Consent form

I am Sarath Sreedharan, an Assistant Professor in the Computer Science Department at Colorado State University. I am conducting a research study to find out the effectiveness of various ways in which you can interact with an AI agent (robot). The study aims to understand how collaborative decision-making between a human and an AI agent can be improved through the use of various interaction mediums. The study will involve the participants observing a series of task settings and asking them to provide an instruction to the AI agents to achieve some objective. You will be compensated $18.5 for participating in the study. We will need to record all the responses provided by the participants during the study, and each participant would additionally need to complete a questionnaire at the end to be eligible for your payment. The study will last less than 60 minutes. You have the right not to answer any question and to stop participation at any time without penalty. Your participation in this study is completely voluntary. Participating in this study will help us improve AI agents to work effectively with people. There are no foreseeable risks or discomforts associated with your participation nor will you have direct benefits from participating. To protect your privacy, responses from participants will never be used individually while compiling or presenting the results of the study. The results of this study may be used in reports, presentations, or publications only in aggregate form. There will be no audio/video recording.

Benefits: There are no benefits associated with participating in the study. If you have any questions about the research, please contact me, Sarath Sreedharan at email: ssreedh3@colostate.edu Phone: (970) 491-5792. If you have any questions about your rights as a volunteer in this research, contact the CSU IRB at: CSU_IRB@colostate.edu; 970-491-1553.

Prolific Id

By clicking the accept button you are agreeing to be part of the study.

- Accept

→

Study overview

This study is composed of **3 cases** where you will observe a robot's actions and then, according to the survey, be asked to come up with a specification that generates its observed behavior (i.e., the observed sequence of robot actions). In the study, there is no **"Back"** button available. Once you proceed to the next page, you won't be able to go back to the previous page.

Instructions

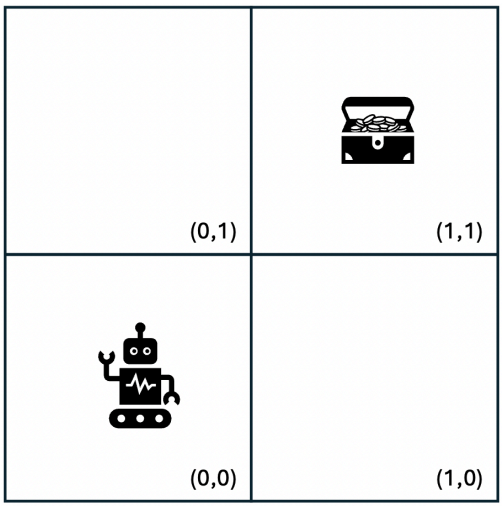
Please take a moment to understand the key concepts.

Definitions:

- A state captures the current configuration of the robot environment at any point in time. For our purposes, we will represent a state by a set of facts that are true about the environment at a given time.
- A fact is some description of the environment that can either be true or false. Facts are only changed as a result of the robot's actions.

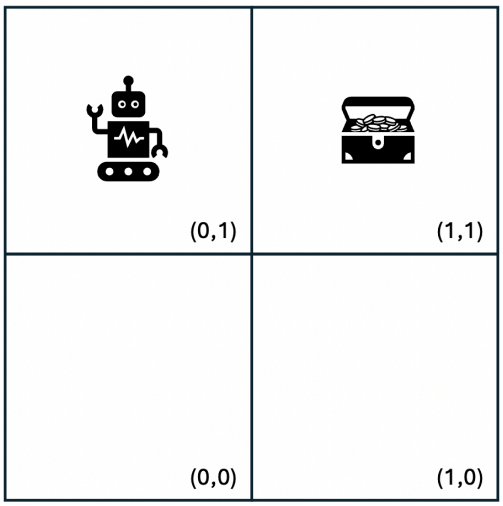
The example:

- Consider robot operates in a grid of cells labeled with two digits, e.g., (0,0), (0,1), (1,0), and (1,1).
- Each cell can be empty, have a robot, or have a treasure.
- The robot's possible actions include: moving **up** ↑, **down** ↓, **right** →, **left** ← .
- Please see the following illustration:



Initially, the following facts are true in the initial state: The robot is at cell (0,0), and the

treasure is at cell (1,1).



After the robot takes the action moving **up** ↑, the facts that are true in the new state are: The robot is at cell (0,1), and the treasure is at cell (1,1).

Objective Specification Mechanisms

- The objective specification mechanism refers to the process of giving or defining objectives that will guide the robot.
- There are two widely used mechanisms:
  1) Objective specification mechanism - Facts: You will choose a set of facts you want the robot to achieve. The robot will then generate a behavior that will achieve the tasks in the least number of steps and then exit the task.
  2) Objective specification mechanism - Scores: You will assign points to the robot for doing some actions in the presence of some facts. The objective of the robot would be to generate behaviors that maximize the total points it gets.

→

Robot Navigation Domain

This domain comprises of **two surveys**: An **Objective Specification Mechanism - Facts** survey and an **Objective Specification Mechanism - Scores** survey.

The environment:

- Consider robot operates in a small workspace (see Figure 1).

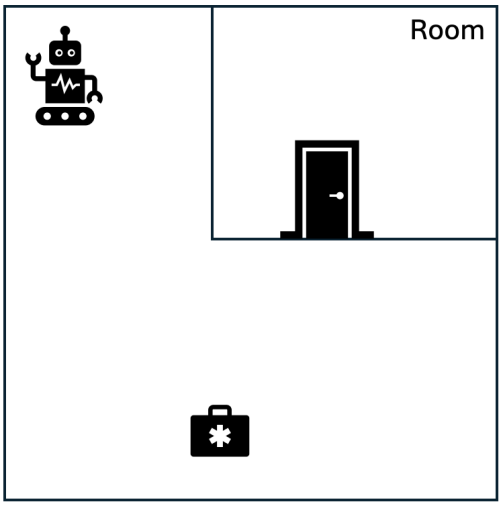


Figure 1: Starting position

- The facts that are initially **true** include:

    1. The door is closed,
    2. The robot is not holding the suitcase,
    3. The suitcase is outside the room.

- The facts that are initially **false** include:

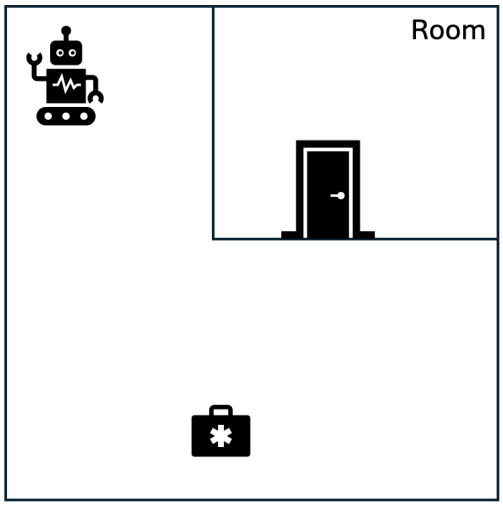
    1. The door is open,
    2. The robot is holding the suitcase,
    3. The suitcase is inside the room.

- Now, the actions the robot can perform will include:

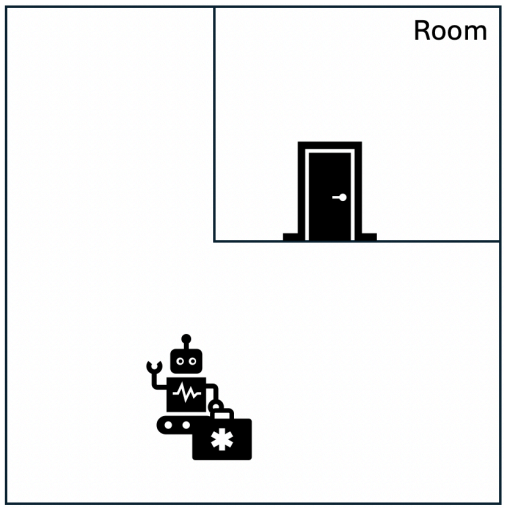
    1. Open the door,
    2. Pick up the suitcase outside the room,
    3. Dropoff the suitcase inside the room,
    4. Exit the task.

- Note that there are some restrictions to robot actions. The robot will have to open the door before it can drop off the suitcase inside the room. Also, it needs to pick up the suitcase before it can drop it off and cannot pick up the suitcase once it's dropped off.
- Exiting the task just stops the task.

Illustration:



Initially, the following facts are true in the initial state: The door is closed, the robot is not holding the suitcase, and the suitcase is outside the room.



After the action pick up the suitcase outside the room → The facts that are true in the new state are: The door is closed, the robot is holding the suitcase, and the suitcase is outside the room.

→

Objective Specification Mechanism - Facts

→

Objective Specification Mechanism - Facts

Under this specification mechanism, **you are asked to choose a set of facts that the robot will need to achieve at the end state**. Once the robot achieves a state, where all the specified facts are true, it will exit the task. The robot will try to achieve its specified objectives in the least number of steps.

Example description

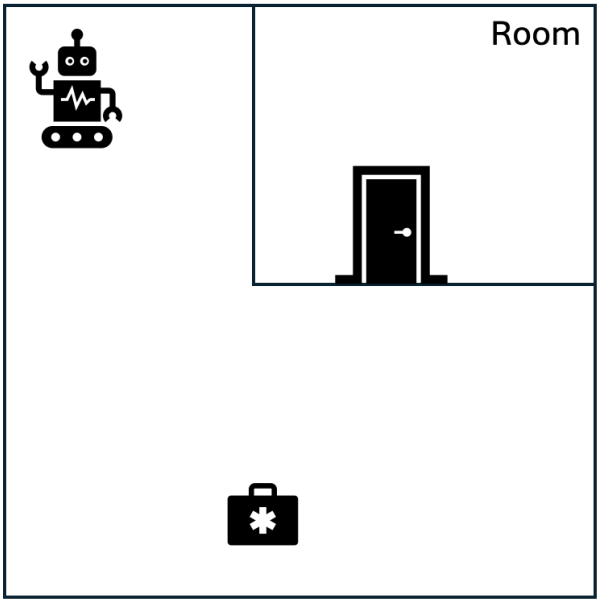


Figure 1: Example environment

Facts

The facts that can be true in the Figure 1 example are as follows:

1. The door is closed
2. The door is open
3. The robot is holding the suitcase
4. The robot is not holding the suitcase
5. The suitcase is inside the room
6. The suitcase is outside the room.

Actions

The actions that can be taken in the Figure 1 example are as follows:

1. Open the door
2. Pick up the suitcase outside the room
3. Dropoff the suitcase inside the room
4. Exit the task.

Note: *These actions allow the robot to navigate the environment effectively. The* **Exit the task** *action is enabled at the end of the robot's execution, when the task is achieved.*

Facts scheme:

- A fact cannot be true and false at the same time.
- Several facts can be true at the same time.
- Some facts can be incompatible with each other, that is, they cannot be true at the same time. For example, the fact that "The suitcase is inside the room" and "The suitcase is outside the room" cannot be true at the same time.

Example illustration

For this example, watch the robot move through the scene while the list of the **Facts that are true** (Current State) is changing during its navigation.

Facts to be achieved will be The robot is holding the suitcase.

0:00 / 0:04

Objective Specification Mechanism - Facts

For this demonstration example, what fact(s) about the environment are true at the end of the robot execution that is the end state?

- [ ] The robot is not holding the suitcase
- [ ] The robot is holding the suitcase
- [ ] The door is open
- [ ] The suitcase is outside the room
- [ ] The door is closed
- [ ] The suitcase is inside the room

→

Test section

0657

Test description

Welcome to the Robot Scenario test! In this test, you'll step into the world of a robot that needs to pick up and drop off a suitcase at different locations.

You will have 7 minutes to complete this test, as indicated by the timer at the beginning of the page.

Test illustration

After playing the following video and observing the robot's behavior, please choose the adequate facts in the **Objective Specification Mechanism - Facts** that will result in the same behavior.


0:00 / 0:09

Objective Specification Mechanism - Facts

Drag the adequate Fact(s) that will allow us to recreate the same behavior seen in the previous video and drop them into the Facts to be achieved. Try to list the minimal number of facts to be achieved, that will generate the expected behavior.

Facts

The door is closed

The robot is not holding the suitcase

The suitcase is inside the room

The suitcase is outside the room

The robot is holding the suitcase

The door is open

Facts to be achieved

At the end of the scenario, where was the suitcase?

inside the room ○ outside the room ○

→

Please use the sliders below to answer each of the provided questions.

How much mental and perceptual activity, was required (eg., thinking. deciding, calculating, remembering. looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**
0 20

Mental Demand

How much physical activity was required (e.g.. pushing, pulling, turning. controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous restful or laborious?

Low **High**
0 20

Physical Demand

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low **High**
0 20

Temporal Demand

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Poor **Good**
0 20

Performance

Please move the slider to ten to show you are paying attention to this question.

Low **High**
0 20

Slider

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**
0 20

Effort

How insecure, discouraged, irritated. stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**
0 20

Frustration

For the following pair-wise comparisons of the six scales (**Mental Demand**, **Physical Demand**, **Temporal Demand**, **Performance**, **Effort**, **Frustration**) choose the one that contributed more to the workload of this survey.

Effort Performance

Temporal Demand Frustration

Temporal Demand Effort

Physical Demand Frustration

Performance Frustration

Physical Demand Temporal Demand

Physical Demand Performance

Temporal Demand Mental Demand

Frustration Effort

Performance Mental Demand

Performance Temporal Demand

Mental Demand Effort

Mental Demand Physical Demand

Effort

Physical Demand

Frustration

Mental Demand

→

Objective Specification Mechanism - Scores

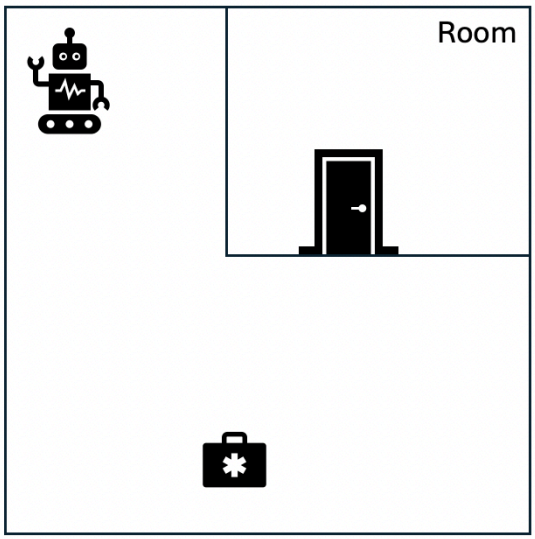
→

Objective Specification Mechanism - Scores

Under this specification mechanism, **you are asked to assign some points to the robot doing an action in the presence of some facts**. Now, when the robot performs an action in a state, the score for each fact adds up, and the robot gets a total point. If you don't specify a number for an action fact pair, it will by default get a value of zero. The robot will try to achieve its specified objectives in the least number of steps.

Example description

Task:
The robot is holding the suitcase



Available actions

Available facts	Open the door	Pick up the suitcase outside the room	Dropoff the suitcase inside the room	Exit the task
The door is closed	-1	0	0	0
The door is open	-1	0	0	0
The robot is holding the suitcase	-1	0	0	50
The robot is not holding the suitcase	-1	0	0	0
The suitcase is inside the room	-1	0	0	0
The suitcase is outside the room	-1	0	0	0

Figure 1: Example environment with a scoring scheme.

In this example, we'll explore pairs of the form **<Fact, Action>** within a robot task.

The example **Facts** that can be achieved:

1. The door is closed
2. The door is open
3. The robot is holding the suitcase
4. The robot is not holding the suitcase
5. The suitcase is inside the room
6. The suitcase is outside the room.

The example **Actions** that can be taken:

1. Open the door
2. Pick up the suitcase outside the room
3. Dropoff the suitcase inside the room
4. Exit the task.

Note: *These actions allow the robot to navigate the environment effectively. The* **Exit the task** *action is enabled at the end of the robot's execution, when the task is achieved.*

Scoring scheme:

- Default value: 0.
- The range of values that you can put in for each combination of fact and action is a number between -100 and 100.
- The robot takes actions so as to maximize the total points and you can penalize the robot for performing unnecessary actions by giving negative points.

Example illustration

Please watch the video to see the robot moving through the scene. As the robot moves through the scene, the **Total Points** change based on which **<Fact, Action>** pairs are true. To make it easier, we highlighted the **<Fact, Action>** pairs that are true at any given step.

You can notice that there is a color code for the highlighted pairs and scores:

- : current set of facts that are true and the actions being taken by the robot.
- : non-negative score.
- : negative score.

0:00 / 0:12

Objective Specification Mechanism - Scores

Make sure to fill out the **<Fact, Action>** pair(s) with the appropriate values from the above example.

Each cell in the table of scores will have a default value of zero. For the specification, update the relevant cells. If they are not updated, they will contribute zero points to the total score. The range of values that you can put in for each cell is a number between -100 and 100.

	Open the door	Pick up the suitcase outside the room	Dropoff the suitcase inside the room	Exit the task
The door is closed	0	0	0	0
The door is open	0	0	0	0
The robot is holding the suitcase	0	0	0	0
The robot is not holding the suitcase	0	0	0	0
The suitcase is inside the room	0	0	0	0
The suitcase is outside the room	0	0	0	0

☐ I have filled out the above table with the appropriate values.

→

Test section

0657

Test description

Welcome to the Robot Scenario test! In this test, you'll step into the world of a robot that needs to pick up and drop off a suitcase at different locations.

You will have 7 minutes to complete this test, as indicated by the timer at the beginning of the page.

Test illustration

After playing the following video and observing the robot's behavior, please fill out the **Objective Specification Mechanism - Scores** Table of **<Fact, Action>** pairs with adequate values that will result in the same behavior.

0:00 / 0:09

Objective Specification Mechanism - Scores

Each cell in the table of scores will have a default value of zero. For the specification, update the relevant cells. If they are not updated, they will contribute zero points to the total score. The range of values that you can put in for each cell is a number between -100 and 100. Try to fill in the minimal number of cells that will generate the expected behavior.

	Open the door	Pick up the suitcase outside the room	Dropoff the suitcase inside the room	Exit the task
The door is closed	0	0	0	0
The door is open	0	0	0	0

	Open the door	Pick up the suitcase outside the room	Dropoff the suitcase inside the room	Exit the task
The robot is holding the suitcase	0	0	0	0
The robot is not holding the suitcase	0	0	0	0
The suitcase is inside the room	0	0	0	0
The suitcase is outside the room	0	0	0	0

☐ I have filled out the above table with the appropriate values.

At the end of the scenario, where was the suitcase?

inside the room ○ outside the room ○

→

Powered by Qualtrics

Please use the sliders below to answer each of the provided questions.

How much mental and perceptual activity, was required (eg., thinking. deciding, calculating, remembering. looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**
0 20

Mental Demand

How much physical activity was required (e.g.. pushing, pulling, turning. controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous restful or laborious?

Low **High**
0 20

Physical Demand

Please move the slider to fourteen to show you are paying attention to this question.

Low **High**
0 20

Slider

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low **High**
0 20

Temporal Demand

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Poor **Good**
0 20

Performance

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**
0 20

Effort

How insecure, discouraged, irritated. stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**
0 20

Frustration

For the following pair-wise comparisons of the six scales (**Mental Demand**, **Physical Demand**, **Temporal Demand**, **Performance**, **Effort**, **Frustration**) choose the one that contributed more to the workload of this survey.

Effort Performance

Temporal Demand Frustration

Temporal Demand Effort

Physical Demand Frustration

Performance Frustration

Physical Demand Temporal Demand

Physical Demand Performance

Temporal Demand Mental Demand

Frustration Effort

Performance Mental Demand

Performance Temporal Demand

Mental Demand Effort

Mental Demand Physical Demand

Effort

Physical Demand

Frustration

Mental Demand

→

Self-Driving Vehicle Domain

This domain comprises of **two surveys**: An **Objective Specification Mechanism - Facts** survey and an **Objective Specification Mechanism - Scores** survey.

The environment:

- Consider a self-driving car operating in a small area (see Figure 1).

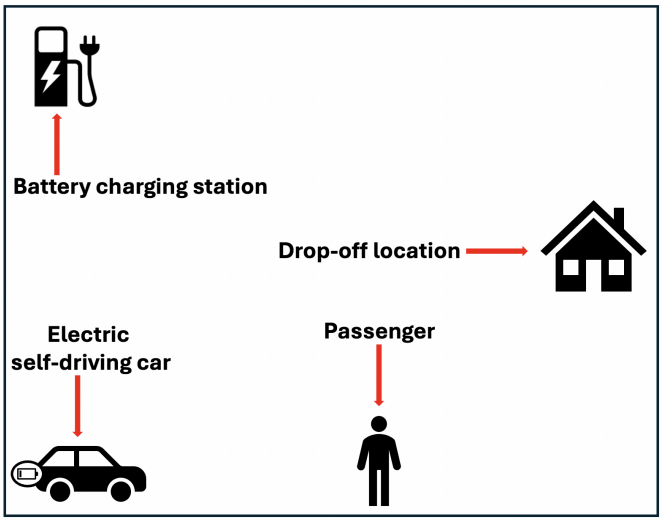


Figure 1: Starting position

- The facts that are initially **true** include:

    1. The car is empty,
    2. The passenger is not at the drop-off location,
    3. The car battery is not full.

- The facts that are initially **false** include:

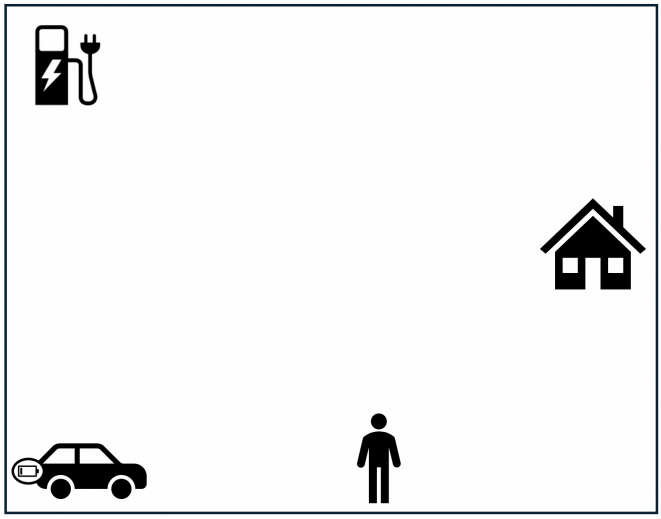
    1. The car has the passenger,
    2. The passenger is at the drop-off location,
    3. The car battery is full.

- Now, the actions the robot can perform will include:

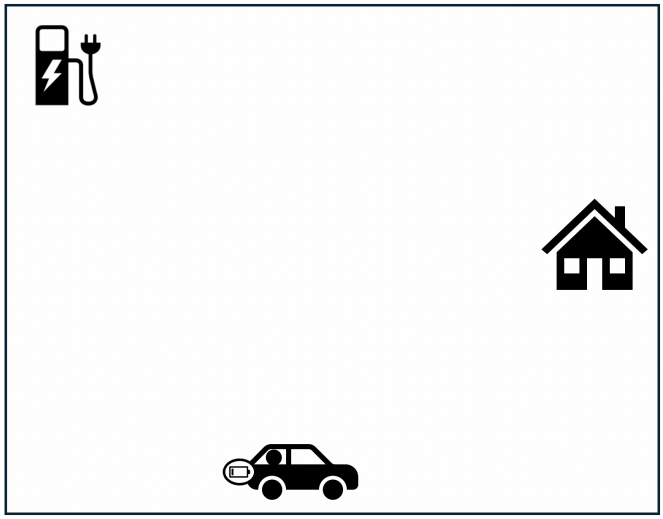
    1. Pick up the passenger from the initial position,
    2. Drop off the passenger at the drop-off location,
    3. Go to the battery charging station,
    4. Exit the task.

- Note that there are some restrictions to car actions. The car must be empty before it can pick up the passenger from the initial position. It needs to pick up the passenger before it can drop it off. It can only pick up a passenger once. Finally, it can go to the battery charge station if it is away from it and the passenger has been dropped off.
- Exiting the task just stops the task.

Illustration:



Initially, the following facts are true in the initial state: The car is empty, the passenger is not at the drop-off location, and the car battery is not full.



After the action pick up the passenger → The facts that are true in the new state are: The car has the passenger, the passenger is not at the drop-off location, and the car battery is not full.

→

Objective Specification Mechanism - Facts

→

Objective Specification Mechanism - Facts

Under this specification mechanism, **you are asked to choose a set of facts that the self-driving car will need to achieve at the end state**. Once the car achieves a state, where all the specified facts are true, it will exit the task. The car will try to achieve its specified objectives in the least number of steps.

Example description

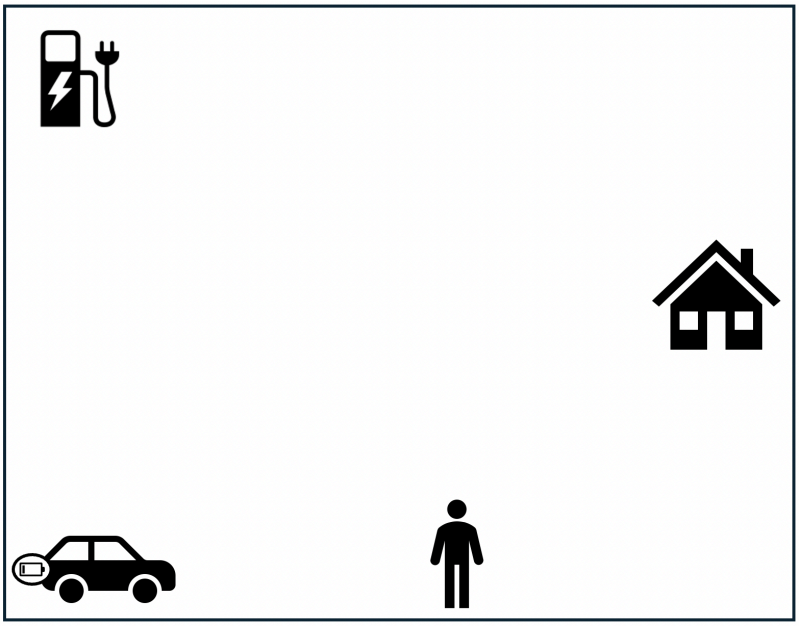


Figure 1: Example environment

Facts

The facts that can be true in the Figure 1 example are as follows:

1. The car is empty
2. The car has the passenger
3. The passenger is not at the drop-off location
4. The passenger is at the drop-off location
5. The car battery is not full
6. The car battery is full.

Actions

The actions that can be taken in the Figure 1 example are as follows:

1. Pick up the passenger from the initial position
2. Drop off the passenger at the drop-off location
3. Go to the battery charging station
4. Exit the task.

Note: *These actions allow the car to navigate the environment effectively. The* **Exit the task** *action is enabled at the end of the car's execution, when the task is achieved.*

Facts scheme:

- A fact cannot be true and false at the same time.
- Several facts can be true at the same time.
- Some facts can be incompatible with each other, that is, they cannot be true at the same time. For example, the fact that "The car is empty" and "The car has the passenger" cannot be true at the same time.

Example illustration

For this example, watch the car move through the scene while the list of the **Facts that are true** (Current State) is changing during its navigation.

Facts to be achieved will be The car has the passenger.

0:00 / 0:06

Objective Specification Mechanism - Facts

For this demonstration example, what fact(s) about the environment are true at the end of the car execution that is the end state?

- [ ] The passenger is not at the drop-off location
- [ ] The car has the passenger
- [ ] The car battery is full
- [ ] The car is empty
- [ ] The passenger is at the drop-off location
- [ ] The car battery is not full

→

Test section

0657

Test description

Welcome to the Self-Driving Car Scenario test! In this test, you'll step into the world of a self-driving car that needs to move at different locations.

You will have 7 minutes to complete this test, as indicated by the timer at the beginning of the page.

Test illustration

After playing the following video and observing the car's behavior, please choose the adequate facts in the **Objective Specification Mechanism - Facts** that will result in the same behavior.


0:00 / 0:29

Objective Specification Mechanism - Facts

Drag the adequate Fact(s) that will allow us to recreate the same behavior seen in the previous video and drop them into the Facts to be achieved. Try to list the minimal number of facts to be achieved, that will generate the expected behavior.

Facts

The passenger is at the drop-off location

The car battery is full

The passenger is not at the drop-off location

The car is empty

The car battery is not full

The car has the passenger

Facts to be achieved

At the end of the scenario, where was the car?

at the battery charging station ○

at the drop-off location ○

→

Please use the sliders below to answer each of the provided questions.

How much mental and perceptual activity, was required (eg., thinking. deciding, calculating, remembering. looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**
0 20

Mental Demand

How much physical activity was required (e.g.. pushing, pulling, turning. controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous restful or laborious?

Low **High**
0 20

Physical Demand

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low **High**
0 20

Temporal Demand

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Poor **Good**
0 20

Performance

Please move the slider to eight to show you are paying attention to this question.

Low **High**
0 20

Slider

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**
0 20

Effort

How insecure, discouraged, irritated. stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**
0 20

Frustration

For the following pair-wise comparisons of the six scales (**Mental Demand**, **Physical Demand**, **Temporal Demand**, **Performance**, **Effort**, **Frustration**) choose the one that contributed more to the workload of this survey.

Effort Performance

Temporal Demand Frustration

Temporal Demand Effort

Physical Demand Frustration

Performance Frustration

Physical Demand Temporal Demand

Physical Demand Performance

Temporal Demand Mental Demand

Frustration Effort

Performance Mental Demand

Performance Temporal Demand

Mental Demand Effort

Mental Demand Physical Demand

Effort

Physical Demand

Frustration

Mental Demand

→

Objective Specification Mechanism - Scores

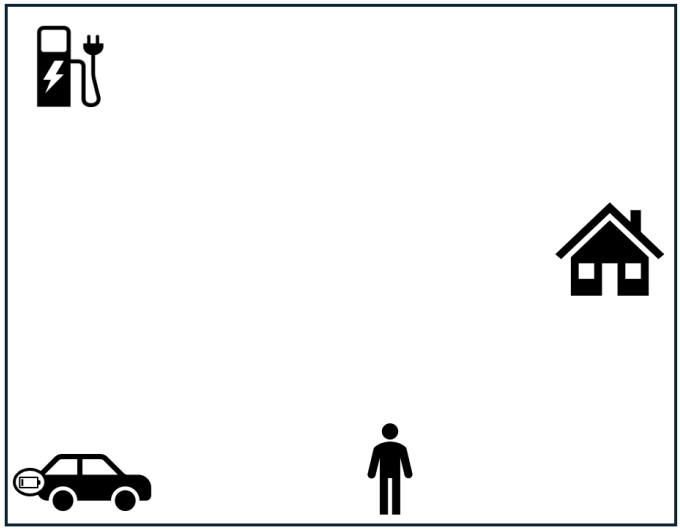
→

Objective Specification Mechanism - Scores

Under this specification mechanism, **you are asked to assign some points to the car doing an action in the presence of some facts**. Now, when the car performs an action in a state, the score for each fact adds up, and the car gets a total point. If you don't specify a number for an action fact pair, it will by default get a value of zero. The car will try to achieve its specified objectives in the least number of steps.

Example description

Task
The car has the passenger



Available facts	Pick up the passenger from the initial position	Drop off the passenger at the drop-off location	Go to the battery charging station	Exit the task
	Available actions			
The car is empty	0	0	-1	0
The car has the passenger	0	0	-1	50
The passenger is not at the drop-off location	0	0	-1	0
The passenger is at the drop-off location	0	0	-1	0
The car battery is not full	0	0	-1	0
The car battery is full	0	0	-1	0

Figure 1: Example environment with a scoring scheme.

In this example, we'll explore pairs of the form **<Fact, Action>** within a car task.

The example **Facts** that can be achieved:

1. The car is empty
2. The car has the passenger
3. The passenger is not at the drop-off location
4. The passenger is at the drop-off location
5. The car battery is not full
6. The car battery is full.

The example **Actions** that can be taken:

1. Pick up the passenger from the initial position
2. Drop off the passenger at the drop-off location
3. Go to the battery charging station
4. Exit the task.

Note: *These actions allow the car to navigate the environment effectively. The* **Exit the task** *action is enabled at the end of the car's execution, when the task is achieved.*

Scoring scheme:

- Default value: 0.
- The range of values that you can put in for each combination of fact and action is a number between -100 and 100.
- The car takes actions so as to maximize the total points and you can penalize the car for performing unnecessary actions by giving negative points.

Example illustration

Please watch the video to see the car moving through the scene. As the car moves through the scene, the **Total Points** change based on which **<Fact, Action>** pairs are true. To make it easier, we highlighted the **<Fact, Action>** pairs that are true at any given step.

You can notice that there is a color code for the highlighted pairs and scores:

- : current set of facts that are true and the actions being taken by the car.
- : non-negative score.
- : negative score.

0:00 / 0:12

Objective Specification Mechanism - Scores

Make sure to fill out the **<Fact, Action>** pair(s) with the appropriate values from the above example.

Each cell in the table of scores will have a default value of zero. For the specification, update the relevant cells. If they are not updated, they will contribute zero points to the total score. The range of values that you can put in for each cell is a number between -100 and 100.

	Pick up the passenger from the initial position	Drop off the passenger at the drop-off location	Go to the battery charging station	Exit the task
The car is empty	0	0	0	0
The car has the passenger	0	0	0	0
The passenger is not at the drop-off location	0	0	0	0
The passenger is at the drop-off location	0	0	0	0
The car battery is not full	0	0	0	0
The car battery is full	0	0	0	0

☐ I have filled out the above table with the appropriate values.

→

Test section

0657

Test description

Welcome to the Self-Driving Car Scenario test! In this test, you'll step into the world of a self-driving car that needs to move at different locations.

You will have 7 minutes to complete this test, as indicated by the timer at the beginning of the page.

Test illustration

After playing the following video and observing the car's behavior, please fill out the **Objective Specification Mechanism - Scores** Table of **<Fact, Action>** pairs with adequate values that will result in the same behavior.

0:00 / 0:29

Objective Specification Mechanism - Scores

Each cell in the table of scores will have a default value of zero. For the specification, update the relevant cells. If they are not updated, they will contribute zero points to the total score. The range of values that you can put in for each cell is a number between -100 and 100. Try to fill in the minimal number of cells that will generate the expected behavior.

	Pick up the passenger from the initial position	Drop off the passenger at the drop-off location	Go to the battery charging station	Exit the task
The car is empty	0	0	0	0

	Pick up the passenger from the initial position	Drop off the passenger at the drop-off location	Go to the battery charging station	Exit the task
The car has the passenger	0	0	0	0
The passenger is not at the drop-off location	0	0	0	0
The passenger is at the drop-off location	0	0	0	0
The car battery is not full	0	0	0	0
The car battery is full	0	0	0	0

☐ I have filled out the above table with the appropriate values.

At the end of the scenario, where was the car?

at the drop-off location ○ at the battery charging station ○

→

Please use the sliders below to answer each of the provided questions.

How much mental and perceptual activity, was required (eg., thinking. deciding, calculating, remembering. looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**
0 20

Mental Demand

How much physical activity was required (e.g.. pushing, pulling, turning. controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous restful or laborious?

Low **High**
0 20

Physical Demand

Please move the slider to sixteen to show you are paying attention to this question.

Low **High**
0 20

Slider

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low **High**
0 20

Temporal Demand

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Poor **Good**
0 20

Performance

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**
0 20

Effort

How insecure, discouraged, irritated. stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**
0 20

Frustration

For the following pair-wise comparisons of the six scales (**Mental Demand**, **Physical Demand**, **Temporal Demand**, **Performance**, **Effort**, **Frustration**) choose the one that contributed more to the workload of this survey.

Effort Performance

Temporal Demand Frustration

Temporal Demand Effort

Physical Demand Frustration

Performance Frustration

Physical Demand Temporal Demand

Physical Demand Performance

Temporal Demand Mental Demand

Frustration Effort

Performance Mental Demand

Performance Temporal Demand

Mental Demand Effort

Mental Demand Physical Demand

Effort

Physical Demand

Frustration

Mental Demand

→

Tabletop Pick and Place Domain

This domain comprises of **two surveys**: An **Objective Specification Mechanism - Facts** survey and an **Objective Specification Mechanism - Scores** survey.

The environment:

- Consider the robot's arm operating in a block world problem to rearrange blocks from a given position to some other position (see Figure 1).

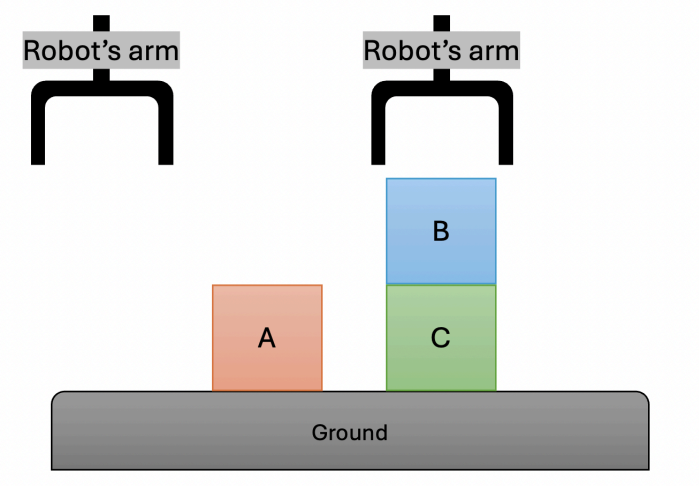


Figure 1: Starting position

- The facts that are initially **true** include:

    1. A on the ground,
    2. B on C,
    3. C on the ground.

- The facts that are initially **false** include:

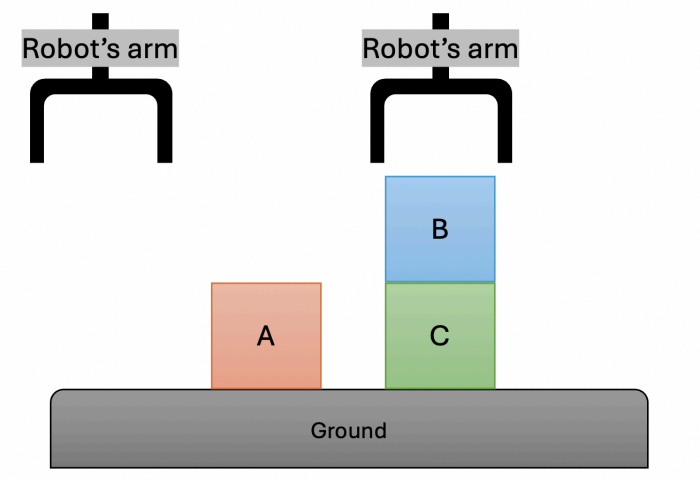
    1. A on B,
    2. A on C,
    3. B on the ground,
    4. B on A.

- Now, the actions the robot can perform will include:

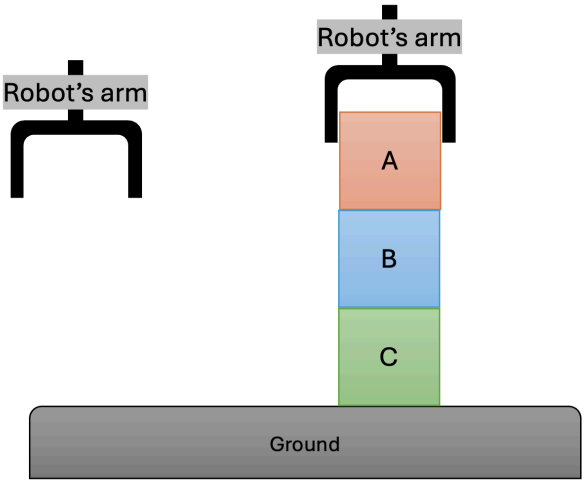
    1. Stack A on B,
    2. Swap A and B,
    3. Stack B on A,
    4. Exit the task.

- Note that there are some restrictions to robot actions. You can only stack a block on top of another block if there are no blocks on top of each block. You can only perform Swap A and B if A is on the table and there is no block on top of B. After the swap, B will be on the table.
- Exiting the task just stops the task.

Illustration:



Initially, the following facts are true in the initial state: A on the ground, B on C, and C on the ground.



After the action stack A on B → The facts that are true in the new state are: A on B, B on C, and C on the ground.

→

Objective Specification Mechanism - Facts

→

Objective Specification Mechanism - Facts

Under this specification mechanism, **you are asked to choose a set of facts that the robot will need to achieve at the end state**. Once the robot achieves a state, where all the specified facts are true, it will exit the task. The robot will try to achieve its specified objectives in the least number of steps.

Example description

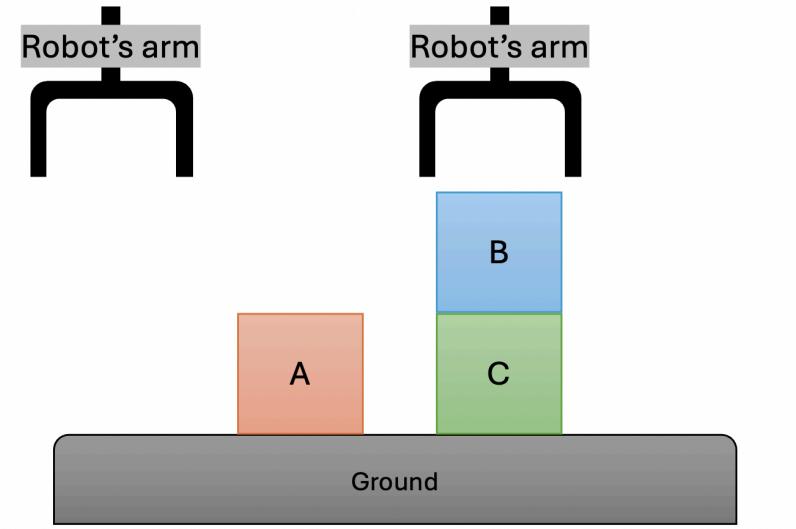


Figure 1: Example environment

Facts

The facts that can be true in the Figure 1 example are as follows:

1. A on the ground
2. A on B
3. A on C
4. B on the ground
5. B on A
6. B on C
7. C on the ground.

Actions

The actions that can be taken in the Figure 1 example are as follows:

1. Stack A on B
2. Swap A and B
3. Stack B on A
4. Exit the task.

Note: *These actions allow the robot's arm to navigate the environment effectively. The* **Exit the task** *action is enabled at the end of the robot's execution, when the task is achieved.*

Facts scheme:

- A fact cannot be true and false at the same time.
- Several facts can be true at the same time.
- Some facts can be incompatible with each other, that is, they cannot be true at the same time. For example, the fact that "A on the ground" and "A on B" cannot be true at the same time.

Example illustration

For this example, watch the blocks moved by the robot's arm through the scene while the list of the **Facts that are true** (Current State) is changing during its navigation.

Facts to be achieved will be C on the ground, B on C, and A on B.

0:00 / 0:03

Objective Specification Mechanism - Facts

For this demonstration example, what fact(s) about the environment are true at the end of the robot execution that is the end state?

- [ ] A on B
- [ ] B on the ground
- [ ] B on C
- [ ] A on the ground
- [ ] B on A
- [ ] C on the ground
- [ ] A on C

→

Test section

0657

Test description

Welcome to the Robot Scenario test! In this test, you'll step into the tabletop pick and place problem, which requires the robot to arrange the blocks into a specific configuration.

You will have 7 minutes to complete this test, as indicated by the timer at the beginning of the page.

Test illustration

After playing the following video and observing the robot's behavior, please choose the adequate facts in the **Objective Specification Mechanism - Facts** that will result in the same behavior.

Objective Specification Mechanism - Facts

Drag the adequate Fact(s) that will allow us to recreate the same behavior seen in the previous video and drop them into the Facts to be achieved. Try to list the minimal number of facts to be achieved, that will generate the expected behavior.

Facts

A on the ground

A on B

A on C

B on the ground

B on A

B on C

C on the ground

Facts to be achieved

At the end of the scenario, where was the block B

on the ground	on top of block A	on top of block C
○	○	○

→

Please use the sliders below to answer each of the provided questions.

How much mental and perceptual activity, was required (eg., thinking. deciding, calculating, remembering. looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**
0 20

Mental Demand

How much physical activity was required (e.g.. pushing, pulling, turning. controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous restful or laborious?

Low **High**
0 20

Physical Demand

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low **High**
0 20

Temporal Demand

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Poor **Good**
0 20

Performance

Please move the slider to nine to show you are paying attention to this question.

Low **High**
0 20

Slider

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**
0 20

Effort

How insecure, discouraged, irritated. stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**
0 20

Frustration

For the following pair-wise comparisons of the six scales (**Mental Demand**, **Physical Demand**, **Temporal Demand**, **Performance**, **Effort**, **Frustration**) choose the one that contributed more to the workload of this survey.

Effort Performance

Temporal Demand Frustration

Temporal Demand Effort

Physical Demand Frustration

Performance Frustration

Physical Demand Temporal Demand

Physical Demand Performance

Temporal Demand Mental Demand

Frustration Effort

Performance Mental Demand

Performance Temporal Demand

Mental Demand Effort

Mental Demand Physical Demand

Effort

Physical Demand

Frustration

Mental Demand

→

Objective Specification Mechanism - Scores

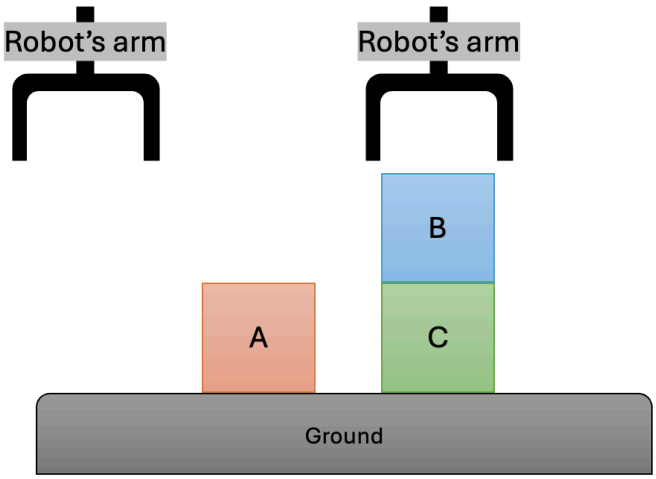
→

Objective Specification Mechanism - Scores

Under this specification mechanism, **you are asked to assign some points to the robot doing an action in the presence of some facts**. Now, when the robot performs an action in a state, the score for each fact adds up, and the robot gets a total point. If you don't specify a number for an action fact pair, it will by default get a value of zero. The robot will try to achieve its specified objectives in the least number of steps.

Example description

Task
Make the following configuration:
C on the ground, B on C, A on B.



Available facts	Stack A on B	Swap A and B	Stack B on A	Exit the task
A on the ground	0	-1	0	0
A on B	0	-1	0	50
A on C	0	-1	0	0
B on the ground	0	-1	0	0
B on A	0	-1	0	0
B on C	0	-1	0	0
C on the ground	0	-1	0	0

Figure 1: Example environment with a scoring scheme.

In this example, we'll explore pairs of the form **<Fact, Action>** within a robot task.

The example **Facts** that can be achieved:

1. A on the ground

2. A on B
3. A on C
4. B on the ground
5. B on A
6. B on C
7. C on the ground.

The example **Actions** that can be taken:

1. Stack A on B
2. Swap A and B
3. Stack B on A
4. Exit the task.

Note: *These actions allow the robot's arm to navigate the environment effectively. The* **Exit the task** *action is enabled at the end of the robot's execution, when the task is achieved.*

Scoring scheme:

- Default value: 0.
- The range of values that you can put in for each combination of fact and action is a number between -100 and 100.
- The robot takes actions so as to maximize the total points and you can penalize the robot for performing unnecessary actions by giving negative points.

Example illustration

Please watch the video to see the blocks moved by the robot's arm through the scene. As the robot's arm moves the blocks, the **Total Points** change based on which **<Fact, Action>** pairs are true. To make it easier, we highlighted the **<Fact, Action>** pairs that are true at any given step.

You can notice that there is a color code for the highlighted pairs and scores:

- : current set of facts that are true and the actions being taken by the robot's arm.
- : non-negative score.
- : negative score.

0:00 / 0:12

Objective Specification Mechanism - Scores

Make sure to fill out the **<Fact, Action>** pair(s) with the appropriate values from the above example.

Each cell in the table of scores will have a default value of zero. For the specification, update the relevant cells. If they are not updated, they will contribute zero points to the total score. The range of values that you can put in for each cell is a number between -100 and 100.

	Stack A on B	Swap A and B	Stack B on A	Exit the task
A on the ground	0	0	0	0
A on B	0	0	0	0
A on C	0	0	0	0
B on the ground	0	0	0	0
B on A	0	0	0	0
B on C	0	0	0	0
C on the ground	0	0	0	0

☐ I have filled out the above table with the appropriate values.

→

Test section

0657

Test description

Welcome to the Robot Scenario test! In this test, you'll step into the tabletop pick and place problem, which requires the robot to arrange the blocks into a specific configuration.

You will have 7 minutes to complete this test, as indicated by the timer at the beginning of the page.

Test illustration

After playing the following video and observing the robot's behavior, please fill out the **Objective Specification Mechanism - Scores** Table of **<Fact, Action>** pairs with adequate values that will result in the same behavior.

0:00 / 0:14

Objective Specification Mechanism - Scores

Each cell in the table of scores will have a default value of zero. For the specification, update the relevant cells. If they are not updated, they will contribute zero points to the total score. The range of values that you can put in for each cell is a number between -100 and 100. Try to fill in the minimal number of cells that will generate the expected behavior.

	Stack A on B	Swap A and B	Stack B on A	Exit the task
A on the ground	0	0	0	0
A on B	0	0	0	0
A on C	0	0	0	0

	Stack A on B	Swap A and B	Stack B on A	Exit the task
B on the ground	0	0	0	0
B on A	0	0	0	0
B on C	0	0	0	0
C on the ground	0	0	0	0

☐ I have filled out the above table with the appropriate values.

At the end of the scenario, where was the block B?

on top of block A ○ on the ground ○ on top of block C ○

→

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Please use the sliders below to answer each of the provided questions.

How much mental and perceptual activity, was required (eg., thinking. deciding, calculating, remembering. looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low **High**
0 20

Mental Demand

How much physical activity was required (e.g.. pushing, pulling, turning. controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous restful or laborious?

Low **High**
0 20

Physical Demand

Please move the slider to fiveteen to show you are paying attention to this question.

Low **High**
0 20

Slider

How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

Low **High**
0 20

Temporal Demand

How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?

Poor **Good**
0 20

Performance

How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low **High**
0 20

Effort

How insecure, discouraged, irritated. stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Low **High**
0 20

Frustration

For the following pair-wise comparisons of the six scales (**Mental Demand**, **Physical Demand**, **Temporal Demand**, **Performance**, **Effort**, **Frustration**) choose the one that contributed more to the workload of this survey.

Effort Performance

Temporal Demand Frustration

Temporal Demand Effort

Physical Demand Frustration

Performance Frustration

Physical Demand Temporal Demand

Physical Demand Performance

Temporal Demand Mental Demand

Frustration Effort

Performance Mental Demand

Performance Temporal Demand

Mental Demand Effort

Mental Demand Physical Demand

Effort

Physical Demand

Frustration

Mental Demand

→

After being asked to fill out the two different surveys about **Objective Specification Mechanisms**. Please answer the following questions:

	Objective Specification Mechanism - Facts	Objective Specification Mechanism - Scores
Which specification mechanism was the easiest to fill out?	○	○
Which specification mechanism was the most intuitive to you?	○	○
Which specification mechanism did you like the most?	○	○
Which specification mechanism was the most challenging ?	○	○

For the specification mechanism that you think is easier, why did you think it was easier?

For the specification mechanism that you think is harder, why did you think it was harder?

What suggestions do you have for improving the objective specification mechanisms?

If you have any additional concerns or remarks about any of surveys please leave them here.

What is your age?

- 18-24 years old
- 25-34 years old
- 35-44 years old
- 45-54 years old
- 55+ years old

How do you identify?

- Woman
- Non-binary
- Man
- Not listed

What is the highest level of education you have completed?

- ○ High school or equivalent
- ○ Attended College/University
- ○ Associate Degree
- ○ Bachelor's Degree
- ○ Master's Degree
- ○ Doctorate Degree

Have you taken any Computer Science courses / Do you consider yourself knowledgeable in Computer Science?

- ○ Yes
- ○ No

Have you taken any Artificial Intelligence courses / Do you consider yourself knowledgeable in Artificial Intelligence?

- ○ Yes
- ○ No

How would describe your knowledge in Artificial Intelligence?

Novice	Intermediate	Advanced	Expert
○	○	○	○

→