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Human-Centered Interaction in Robotics

HCIR Assignment-1

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TASK 1

1.1 Human-Centered Interaction in Robotics

1.1.1 Give an example of a human-robot interaction scenario

Imagine SPOT, the robotic dog manufactured by Boston Dynamics, performing a search and rescue mission in a region devastated by a significant earthquake. Finding survivors among the rubble and debris is a difficult assignment for emergency workers. Spot, the robotic dog, proved to be a great help in this difficult situation.

With the use of a variety of sensors, including as thermal imaging, LIDAR, and cameras, Spot can travel over hazardous terrain and find indications of life. Spot connects with the command centre while moving over the disaster scene, giving it real-time information about its surroundings and any possible threats.

1.1.2 Discuss any four human-centered aspects of interaction between humans and robots in the above scenario.

1. **Safety:** It is crucial to guarantee the safety of survivors as well as human responders. Safety measures including collision avoidance systems and sturdy construction are incorporated into Spot's design to reduce the possibility of accidents or harm while it is in use. Additionally, by lowering their exposure to dangerous situations, Spot's capacity to navigate through difficult terrain and enter cramped areas improves the safety of human responders.

2. **Communication:** Coordination of rescue operations depends on effective communication between Spot and human responders. Spot has communication devices installed that allow it to communicate with the command center and receive commands instantly. Efficient collaboration in a high-stress setting is made possible by Spot and human operators interacting seamlessly thanks to clear and simple interfaces.

3. **Trust:** Establishing trust is essential for promoting productive cooperation between Spot and human responders. Spot is a great resource for search and rescue operations because of its straightforward behavior and consistent performance, which give responders trust in its abilities. Spot increases overall teamwork and effectiveness by gaining the trust of its teammates by reliably providing accurate information and carrying out duties with accuracy.

4. **Ethics:** When it comes to human-robot contact, ethics are very important, especially in delicate situations like search and rescue missions. When using robots such as Spot, human responders need to think about the ethical consequences, such as privacy, permission, and the dignity of survivors. Maintaining a human-centered strategy entails putting the rights and well-being of those impacted by the crisis first, but simultaneously safely and ethically utilizing robotics to improve rescue operations.

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Task 2

2.1 Robot Autonomy v/s Human Control

2.1.1 Give an example of a robotic wheelchair design for each of the following categories

1. **Low robot autonomy + low human control:** The user is given little control over the robotic wheelchair due to its limited autonomous capabilities. Despite having some basic navigation and obstacle avoidance capabilities, the wheelchair primarily relies on human input to move.

2. **Low robot autonomy + high human control:** In this design, the user has more control over the robot while maintaining limited autonomy. Additional features that provide the user exact control over the wheelchair's movements and functions include tilt and recline choices, seating positions that can be adjusted, and control interfaces that can be customized.

3. **High robot autonomy + low human control:** In this case, the robotic wheelchair is equipped with sophisticated autonomous features like automatic navigation, path planning, and obstacle awareness and avoidance. Basic user control commands such as start, stop, and emergency bypass are all that is required. The wheelchair is capable of independent, safe mobility in a wide range of environments.

4. **High robot autonomy + high human control:** The design of this system integrates a high degree of user control with a high degree of robot autonomy. In addition to its sophisticated autonomous features, the wheelchair offers the user a wide range of control options and customization possibilities. When necessary, the user can override autonomous behaviors, change preferences, and modify parameters.

2.1.2 Explain the pros and cons of each design you mentioned above

1. **Low robot autonomy + low human control: Pros:** Simple and easy to use, suitable for users with limited physical capabilities.
   Cons: Limited autonomous capabilities may require more effort from the user for navigation and obstacle avoidance.

2. **Low robot autonomy + high human control: Pros:** Provides users with a high degree of control and customization options.
   Cons: Reliance on user input for navigation may be challenging for individuals with severe mobility impairments.

3. **High robot autonomy + low human control: Pros:** Offers independent navigation and obstacle avoidance, reducing the cognitive and physical load on the user.
   Cons: Restricted user control, Reduced user happiness or insufficient consideration of user desires.

4. **High robot autonomy + high human control: Pros:** Combines advanced autonomous capabilities with user customization and control, providing a balance between independence and personalized user experience.
   Cons: The complexity in determining how user control and autonomous actions interact.

3

Reading – Human-Robot Interaction (HRI)

3.1 Read the following paper and write a scientific summary in 300 - 500 words

P. Vogt et al., "Second Language Tutoring Using Social Robots: A Large-Scale Study," 2019 14th ACM/ IEEE International Conference on Human-Robot Interaction (HRI), 2019, pp. 497-505, doi: 10.1109/ HRI.2019.8673077

The paper "Second Language Tutoring Using Social Robots: A Large-Scale Study" presents a comprehensive investigation into the effectiveness of social robots in teaching young children English vocabulary as a foreign language. The study was conducted as part of the L2TOR project and involved a series of seven lessons designed to help children learn new words using a social robot accompanied by a tablet. The primary objectives of the study were to assess the effectiveness of the robot in teaching new words, the impact of the robot's iconic gestures on word learning and retention, and the comparison of learning from a robot tutor accompanied by a tablet versus learning from a tablet application alone.

The research was conducted on a large scale, involving 194 children, and was statistically well-powered. A seven-session longitudinal study assessed the influence of robots—either utilising iconic and deictic gestures or solely deictic gestures—on teaching fundamental vocabulary from a foreign language to 5- to 6-year-old children. The experiment consists of four conditions: 1) Robot with iconic gestures and tablet, where tutoring is supported using iconic and deictic gestures, and interactions via a tablet game; 2) Tablet-only without robot, with speech output routed through speakers, and 3) Control condition. The study was designed to address the limitations of previous research and to provide valuable insights into the potential of social robots as second-language tutors. The findings of the study demonstrated that children were able to acquire and retain English vocabulary words taught by a robot tutor to a similar extent as when they were taught by a tablet application. Additionally, the study found no beneficial effect of a robot's iconic gestures on word learning and retention.

The paper contributes to the field of human-robot interaction (HRI) by providing evidence of the effectiveness of social robots in structured one-on-one tutoring sessions. It also addresses the limitations and opportunities of using social robots as second-language tutors, highlighting the scale and long-term nature of the experiment. The study was preregistered, ensuring transparency in the research questions, hypotheses, and methods. The study's scale and preregistration made it valuable in demonstrating the limitations and opportunities of using social robots as second-language tutors.

Furthermore, the paper references other relevant studies in the field of social robots for education, including research on expressive robots in education, social robot tutoring for child second language learning, and the effective personalization of a social robot tutor for children's second language skills. These references provide a comprehensive overview of the existing literature and position the current study within the broader context of research on social robots in education.

In summary, the paper "Second Language Tutoring Using Social Robots: A Large-Scale Study" presents a significant contribution to the field of human-robot interaction and education. The study provides valuable insights into the potential of social robots as effective second-language tutors and offers a well-documented and transparent investigation into the impact of social robots on children's language learning.

https://www.youtube.com/watch?v=dtNjn_77u_UVideo of actual representation of the robot

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Classify HRI Study

4.1 Apply the taxonomy

4.1.1 “1) Robot with iconic gestures + tablet” in Section II C. of the paper that you read in Task 3

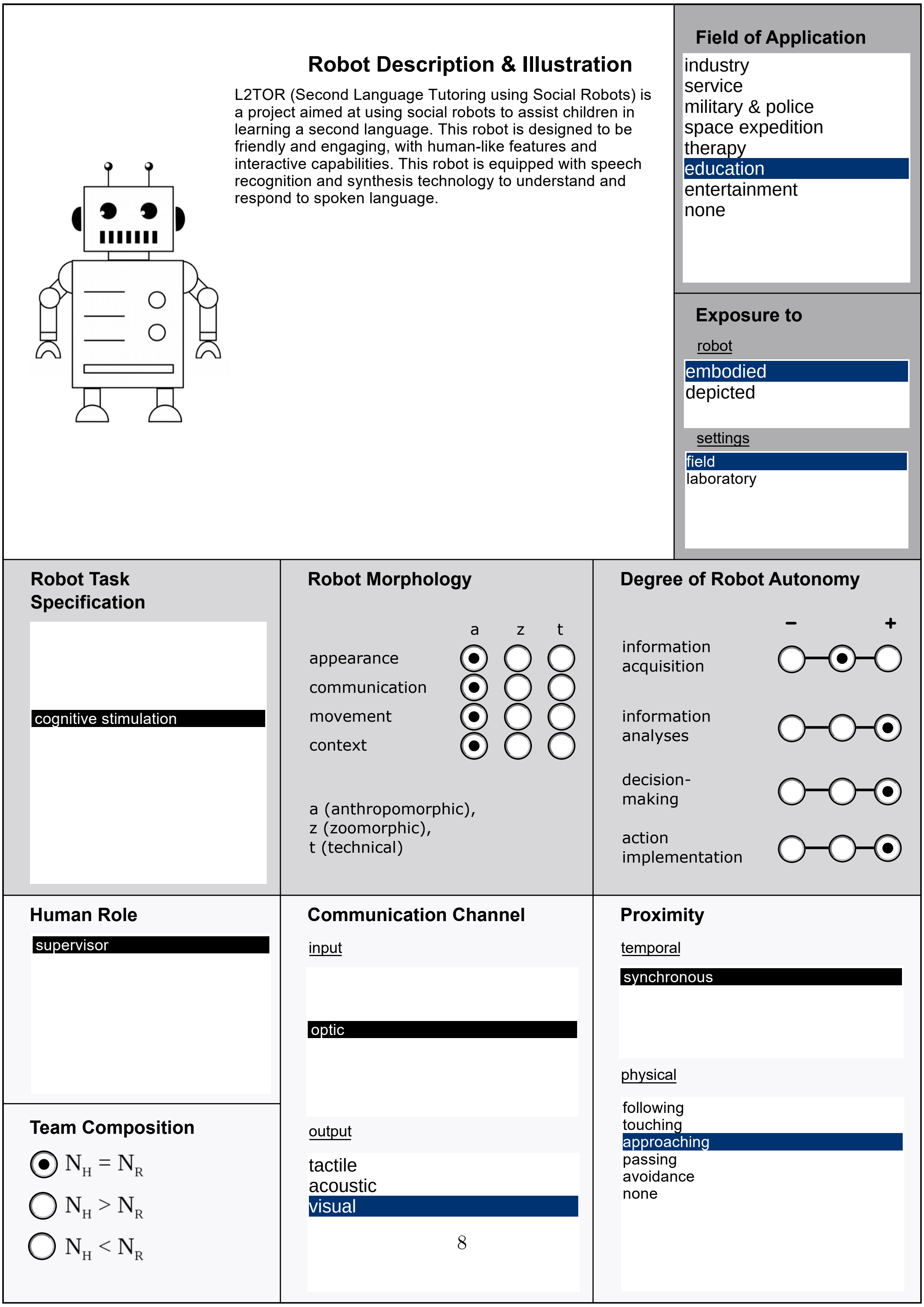

Figure 4.1: HRI Taxonomy

4.2 Explain your choice of categories

1. **Field of Application - Education**: This categorization indicates that the primary domain of application for the robots is in educational settings, specifically targeting children aged 4-6 years to teach them a second language, such as English.

2. **Exposure to - Embodied**: As the robot is a physical entity with a tangible presence in the learning environment, it interacts directly with learners. It has a physical form and can engage with users through physical interaction.

3. **Setting - Field**: This indicates that the robot is deployed in real-world educational settings rather than controlled laboratory environments. The study aims to observe how the robot performs and interacts with users in naturalistic, everyday situations.

4. **Robot task specification - Cognitive stimulation**: The primary function of the robot is to engage users at a cognitive level through verbal and nonverbal communication. In the L2TOR project, the robot is involved in educating and training children in language learning.

5. **Robot Morphology**: The robot is anthropomorphic in all conditions, appearing similar to humans in both appearance and behavior. It can communicate verbally and through actions resembling human gestures and movements.

6. **Human role - Supervisor or Collaborator**: In the L2TOR project, humans may act as supervisors overseeing the robot's activities or as collaborators engaging in joint activities with the robot to facilitate learning.

7. **Team composition**: The interaction may involve one-to-one sessions between the robot and a single child, or the robot may teach multiple children simultaneously, depending on the educational context and objectives.

8. **Proximity - Synchronous**: In a synchronous proximity setting, humans and the robot work together in the same physical space and engage in real-time interaction.

9. **Communication channel**: Input channels include optical (e.g., cameras for visual input) and acoustical (e.g., microphones for auditory input). Output channels include visual (e.g., tablet for displaying information) and acoustic (e.g., speakers for auditory output).

5

Realize Behaviors on Pepper

5.1 In this task, you will use the qibullet simulation tool to complete the following sub tasks

5.1.1 Implement a behaviour that enables Pepper robot to speak a given text.

```python
import time
from gtts import gTTS
from playsound import playsound

def speak():
    # Delay before starting to speak (6 seconds as specified)
    time.sleep(6)

    # Generate spoken message and play it
    tts = gTTS("Hello, welcome to Masters of Autonomous Systems")
    tts.save("message.mp3")
    playsound("message.mp3")
```

Listing 5.1: Python code for pepper to TTS

5.1.2 Implement a waving gesture on Pepper robot

```python
def wave():
    try:
        # Create a simulation manager and launch the simulation
        simulation_manager = SimulationManager()
        client = simulation_manager.launchSimulation(gui=True)

        # Spawn a Pepper robot in the simulation and move it to the initial posture
        pepper = simulation_manager.spawnPepper(client, spawn_ground_plane=True)
        pepper.goToPosture("Crouch", 0.6)
        time.sleep(1)
        pepper.goToPosture("StandInit", 0.6)
        time.sleep(1)

        # Perform waving motion
        for _ in range(5):  # Loop to wave 5 times
            pepper.setAngles("RShoulderPitch",-0.5,0.5) #
            pepper.setAngles("RShoulderRoll",-1.5620, 0.5)
            pepper.setAngles("RElbowRoll",1.5620,0.5)
            time.sleep(1.0)
            pepper.setAngles("RElbowRoll",-1.5620,0.5)
            time.sleep(1.0)
    finally:
        # Stop the simulation when waving motion is completed or in case of an error
        simulation_manager.stopSimulation(client)
```

Listing 5.2: Python code for Pepper to Wave

5.1.3 Add comments in your code to explain your logic

```python
import concurrent.futures

# Multithreading for wave and speak function
with concurrent.futures.ThreadPoolExecutor(max_workers=2) as executor:
    # Schedule wave and speak functions to run concurrently
    future_wave = executor.submit(wave)
    future_speak = executor.submit(speak)

    # Wait for both tasks to complete
    concurrent.futures.wait([future_wave, future_speak])
```

Listing 5.3: Python code for multithreading