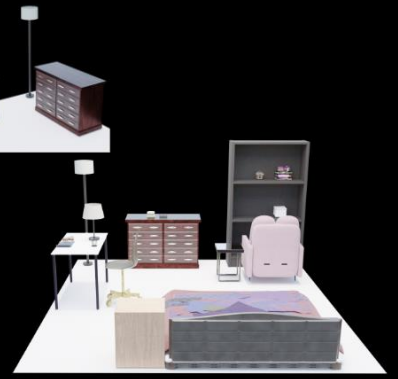
6 **Finish**: Finalize room structure and texture.

Query: A laundromat with 10 machines. Add washing supplies on each machine. Add other related objects, such as baskets, and washthub in the room.

1 **Initializer**: Init a basic scene.

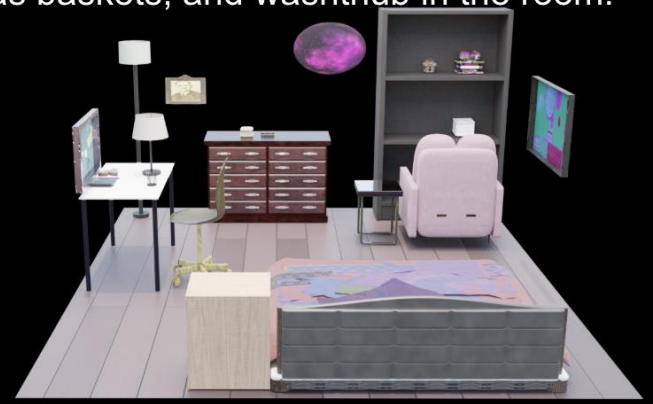


2 **Modifier:** move objects to avoid crowded.



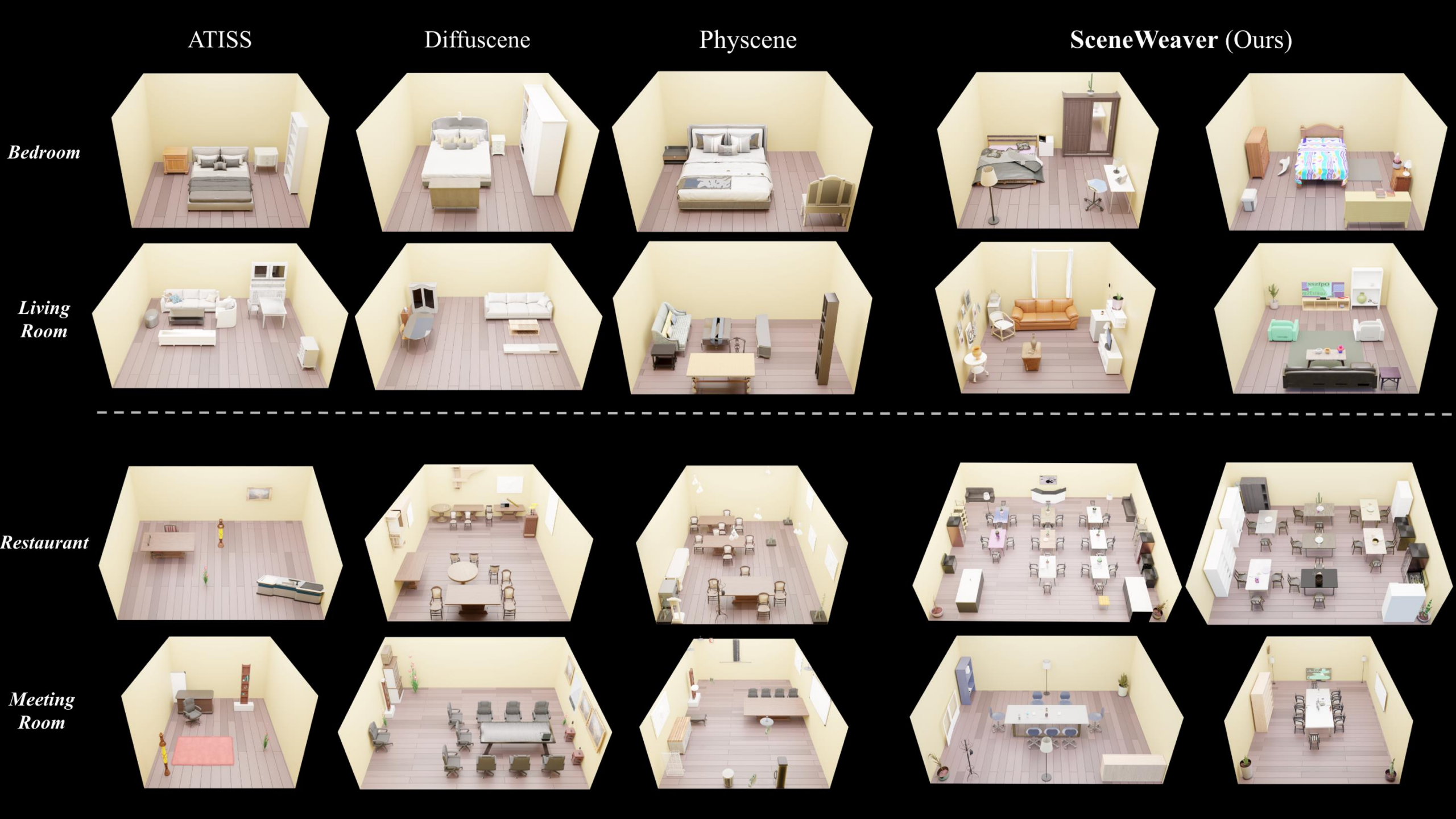
3 **Implementer:** Add objects on the supporter.

4 **Implementer:** Add decorations on the wall.



5 **Finish**: Finalize room structure and texture.

Query: A bedroom rich of furniture, decoration on the wall, and small objects.


ATISS
Diffuscene
Physcene
SceneWeaver (Ours)
Bedroom
Living Room
Restaurant
Meeting Room

Comparison vs. LLM-based methods

Method	Bathroom							Children Room							Gym						
	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.
LayoutGPT	7.7	1.3	1.0	8.3	9.3	7.7	6.0	7.3	1.0	0.7	6.3	8.0	6.0	4.0	6.7	0.7	0.0	6.7	6.7	5.7	3.7
Holodeck	12.0	0.0	1.7	7.7	6.7	7.0	5.3	13.7	0.0	2.0	7.5	7.5	6.5	5.5	20.3	0.0	5.3	9.7	9.3	6.7	6.0
I-Design	9.7	0.0	0.0	7.4	7.2	7.4	5.4	11.3	0.0	0.0	7.8	8.3	6.8	5.5	12.0	0.0	0.8	8.2	8.4	7.0	5.2
Ours	**19.7**	**0.0**	**0.0**	**9.0**	**10.0**	**8.0**	**9.0**	**23.0**	**0.0**	**0.0**	**9.0**	**10.0**	**8.3**	**8.3**	**29.7**	**0.0**	**0.0**	**9.0**	**10.0**	**8.0**	**7.3**

Method	Meeting Room							Office							Restaurant						
	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.
LayoutGPT	7.3	1.0	0.7	4.0	3.0	5.3	2.0	7.3	0.3	0.0	6.7	7.7	6.3	4.0	7.0	0.3	1.7	3.3	2.3	4.7	2.0
Holodeck	27.0	0.0	0.3	9.0	**10.0**	**8.0**	7.0	27.0	0.0	4.7	7.0	6.3	4.3	4.0	35.0	0.0	12.3	5.3	4.3	4.3	3.7
I-Design	18.7	5.3	0.0	6.0	4.5	5.8	4.3	11.7	0.0	0.0	8.0	9.0	6.8	5.4	27.7	0.0	0.0	6.2	5.2	5.2	4.0
Ours	**31.0**	**0.0**	**0.0**	**9.0**	9.0	7.7	**8.0**	**40.0**	**0.0**	**0.0**	**9.0**	**10.0**	**8.0**	**8.7**	**88.0**	**0.0**	**0.0**	**7.3**	**7.0**	**6.5**	**7.3**

Method	Waiting Room							Kitchen							Average						
	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.	#Obj	#OB	#CN	Real.	Func.	Lay.	Comp.
LayoutGPT	6.3	0.0	0.3	6.7	5.7	6.0	4.0	7.7	1.3	1.3	5.7	6.3	4.7	3.7	7.3	0.7	0.7	6.0	6.1	5.8	3.7
Holodeck	24.0	0.0	3.7	8.3	9.3	6.7	5.7	20.0	0.0	1.3	7.3	6.3	6.3	4.3	22.3	0.0	3.9	7.7	7.5	6.2	5.2
I-Design	10.7	0.0	0.0	6.6	6.4	5.8	4.2	11.7	0.0	0.0	6.5	6.8	5.3	3.5	14.3	0.7	0.1	7.1	7.0	6.2	4.7
Ours	**25.7**	**0.0**	**0.0**	**9.0**	**10.0**	**8.0**	**7.7**	**34.7**	**0.0**	**0.0**	**9.0**	**9.3**	**7.3**	**7.7**	**36.5**	**0.0**	**0.0**	**8.8**	**9.4**	**7.7**	**8.0**

SceneWeaver achieves better realism and diversity

Evaluation in simulators

Table A5: **Shift in simulation.** We assess object stability in simulation in Isaac Sim.

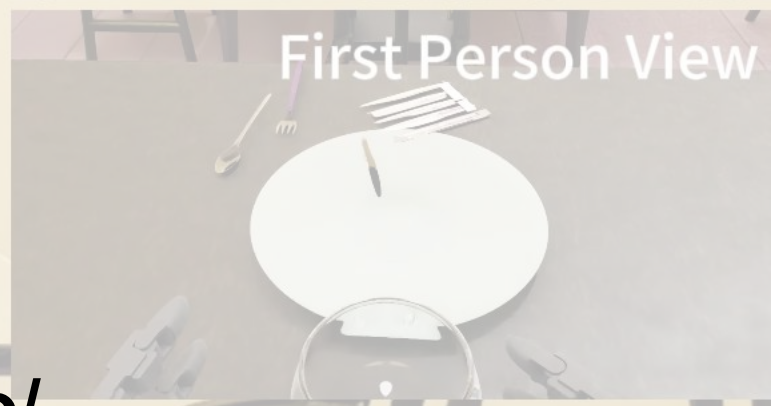
Method	>0.1m ↓	>0.01m ↓	Average Shift ↓
ATISS	35.4%	51.4%	0.356
DiffuScene	26.2%	39.3%	0.190
PhyScene	9.7%	19.6%	0.069
LayoutGPT	39.2%	52.8%	0.477
IDesign	5.0%	11.5%	0.041
Holodeck	17.6%	42.5%	0.113
Ours	**1.0%**	**10.37%**	**0.011**

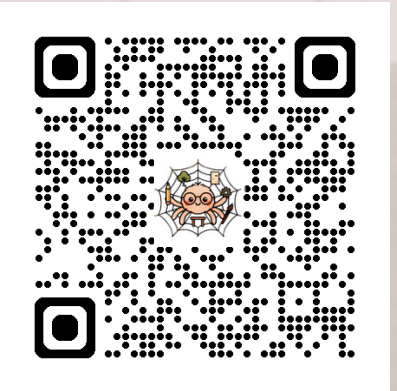
Significant fewer adjustments needed in simulator

SceneWeaver

Q & A

https://scene-weaver.github.io/





BIGAI

RoboGen
IROS 2025

IROS
HANGZHOU 2025

Front View