**بسم الله الرحمن الرحيم**

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**تم رفع هذه الرسالة بواسطة / سلوي محمود عقل**

**بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى مسئولية عن محتوى هذه الرسالة.**

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics Engineering and Electrical Communications

# EMG Pattern Recognition Based Neural System of Lower Locomotive Modes Used For the Controlling of Lower Limb Prosthesis

A Thesis submitted in partial fulfillment of the requirements of the degree of
Doctor of Philosophy in Electrical Engineering
(Electronics Engineering and Electrical Communications)
Submitted by

**TAREK MOHAMED BITTIBSSI**
Master of Science in Electrical Engineering
(Electronics Engineering and Electrical Communications)
Faculty of Engineering, ASU, 2014

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Cairo - (2022)

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Date:1 July 2022

# Statement

This thesis is submitted as a partial fulfillment of in Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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# Thesis Summary

Surface Electromyography (sEMG) signals have a lot of biomedical applications and modern human-machine interactions. sEMG signals received from muscles that require advanced methods for detection, pre-processing, and classification. Current research technologies are focused, principally on deep neural network architectures that collect spatial data from sEMG signals. Low-cost traditional prosthetic leg, available worldwide, can make walking and stair climbing possible but still difficult. This thesis presents the hardware implementation to the sEMG Powered Prosthesis Actuation (PPA) system using recurrent neural network (RNN) model based on three models long-term short-term memory (LSTM), Convolution Peephole LSTM and gated recurrent unit (GRU), which are used to train sEMG benchmark databases, and find the correlation between the input (sEMG) and outputs (gesture). The following techniques were evaluated by calculating the success of a variety of variables like training time, accuracy loss and hyper-parameters which were applied on eight benchmark datasets, in order to demonstrate the validity of these models, with prediction accuracy at almost 99.6 %. The data were collected from benchmark datasets describing different subjects during performance, and analyzing various gait patterns were used to construct the neural network and to alleviate significant model errors in a real-time setting. Processing circuits, interfacing the output with

the controller board, signal amplification, motor driving circuit and single-board computer programming are included in the implementation.

Keywords — sEMG, Recurrent Neural Network, LTSM, Pattern Recognition, RNN, Long-Short Term Memory, Prosthesis leg.

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# List of Abbreviations

| | |
|---|---|
| ABS | Acrylonitrile Butadiene Styrene |
| ADAM | Adaptive Moment Estimation |
| ADALINE | Adaptive Linear Element algorithm |
| AI | Artificial Intelligence |
| APs | Action Potentials |
| ANN | Artificial Neural Network |
| BPTT | Backpropagation through time |
| CNN | Convolutional Neural Network |
| CPU | Central Processing Unit |
| CSV | Comma-separated values |
| DL | Deep Learning |
| DoF | degrees of freedom |
| DC | Direct Control |
| EMG | ElectroMyoGraphy |
| FN | False negatives |
| FP | False positives |
| GPIO | General-Purpose Input/Output |
| GRU | Gated Recurrent Unit |
| IMU | Inertial measurement units |
| Kp,Ki,Kd | Proportional, Integral, Derivative gain |
| K+ | Sodium ion |
| k-NN | k-th Nearest Neighbours |