HAND ACTIVITY RECOGNITION USING A WEARABLE SMART GLOVE

John Neuman Gayan Samarasinghe

(188463H)

Degree of Master of Science in Electronics and Automation

Department of Electronic and Telecommunication Engineering

University of Moratuwa
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December 2020

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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The above candidate has carried out research for the Master's thesis under our supervision.

Name of the supervisor: Dr. Chamira Edussooriya

Signature of Supervisor: ______________________ Date: ________________

Name of the supervisor: Dr. Ranga Rodrigo

Signature of Supervisor: ______________________ Date: ________________

ABSTRACT

This project is aimed at designing, simulating and constructing a wearable device capable of performing activity recognition to track and monitor activities specific to the manufacturing industry.

This was done by designing data capturing glove to capture all necessary signals from the human body and provide necessary filtering to obtain low noise data. This is then passed through suitable pre-processing algorithms to create distinguishing features between activities. The best suited classification and post-processing algorithms were then designed and implemented to classify the captured data in to a specified set of activities.

The device was designed with an ESP8266 and a Raspberry Pi coded in C++ and Python respectively. Accelerometer & gyroscope sensors were used to collect data from the human body while a number of classical machine learning algorithms and convolutional neural networks were tested to classify the data.

For the activities pointing, wiping, tightening, loosening, picking, holding, pulling, pushing, hammering, walking, holding and walking and turning, the system was capable of classifying the test data with accuracies between 86% - 91%. The null set was classified with an accuracy of 100% with support vector machines with a linear kernel and the post processing algorithm. The same algorithm reached an accuracy of 91.3% for the activity classification while the support vector machine with RBF kernel and post processing algorithm reached an accuracy of 89.7%. The convolutional neural network trained on pre-processed 3D activity images and the post processing algorithm reached an accuracy of 86.2%.

The successfully created device will be used to obtain necessary analysis in the manufacturing space to optimize performance of the workers.

Key Words: Hand, Activity Recognition, Machine Learning, Convolutional Neural Network, Kalman Filter, Manufacturing, Industry

ACKNOWLEDGEMEMT

My master's degree and research would not have been possible if it was not for the following people. I would like to thank;

My supervisors, Dr. Chamira Edussooriya and Dr. Ranga Rodrigo for their constant support, guidance and patience. Their constant back up and check and adjust in moving forward with this research and thesis has helped me immensely.

The academic and administrative staff of the Department of Electronic and Telecommunication Engineering, University of Moratuwa for their input throughout this MSc Program.

My fellow students in the same MSc Program who have worked together with me to get through many hurdles throughout the program

My wife, Gayathri Karunaratne, who has been a constant source of support & encouragement during the challenges of work, student work and life. I am truly thankful for having you in my life.

My parents, Dr. Merril and Dr. Jayanthi Samarasinghe, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

My friends and family who have offered their help in the data collection process

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LIST OF ABBREVIATIONS

	Definition
1-CNN	Described in section 4.4.4
ANN	Artificial neural network
AR	Augmented reality
CM	Confusion matrix
CNN	Convolutional neural network
dim	Dimension
DoF	Degree of freedom
DFT	Discrete Fourier transform
DRR	Dropout regularization ratio
DT	Decision tree
EMG	Electromyography
FC	Fully connected
FFT	Fast Fourier transform
GMM	Gaussian mixture model
HAR	Hand activity recognition
HOB	Histogram of bends
HOG	Histogram of gradients
IC	Integrated circuit
IMU	Inertial measurement unit
IoT	Internet of things
k-NN	K- nearest neighbors
LDA	Linear discriminant analysis
LSTM	Long short-term memory
MCU	Micro controller unit
MEMS	Micro-electromechanical system
ML	Machine learning
MQTT	Message query
x-NN	x-nearest neighbors
sEMG	Surface electro-Myograph
RBF	Radial-basis function
ReLU	Rectified linear unit
RNN	Recurrent neural network
RPi	Raspberry Pi rev.3 model B
SVD	Singular value decomposition
SVM	Support vector machine
VR	Virtual reality
WCS	Worst case scenario
WFS	Wearable flexible sensors
$\boldsymbol{acc_x}$	Accelerometer X value
$\boldsymbol{acc_y}$	Accelerometer Y value
$\boldsymbol{acc_z}$	Accelerometer Z value
$\boldsymbol{gyro_x}$	Gyroscope around X-axis
$\boldsymbol{gyro_y}$	Gyroscope around Y-axis
$\boldsymbol{gyro_z}$	Gyroscope around Z-axis
$\boldsymbol{\alpha}$	Roll value
$\boldsymbol{\beta}$	Pitch value
$\boldsymbol{\gamma}$	Yaw value

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