

Rulebook

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Chapter 1

Introduction

With the arrival of a global aging society, eldercare shows the general trend of demand greater than supply. The elderly are expected to enjoy a better quality of life through robot services. For example in the place where supervising taking medicine, a robot which can accompany the elder warmly like a nurse is far more effective than an alarm clock. When the elder encounters a dangerous situation such as falling down, timely warning by a robot can significantly reduce the risk of accidents. In fact, the abilities to moving, perceiving and serving forwardly offers a first-rate experience that no other solution can replace. Although there are more and more useful technologies of robotic developed in recent years, there is no mature and stable application in eldercare that can be truly industrialized.

The IJCAI-2019 Eldercare Robot Challenges aim at promoting the industrialization of eldercare robots in the future and speeding up product-level applications through this competition. We hope to see from the competition some concrete solutions and outcomes in real-world applications in near future.

Our competition this year focuses on vision-related tasks in home scenarios where the elderly live alone and heartwarming services are welcomed by them. The main technologies involved are people tracking, activity identification, pose detection, object detection, navigation, human-robot interaction and so on.

The competition include two challenges: the Robot Task Challenge and the Elderly-Care Robot Design Challenge. A team can choose one or both to participate in.

In the Robot Task Challenge, there are three tests including medicine-taking reminder, daily service and searching for missing objects. Specifically:

- **medicine-taking reminder:** The robot is expected to provide the elder with heartwarming and attentive reminders to take medicine on time as well as not take wrong medicine or take too much.
- **daily service:** The robot is expected to follow the elder during the daily life and send alarm signals when an emergency occurs and take photos to record what the elder is doing.
- **searching for missing objects:** The robot is expected to follow the elder, observe the elder's movements, and remember the new positions of the objects with its extraordinary memory. When the elder asks for something, the robot is supposed to offer help.

In the Elderly-Care Robot Design Challenge, a team is expected to submit a report on their design of solution to the elderly-care by robots in domestic environments, while detailed implementation of the proposed solution is not required. The evaluation criteria include practicability, novelty, and general applicability of the design.

Chapter 2

General Rules

All teams should comply with the general rules in the whole process. Each rule in this section applies to all challenges of this competition. If additional rules in other sections are not in line with the rules mentioned in this section, the additional rules prevail.

2.1 Arena

The competition is held in the elderly-care robot challenge arena. The following rules cover the arena and objects inside.

2.1.1 Arena

The elderly-care robot challenge arena simulates the typical living environment of a solitary old person. It might be a house of 60–100 square meters consisting of a bedroom, a living room, a kitchen and a bathroom. Compared with the living environment of a normal family, this house has relatively narrower rooms with curtains, crowded corridors, and sundries on the floor.

2.1.2 Requirements on Walls, Floors, and Doors

1. **Wall** The wall is at least 60 cm high. The wall setting should apply to the audience's view. Walls are firmly fixed on the floor so that when a robot collides or a person leans against a wall, the wall does not shake or shift.
2. **Door** The house is designed with at least two doors, one for entry and the other for exit. The door width is not greater than 90 cm and not less than 65 cm. Any two rooms in the arena are connected by a door. A door consists of two parts: a door with a handle for pulling and pushing and a curtain hanging from the top frame to the floor. In the competition, robots can pass through the curtains directly, but have to avoid closed doors.
3. **Floor** Initially, the floor is flat, anti-skid, and with no stairs. However, during the competition there will be thresholds, small stairs, carpets, wires and other objects to produce uneven surfaces.
4. **Corridor** A room has at least one narrow corridor which is at least 3.0 m long and 0.8 m to 1.0 m wide.
5. **Decoration** The floor and walls are painted solid colors. There might be some portrait posters on the walls. Portraits in the posters are almost life-size.

2.1.3 Furniture

The arena will be equipped with furniture. The minimal configuration is as follows:

- a dining table with two chairs;
- a bed and a nightstand;
- a sofa;
- a vertical cupboard;
- a tea table;
- a bookshelf;
- two small occasional tables;

It is also advised to add a TV and two green plants.

2.1.4 Arena Setting Changes

In real family life, objects may not always be fixed at specific locations. Therefore, object location changes in the competition. When these changes occur, no additional notice will be given to teams.

1. **Change to Furniture Location:** The location of large furniture will be announced in advance. The changes include moving and rotating the furniture within a certain range (usually 1 m) near the announced original location. The organization committee (OC) ensures that location change will not happen during the period half an hour before and after each test.
2. **Change to Scenes:** The walls will not move.
3. **Change to Object Location:** The location of objects (not furniture) such as chairs and teacups will change at any time of the tests.

2.1.5 Scene Change

1. **Change to Settings:** In tests that are more difficult, changes will be made to walls, doors, and floors. Changes include but are not limited to the following ones: Place cables on the floor, install thresholds, let down hanging curtains, place more sundries on the floor, place clothes and carpets on the floor, and put up portrait posters on walls.
2. **Furniture Change:** In tests that are more difficult, some furniture will be replaced and the furniture location and type remain unchanged. Changes include but are not limited to the following ones: Change a closet cabinet to a cabinet with mirror, replace the tables with striped tables, replace wooden chairs with metal chairs, and remove tablecloth that hangs down to the floor.
3. **Object Change:** In tests that are more difficult, objects will be replaced. For details, see test requirements 4.1.4 4.3.4.

2.1.6 Objects

Some tests include object recognition. These objects are the ones commonly used by old solitary people, which include but are not limited to medicine, water bottles, glasses boxes, books, and remote controls. In tests that are more difficult, objects will be replaced. The technical committee (TC) publishes a list of at least 10 objects on the first day of the setup days. These objects are classified as models, pill boxes, simple objects (objects that can be easily recognized), alike objects, and difficult objects (objects that cannot be easily recognized). Objects not in the list are taken as unknown objects.

1. **Model:** It is the easiest to recognize models. Cuboid and cylinder models of different sizes and colors are used to replace different objects.
2. **Pill Box:** The pill boxes can be square and round.
3. **Simple Object:** A simple object is similar to a cylinder, a cone, a circular table, a cuboid, or a sphere object. Simple objects have regular shapes like coke cans, cups, balls, books, and so on.
4. **Alike Object:** alike objects are similar articles with small difference. For example, several apples or bananas.
5. **Difficult Object:** It is difficult to recognize difficult objects because they are too small or irregular in shape. For example, a key ring, glasses case, or remote control.
6. **Unknown Object:** Objects not mentioned in the preceding context are unknown objects.

2.1.7 Prior Knowledge

There is certain prior knowledge for this competition. It will be provided when the competition setup starts. The prior knowledge includes the following:

1. **Location:** The TC will publish the location information, including the names and types of object locations, and how the objects are placed.
2. **Room:** The TC will publish room names, such as living room and bedroom. Teams should use the names published by the TC in the competition.
3. **Others:** Prior knowledge for specific challenges is described in detail in corresponding challenge rules.

2.2 Robot

There are no special requirements on hardware platforms of robots used in the competition. Teams are expected to use their own robots. Robots should meet the safety requirements, and the design of robots should apply to specific rules of each challenge and scene settings of the arena. Before the challenges start, all robots need to be qualified and the TC will check the robots. The check aspects include but are not limited to the following ones:

2.2.1 Autonomous and Mobile

Robots can be controlled autonomously by itself and have navigation and obstacle avoidance functions. Any mistakes caused by control and movement will affect team performance.

2.2.2 Number of Robots

Requirements on the number of robots that can be used in each phase are as follows.

1. **Qualification:** Each team can only provide a maximum of two robots for qualification.
2. **Robot Task Challenge:** Each team is allowed to use only one of the qualified robots in each test. This challenge consists of three formal tests. It is allowed to use a different qualified robot for a different test.
3. **Elderly-Care Robot Solution Challenge:** In this challenge, all qualified robots can be used.

2.2.3 Robot Specifications

Robot specifications include dimensions, weight, appearance, and transport description in special cases.

1. **Dimension:** Robots are expected to pass through doors and narrow corridors in the competition; therefore, robots should not be wider or higher than the narrowest door or corridor. The robot height should not exceed 1.5 m. For details, see **Requirements on Walls, Floor, and Doors 2.1.2**.
2. **Weight:** The weight of a robot should not exceed the standard weight of an adult to ensure that robot pressure on the floor is acceptable.
3. **Appearance:** The robot appearance should meet requirements of challenge scenarios and no bare circuit board, messy wiring, and tapes are exposed.
4. **Transport:** During the qualification and challenges, if a robot cannot move autonomously due to certain reasons, the team should be able to move the robot out of the arena in a simple and quick way without affecting following tests.

2.2.4 Emergency Stop Button

A robot must be equipped with an emergency stop button to ensure the safety of the arena. Requirements on the emergency stop button include the installation location, color, and robot behavior that can be controlled with this button.

1. **Location:** The emergency stop button must be installed in a location that is easy to find and press.
2. **Color:** The emergency stop button must be red and the only red button on the robot. Other red buttons should be hidden or removed.
3. **Robot Behavior:** When you press the emergency stop button, the robot and its components should stop moving immediately.

2.2.5 Starting Mode

Teams use different robot hardware platforms; therefore, there are no special requirements on the starting mode. However, it should meet the following basic requirements and be reported and explained to the TC in the qualification.

1. **Requirements:** Only one click operation can be performed to start the robot in each test. No limitations for the operation. Please note that the starting mode in each test must be the same.
2. **Check:** In the qualification, the starting mode will be checked by following the real competition process.

2.2.6 Interaction Using Audio Messages

Human-robot interaction is essential. Therefore, it is necessary to have the robot equipped with a speaker. Interaction using audio messages enables viewers and referees to understand what the robot is doing. Requirements on devices and content for voice input and output are as follows.

1. **Device:** The robot must be equipped with speech input device and audio message output device.
2. **Speech input:** The robot must be able to identify voice commands specified in the competition.
3. **Audio message output:** In the TC check and challenge, the robot should send clear, loud enough, and understandable audio messages to express what it is doing.

2.2.7 GUI

The TC may operate the robot behavior through a graphical user interface (GUI) and check detailed information of the robot. Therefore, a simple GUI is mandatory. There are no specific requirements on the GUI, but the following basic content must be included. Teams can also add more content. In both the qualification and challenges, the GUI practicality and design will be scored.

1. **Status:** shows the room where the robot is located and the task being executed.
2. **Vision:** displays the scene that the robot camera is shooting.

2.2.8 Safety

Robot on operation should meet the safety requirements of the competition and does not damage the arena or affect participants. The following safety rules apply to all robots and are part of the TC check.

1. **Appearance:** Robots should not have sharp edges, or other parts that may cause harm to people.

2. **Usage:** Robots on operation should not produce too much noise, glaring lights, or other annoying factors.
3. **Speed:** Robots should move in a proper speed to keep a safe distance from people.

2.3 Organization of the Competition

2.3.1 Challenge Parts

The competition consists of two challenges as below:

1. **Robot Task Challenge:** This challenge is composed of three tests, including medicine-taking reminder, daily service, and searching for missing objects. Each test contains several stages which are set to rising uncertainty and difficulty in turn. Each team must participate in the first stage of each test. Only teams with good performance in the first stage can participate in the next stage of the test.
2. **Elderly-Care Robot Design Challenge**

2.3.2 Arrangement

The OC is responsible for the arrangement of all challenges and teams. After the arena layout is completed, all teams will be scheduled interleaved to enter the arena to get familiar with the arena. Preparation time may be any time before each test, usually one hour before each test. During the preparation time, only teams participating in the test can enter the arena. The OC determines the entering order of teams. Only robots that are being tested can stay in the arena. Other teams wait at the entrance and should enter the arena in three minutes once required.

2.3.3 Punishment and Reward

Punishment

1. **Not Attending:** If a team is not able to participate in a test for certain reasons, it must declare to the OC one hour before the test starts. If a team does not appear at the supposed start position, it is not allowed to participate in the test. If a team neither declare in advance nor appear at the start position, it will be deducted 100 points and get -100 points.
2. **Collision:** A robot is allowed to touch objects and people gently. However, it is not allowed to bump into objects and people. If two robots meet, they must be able to avoid each other. If a robot does not move within 30s, the team drops out of the challenge. If a serious collision occurs or is about to occur, the TC can terminate the test immediately. If a serious collision happens, the team will get zero points in this test.
3. **Remote Control:** Remote control is not allowed. Teams that violate this rule will be deducted or disqualified from the test or even the competition.

Reward

1. Robots with outstanding performance will be given an extra bonus of 10% of its total score.
2. A team that shows outstanding innovation and high adaptability will be rewarded an extra bonus of 10% of its total score.
3. After teams introduce the innovation and advantages of their solutions, the TC decides whether to give an extra bonus.

2.4 Challenge Requirements**Safety**

1. An emergency button is mandatory to stop the robot immediately.
2. Teams must inform the OC of how to stop the robot urgently in advance.

Number of Players Inside the Arena

1. In the Robot Task Challenge, only one player of each team can stay inside.
2. In the Elderly-Care Robot Design Challenge the number of players that can stay inside is not limited.

Fairness

Each team is sure to be fair in the following cases:

1. Evaluating the performance of other teams;
2. Evaluating its own performance;
3. Interacting with robots of other teams (Do not deliberately increase the interaction difficulty.)

Automatic Control

1. It is not allowed to manually control the robot in tests. It is not allowed to touch or remote control robots.
2. Only gestures (including but not limited to hand signals) and voice commands can be used to interact with robots.
3. Teams that violate this rule will be deducted or disqualified from the test or even the competition.

Entry and Department

1. Before a test starts, robots should stay in the start position for preparation.
2. When a test ends, participants must be able to control the robots to leave the arena quickly.

Start

1. When a start signal is given by the TC, teams can give an ‘one click operation’ . After that, the challenge begins and no operation can be done on robots.
2. If the ‘one click operation does not work’ (due to certain mechanical fault or other problems) and additional operation is needed, the team is allowed to continue the operation to restart the robot at the start position. Kindly note that the time of restart operation is also included in the total duration.

Referee

1. Each test should be performed and scored by at least one TC member and two referees. The TC member serves as the chief referee.
2. The referees (except the chief referee) are chosen by the executive committee (EC), TC or OC.
3. The referees have no stake in teams.
4. The referees can be not team members.
5. Referees’ interactive instructions must meet the requirements stated in advance.

Interaction

1. Robots interact with a TC member, a referee, or a person selected by the TC.
2. If a robot cannot interact with the TC member, referee, or the person selected by the TC, the team can apply to interact with the robot. In this case, the team can get only 70% of the original score.
3. If a team use QR-code to interact with robots, the team can get only 50% of the original score.

Scoring Supervision

Each team can send a member to supervise the scoring. A supervisor has the following tasks:

1. Describing the test;
2. Impartiality evaluating the robot performance;
3. Speaking in English; 4. Obeying decisions of the TC.

Time Limit

1. In stage 1, the test duration cannot exceed 10 minutes.
2. In stage 2, the test duration cannot exceed 15 minutes.

OC

1. Provide referees with necessary materials, such as paper, pens, and scoring sheets.
2. Put up the schedules to the specified location known by all teams in scheduled time.

Chapter 3

General Setup and Preparation

Before the challenges start, all robots need to be qualified. The arena will open in advance so that each team can assemble and commission the robot.

3.1 General Setup

1. **Start:** When all teams arrive and the arena opens, teams can prepare for the competition.
2. **Workspace Allocation:** Before the competition, each team will be randomly allocated a workspace to commission robots during the competition.
3. **Arena:** In the setup days, the arena is accessible to all teams. During the competition, teams can commission robots in the commissioning time announced by the TC.
4. **Objects:** The objects used in the challenges (for details, see scene settings 2.1.6) will be purchased in advance. It is allowed to test with these objects in advance.

3.2 Qualification

A robot needs to have interaction using audio messages with people and repeat the operations in challenges. For the safety of people and the arena, each robot must be tested in the qualification. For details about the qualification, see **Robot 2.2**. There are two qualification check results: **passed** and **failed**. Only robots that pass all check aspects can participate in the challenges. Specific check aspects are as follows:

1. **Process:** The qualification and challenges follow the same process. The qualification tests start at the arena entrance. Teams and their robots take turns entering into the arena, completing all test tasks based on instructions, and leaving from the exit.
2. **Purpose:** Check whether a robot meets basic safety requirements and other requirements.
3. **Checked aspects:** the size, starting mode, emergency stop button, automatic obstacle avoidance, interaction using audio message, and GUI of the robot.
4. **Rechecked:** If a robot fails to continue the tests, the robot needs to be transported outside the arena in time. After being commissioned, it can be rechecked. If a robot fails certain check aspects, the team needs to modify the robot based on the requirements of the TC. After the modification, the robot can be rechecked.
5. **Appearance:** Apart from necessary functional checks, the TC will also check the robot appearance to ensure that no bare circuit board, messy wiring, and tapes are exposed.

6. **Team member to follow the qualification:** Only one member of each team is allowed to follow the robot.

Test details will be announced two hours before the qualification.

Chapter 4

Robot Task Challenge

4.1 Medicine-taking Reminder

4.1.1 Target

The robot is able to provide heartwarming and attentive reminders for the old person to take medicine on time. It should also be able to provide accurate information of the medicine name and dosage so that the old person will not take wrong medicine or take too much. Kindly note that what we need is not a timed alarm clock, but a caring partner whose service and care are welcomed by the elderly. Robots need to provide certain reminders based on specific actions of the old person.

4.1.2 Forcus

This challenge will test robots' capabilities of object detection, people detection, object recognition, pose recognition, and human-robot interaction.

4.1.3 Tasks

1. **Start position:** A robot is placed at a specified position before it executes a specific task. The position will be announced two hours before the challenge.
2. **Obtaining a prescription:** The OC will provide each robot with QR code that contains information of a unique prescription for scanning. After scanning, the robot is expected to give a response that "Prescription received."and repeat the content of the prescription.
3. **Reminding the old person to take medicine:** When it is time to take medicine, the robot starts to look for the old person in the house. The state (location and action) of the old person varies in stages of different levels of difficulty. When the robot is located at a proper location, it is expected to let out an audio message to show that it locates the old person and then approach the old person. If the robot detects that the old person does not start to take medicine (which means that the old person is not near to the place where the medicine is placed or there is no medicine on the front table or in hands), it is supposed to give a reminder. If the robot detects that the old person starts to take medicine, it is expected to send a clear audio message to show that the old person is taking medicine. After that, it cannot make noise or give a reminder.

4. **When the old person is taking medicine:** The robot should not give reminders to the old person unless the old person takes the wrong medicine, takes too much, or asks for help.
5. **Ask-for-help I:** The old person may ask the robot for the prescription. The robot is supposed to answer. If the old person does not ask, the robot cannot make noise or give a reminder.
6. **Ask-for-help II:** The old person may not know what the medicine is, and the robot is supposed to tell the medicine name and the dosage.
7. **Mistake I:** If the old person does not take enough medicine and leaves the medicine site, the robot should follow the old person and give a reminder.
8. **Mistake II:** If the old person takes the wrong medicine, the robot should give a reminder in time.
9. **End:** When the old person takes medicine correctly, the robot outputs an audio message or displays the message on screen to indicate that the medicine-taking task is completed and outputs a report.

4.1.4 Difficulty Level

Location of the Old Person

- **Level I:** The old person is next to the medicine site.
- **Level II:** The old person is in the room where the medicine is placed.
- **Level III:** The old person is in the room where the medicine is placed.
- **Level IV:** The old person is in the room where the medicine is placed.

Medicine-Taking Mistakes and Asking for Help

- **Level I:** There are no medicine-taking mistakes. The old person asks for help about the prescription, medicine names and dosage (Ask-for-help I and II).
- **Level II:** The medicine-taking mistake I occurs. The old person asks for help about the prescription, medicine names and dosage (Ask-for-help I and II).
- **Level III:** The medicine-taking mistake I and II occur. The old person asks for help about the prescription, medicine names and dosage (Ask-for-help I and II).
- **Level IV:** The medicine-taking mistake I and II occur. The old person asks for help about the prescription, medicine names and dosage (Ask-for-help I and II).

Ways of Getting the Medicine

- **Level I:** The old person gets the medicine in a relatively slow speed without blocking the robot's vision on the medicine.
- **Level II:** The old person gets the medicine in a normal speed without blocking the robot's vision on the medicine.
- **Level III:** The old person gets the medicine as people usually do, which may block the robot's vision on the medicine. The speed is normal.

- **Level IV:** The old person gets the medicine as people usually do, which may block the robot's vision on the medicine. The speed is normal. After picking up the medicine, the old person may take it in hands for a while and put it back to the corresponding medicine box or bottle.

Medicine Model

- **Level I:** The medicine is regular geometry models, including balls, cylinders, and cuboids, of different bright colors and shapes.
- **Level II:** The medicine is regular geometry models of different shapes and colors.
- **Level III:** The medicine is regular geometry models of different shapes and colors.
- **Level IV:** The medicine is real drugs.

4.1.5 Additional Rules and Remarks

1. The old person is bound to take medicine at the medicine site.
2. Medicine is placed on the tables, not on the cabinet or shelf.
3. Reminders for the old person are expected to be caring and heartwarming, instead of only medicine names and dosage. Teams are encouraged to develop new reminding ways, such as an audio message, a message displayed on the screen, and postures.
 - An audio message, for example:
 - "Please take the medicine at far left."
 - "Please take the white pills."
 - Displaying a message on the screen:
 - Display the picture, name, and dosage of the medicine on the screen.
 - Postures, for example:
 - The robot lifts its arms and points to the medicine.
 - The robot uses a searchlight to generate a beam of light to the medicine.
4. A report with more details can get a higher score. If a report records only the action sequence of taking medicine and making mistakes, it gets a low score. If a report records the time point of picking up a cup, the action of getting the medicine, swallowing, and placing the cup on a table, it gets a high score. The specific score is given by the TC based on difficulty levels and the accuracy of robots' actions when all teams finish a test. Teams are encouraged to record more challenging events.

4.1.6 Note

1. First day of the competition: Offer models of the medicine or pill boxes or bottles.
2. Two hours before the test: Release the medicine sites.

4.1.7 Referee Instructions

Two hours before the test each team will receive a unique prescription. The TC will demonstrate the defined slow and normal speed to get the medicine.

4.1.8 Score Sheet

Robot Action	Level I	Level II	Level III	Level IV
Obtaining a prescription				
Repeats the complete prescription correctly.	5	5	5	5
Looking for the old person and giving a reminder				
Finds the old person.	10	20	20	20
Gives a proper reminder for medicine-taking.	30	30	30	30
Gives a useless reminder.	0	-20	-40	-40
In the course of taking medicine				
Answers all questions in Ask-for-help I.	25	10	10	10
Answers all questions in Ask-for-help II.	75	20	20	20
Handles the situation Mistaken I.	-	70	20	20
Handles the situation Mistaken II.	-	-	50	50
Gives useless reminders.	$-30 \times n$	$-20 \times n$	$-20 \times n$	$-50 \times n$
Cold response	$\times 0.5$	$\times 0.5$	$\times 0.5$	$\times 0.5$
Gentle response	$\times 0.8$	$\times 0.8$	$\times 0.8$	$\times 0.8$
Caring response	$\times 1.0$	$\times 1.0$	$\times 1.0$	$\times 1.0$
After taking medicine				
Shows that the old person has taken medicine.	5	5	5	5
Report	50	50	50	50
Total	200	210	210	210

4.2 Daily Service

The robot is expected to follow the old person's basic instructions such as playing music and reading news. It can also follow the old person, send alarm signals when an emergency occurs, and take photos to record what the old person is doing.

4.2.1 Target

Currently, many old people live alone in the increasingly busy world. Although robots cannot give the old person enough care yet, robots can track their lives, record their moments, and monitor and report their safety.

4.2.2 Focus

The main concerns are human-robot interaction, people tracking and activity identification. Technologies involved are people recognition, pose recognition, and indoor navigation.

4.2.3 Setup

1. **Door:** Doors are open.
2. **Obstacle:** Obstacles in scenes of different difficulty levels are different in sizes, types, and quantities.
3. **Operator:** The old person selected by the TC serves as an operator to interact with robots.
4. **Other Person:** There will be other persons causing interference in scenes of higher levels of difficulty.
5. **Start Position:** Start positions of the old person and robots are specified before tests and vary in scenes of different levels of difficulty.
6. **Path Design:** In following tests, the paths followed by the old person and waypoints are designated in advance, but will not be announced before the test.

4.2.4 Tasks

1. **Preparation:** First, a robot and the old person stay together, and the robot registers the old person's information. The robot and the old person move to their own start positions, and an operator (not the old person) will come to the front of the robot and send a start signal.
2. **Interaction:** When the test starts, the robot approaches the old person and gives greetings. When the old person is ready to move, the robot detects whether the old person wears a smart wristband on the right wrist. If the old person does not wear, the robot is expected to remind.

3. **Following:** The old person sends a following instruction and begins to walk when the robot replies that it is ready. The old person walks along a path designated before and passes waypoint 1, 2, and 3.
4. **Action detection:** After passing three waypoints, the old person continues to walk and the robot follows the old person. From now on, some random events may happen. For example, the old person falls down. The random events are defined in the following part.

4.2.5 Difficulty Level

Start Position

- **Level I:** The start positions of the old person and the robot are always beside the sofa in the living room.
- **Level II:** The old person can be at any location in the living room, whereas the robot is outside the house. The robot needs to find the old person in the living room first.
- **Level III:** The old person can be at any location in the living room, whereas the robot is outside the house. The robot needs to find the old person in the living room first.
- **Level IV:** The old person can be at any location in the living room, whereas the robot is outside the house. The robot needs to find the old person in the living room first.

Obstacle Setting

- **Level I:** There are sundries that can be detected by laser light on the floor.
- **Level II:** There are sundries that can be detected by laser light on the floor.
- **Level III:** There are more sundries that can be detected by laser light on the floor.
- **Level IV:** There are hollowed-out obstacles and sundries that cannot be detected by laser light on the floor.

Other Persons

- **Level I:** No persons causing interference exist in the arena.
- **Level II:** Several persons causing interference exist in the arena. When approaching waypoint 3 from waypoint 2, these people block the vision of the robot for 2s to 3s by walking through the space between the robot and the old person.
- **Level III:** Several persons causing interference exist in the arena. When approaching waypoint 3 from waypoint 2, the old person passes through this group of people.
- **Level IV:** Several persons causing interference walk anywhere in the arena. The old person may pass through this group of people at any time.

Smart Wristband Detection

- **Level I:** When standing up, the old person deliberately raises the right arm to the front of the robot.
- **Level II:** When standing up, the old person lets the right arm hang naturally and does not block the robot vision.

- **Level III:** When standing up, the old person lets the right arm hang naturally and does not block the robot vision.
- **Level IV:** When standing up, the old person lets the right arm hang naturally and blocks a part of the robot vision.

Difficulty Levels in Following Tests

- **Level I:** Apart from the waypoints, the old person may stop at some other points for some reason, then the robot stops. When the old person continues to walk, the robot follows. The old person walks slowly and stays in sight of the robot even at the corner.
- **Level II:** When passing a corner and a door between waypoint 1 and 2, the old person walks out of sight. Then, the old person stops and waits around the corner, and the robot has to find the old person and continue to follow.
- **Level III:** When passing a corner and a door between waypoint 1 and 2, the old person walks out of sight. However, the old person does not stop to wait.
- **Level IV:** The old person may walk out of sight when passing a corner and a door at any time and does not stop to wait.

Possible Actions and Robot Response in Action Detection Phase

- **Level I:**
 - *Falling down:* When the old person falls down, the robot is expected to call a specified phone number, generate an accident report, and take photos to record.
- **Level II:** The robot takes photos to record the random events of the old person. The following random events may happen:
 - *Falling down:* When the old person falls down, the robot generates an accident report and brings a doctor waiting at the door to the old person.
 - *Sitting down:* When the old person sits on a chair, the robot gets close and waits for what the old person is going to do.
- **Level III:** The old person may command the robot to stay put, and a random accident happens when the old person walks away. Alternatively, the robot is following the old person and its vision is blocked when an accident happens. In both the preceding cases, the robot is also expected to respond correctly.
 - *Falling down:* When the old person falls down, the robot generates an accident report and brings a doctor waiting at the door to the old person.
 - *Waving:* The old person asks for the robot by waving, and the robot is supposed to approach the old person.
 - *Holding the wall:* When the old person holds the wall, the robot is supposed to approach and ask kindly, and generate a report.
 - *Sitting down:* When the old person sits on a chair, the robot gets close and waits for what the old person is going to do.
- **Level IV:** The old person may command the robot to stay put, and a random accident happens when the old person walks away. Alternatively, the robot is following the old person and its vision is blocked when an accident happens. In both the preceding cases, the robot is also expected to respond correctly.

- *Falling down*: When the old person falls down, the robot generates an accident report and brings a doctor waiting at the door to the old person.
- *Waving*: The old person asks for the robot by waving, and the robot is supposed to approach the old person.
- *Holding the wall*: When the old person holds the wall, the robot is supposed to approach and ask kindly, and generate a report.
- *Smoking*: When the old person takes out cigarette from the pocket, the robot is expected to get close and give a reminder that “Smoking is harmful.”
- *Sitting down*: When the old person sits on a chair, the robot gets close and waits for what the old person is going to do.

4.2.6 Additional Rules and Remarks

1. **Safety**: During the test, the robot is not allowed to touch any person. If a robot shows any unsafe action, the TC has the right to stop the test immediately. The referees, OC members, and TC members will keep monitoring the status of robots. The TC will arrange for an operator to be ready to press emergency stop buttons at any time.
2. **Instruction**: Robots interact with the operator selected by the TC rather than team members.
3. **Vision blocking**: When other persons causing interference block out the path of a robot, the robot should politely ask for passing.
4. **Natural walking**: In following tests, the old person walks naturally and should not speed up suddenly. It means that the old person should gradually and properly speed up or slow down. The old person’s speed cannot exceed a specific maximum value.
5. **Photo**: Robots take photos to record random events mentioned in the preceding part, but not the walking activity.
6. **Action detection and response**: Robots should send clear audio messages to report what the old person did and what it will do next.

4.2.7 Referee Instructions

Two hours before the tests, the referees has the following tasks:

1. planning the paths and waypoints;
2. determining obstacle positions;
3. deciding the start positions of the old person and robots;
4. planning the locations of persons causing interference;
5. designing the actions to be detected and the locations of the old person.

4.2.8 Score Sheet

There will be a test for each level of difficulty. The maximum duration of each test is 5 minutes. If a team gets the specified target score of a stage, the team passes the stage and is eligible to participate in the next stage.

Robot Action	Level I	Level II	Level III	Level IV
Interaction				
Approaching the old person	-	10	10	20
Greeting the old person	10	10	10	10
(Optional) Judging whether wearing a smart wristband	10	10	10	10
Failing to judge	-10	-10	-10	-10
Following				
Arriving at waypoint 1	30	30	30	50
Arriving at waypoint 2	30	50	50	50
Arriving at waypoint 3	30	50	50	50
Action detection				
Correctly responding to the falling accident	20	20	10	5
Correctly responding to the sitting-down action	-	20	10	5
Correctly responding to the waving action	-	-	10	10
Correctly responding to the holding-the-wall action	-	-	10	10
Correctly responding to the smoking action	-	-	-	10
Taking photos	20	20	20	20
Total	150	220	220	250

4.3 Searching for Missing Objects

The old person will constantly change the position of objects during the test. Robots should follow the old person and memorize the current position of the objects. When the old person asks for some object, the robot is expected to help.

4.3.1 Target

In real family life, we often fail to find something. So do the elderly. They often pick up an object and put it in another place, and forgot it later. The robot is expected to follow the old person, observe the old person's movements, and remember the new positions of the objects with its extraordinary memory. When the old person asks for something, the robot is supposed to offer help.

4.3.2 Focus

Object tracking and identification, indoor navigation, and people detection

4.3.3 Tasks

1. **Start:** The operator sits on a specified chair. The robot enters the arena.
2. **Observation:** In tests that are more difficult, the robot needs to walk through the house for observation within limited time. Before the time runs out, the robot must approach the old person and clearly states that it is ready. If the robot fails to state in time, the TC will penalize the team. If the robot completes the task within 30s since the limited time, the team will get only 50% of the score. If the robot does not complete the task within 30s since the limited time, the test ends and the team gets no score.
3. **Standing up:** When the old person stands up from the chair, the test starts.
4. **Changing object positions:** The old person picks up objects from a place and places them in another place. Specific ways (of picking up objects, walking from one place to another, and choosing other places to put down the objects) vary in stages of different difficulty levels.
5. **Sitting down:** When the old person sits down on the chair, test is over.
6. **Question:** When the old person asks robots for something, the robot answers based on specific questions.

4.3.4 Difficulty Level

Object Positions

- **Level I:** At the beginning of a test, all objects are put at one place (usually on a table) which will be announced before the test.
- **Level II:** At the beginning of a test, all objects are put at different places of a room and will be announced before the test.

4.3. SEARCHING FOR MISSING OBJECTS CHAPTER 4. ROBOT TASK CHALLENGE

- **Level III:** At the beginning of a test, all objects are put at different places of a room and will be announced before the test. They might be placed on the floor near a shelf or location specified in **Prior Knowledge**.
- **Level IV:** At the beginning of the test, all objects may be put at different places of a room and will not be announced. They might be placed on the floor near a shelf or location specified in **Prior Knowledge**. The old person changes the positions of objects on these places.

Scene Change

- **Level I:** There are no sundries on the floor.
- **Level II:** There are sundries that can be detected by laser light on the floor.
- **Level III:** There are sundries that can be detected by laser light on the floor.
- **Level IV:** There are hollowed-out obstacles and sundries that cannot be detected by laser light on the floor.

Object Classification

- **Level I:** All objects are models.
- **Level II:** Simple objects and alike objects are included.
- **Level III:** Simple objects, alike objects, and difficult objects are included.
- **Level IV:** Simple objects, alike objects, and difficult objects are included.

Picking Up and Putting Down Operation

- **Level I:** The operation is performed slowly without blocking the robot's vision on objects. Arrange the objects in a new order and slightly adjust the directions.
- **Level II:** The operation is performed in a normal speed without blocking the robot's vision on objects. Arrange the objects in a new order and slightly adjust the directions.
- **Level III:** Pick up objects as people usually do, which might block the robot's vision on objects. Other objects besides are not touched or moved.
- **Level IV:** Pick up objects as people usually do, which might block the robot's vision on objects. Arrange the objects in a new order and slightly adjust the directions. The objects may be held in the old person's hands or hidden in pockets.

Following the Old Person

- **Level I:** The old person walks at a speed that is half of the natural one. If the robot loses the walker, it can ask the walker back and continue to follow.
- **Level II:** The old person walks at a natural walking speed. If the robot loses the walker, it can ask the walker back and continue to follow.
- **Level III:** The old person walks at a natural walking speed and does not care whether the robot follows.
- **Level IV:** The old person walks at a natural walking speed and does not care whether the robot follows. When manipulating an object on the shelf or floor, the old person may squat or stand a tiptoe.

Observation Time Limit

- **Level I:** 1 min.
- **Level II:** 2 min.
- **Level III:** 3 min.
- **Level IV:** 0 min. The robot observes objects when the old person places the objects.

4.3.5 Additional Rules and Remarks

1. **Questions:** The old person may ask two types of questions.
 - Type 1: What is the position of an object?
 - Type 2. How many pieces are there of a type of object?
2. **Answers:**
 - For questions of type 1, the robot can answer by either letting out an audio message or by showing a picture to indicate the position.
 - For questions of type 2, the robot must answer by letting out an audio message.
3. **People in the arena:** In the room where the robot is being tested, only one referee is allowed to be present.

4.3.6 Referee Instructions

Referees output a list of objects placed and a list of objects to be picked up before tests. Each test is executed based on two specific lists.

4.3.7 Score Sheet

Robot Action	Level I	Level II	Level III	Level IV
The robot gives the right object position.	10×3	10×3	10×5	10×5
The robot gives the right number of an object.	10×3	10×3	10×5	10×5
The robot gives right positions of all asked objects.	10	15	20	30
The robot gives the right number of all asked objects.	10	15	20	30
Total	80	90	140	160

Chapter 5

Elderly-Care Robot Design Challenge

In the **Elderly-Care Robot Design Challenge**, teams are expected to submit their design report on the implementation of elderly-care robots, while concrete implementation of the proposed solution is not required. The evaluation criteria of the submitted design reports include practicability, novelty, and general applicability of the design. Teams are encouraged to design a complete task scenario, not only the robot itself.

5.1 Submission

A design report is required to be no more than 6 pages. No specific format is assumed. A design report is expected to include a proposed scenario of elderly-care as well as some services provided by a robot. Technologies for realizing these services may be described in the report. But the description is not a necessary part of a design. Any design report should be submitted through email to yoyo@ustc.edu.cn by **Aug. 1, 2019**.

5.2 Evaluation and Awards

The evaluation criteria include:

- **practicability**: The scenario should be practical for elderly-care;
- **novelty**: The design should be novel, that is, substantially different from those that have occurred in previous competitions or designs of elderly-care services;
- **general applicability**: The proposed scenario and services should be applicable to common contexts of elderly-care, not rare ones.

The evaluation of all submissions will be made by an award committee for this challenge. The committee will decide the awards before the end of the competition and announce the winners at the awards ceremony of the competition.