DEPARTMENT OF
Electrical and Computer Engineering

11-203 Donadeo Innovation Centre for Engineering
9211-116 Street NW
University of Alberta
Edmonton, Alberta
Canada T6G 1H9

Proposal Response: Device to Administer Motor Task Training to Lab Animals

Proposal Sponsor: Keith Fenrich, Ph.D. Research Associate, Adjunct Professor, Faculty of Rehabilitation Medicine, University of Alberta

Objective

The proposal objective is to develop an automated training system that administers and evaluates animals' performance in the string-pulling task. The system shall be adopted to the peripheral video capture system allowing the training metadata to be recorded.

Introduction

Rehabilitation training is a practical treatment strategy for most types of nervous system injury and disease. Despite the universal application of rehabilitation training (e.g., bimanual skilled movements training) in the clinic and the recognition that the training contributes to the beneficial effect of drag designed to promote nervous system recovery, the effect of rehabilitation training is rarely investigated in pre-clinical biomedical testing, which is due to its time consuming and costly nature. To overcome those barriers, Dr. Fenrich's laboratory is developing robotic systems to automate the rehabilitation training and evaluate rats/mice in skilled movement tasks.

The string-pulling task is one of the bimanual skilled motor tasks recently developed in the laboratory to assess bimanual forelimb function in rats/mice. The main process of the task is to motivate the animals to pull strings, which is usually done by tying food rewards to the string ends. However, the original setting requires tedious preparation, as it involves over one thousand repetitions of the string tying operation per week. Looking for a commercial solution is impracticable, as those devices in the market are either expensive or incapable to meet the training requirements. A new design shall be proposed to address such inconvenience.

The design we proposed includes a string-pulling device, sensors, and encoders to record the metadata, step motors to adjust the pull force, a food pellet reward dispenser, and an integrated control/storage module. The fundamental functionalities of the new design include automated control of the training parameters (e.g., pull force, pull distance, time limitation), food pellet dispensing, as well as performance data recording and storage. The automated training system shall be easily and reliably connected/detached from the training enclosure.

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Proposed Solution

Our conceptual design consists of the following modules:

(1) The string-pulling module: This module is expected to provide the pulling training for animals. It shall tolerate edge cases (e.g., animal chewing or biting) and accommodate multiple sizes of training targets, from mice to rats. The module consists of a pulley system.
(2) The force-controlling module: This module is expected to control the force needed to pull the string. It shall communicate to the system control/storage module to set and record the pull-force. The challenge we face is the lack of sensor types in the market, but we have come up with several feasible solutions, which consist of the stepper motor to control the string motion and the weight sensor to detect the string tension.
(3) The dispenser module: This module is expected to dispense the food pellet. The system control/storage module shall determine the dispensing time and volume. The module consists of a stepper motor and a container.
(4) The system control/storage module: This module is expected to control the whole string-pulling system. A GUI shall be provided, allowing the user to set and record the training parameters (e.g., pull-force, food pellet volume). It could also record other training information, such as the number of completed tasks. The module consists of a Raspberry Pi board.
(5) The distance-measuring and timer modules: Those two modules are optional and could be designed and integrated into the system once the latter meets the fundamental requirements. The distance-measuring and timer module is expected to measure the string displacement and time elapsed once the training target starts pulling, respectively. And they shall both communicate to the system control/storage module. We believe it is practical to design those two modules using the components in the modules mentioned above.

The operating environments: The automated training system shall be easily and reliably connected/detached from the training enclosure. The system shall be adopted to the peripheral video capture system allowing the training metadata to be recorded.

Our targeted outcome: We would build a prototype of our design. We first construct modules (1) to (4) and verify their functionalities. Then we assemble the modules into the system and perform an overall verification. Due to the quarantine policy, we could not access the lab animal. Therefore, we use our hands to mimic the pulling actions. We would work on module (5) if time allowed. Finally, we would have a demonstration to show that the prototype meets the requirements.

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Project Overview Statement (POS)

Table 1 Project Overview Statement

<table>
<tr><td>Project Overview Statement</td><td>Project Name
Device to Administer Motor Task Training to Lab Animals</td><td>Project Number
1</td><td>Project Manager
Ruichen Chen</td></tr>
<tr><td colspan="4">Problem/Opportunity

Researchers need to have easy access to different experiment conditions and analyze the result.</td></tr>
<tr><td colspan="4">Goal

develop an animal training system that can perform string-pulling task as well as recording the performance for evaluation and further research</td></tr>
<tr><td colspan="4">Objectives

1. The string structure can fulfill the rehabilitation requirements.
2. Reward should be given automatically when animal successfully performs the task.
3. The pull-force of the string can be controlled and changed by user.
4. The length of the string pulled should be recorded.
5. Easy to install on most cases.
6. The system is able to be positioned for video recording.</td></tr>
<tr><td colspan="4">Success Criteria

1. Final product in 3 months.
2. Both hardware and software should be working.
3. Cost < $400</td></tr>
<tr><td colspan="4">Assumptions, Risks, Obstacles

1. Due to the limitation of the equipment, it may not be effective for animals too large or too small.
2. System may exist unexpected problem because experiment with real animal can’t be performed.
3. May need design carefully to fit most cases.</td></tr>
<tr><td>Prepared by
Ruichen Chen</td><td>Date
2021/01/22</td><td>Approved by</td><td>Date</td></tr>
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Intellectual Property Statement

Note: Public presentation and, hence, disclosure is a course requirement.

- Any open−source materials used in this project will be identified to the client prior to inclusion.
- All results and intellectual property created will be owned by the Faculty of Rehabilitation Medicine, represented by Keith Fenrich.
- Students from the capstone group have the right to obtain a royalty-free license for the technology as it exists May 30, 2021 (written agreement required).

Contacts

Name	Email
Ang Li	ang6@ualberta.ca
Hao Xuan	hxuan@ualberta.ca
Maocheng Shi	mshi1@ualberta.ca
Ruichen Chen	ruichen1@ualberta.ca