Topic #1

Context

In a partially automated industrial context of automobile production, a state-of-the-art humanoid robot, named GR-1, is integrated into the assembly line to perform the task of assembling car electric windows regulators. Equipped with an anthropomorphic and articulated structure, GR-1 is outfitted with a wide range of advanced sensors (two cameras, tactile sensors, proprioception sensors, IMUs) and actuators, as well as sophisticated computing and control capabilities. GR-1 can move in the environment, recognise objects, pick-up objects, put them down, and in general manipulate them.

The assembly process of a car electric window regulator involves several steps to ensure the proper functioning of the window mechanism. The assembly process is described as follows:

1/ Component Preparation. The process begins with the preparation of all components required for the electric window regulator assembly, that is, these components must be taken from their shelves in the warehouse and positioned on the working table in specific locations. These components typically include the motor, regulator mechanism, mounting brackets, cables, pulleys, switches, and wiring harness.

GR-1 knows:
a) the location of these components in the warehouse, and its payload is enough to transport them one by one to the assembly table.

2/ Motor Installation. The electric motor, which drives the window regulator mechanism, is installed onto the door frame or inner door panel. It is securely mounted in a designated location to ensure stability and proper alignment.

GR-1 knows how to:
a) identify the proper location in the door frame,
b) manipulate the motor,
c) align the motor to the door frame.

3/ Regulator Mechanism Attachment. The regulator mechanism, which translates the rotational motion of the motor into vertical movement of the window glass, is attached to the motor.

GR-1 knows how to:
a) identify the mounting location,

b) identify the mechanism,
c) manipulate the mechanism,
d) fix the mechanism to the motor.

4/ Mounting Bracket Installation. Mounting brackets are affixed to the door frame or inner door panel to provide support for the regulator mechanism and window glass. These brackets are carefully positioned and secured using fasteners such as screws or bolts.

GR-1 knows how to:
a) identify the mounting location in the door frame,
b) manipulate the brakes,
c) mount the brakes,
d) manipulate fasteners (screws and bolts).

5/ Cable and Pulley Assembly. Cables and pulleys are assembled onto the regulator mechanism to facilitate the smooth movement of the window glass. The cables are threaded through the pulleys and properly tensioned to ensure reliable operation.

GR-1 knows how to:
a) identify the regulator mechanism,
b) manipulate (especially, thread and tension) the cables.

6/ Switch and Wiring Installation. Electric switches for controlling the window operation are installed on the door panel. These switches are connected to the wiring harness, which routes electrical signals between the switches, motor, and power source. Proper routing and insulation of the wiring harness are essential to prevent electrical faults and ensure safety.

GR-1 knows how to:
a) identify and manipulate the switches on the working table,
b) connect the switches to the wiring harness,
c) route the cables among the switches, motor, and power source.

Problem

You must design and implement a PDDL domain which models the “car electric windows regulators scenario”. Furthermore, you must design at least one PDDL problem generating a valid plan. Use ALL the things GR-1 knows.

Topic #2

Context

In a context of space exploration on the planet Mars, a next-generation autonomous rover, named MR-1, is tasked with conducting terrain analysis operations to collect scientific data. Equipped with a series of advanced sensors (including spectrometers, multispectral cameras, and radar for analysis activities, and stereoscopic cameras and IMU for navigation and attitude control) and sophisticated data processing capabilities, MR-1 is designed to explore Martian terrain and gather crucial mission information.

The whole analysis process involves carrying out a specific mission with several steps to ensure the successful gathering of chemical information from the soil. The process can be described as follows:

1/ Navigation and Positioning. MR-1 navigates across the Martian surface using its onboard mobility system, such as wheels or tracks, guided by pre-defined paths or real-time navigation algorithms. It utilises its onboard sensors, including cameras and IMUs, to determine its position relative to its surroundings and maintain stability over varied terrain.

MR-1 knows how to:
a) move between various locations, which are described using a topological map of the environment, where nodes represent locations themselves and edges represent predefined, doable trajectories between any two locations;
b) once a specific location where soil data must be collected is reached, position firmly on the ground to maintain stability.

2/ Deployment of Scientific Instruments. Upon reaching a designated location and securing its stable operation, MR-1 deploys its scientific instruments designed for terrain analysis. These instruments may include spectrometers, cameras, radar systems, and other sensors capable of detecting and measuring various properties of the Martian surface, such as composition, topography, temperature, and humidity.

MR-1 knows how to:
a) elongate (“untack”) a manipulator out of the main rover chassis;
b) position the manipulator’s end-effector in different configurations around the robot location;
c) use the sensors located on the manipulator’s end-effector to collect various soil chemical information;
d) retract (“tack”) the manipulator in its home configuration once samples have been acquired.

3/ Data Collection. Once the manipulator is deployed, MR-1 activates the scientific instruments located on its end-effector to collect data about the Martian terrain. Not all scientific instruments must be used in all locations. In fact, the knowledge of which instrument must be used in each location is a location-specific information. For example: (i) a spectrometer may analyse the composition of surface rocks and minerals by measuring the wavelengths of light reflected off the surface; (ii) cameras may capture images of the terrain from different perspectives, providing visual data for analysis to the team on Earth; (iii) radar systems may penetrate beneath the surface to map subsurface features like underground ice deposits or geological structures.

MR-1 knows how to:
a) activate and deactivate each single instrument;
b) acquire information from each instrument once it is placed correctly and activated.

4/ Data Processing. The raw data collected by the scientific instruments must be processed partly onboard the rover using built-in computing resources, and partly by transferring it to Earth for heavier processing. Given that the analysis to be done depends on which instruments have been used, which on its turn depends on the locations visited by MR-1, this phase cannot follow a pre-scripted data flow, and the data analysis algorithms must be properly activated or deactivated.

MR-1 knows how to:
a) perform spectrometer-based analyses;
b) perform cameras-based analyses;
c) perform radar-based analyses;

5/ Decision Making. Since spectrometers, cameras, and radars are characterised by different performance related to the acquired data, in certain locations it may be necessary to carry out a specific reading twice; this is a location-specific information.

MR-1 knows:
a) the number of times it must collect data related to a specific sensor in each location.

6/ Data Transmission. At the end of each data collection session, and after MR-1 has returned to its home base, it must transmit collected data back to Earth.

MR-1 knows how to:
a) wait for a suitable communication window where data transmission is possible;
b) send data;

c) close the communication link.

Problem

You must design and implement a PDDL domain which models the “scientist Martian rover scenario”. Furthermore, you must design at least one PDDL problem generating a valid plan. Use ALL the things MR-1 knows.

<u>Topic #3</u>

Context

In a context of home assistance for elderly people, a next-generation domestic assistant robot, named AR-1, is designed to perform a series of household tasks, meal preparation and, in general, working in the kitchen. Equipped with a flexible structure and a wide range of advanced sensors (including cameras, tactile and pressure sensors, temperature sensors), AR-1 can operate (partially) autonomously within the home environment, of which it has a 3D mapping obtained during an initial calibration phase.

Let us focus on a robot capable of making coffee ("espresso") using an Italian moka machine in the kitchen. The whole process can be described as follows:

1/ Prepare Ingredients. AR-1 must gather the necessary ingredients for making coffee, including coffee beans or ground coffee, filtered water, and optionally, sugar or milk. The ingredients are in various locations of the kitchen. Their locations in the kitchen must be specified as part of the problem.

AR-1 knows how to:
a) pick-up, put-down and in general manipulate all necessary objects;
b) open and close drawers and closets;
c) open and close jars and other containers;
d) operate on kitchen appliances, such as the water tap, etc.

2/ Grind Coffee. If using whole coffee beans, AR-1 must grind them to a medium-fine consistency. The grind size should be like that of table salt for best results. Both the options (coffee beans or ground coffee) are possible, and this should be specified in advance.

AR-1 knows how to:
a) pour coffee beans inside the grinder;
b) operate (switching on and off, activate) the grinder.

3/ Fill Water Reservoir. AR-1 must unscrew the top part of the moka pot and fill the bottom reservoir with filtered water.

AR-1 knows how to:
a) manipulate (screw, unscrew) the moka pot and its parts;
b) pour water inside the bottom reservoir.

4/ Insert Filter and Coffee. AR-1 must place the filter basket into the bottom chamber of the moka pot; add the ground coffee into the filter basket, distributing it evenly and levelling it off with a tool (for example, a coffee spoon) to ensure uniform extraction.

AR-1 know how to:
a) extract the ground coffee from a container (for example, with a small spoon);
b) fill the filter basket with ground coffee (for example, with a small spoon);
c) level the coffee on the filter (for example, with a spoon).

5/ Assemble Moka Pot and heat. AR-1 must screw the top portion of the moka pot onto the bottom reservoir tightly but without applying excessive force; it must also place the moka pot on the stovetop burner set to medium heat.

AR-1 knows how to:
a) manipulate (screw, unscrew) the moka pot and its parts;
b) operate on the stovetop burner.

It is assumed here that the stovetop burner will automatically stop when the coffee will be ready: however, any ideas about how to model the processes of screwing the moka without excessive force, or of waiting for the coffee to be ready?

6/ Serve: AR-1 must untap the top portion of the moka pot and pour the freshly brewed coffee into cups or mugs.

AR-1 knows how to:
a) manipulate (screw, unscrew) the moka pot and its parts;
b) pour liquids in coffee cups.

Problem

You must design and implement a PDDL domain which models the "coffee making scenario". Furthermore, you must design at least one PDDL problem generating a valid plan. Use ALL the things AR-1 knows.