

LANGUAGE MODELS AS ZERO-SHOT PLANNERS: EXTRACTING ACTIONABLE KNOWLEDGE FOR EM- BODIED AGENTS

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A APPENDIX

A.1 EXAMPLE PROGRAM IN VIRTUALHOME

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[Walk] < living_room > (1)
[Walk] < television > (1)
[Find] < television > (1)
[SwitchOn] < television > (1)
[Find] < sofa > (1)
[Sit] < sofa > (1)
[TurnTo] < television > (1)
[Watch] < television > (1)
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Table 1: An example program for the activity "Relax on sofa".

A.2 EXAMPLE PROMPT CONTAINING STEP-BY-STEP INSTRUCTIONS

Task: Read book Description: Walk to home office, turn on light, grab a book, sit in chair, start to read the book. Step 1: Walk to home office Step 2: Walk to light Step 3: Find light Step 4: Switch on light Step 5: Find novel Step 6: Grab novel Step 7: Find chair	Step 8: Sit on chair Step 9: Read novel Task: Find dictionary Description: Move towards the bookshelf, scan the bookshelf for the dictionary, when the dictionary is found, pick up the dictionary.
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Figure 1: An example prompt containing step-by-step instructions.

A.3 HYPERPARAMETER SEARCH

For each evaluated method, we perform grid search over the following hyperparameters:

Name	Description	Search Values
epsilon (ϵ)	OOD cutoff threshold used in iterative action translation	{0, 0.4, 0.8}
temperature	sampling parameter adjusting relative probabilities across tokens	{0.1, 0.3, 0.6}
k	number of samples generated when querying LMs each time	{1, 10}
frequence_penalty	OpenAI API specific; penalize new tokens based on their existing frequency in the text so far	{0.1, 0.3, 0.6, 0.9}
presence_penalty	OpenAI API specific; penalize new tokens based on whether they appear in the text so far	{0.3, 0.5, 0.8}
repetition_penalty	Hugging Face Transformers specific; penalize new tokens based on whether they are repeating existing text	{1.0, 1.2, 1.5, 1.8}

For methods that use fixed example across evaluated tasks, we search over the following three randomly chosen examples:

Example 1	Example 2	Example 3
Task: Use computer Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard	Task: Relax on sofa Step 1: Walk to home office Step 2: Walk to couch Step 3: Find couch Step 4: Sit on couch Step 5: Find pillow Step 6: Lie on couch	Task: Read book Step 1: Walk to home office Step 2: Walk to novel Step 3: Find novel Step 4: Grab novel Step 5: Find chair Step 6: Sit on chair Step 7: Read novel

A.4 RANDOM SAMPLES OF GT, VANILLA CODEX, AND TRANSLATED CODEX

Annotated Ground-Truth	Codex	Translated Codex (Ours)
Task: Go to sleep Step 1: Walk to bedroom Step 2: Walk to bed Step 3: Find bed Step 4: Turn to bed Step 5: Look at bed Step 6: Sit on bed Step 7: Sleep	Task: Go to sleep Step 1: Walk to bedroom Step 2: Walk to bed Step 3: Find bed Step 4: Sit on bed Step 5: Find pillow Step 6: Sleep on pillow	Task: Go to sleep Step 1: Walk to bedroom Step 2: Walk to bed Step 3: Lie on bed Step 4: Sleep
Task: Browse internet Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard	Task: Browse internet Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard	Task: Browse internet Step 1: Walk to home office Step 2: Walk to desk Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Find mouse Step 8: Grab mouse Step 9: Turn to computer Step 10: Point at computer

<p>Task: Listen to music Step 1: Walk to bedroom Step 2: Walk to computer Step 3: Find computer Step 4: Turn to computer Step 5: Look at computer Step 6: Walk to computer Step 7: Find chair Step 8: Pull chair Step 9: Sit on chair Step 10: Find headset Step 11: Grab headset Step 12: Put on headset Step 13: Switch on computer Step 14: Find keyboard Step 15: Type on keyboard</p>	<p>Task: Listen to music Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard</p>	<p>Task: Listen to music Step 1: Walk to home office Step 2: Walk to computer Step 3: Sit on chair Step 4: Switch on computer Step 5: Find music stand</p>
<p>Task: Brush teeth Step 1: Walk to bathroom Step 2: Walk to tooth paste Step 3: Find tooth paste Step 4: Grab tooth paste Step 5: Find toothbrush Step 6: Grab toothbrush</p>	<p>Task: Brush teeth Step 1: Walk to bathroom Step 2: Walk to sink Step 3: Find toothbrush Step 4: Pick up toothbrush Step 5: Put toothbrush in mouth Step 6: Move brush around mouth for two minutes Step 7: Spit out toothpaste and brush into sink Step 8: Turn on water in sink and rinse brush for one minute Step 9: Turn off water in sink and return brush to cupboard</p>	<p>Task: Brush teeth Step 1: Walk to bathroom Step 2: Open door Step 3: Walk to sink Step 4: Put pot on sink Step 5: Put brush on toothbrush Step 6: Turn to toothpaste Step 7: Put toothpaste on toothbrush Step 8: Put teeth on toothbrush</p>
<p>Task: Dry soap bottles Step 1: Find towel Step 2: Find soap Step 3: Grab soap Step 4: Wipe soap Step 5: Put back soap Step 6: Find shampoo Step 7: Grab shampoo Step 8: Wipe shampoo Step 9: Put back shampoo Step 10: Find shampoo Step 11: Grab shampoo Step 12: Wipe shampoo Step 13: Put back shampoo</p>	<p>Task: Dry soap bottles Step 1: Walk to kitchen Step 2: Walk to sink Step 3: Find sink Step 4: Turn on water tap Step 5: Wait for water to be hot enough Step 6: Fill container with hot water Step 7: Find soap bottles Step 8: Pour soap into container with hot water Step 9: Wait for soap to dissolve in water Step 10: Turn off tap and empty container into sink</p>	<p>Task: Dry soap bottles Step 1: Walk to bathroom Step 2: Walk to shower Step 3: Find soap</p>

<p>Task: Vacuum</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to computer</p> <p>Step 3: Find vacuum cleaner</p> <p>Step 4: Switch on vacuum cleaner</p> <p>Step 5: Switch off vacuum cleaner</p>	<p>Task: Vacuum</p> <p>Step 1: Walk to hallway</p> <p>Step 2: Walk to closet</p> <p>Step 3: Find closet</p> <p>Step 4: Open closet</p> <p>Step 5: Find vacuum cleaner</p> <p>Step 6: Turn on vacuum cleaner</p> <p>Step 7: Walk to living room</p> <p>Step 8: Vacuum floor in living room</p>	<p>Task: Vacuum</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to dresser</p> <p>Step 3: Open dresser</p> <p>Step 4: Find vacuum cleaner</p> <p>Step 5: Grab vacuum cleaner</p> <p>Step 6: Pull vacuum cleaner</p> <p>Step 7: Plug in vacuum cleaner</p> <p>Step 8: Switch on vacuum cleaner</p> <p>Step 9: Pull vacuum cleaner</p> <p>Step 10: Push vacuum cleaner</p>
<p>Task: Find dictionary</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to bookshelf</p> <p>Step 3: Turn to bookshelf</p> <p>Step 4: Look at bookshelf</p> <p>Step 5: Turn to bookshelf</p> <p>Step 6: Look at bookshelf</p> <p>Step 7: Turn to bookshelf</p> <p>Step 8: Look at bookshelf</p> <p>Step 9: Turn to bookshelf</p> <p>Step 10: Look at bookshelf</p> <p>Step 11: Turn to bookshelf</p> <p>Step 12: Look at bookshelf</p> <p>Step 13: Turn to bookshelf</p> <p>Step 14: Look at bookshelf</p> <p>Step 15: Find novel</p> <p>Step 16: Grab novel</p>	<p>Task: Find dictionary</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find dictionary</p> <p>Step 6: Open dictionary</p> <p>Step 7: Look at dictionary</p>	<p>Task: Find dictionary</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to book</p> <p>Step 3: Find textbook</p>
<p>Task: Wash monitor</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to computer</p> <p>Step 3: Find computer</p> <p>Step 4: Turn to computer</p> <p>Step 5: Look at computer</p> <p>Step 6: Switch off computer</p> <p>Step 7: Find brush</p> <p>Step 8: Turn to brush</p> <p>Step 9: Look at brush</p> <p>Step 10: Grab brush</p> <p>Step 11: Wipe computer</p> <p>Step 12: Drop brush</p> <p>Step 13: Find napkin</p> <p>Step 14: Grab napkin</p> <p>Step 15: Wash napkin</p> <p>Step 16: Wipe computer</p>	<p>Task: Wash monitor</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find computer</p> <p>Step 6: Switch on computer</p> <p>Step 7: Turn to computer</p> <p>Step 8: Look at computer</p> <p>Step 9: Find keyboard</p> <p>Step 10: Type on keyboard</p>	<p>Task: Wash monitor</p> <p>Step 1: Walk to check</p> <p>Step 2: Walk to desk</p>
<p>Task: Read newspaper</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find newspaper</p> <p>Step 6: Grab newspaper</p> <p>Step 7: Open newspaper</p> <p>Step 8: Read newspaper</p>	<p>Task: Read newspaper</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find newspaper</p> <p>Step 6: Open newspaper</p> <p>Step 7: Read newspaper</p>	<p>Task: Read newspaper</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find newspaper</p> <p>Step 6: Grab newspaper</p> <p>Step 7: Read newspaper</p>

<p>Task: Apply lotion Step 1: Find bed Step 2: Turn to bed Step 3: Point at bed Step 4: Wash bed Step 5: Turn to bed Step 6: Look at bed Step 7: Push bed Step 8: Sit on bed</p>	<p>Task: Apply lotion Step 1: Walk to bathroom Step 2: Walk to cabinet Step 3: Open cabinet Step 4: Find lotion Step 5: Apply lotion on hands Step 6: Rub hands together for 10 seconds Step 7: Apply lotion on face</p>	<p>Task: Apply lotion Step 1: Walk to bathroom Step 2: Turn to lotionbottle Step 3: Grab lotionbottle</p>
<p>Task: Draw picture Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find desk Step 6: Open desk Step 7: Find check Step 8: Grab check Step 9: Put check on desk Step 10: Find pencil Step 11: Grab pencil Step 12: Close desk</p>	<p>Task: Draw picture Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard</p>	<p>Task: Draw picture Step 1: Walk to home office Step 2: Walk to wall Step 3: Walk to drawing Step 4: Find drawing Step 5: Turn to drawing Step 6: Look at drawing Step 7: Touch drawing Step 8: Pull drawing Step 9: Push drawing</p>
<p>Task: Prepare pot of boiling water Step 1: Walk to dining room Step 2: Walk to pot Step 3: Find pot Step 4: Grab pot Step 5: Walk to sink Step 6: Find faucet Step 7: Switch on faucet Step 8: Put pot on sink Step 9: Grab pot Step 10: Switch off faucet Step 11: Grab pot Step 12: Walk to oven Step 13: Put pot on oven Step 14: Switch on oven</p>	<p>Task: Prepare pot of boiling water Step 1: Walk to kitchen Step 2: Walk to sink Step 3: Find sink Step 4: Turn on tap Step 5: Fill kettle with water Step 6: Put kettle on stove Step 7: Turn on stove Step 8: Wait for water to boil</p>	<p>Task: Prepare pot of boiling water Step 1: Walk to kitchen Step 2: Walk to cabinet Step 3: Find pot Step 4: Grab pot Step 5: Walk to stove Step 6: Find stove Step 7: Switch on stove</p>
<p>Task: Look at mirror Step 1: Walk to bathroom Step 2: Walk to mirror Step 3: Find mirror Step 4: Turn to mirror Step 5: Look at mirror</p>	<p>Task: Look at mirror Step 1: Walk to bathroom Step 2: Walk to mirror Step 3: Look at mirror</p>	<p>Task: Look at mirror Step 1: Walk to bedroom Step 2: Walk to mirror Step 3: Find mirror Step 4: Turn to mirror Step 5: Look at mirror</p>
<p>Task: Wipe down sink Step 1: Walk to dining room Step 2: Walk to rag Step 3: Find rag Step 4: Grab rag Step 5: Walk to sink Step 6: Wipe sink Step 7: Put back rag</p>	<p>Task: Wipe down sink Step 1: Walk to kitchen Step 2: Walk to sink Step 3: Find sink Step 4: Wipe down sink Step 5: Return to kitchen</p>	<p>Task: Wipe down sink Step 1: Walk to bathroom Step 2: Walk to cleaning solution Step 3: Find cleaning solution Step 4: Grab cleaning solution Step 5: Find sink Step 6: Pour cleaning solution into glasses Step 7: Find faucet Step 8: Switch on faucet Step 9: Scrub sink Step 10: Wash sink</p>

<p>Task: Complete surveys on amazon turk</p> <p>Step 1: Walk to chair</p> <p>Step 2: Sit on chair</p> <p>Step 3: Find computer</p> <p>Step 4: Switch on computer</p> <p>Step 5: Turn to computer</p> <p>Step 6: Look at computer</p> <p>Step 7: Find mouse</p> <p>Step 8: Grab mouse</p> <p>Step 9: Turn to computer</p> <p>Step 10: Point at computer</p> <p>Step 11: Find check</p> <p>Step 12: Grab check</p> <p>Step 13: Read check</p> <p>Step 14: Put back mouse</p> <p>Step 15: Find keyboard</p> <p>Step 16: Type on keyboard</p>	<p>Task: Complete surveys on amazon turk</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find computer</p> <p>Step 6: Switch on computer</p> <p>Step 7: Turn to computer</p> <p>Step 8: Look at computer</p> <p>Step 9: Find keyboard</p> <p>Step 10: Type on keyboard</p>	<p>Task: Complete surveys on amazon turk</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to desk</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find computer</p> <p>Step 6: Switch on computer</p>
<p>Task: Write book</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to laptop</p> <p>Step 3: Find laptop</p> <p>Step 4: Grab laptop</p> <p>Step 5: Find electrical outlet</p> <p>Step 6: Plug in laptop</p> <p>Step 7: Walk to love seat</p> <p>Step 8: Sit on love seat</p> <p>Step 9: Switch on laptop</p> <p>Step 10: Find keyboard</p> <p>Step 11: Type on keyboard</p>	<p>Task: Write book</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find computer</p> <p>Step 6: Switch on computer</p> <p>Step 7: Turn to computer</p> <p>Step 8: Look at computer</p> <p>Step 9: Find keyboard</p> <p>Step 10: Type on keyboard</p>	<p>Task: Write book</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to light</p> <p>Step 3: Find light</p> <p>Step 4: Switch on light</p> <p>Step 5: Find pen</p> <p>Step 6: Grab pen</p> <p>Step 7: Find chair</p> <p>Step 8: Sit on chair</p> <p>Step 9: Turn to novel</p>
<p>Task: Paint ceiling</p> <p>Step 1: Find drawing</p> <p>Step 2: Turn to drawing</p> <p>Step 3: Point at drawing</p> <p>Step 4: Watch drawing</p> <p>Step 5: Touch drawing</p> <p>Step 6: Walk to bedroom</p>	<p>Task: Paint ceiling</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to chair</p> <p>Step 3: Find chair</p> <p>Step 4: Sit on chair</p> <p>Step 5: Find paint can</p> <p>Step 6: Open paint can</p> <p>Step 7: Pour paint into paint can</p> <p>Step 8: Close paint can</p> <p>Step 9: Find roller</p> <p>Step 10: Roll paint onto ceiling</p>	<p>Task: Paint ceiling</p> <p>Step 1: Walk to home office</p> <p>Step 2: Walk to ceiling</p> <p>Step 3: Walk to painting</p> <p>Step 4: Find painting</p> <p>Step 5: Turn to painting</p> <p>Step 6: Look at painting</p> <p>Step 7: Touch painting</p> <p>Step 8: Pull painting</p> <p>Step 9: Push painting</p>
<p>Task: Change clothes</p> <p>Step 1: Walk to bedroom</p> <p>Step 2: Walk to dresser</p> <p>Step 3: Open dresser</p> <p>Step 4: Find dress</p> <p>Step 5: Grab dress</p> <p>Step 6: Put on dress</p> <p>Step 7: Close dresser</p>	<p>Task: Change clothes</p> <p>Step 1: Walk to closet</p> <p>Step 2: Open closet</p> <p>Step 3: Find clothes</p> <p>Step 4: Put on clothes</p> <p>Step 5: Close closet</p>	<p>Task: Change clothes</p> <p>Step 1: Walk to bedroom</p> <p>Step 2: Walk to dresser</p> <p>Step 3: Find dresser</p> <p>Step 4: Open dresser</p> <p>Step 5: Find pants</p> <p>Step 6: Grab pants</p> <p>Step 7: Put on pants</p> <p>Step 8: Find shirt</p> <p>Step 9: Grab shirt</p> <p>Step 10: Put on shirt</p> <p>Step 11: Close dresser</p>

<p>Task: Make bed Step 1: Walk to bedroom Step 2: Walk to bed Step 3: Find sheets Step 4: Grab sheets Step 5: Pull sheets</p>	<p>Task: Make bed Step 1: Walk to bedroom Step 2: Walk to bed Step 3: Find bed Step 4: Sit on bed Step 5: Find sheet Step 6: Pick up sheet Step 7: Find pillow Step 8: Pick up pillow Step 9: Find blanket Step 10: Pick up blanket</p>	<p>Task: Make bed Step 1: Stand up Step 2: Walk to bedroom Step 3: Walk to bed Step 4: Turn to bed Step 5: Put sheets on bed</p>
<p>Task: Read yourself to sleep Step 1: Walk to bedroom Step 2: Walk to novel Step 3: Find novel Step 4: Grab novel Step 5: Find bed Step 6: Sit on bed Step 7: Find bookmark Step 8: Grab bookmark Step 9: Read novel Step 10: Put bookmark on novel Step 11: Sleep</p>	<p>Task: Read yourself to sleep Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard</p>	<p>Task: Read yourself to sleep Step 1: Walk to bedroom Step 2: Walk to book Step 3: Sit on chair Step 4: Read check Step 5: Sleep</p>
<p>Task: Hang keys Step 1: Walk to bedroom Step 2: Walk to dresser Step 3: Find purse Step 4: Grab purse Step 5: Open purse Step 6: Find keys Step 7: Grab keys Step 8: Find bowl Step 9: Put keys on bowl Step 10: Close purse Step 11: Put back purse</p>	<p>Task: Hang keys Step 1: Walk to home office Step 2: Walk to chair Step 3: Find chair Step 4: Sit on chair Step 5: Find computer Step 6: Switch on computer Step 7: Turn to computer Step 8: Look at computer Step 9: Find keyboard Step 10: Type on keyboard</p>	<p>Task: Hang keys Step 1: Walk to home office Step 2: Walk to table Step 3: Find keys Step 4: Grab keys Step 5: Walk to wall Step 6: Find hanger Step 7: Put keys on hanger</p>
<p>Task: Eat cheese Step 1: Walk to dining room Step 2: Walk to freezer Step 3: Open freezer Step 4: Find cheese Step 5: Grab cheese Step 6: Eat cheese</p>	<p>Task: Eat cheese Step 1: Walk to fridge Step 2: Open fridge Step 3: Find cheese Step 4: Pick up cheese Step 5: Walk to table Step 6: Place cheese on table Step 7: Close fridge Step 8: Walk to chair Step 9: Sit on chair Step 10: Eat cheese</p>	<p>Task: Eat cheese Step 1: Walk to dining room Step 2: Walk to table Step 3: Find table Step 4: Turn to table Step 5: Find chair Step 6: Sit on chair Step 7: Find food Step 8: Grab food Step 9: Find plate Step 10: Put food on plate</p>