ROBOT THERAPIST FOR ASSISTING IN AT-HOME REHABILITATION OF SHOULDER SURGERY PATIENTS

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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

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 generate 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.

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

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

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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.

TYPICAL RECOVERY TIME-TABLE

<table>
<thead>
<tr>
<th>Time</th>
<th>Patient Duties</th>
<th>Robot Duties</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 weeks</td>
<td>No movement</td>
<td>No interaction</td>
</tr>
<tr>
<td>6-12 weeks</td>
<td>Limited mobility</td>
<td>Perform calibration</td>
</tr>
<tr>
<td>3-6 months</td>
<td>Perform monthly performance test</td>
<td>Prompt patient to exercise daily</td>
</tr>
</tbody>
</table>

PHYSICAL THERAPY EXERCISES

- Wall Push
- Side Pendulum
- Front Pendulum
- Side Raise
- Front Raise

ROBOTIC PROTOCOL FOR THERAPY

Execution 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.