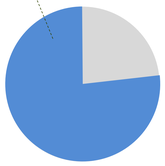
Robot Therapist for Assisting in At-Home Rehabilitation of Shoulder Surgery Patients

Mahsa Alborz, Rachael Bevill, Zac Chalup, Scott Downen, Kelsey Genuino, Chelsea Nayback, Noelle Nesbitt, Chung Hyuk Park
The George Washington University, Department of Biomedical Engineering

MOTIVATION

76%

Percentage of traditional patients who **do not** fully adhere to their physical therapy regimen due to soreness, lack of supervision, and/or lack of incentive.



INTRODUCTION

Annually in the US, there are:

- 53,000 shoulder replacements
- 650,000 rotator cuff injury surgeries
- 4.5 million doctor visits for “extreme shoulder pain”

The **mean age** of shoulder surgery recipients is **increasing** (currently 50.9 years old), along with the number of surgeries performed. Older patients are **less likely to complete** their post-surgery therapy regimen than younger patients. Patients are more likely to complete their exercise **under supervision**. However, patients prefer to **exercise at home** over traveling to a session.

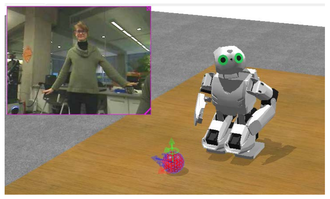
PURPOSE OF THE SYSTEM

To resolve the abovementioned issues, we propose the use of an autonomous, interactive robot for patient rehabilitation as they recover from shoulder surgery. This robot introduces customized training and encouragement regimens, to increase physical therapy adherence and improve the patient's recovery experience from the comfort of their own home.

SUB-SYSTEMS

- Robotic system – ROBOTIS-OP2 (“OP2”)
- Physical therapy exercises
- Feedback style
- Programming interface

Right: The camera inside the physical OP2 robot can be used to interact with the patient and control the Webots simulation for testing.

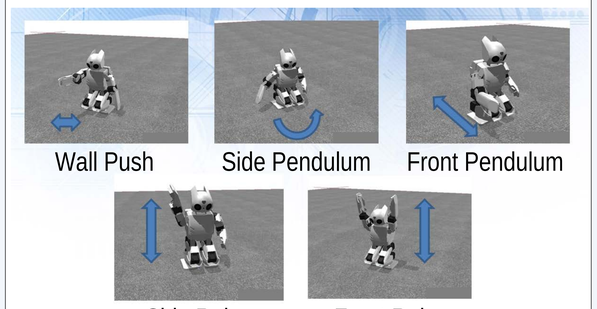


TYPICAL RECOVERY TIME-TABLE

Resting Period | Calibration | Coaching | Recover & Record

Time	Patient Duties	Robot Duties
0-6 weeks	No movement	No interaction
6-12 weeks	Limited mobility	Perform calibration
3-6 months	Perform monthly performance test	Prompt patient to exercise daily
	Provide feedback on exercise and coaching preferences	Provide verbal coaching based on user & goal data

PHYSICAL THERAPY EXERCISES



Wall Push | Side Pendulum | Front Pendulum

Side Raise | Front Raise

Roughly three months following surgery, a typical rehabilitation program involves several commonly used movements, demonstrated by the Robotis-OP2 above.

Exercise Program

- Initial range of motion and pain levels recorded during calibration
- OP2 guides the user through the physician-prescribed rehabilitation program and movements
- OP2 first demonstrates the exercises, then observes the user’s performance and gives performance feedback

The movements targeted for the purpose of this study include internal rotation, glenohumeral abduction, glenohumeral flexion, and passively performed pendulum movements.

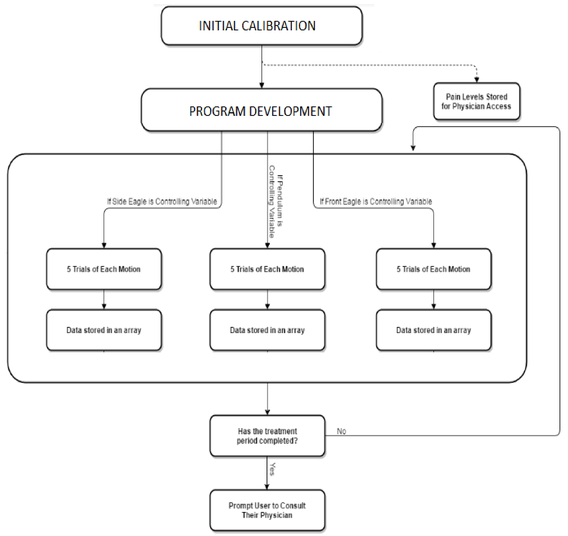
FEEDBACK STYLE

- Research shows users respond positively to robots when they exhibit and respond to social cues
- OP-2 provides active verbal feedback to the user based on performance
- Role model systems: promotion (positive feedback) and prevention (negative feedback) vary in their affect on individual user motivation
- Feedback style is altered throughout the rehabilitation program as OP-2 learns user preference and observes which styles generates the most patient improvement

PROGRAMMING INTERFACE

To develop an accurate representation of the expected environment, Webots robot simulator was used. Through these development tools, full simulations can be run to maximize performance of the OP2 in the real world, including user motion tracking, motion demonstrations, verbal communication, social cues and sensing elements.

ROBOTIC PROTOCOL FOR THERAPY

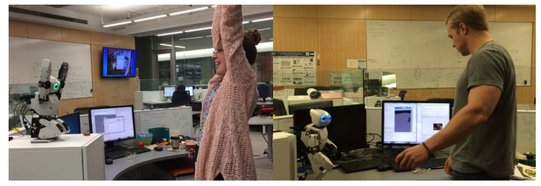


Above: Diagram breakdown of the robotic rehabilitation program. The recovery process, including exercise intensity and feedback style, is custom-tailored to each patient.

FEASIBILITY, CURRENT CAPABILITIES

Initial feasibility studies have proven promising. After completing the primary programming phase, the robot is currently able to:

- Perform calibration routines
- Demonstrate movements
- Retain user calibration information including pain values and initial range of motion of the joint
- Automatically generate a custom rehabilitation program based on initial calibration
- Track user movement
- Provide verbal feedback
- Adapt feedback style based on patient performance



Left: OP2 completes exercise at the same time as participant. Right: OP2 observes the participant’s progress as he performs the shoulder exercise. Robot’s vision from camera can be seen on the right side of the computer screen.

Additional feasibility studies are needed to determine long-term performance of the OP-2.

FUTURE WORK

The researchers would like to:

- Advance therapy coverage for additional joints
- Remotely report patient progress to the medical professional
- Allow for remote adjustment of the exercise regimen by a medical professional
- Program robot to follow patient – currently stands in place, does not utilize walking capabilities

ACKNOWLEDGEMENTS

The researchers would like to thank Dr. Chung Hyuk Park for his instruction and guidance on this project, as well as for the use of his lab and Robotis-OP2. They would also like to thank the Cyberbotics support team for their assistance in resolving Webots cross-compilation errors.