Assistive Writing Device for Parkinson's Patient

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ABSTRACT

Parkinson patients face a lot of difficulties in their daily lives. Due to some problems in their brains, they can't control their bodies properly.

Therefore, we decided to design a kind of wearable device that assists them to write. The device's function is to eliminate the tremors of Parkinson's patients and stabilize their hands for writing task, hoping to alleviate some problems in their lives.

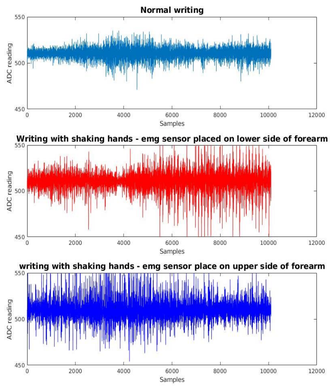
BACKGROUND

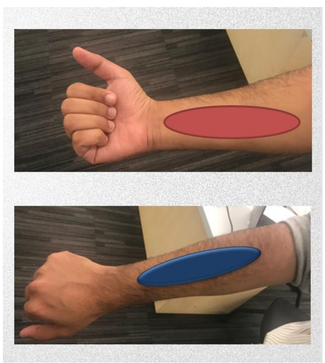
Motivations

- Parkinson Disease affects approximately seven million people globally and one million people in the United States [1]. The number of new cases per year of PD is between 8 and 18 per 100,000 person [2]. Therefore, such high incidence rates will inevitably cause a large burden to the patient's families and to the society as a whole.
- Although there are current devices that exist in the market and reported by media to help Parkinson's patients, their high price has discouraged many patients from buying them. So, we aim to build a wearable device using open source platforms and simple components, so that the device can be made available to a more number of patients.

Problem Analysis

- We imitated writing activities of the Parkinson patients and normal people and place the EMG sensor on different area of arms to detect muscular activities data, which is showed below.
- The Parkinson patients do want to control the involuntary torque produced by the forearm muscles, but this kind of behavior sets up a positive feedback loop which will continuously amplify the hand tremors of patients, intensifying the hand movements, making it very difficult for the patient to write.





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[1] de Lau LM, Breteler MM (June 2006). Epidemiology of Parkinson's disease. The Lancet. Neurology. 5 (6): 525{35. doi:10.1016/S1474-4422(06)70471-9.

[2] Elbers RG, Verhoef J, van Wegen EE, Berendse HW, Kwakkel G (October 2015). Interventions for fatigue in Parkinson's disease. The Cochrane Database of Systematic Reviews (10): CD010925. doi:10.1002/14651858.CD010925.pub2. PMID 26447539

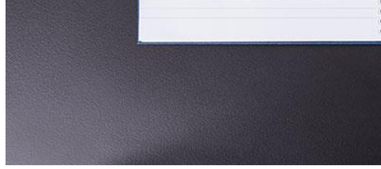
METHODS

Methodology

We cancel the involuntary torque produced by the patients' forearm, we can help them to write.

$$\theta = f(x) + U_{voluntary} + D_{forearm} \quad \text{-S(u)}$$

$f(x)$ is the dynamic model of the fore-arm
$U_{voluntary}$ is the torque exerted by the patient to control the hand and forearm.
$D_{forearm}$ is the disturbance torque generated from other muscles of the patient.

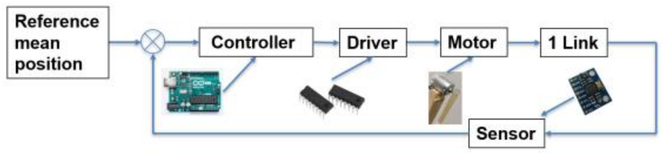


Dynamic Modeling

We used Newton Euler approach to develop the dynamic model of the one link pendulum to simulate the patients' tremors.

Simulation and experimental validation

We built a prototype to test the validity of our controller and understand the limitations of our simulation. Figure below shows the block diagram of major components of our prototype:



Emma Project's Picture
https://www.microsoft.com/en-us/research/project/project-emma/

RESULTS

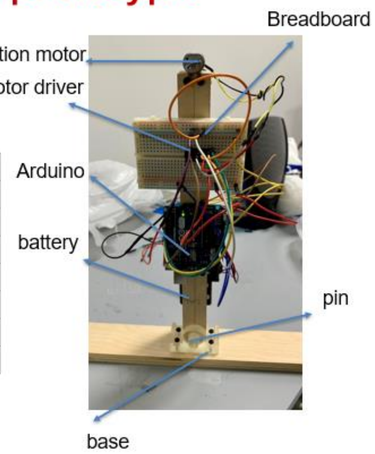
Prototype Construction

We built a prototype which is shown above. The pendulum is pinned to the 3D printed base linkage. The base linkage is mounted to the wooden base using 4 screws. In the front, we have Arduino Uno which is our single board computer where control algorithms are run. The motor driver is mounted on the 400 pin breadboard. At the back, we have 9v battery to power the Arduino and 2 × 3V battery to power up the motor.

Introduce the prototype

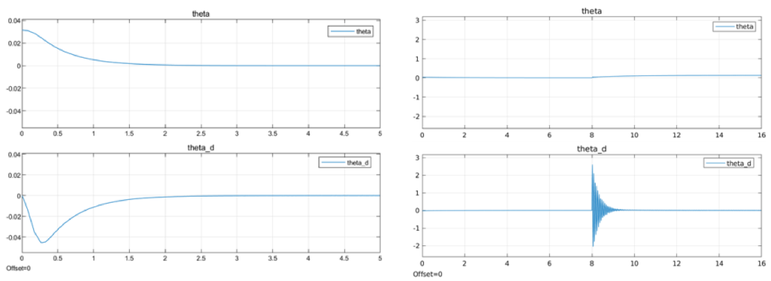
Parts Included In The Prototype

Item	Mass(gram)	Inertia($kg \cdot m^2 \times 10^{-4}$)
Arduino	27.22	4.6
Breadboar	86.18	36.22
MPU-6050	18.14	3.56
Motor	19.54	14.24
Battery(9v) and holder	43	2.1
Button cell and holder	5.27	0.64
Total	241.6	68.50



Simulation Result

A Simulation of one link pendulum that can be balanced by tuning the gains of the PD controller as well as a LQG controller.



CONCLUSIONS

- We have defined a design process for designing a Parkinson's assistive device which is based out of strong mathematical framework supported by simulation and experimental validation
- An extension to the 3D case requires more rigorous simulations, experimental testing and data collection with the actual PD patients
- The device cancels out the tremors of the patient to make motion of hand stable
- The device is light weight. It should not interfere with normal function of the limb
- The device is easy to wear and easy to switch on/off
- The device is operated on battery power, it needs to be energy-efficient