

Electronic Supplementary Material 1

On the Role of Beliefs and Trust for Using Service Robots: An Integrated Trustworthiness Beliefs Model for Robot Acceptance

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Stimulus Material and Vignettes Used in the Online Study

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What are service robots?

In recent years, robots are becoming more and more involved in **everyday life**.

Robots that can perform useful **services**, **assistance** and **tasks** to support humans are referred to as **service robots**.

They work partially or fully autonomously, meaning they perform parts of the task or the entire task **on their own**.

We encounter them in **public places**, but increasingly they can also be found in our **homes**. At the same time, service robots can look very different, have different capabilities and perform different tasks.

Examples of service robots are **delivery robots**, **cleaning robots**, **entertainment robots** or **care robots**.

This excludes, for example, robots that are used in production facilities of industrial companies.

Where and for what are service robots used?

The application areas for service robots are growing faster and faster in both the public sector and the private sector.

In the **public sector**, the following tasks can be performed by service robots currently or in the near future:

- Delivery of food to households
- Parcel delivery
- Security monitoring
- Cleaning of floors or other surfaces
- Shopping assistance

In **private households**, the following tasks can be performed by service robots currently or in the near future:

- Storing groceries
- Tidying up the apartment
- Preparation of simple meals
- Filling and clearing out the dishwasher
- Bringing food or drinks from the kitchen

In addition, service robots have the following **characteristics** and **capabilities**:

- Sensors for environment and object recognition
- Mechanisms for handling objects (e.g., manipulator)
- Ability to perform a task (e.g., cleaning module)
- Possibility of locomotion (e.g., wheels)
- Communication via speech and/or displays

In the following, we would like to know your opinion about service robots based on your current impression. For this purpose, we ask you to answer questions about **service robots in general** on the following pages.

Autonomy of robots

Robots can perform tasks with **varying degrees of autonomy**.

This means that different robots can differ in the extent to which they make **autonomous** and **independent decisions** when performing tasks.

Robots that function **fully autonomously** perform their tasks independently to a high degree. They do not coordinate the individual steps of a task with the human user.

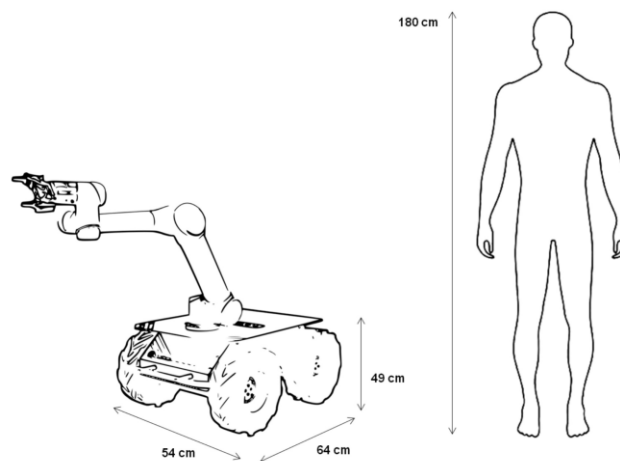
Partially autonomously functioning robots do not perform their tasks independently. They coordinate the individual steps of a task with the human user.

Service robot prototype

The robot prototype you will now get to know is an **assistance robot** that can help with various tasks.

The robot moves on a **platform with 4 wheels** and has an extendable **gripper** (140 cm) with which it can grab objects of different sizes and shapes, lift and manipulate (e.g. move) them.

The following figure shows the robot. A male person of average height is shown for size comparison:



The robot has **sensors** that allow it to sense its environment and orient itself. This prevents the robot from hitting objects or walls.

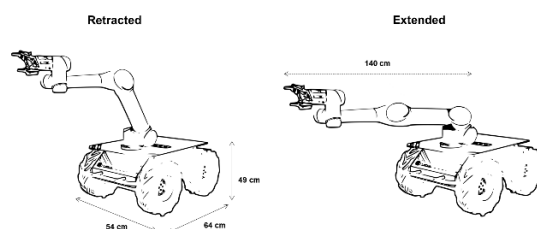
The robot can **recognize objects** and classify them into **categories**. It can learn the meaning of objects and which actions can be performed for a particular object in a category.

Based on the knowledge that the robot builds up, it is able to assist humans in tasks where, for example, objects have to be transported.

More information about the assistance robot can be found in the following table. For orientation purposes, the prototype is shown again with different positions of the gripper arm.

Weight	43.4 kg (including battery)
Platform size	64 x 54 x 49 cm
Gripper arm reach	140 cm
Maximum pickup gripper	15 kg
Speed	4 km/h
Material	Metal/plastic
Battery	520 minutes per charging cycle

Prototype with different positions of the gripper:



Description of the robot: Where is the robot used? [private]

The robot is used in **private households** to assist its owners with various tasks.

Examples are:

- Bringing up required items
- Stowing groceries on shelves, in cupboards and in the refrigerator
- Helping to cook recipes: the robot helps you find the ingredients you need and brings them to you
- Cleaning up clothes and other items
- Wiping dirty surfaces
- Reminding you of important appointments

*[Description of the robot's level of autonomy – see next page]

Now imagine the following situation:

You have purchased the described robot on a trial basis for your **private use** at home. It has just been delivered and you are about to **use** it for the first time.

Imagine you are **interacting** with the robot described.

Please answer the following questions based on the description about the prototype you've just read.

Description of the robot: Where is the robot used? [public]

The robot is used in **public areas** (e.g., supermarket or sports store) to assist customers with various tasks.

Examples are:

- Bringing up required items
- Stowing purchases in shopping bags or shopping carts
- Helping to cook recipes: the robot helps you find the ingredients you need and brings them to you
- Tidying up the supermarket shelves after the customer has taken something out or put it in a wrong place
- Wiping dirty surfaces
- Returning products that are not needed

*[Description of the robot's level of autonomy – see next page]

Now imagine the following situation:

A **supermarket** near your neighborhood, where you regularly shop, has purchased the described assistance robot for **public use** in the supermarket.

It has just been delivered and you are **using** it as a customer for the first time.

Imagine you are **interacting** with the described robot.

Please answer the following questions based on the description about the prototype you've just read.

Description of the robot: What can the robot do? *[fully automated]*

The developed robot acts **fully autonomously** (i.e. autonomously and independently).

It is able to collect and analyze information **independently**. The execution of a task is done **independently** and is not coordinated step by step with the human user.

Based on the collected information, the robot can **weigh up** between different courses of action **itself**. The robot then **independently decides** on one action without further coordination with the human operator.

The robot can thus act **independently** of humans and perform its tasks **without control or input from a human operator**.

_____ *[task examples – private]* _____

The following tasks and examples are intended to illustrate the capabilities of the robot:

- **Helping with cooking recipes and bringing up objects:** You tell the robot that you want to bake a cake and show it the recipe. The robot drives off independently and brings you the products you need (e.g., milk, eggs, oil, sugar, etc.).
- **Tidying up objects:** You tell the robot that you don't need a certain product (e.g., milk) after all. The robot takes the product and puts it back into the refrigerator.
- **Putting objects away:** You return from grocery shopping and put your purchases on the table. The robot moves next to you and puts your purchases away.

_____ *[task examples – public]* _____

The following tasks and examples are intended to illustrate the capabilities of the robot:

- **Helping with cooking recipes and bringing up objects:** You tell the robot that you want to bake a cake and show it the recipe. The robot drives off independently and brings you the products you need (e.g., milk, eggs, oil, sugar, etc.).
- **Tidying up objects:** You tell the robot that you don't need a certain product (e.g., milk) after all. The robot takes the product out of your shopping cart or bag and puts it back into the cooling shelf.
- **Putting objects away:** You are standing at the checkout and the cashier pulls your purchases over the shopping belt. The robot moves next to you and puts your purchases into your shopping cart or shopping bags.

Description of the robot: What can the robot do? *[partially automated]*

The developed robot does **not** act **fully autonomously** (i.e., autonomously and independently).

It is able to collect and analyze information independently. However, the execution of a task is **not** done **independently**, but is **coordinated step by step** with the human user.

Based on the collected information, the robot can **determine different courses of action** and **propose them to a human operator**.

Thus, the robot does **not decide** on an action **independently**, but **coordinates the choice** with the human operator before acting.

Thus, the robot **cannot act independently** of a human **to some extent**. It needs **control and input from a human operator** to perform its tasks.

_____ *[task examples – private]* _____

The following tasks and examples are intended to illustrate the capabilities of the robot:

- **Helping with cooking recipes and bringing up objects:** You tell the robot that you want to bake a cake and show it the recipe. The robot asks for each product in turn whether you need it (e.g., milk, eggs, oil, sugar, etc.). You can confirm each product or not. Then the robot drives off and brings you the products you have specified.
- **Tidying up objects:** You tell the robot that you don't need a certain product (e.g., milk) after all. The robot asks whether it should take the product and bring it back. You can confirm the desired action. The robot takes the product and puts it back into the refrigerator.
- **Putting objects away:** You return from grocery shopping and put your purchases on the table. The robot moves next to you and asks if it should assist you. You can confirm the desired action. Then the robot puts your purchases away.

_____ *[task examples – public]* _____

The following tasks and examples are intended to illustrate the capabilities of the robot:

- **Helping with cooking recipes and bringing up objects:** You tell the robot that you want to bake a cake and show it the recipe. The robot asks for each product in turn whether you need it (e.g., milk, eggs, oil, sugar, etc.). You can confirm each product or not. Then the robot drives off and brings you the products you have specified.
- **Tidying up objects:** You tell the robot that you don't need a certain product (e.g., milk) after all. The robot asks whether it should take the product and bring it back. You can confirm the desired action. The robot takes the product from your shopping cart or bag and puts it back into the cooling shelf.
- **Putting objects away:** You stand at the checkout and the cashier pulls your purchases over the shopping belt. The robot moves next to you and asks if it should assist you. You can confirm the desired action. Then the robot puts your purchases into your shopping cart or shopping bags.