Design of a Functional Electrical Stimulation Device Adaptive to Walking

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Design of a Functional Electrical Stimulation system combining state-of-the-art sensors and machine learning to enhance the walking experience of people affected by multiple sclerosis or stroke.

INTRODUCTION

- Functional Electrical Stimulation (FES) makes use of electrical nerve stimulation to achieve functional muscle contraction lost due to central neurological dysfunction.
- People affected by stroke or multiple sclerosis suffer from Drop Foot (DF), which arises due to the weakness or paralysis of the dorsiflexor muscles in the leg.
- DF is insufficient dorsiflexion and eversion in walking, leading to reduced ground clearance in swing and ankle instability in stance.
- FES devices treat DF by stimulating the common peroneal nerve or the tibialis anterior muscle to enable ankle dorsiflexion.

OBJECTIVES

- Analyse the usage of the stimulator in different walking scenarios and identify the problems related to it.
- Develop a Machine Learning model to classify different walking scenarios based on sensor data.
- Design a control strategy to control the FES and regulate the stimulation parameters as required to encounter different walking scenarios.

PROPOSED METHODOLOGY

Step 1: Collect data from sensors for predicting walking scenarios in people with altered gait.
Step 2: Construct a predictive model using a Machine Learning algorithm to classify different walking scenarios.
Step 3: Train and test the model using the sensor data obtained from healthy participants.
Step 4: Identify different combinations of electrode placement and stimulation combinations.
Step 5: Design and develop an adaptive closed-loop FES system.
Step 6: Regulate the stimulation parameter as required to walk on different each scenario.

INITIAL RESULTS

- A suitable sensor was identified and its ability in predicting walking scenarios is being validated.
- The average accuracy of the result is 97.57% with 95% confidence interval (CI) ±1.327 for the estimated distance and 99.01% with 95% CI ±0.266 for the time (Anwary, 2018).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Actual</th>
<th>Left leg</th>
<th>Right leg</th>
</tr>
</thead>
<tbody>
<tr>
<td>distance (m)</td>
<td>37.77</td>
<td>37.81</td>
<td>37.19</td>
</tr>
<tr>
<td>velocity (m/s)</td>
<td>0.73</td>
<td>0.73</td>
<td>0.73</td>
</tr>
<tr>
<td>stride number</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>step number</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Table: Parameter accuracy estimation (Anwary, 2018)

CONCLUSION

- The combination of a smart sensor module and a closed-loop control strategy may allow the user to walk more confidently in different walking scenarios.
- This adaptive FES is expected to provide a more reliable system for the users and pave way for more similar future research.

REFERENCE