Interactive Handshake with Spot Robot using Impedance Control

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Abstract. The Human-robot handshake serves multiple purposes, from enhancing the interaction to increasing acceptance and affinity and establishing a bond between the robot and human in a collaborative framework. In this paper, we present an interactive demonstration of a Human-robot handshake with the Boston Dynamics Spot robot using the dedicated robotic arm mounted on the top of the robot. Our system utilizes the software SDK of Boston Dynamics to control the robotic manipulator and grip, achieving an enjoyable, lifelike handshake performance.*

1 Introduction

Robots have been increasingly deployed in applications requiring direct collaboration with human individuals. Ensuring a smooth and efficient integration of robots into human societies requires high acceptance and trust, which can be achieved through intuitive humanistic gestures, including handshaking. Spot robot is a relatively fast, large, and cumbersome robot that weighs approximately $50kgs$, with a robotic arm mounted on top of it, making it appear as intimidating. Our proposed system enables the users to break the ice and establish a bond by joining a handshake with the Spot robot using the robotic arm. We aim to raise the affinity and rapprochement during Human-Robot interaction by making the appearance and movement very close to Human beings[1]. Subsequently, better Human-Robot interaction will increase the enjoyability and efficiency of solving the related tasks[2]

2 Quadruped robots in literature

Research on quadruped robots contains several interconnected specialized domains elaborated in Figure 1, from developing the mechanical design and structure to improving the locomotion and spatial navigation capabilities. The outcome of research on these two domains lays a solid foundation for developing

* Demonstration video link: https://drive.google.com/drive/folders/1iPN35KW7ddDqO9Vv4f54AL8SAP8LZFMu?usp=drive_link

specific applications using quadruped robots. In addition, Improving Human-Robot Interaction (HRI) is also one of the main research categories on quadruped robots, which aims to boost Communication with human users through voice and gesture commands, understanding emotions, and handshaking are remarkable symbols of trust and collaboration.

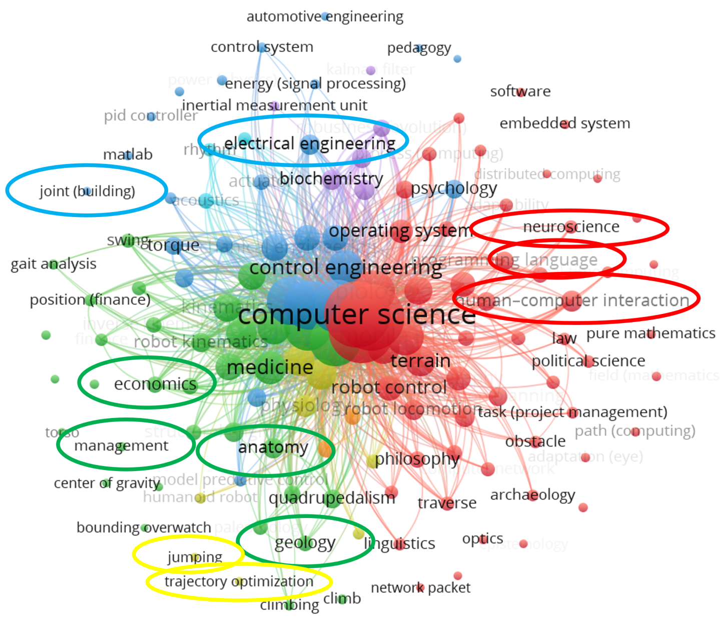

Fig. 1: Literature bibliometric map showcasing the main research areas on quadruped robots. Human-Robot Interaction (HRI) in red, Locomotion and gait control in yellow, developing specific applications in green, and design and structure in cyan

3 System Overview

In the beginning, the robot is in an initial seated position; the motors are turned off, and the arm is stowed and docked on top of the robot. When the handshake program is executed, the system passes through the following 3 main modules:

1. **Robot initialization**: The motors are powered on, and the robot stands up. The arm is unstowed and half extended to the front and the gripper is opened.
2. **Handshake performance**: The user grasps the gripper and initiates the movement, and the robot responds with the following. The gripper is half-closed. The robotic arm moves in a reactive motion, complying with the

shaking force of the user. When the user stops shaking the robotic arm, the gripper opens, indicating the termination of the handshake performance.

3. **Robot deactivation**: After completing tasks, the robot enters the robot deactivation module. The gripper is closed, the arm is retracted and stowed, the robot sits down, and the motors are powered off.

Figure 2 shows the state machine UML diagram, elaborating the main 3 modules of the system. The transitions between the modules are defined by the following rules:

1. After a successful initiation the system transitions to an idle state.
2. Once the user initiates the handshake motion, the system transitions to the handshake performance module.
3. After a successful initiation the system transitions to an idle state.
4. If the robot reaches 20 sec in idle mode, the system transitions to the deactivation module.

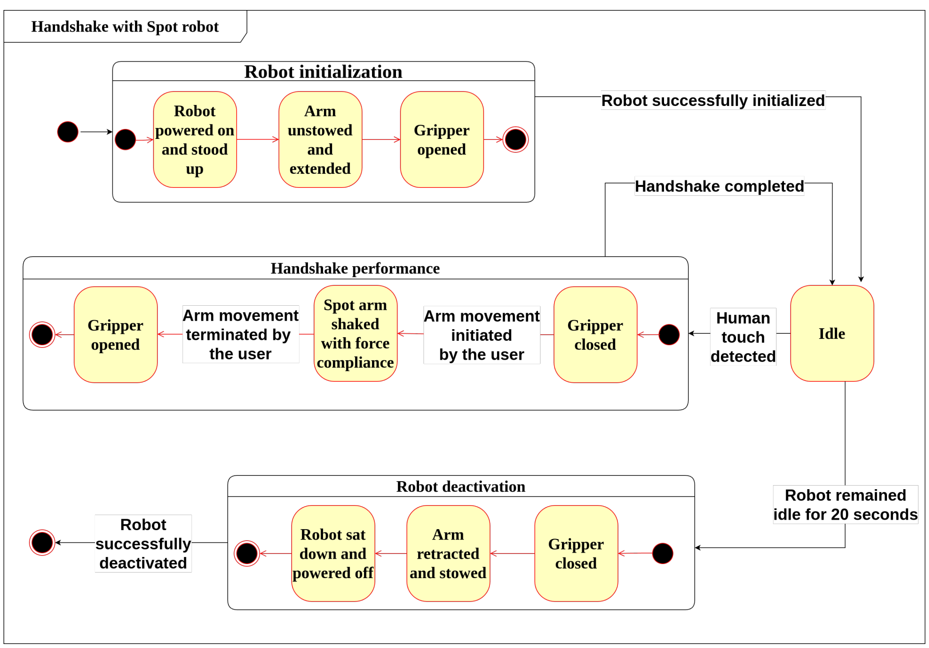

Fig. 2: State machine UML diagram elaborating the main stages of the handshake demonstration

4 Implementation Details

4.1 Programming environment and tools

The robotic handshake system is implemented using Python programming language and Boston Dynamics Spot SDK. The SDK provides the required functionalities to achieve the task. It facilitates real-time communication and passing requests to the robot without running the program on the robot itself. The SDK is responsible for powering the robot on/off, standing up and sitting down, and stowing/ unstowing the arm.

4.2 Touch Detection

The user touch is detected when a minimal force is applied to the end effector at any axis. We set the minimal force threshold to 5 Newtons, which is close to the weight of the human arm when relaxed, and it is high enough that random outer minimal forces do not trigger the handshaking.

4.3 Handshake performance module

The robotic arm is set to apply zero force in any direction and zero torque around any axis to the human hand when it is in the initial position, and the human hand is not applying any force to the robotic arm. Once the user starts the shake, the arm applies stiffness and damping forces. The stiffness forces determine how challenging it is to move the robotic arm away from the initial position, and the damping forces determine how fast the arm will return when moved away from the initial position. Boston Dynamics SDK recommends certain values for the translational/ rotational stiffness and damping coefficients. We use these coefficients with a lowered value for the Z axis by 50%, which guides the motion to be twice more facilitated in the up/down range than the front/back and left/right ranges.

5 Conclusion

The designed handshaking system enables the users to participate in a Human-robot handshake with the Boston Dynamics Spot robot. The simple gesture enables the users to connect with the robot and prepares them for further interaction and collaboration. We plan further improvements, including triggering the handshake when the user approaches the robot with an extended arm. The touch detection could also be enhanced by incorporating a haptic sensor and user profiling could help personalize the handshake as well.

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