https://doi.org/10.31256/Gn9Mg2I

Dynamic Camera Usage in Mobile Teleoperation System for Buzz Wire Task

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***Abstract*—Visual feedback is the most important form of perception within teleoperation, therefore there is a need for a solution that allows for increased potential information gain that a camera can provide, this can be obtained by having a camera that is able to move its position relatively to the base robot. Therefore, this paper focuses on the use of a drone to act as dynamic camera in teleoperation scenarios. The drone control is performed via the use of hand tracking through a wearable motion capture suit and is built upon an existing teleoperation control framework. The usability of the dynamic camera is demonstrated through the use of a simulated drone to act as a dynamic camera in a simulated buzz wire task.**

***Index Terms*—legged manipulator, quadruped robot, teleoperation, dynamic camera**

I. INTRODUCTION

Teleoperation has been a rather useful application of robotics, in that robots can operate in scenarios that are too demanding or unsuitable for humans. However, for a teleoperated robot to be effective, the feedback from the robotic system must also be of high quality. Visual feedback is the main source of information for teleoperators controlling a robot and when operating in distant environments, the location of the camera is typically limited to the teleoperated robot. This allows for the robot to complete simple tasks, however, when delicate tasks such as moving hazardous objects or surgical scenarios, the placement of the camera can make teleoperation much more difficult. Traditionally, cameras have always been physically connected to the teleoperated robot, however, due to this limitation, there is a risk of other objects located on the robot such as robotic arms blocking the vision of the camera and impeding the teleoperation process. A mobile dynamic camera has the potential to avoid issues like these and also give the teleoperator a greater sense of depth and perception when considering a manipulation environment.

When teleoperated robots use only a single camera mounted on the robot, perception is more difficult for the teleoperator [1]. Manipulation difficulties can be avoided through use of object-orientated manipulation, however, this requires prior knowledge about the object being manipulated [2].

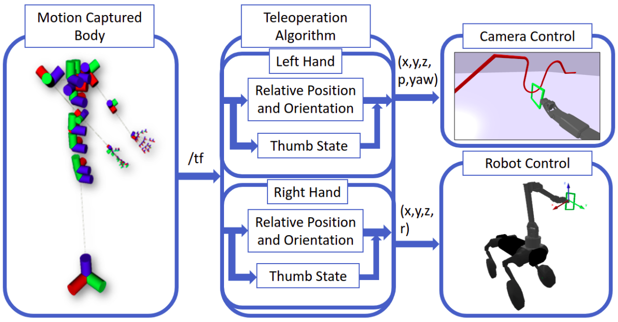

Fig. 1. An system overview of the control framework within the simulated task.

Cameras which span 360 degrees are a new innovation that have seen use on many teleoperated systems, however, as the camera itself is typically located in a fixed position on the robot, it is not possible for a teleoperator look beyond objects obstructing the cameras vision without moving the robot itself [3].

In this paper, a simulated drone based dynamic camera controlled via the use of hand tracking in a motion capture system is combined with a mobile manipulator system that is teleoperated in a simulated environment to complete a buzz wire task.

II. SYSTEM OVERVIEW

For our teleoperated system, we use the Unitree's Aliengo quadruped robot, with additional actuated wheels on the feet, to provide linear movement, and a mounted ViperX 300, a 5 degree-of-freedom (DoF) robotic arm produced by Trossen Robotics, located on the top of the robot. Wheels allow the quadruped to perform linear movement without generating additional oscillations from actions such as stepping, which would be detrimental in this task. This also allows the quadruped to freely use its legs to adjust it's base height, effectively increasing the workspace of the robotic arm. Control of this robotic system is performed via sending position and orientation references to the end-effector of the robotic arm. These references are then coupled with the rest of the robot using a whole-body controller [4].

The dynamic camera system is built upon an existing teleoperation system [5] which uses a wearable inertia-based suit to control robotic systems through hand movements and finger-based triggers. In this scenario, the left hand is responsible for controlling linear movement and orientation of the dynamic camera, using the thumb as a trigger to switch between linear movement and orientation control. The right hand controls the

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This work was supported by the EPSRC [grant numbers EP/R513258/1-2441459, EP/V026801/2], the AMPI [Innovate UK project number 84646] and the UKRI Future Leaders Fellowship [grant number MR/V025333/1].

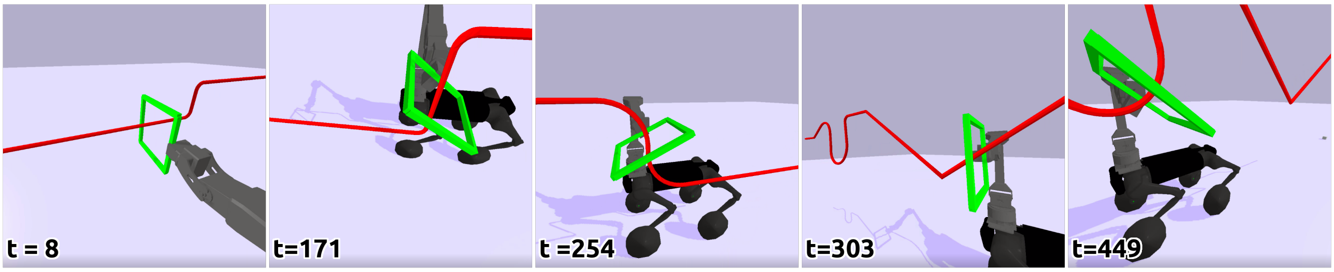

Fig. 2. Snapshots of the various angles and positions achieved by the dynamic camera used by the teleoperator when controlling the robot during the simulated task.

TABLE I
CONTROL STRATEGIES

Hand	Thumb Open	Resultant Control
Left	True False	Dynamic Camera Linear Position Dynamic Camera Orientation
Right	True False	End-Effector Linear Position End-Effector Linear Position and Orientation

position and orientation of the robotic arm end-effector, using the thumb as a trigger to toggle orientation control on and off. This control strategy is outlined in Table I. A overview of the teleoperation system is illustrated in Fig. 1

III. SIMULATION

To demonstrate the capabilities of the dynamic drone camera, a simulated version of a buzz wire game was created using PyBullet. The simulation environment features a large wire frame, illustrated in Fig. 3, extending outwards in a direction parallel to the robot. The robot arm end-effector has been replaced with a square shaped ring, primarily to enhance the collision detection within Pybullet itself to ensure the simulation runs smoothly. The arm is orientated at the start so that the ring starts around the wire. The dynamic camera is positioned in the simulation with respect to the robot, allowing for the camera to move with the robot without requiring action from the teleoperator. During the simulated task, through the use of the dynamic camera in collaboration with the teleoperation framework, the end-effector was successfully maneuvered in a way which lead to it not making any contact with the wire. Snapshots at various points in the simulated task with the respected perspective of the dynamic camera at that time is shown in Fig. 2.

Fig. 4 illustrates the relationship of the vertical position of the robotic arm end-effector with the desired vertical position provided by the teleoperation framework. Throughout the simulated task, the dynamic camera was used to ensure that the end-effector was clear to move in locations where it could potentially make contact with the wire frame, demonstrating its value in tasks where careful movements are required and achieving its goal of providing the teleoperator with more information concerning the environment.

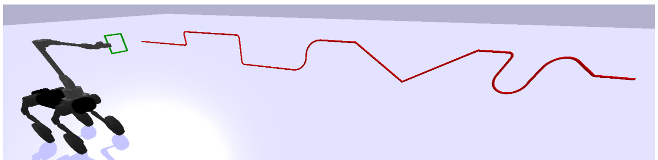

Fig. 3. View of the simulated environment and robot.

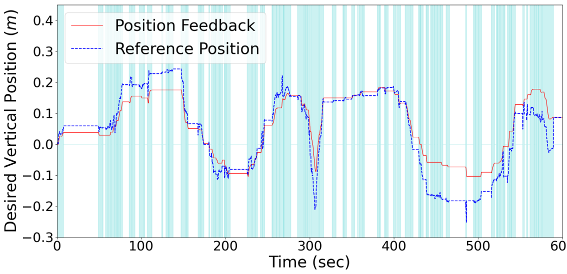

Fig. 4. Chart illustrating the vertical position of the robotic arm end-effector of the robotic arm when provided with a reference position from the teleoperation framework. Highlighted areas indicate when a trigger is active to allow the reference to be sent to the robot.

IV. CONCLUSION

In this work, the use of a dynamic camera system was shown to be beneficial to a mobile teleoperation task, allowing for the teleoperator to obtain information about the environment before acting. Future works include hardware implementation of the dynamic camera system into the existing teleoperation system.

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