# ET-PLAN-BENCH: EMBODIED TASK-LEVEL PLANNING BENCHMARK TOWARDS SPATIAL-TEMPORAL COGNITION WITH FOUNDATION MODELS

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# Main Contribution

- 1. Design complex planning tasks with spatio-temporal constraints and introduce new, more challenging embodied planning benchmarks.
- 2. Propose an automated generation of planning tasks with spatio-temporal constraints and a framework for automatically evaluating the performance of foundational models.
- 3. Conduct benchmarking based on various foundational models and study the effectiveness of supervised fine-tuning.

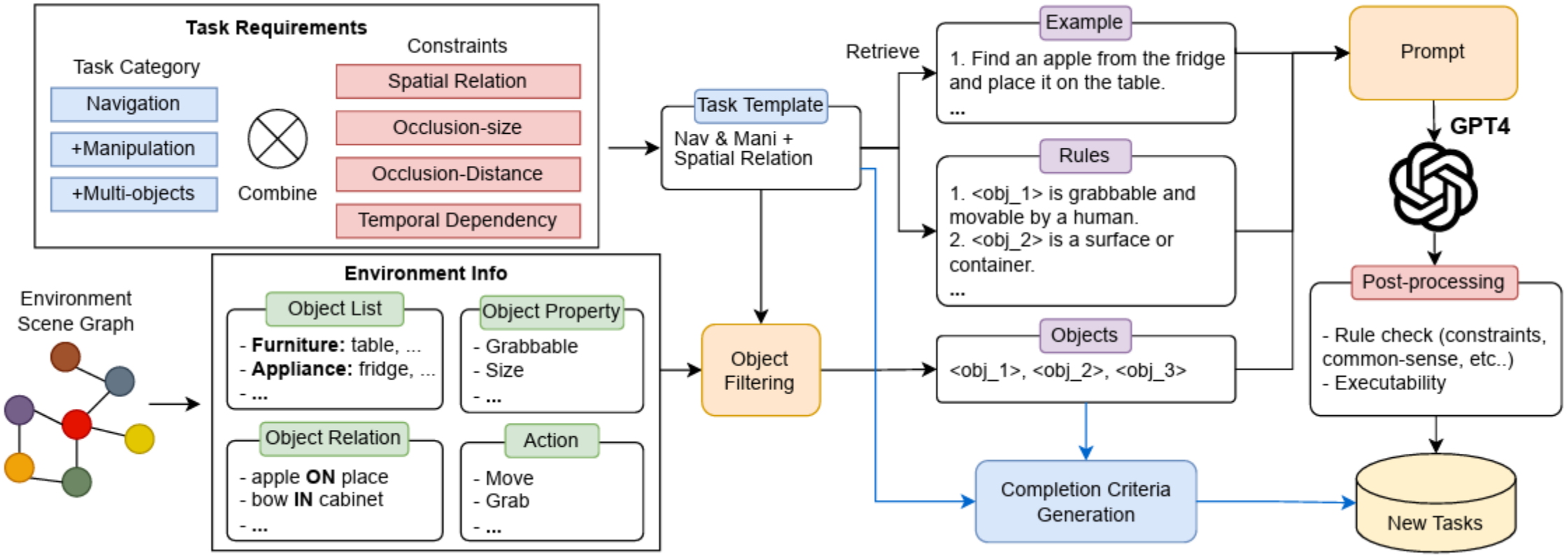
# Related Work

| Dataset | Task | Multi-Modality | Data Size | Auto Data | LLM Eval | Open Voc | Level of Obs | Spatial | Temporal/ Causal | Env Inter |
|---|---|---|---|---|---|---|---|---|---|---|
| ActivityPrograms(Puig et al., 2018) | | ✔ | 2821 | ✗ | ✗ | ✔ | P | ✗ | ✗ | ✔ |
| WAH(Puig et al., 2020) | | ✗ | 1211 | ✗ | ✗ | ✗ | P/ G | ✗ | ✗ | ✔ |
| ALFRED(Shridhar et al., 2020a) | | ✔ | 8055 | ✗ | ✗ | ✔ | P | ✗ | ✗ | ✔ |
| WAH-NL(Choi et al., 2024) | | ✗ | 611 | ✗ | ✔ | ✔ | P | ✗ | ✗ | ✔ |
| RoboGen(Wang et al., 2023) | | ✔ | ∞ | ✔ | ✔ | ✔ | P | ✗ | ✗ | ✔ |
| BEHAVIOR(Srivastava et al., 2022) | | ✗ | 100 | ✗ | ✗ | ✗ | P | ✗ | ✗ | ✔ |
| Mini-BEHAVIOR(Jin et al., 2023) | TGP | ✗ | 20 | ✗ | ✗ | ✗ | P | ✗ | ✗ | ✔ |
| BEHAVIOR-1K(Li et al., 2023) | | ✗ | 1000 | ✗ | ✗ | ✗ | P | ✗ | ✗ | ✔ |
| EgoCOT(Mu et al., 2024) | | ✔ | 129 | ✗ | ✔ | ✔ | P | ✗ | ✗ | ✗ |
| EgoPlan-Bench(Chen et al., 2023) | | ✔ | 2406 | ✔ | ✔ | ✔ | P | ✗ | ✗ | ✔ |
| EgoPlan-IT(Chen et al., 2023) | | ✔ | 50K | ✔ | ✔ | ✔ | P | ✗ | ✗ | ✔ |
| HandMeThat(Wan et al., 2022) | | ✗ | 300K | ✔ | ✗ | ✔ | P/ G | ✗ | ✗ | ✔ |
| EgoVQA(Fan, 2019) | | ✔ | 520 | ✗ | ✗ | ✔ | P/ G | ✗ | ✗ | ✗ |
| EgoTaskQA(Jia et al., 2022) | EQA | ✔ | 40K | ✗ | ✗ | ✔ | P | ✔ | ✔ | ✗ |
| Egothink(Cheng et al., 2024) | | ✔ | 700 | ✗ | ✔ | ✔ | P | ✔ | ✔ | ✗ |
| OpenEQA(Majumdar et al., 2024) | | ✔ | 1600 | ✗ | ✔ | ✔ | P | ✗ | ✗ | ✔ |
| **ET-Plan-Bench** | TGP | ✔ | ∞ | ✔ | ✔ | ✔ | P/ FP/ G | ✔ | ✔ | ✔ |

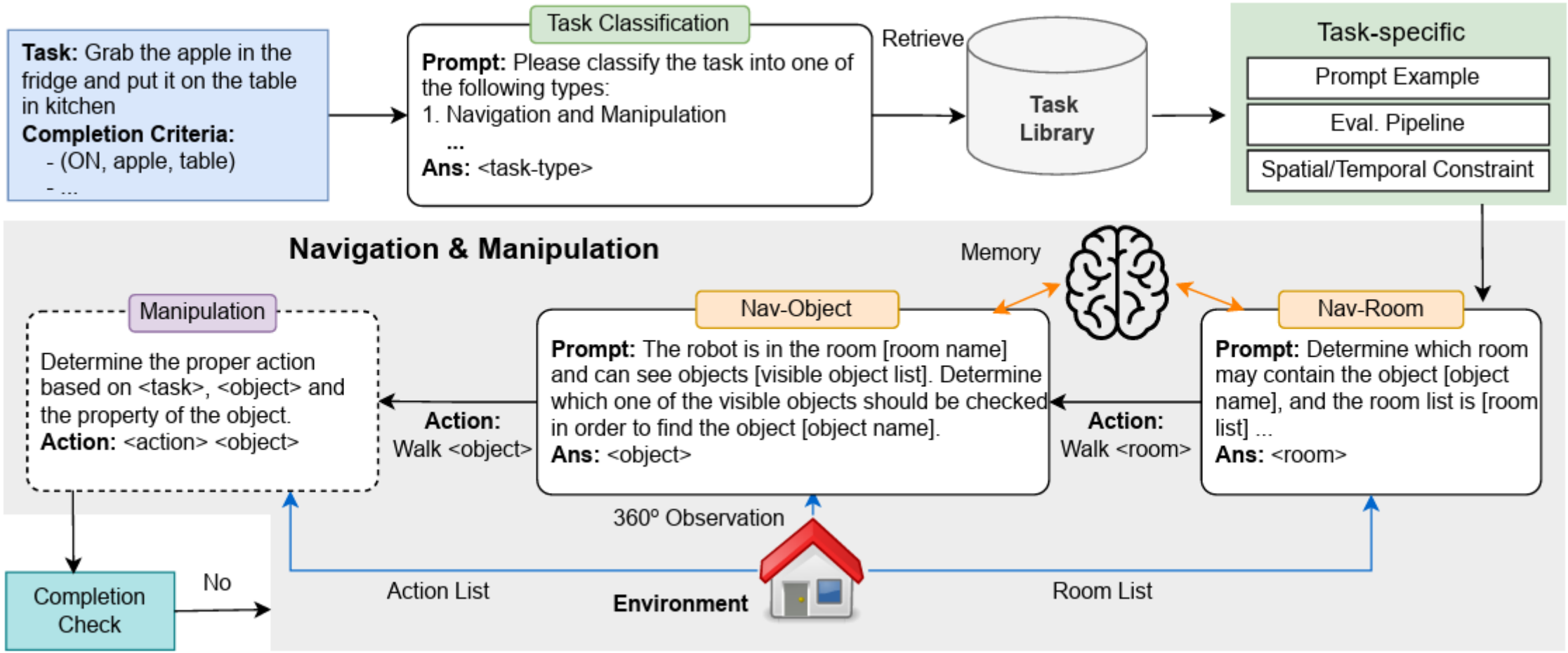
# Task Difficulty Dimension

- Action Sequence Length
- Prior Knowledge
- Spatial Relationship Constraints
- Occlusion
- Temporal and Causal Relationship Constraints

# Embodied Task Generation Pipeline



# LLM Agent Pipeline



# Experiment Results

| | Success Rate | | Seq Length | | Longest Common Seq (Ratio) | | Moving Distance | |
|---|---|---|---|---|---|---|---|---|
| Tasks | GPT4 | LLAMA 7B SFT | GPT4 | LLAMA 7B SFT | GPT4 | LLAMA 7B + SFT | GPT4 | LLAMA 7B+ SFT |
| Navigation Tasks with or without Spatial Constraints | | | | | | | | |
| Navi + *Layout Map* | 90.77% | 91.13% | 3.76 | 3.96 | 1.32 (89.64%) | 1.34 (90.11%) | 10.79 | 10.83 |
| Navi | 79.26% | 80.58% | 6.77 | 6.75 | 1.59 (78.74%) | 1.62 (80.01%) | 14.10 | 14.59 |
| Navi + *Occlusion_Size* | 72.46% | 76.05% | 7.99 | 7.89 | 1.53 (74.95%) | 1.59 (78.14%) | 14.08 | 16.65 |
| Navi + *Occlusion_Distance* | 73.65% | 76.65% | 7.94 | 7.69 | 1.60 (77.40%) | 1.65 (80.24%) | 19.36 | 17.38 |
| Navi + *Relation* | 62.61% | 64.09% | 9.20 | 9.20 | 1.78 (88.75%) | 1.75 (86.05%) | 12.45 | 14.08 |
| Navi + *Relation* + *Occlusion_Size* | 60.74% | 61.48% | 9.68 | 9.91 | 1.74 (85.19%) | 1.70 (83.21%) | 13.26 | 16.05 |
| Navi + *Relation* + *Occlusion_Distance* | 54.81% | 55.56% | 10.41 | 10.31 | 1.73 (86.67%) | 1.67 (82.96%) | 15.75 | 16.22 |
| Navigation & Manipulation Tasks with or without Spatial Constraints | | | | | | | | |
| Navi & Mani + *Layout Map* | 83.98% | 83.96% | 12.36 | 12.09 | 4.20 (82.68%) | 4.17 (81.97%) | 22.22 | 21.67 |
| Navi & Mani | 73.76% | 74.33% | 17.02 | 16.47 | 4.17 (78.56%) | 4.22 (78.92%) | 28.51 | 26.99 |
| Navi & Mani + *Occlusion_Size* | 65.85% | 67.60% | 20.00 | 19.21 | 3.94 (75.00%) | 4.00 (75.27%) | 29.46 | 28.79 |
| Navi & Mani + *Occlusion_Distance* | 72.09% | 74.66% | 18.83 | 17.20 | 4.06 (75.50%) | 4.21 (78.08%) | 37.92 | 30.45 |
| Navi & Mani + *Relation* | 49.65% | 50.35% | 24.08 | 23.78 | 4.11 (73.60%) | 4.12 (72.14%) | 27.70 | 27.72 |
| Navi & Mani + *Relation* + *Occlusion_Size* | 43.03% | 42.75% | 26.52 | 26.39 | 3.81 (69.02%) | 3.82 (67.05%) | 31.55 | 28.42 |
| Navi & Mani + *Relation* + *Occlusion_Distance* | 49.88% | 50.00% | 23.96 | 23.79 | 4.20 (73.69%) | 4.25 (72.57%) | 34.85 | 30.83 |
| Navigation & Manipulation Tasks with Temporal Constraints | | | | | | | | |
| Navi & Mani + *Multi Objects* | 56.73% | 55.05% | 38.25 | 42.80 | 7.57 (69.92%) | 7.85 (69.09%) | 50.39 | 47.40 |
| Navi & Mani + *Multi Objects* + *Optimal Path with 2 Arms* | 72.04% | 74.21% | 28.12 | 28.51 | 5.60 (66.07%) | 5.61 (64.32%) | 38.25 | 39.17 |
| Navi & Mani + *Multi Objects* + *Temp Dependency* | 58.60% | 60.35% | 43.43 | 41.04 | 6.00 (64.05%) | 5.96 (62.71%) | 51.38 | 45.52 |

# Case Study: An Example of a Spatial constrained task


Can you get the box on the wall shelf?


1: Walk to the livingroom

2: Walk to the wall shelf (1)

3: Walk to the wall shelf (2)

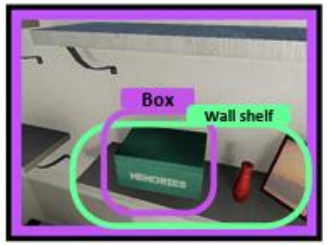
4: Walk to the wall shelf (3)


5: Walk to the bedroom

6: Walk to the wall shelf (4)

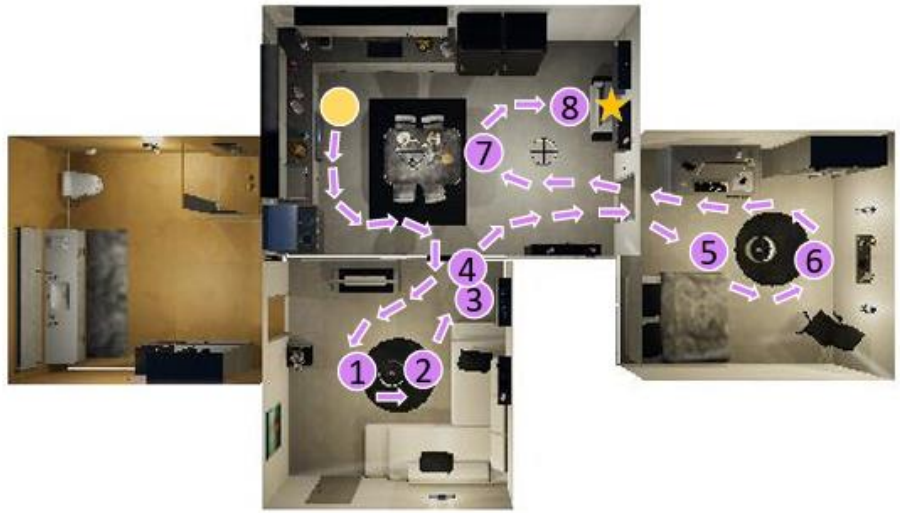

7: Walk to the kitchen


8: Walk to the box



Detected object


Final state




**Navi + Relation**

**Task: Can you get the box on the wall shelf?**

1: Walk to the livingroom
2: Walk to the wall shelf (1)
3: Walk to the wall shelf (2)
4: Walk to the wall shelf (3)
5: Walk to the bedroom
6: Walk to the wall shelf (4)
7: Walk to the kitchen
8: Walk to the box