CHARACTERIZATION OF GAIT USING INERTIAL MEASUREMENT UNITS AND NEURAL NETWORKS

Stephen Slaughter, Caroline Hilbert, Noah Jouett, and Maureen McEwen

University of Dallas, Irving, Texas
e-mail: stephens@udallas.edu

INTRODUCTION

A wearable inertial measurement unit (IMU) can be used to gather acceleration, rotational and magnetic field data on human movement and stability. Using these values to predict limits of stability (LOS) and distinguish them from activities of everyday living will lead to systems capable of warning a subject as the risk for falling increases (Wu. 2000; Luinge. 2005). The ability to model activities of everyday living is essential for customizing devices to an individual's movement characteristics. Neural networks have previously been used to classify fall risk based on balance (Giansanti et al. 2008). The purpose of this study was to determine the efficacy of using back-propagation neural networks to adequately model gait.

METHODS

Normal gait was performed by 14 healthy younger adults, 8 females and 6 males (20.1 ± 1.34 years).

Subjects walked for 10 meters while wearing an IMU at the level of their center of mass (COM). Data recorded included x-y-z acceleration in (Gs), x-y-z rotation in (degrees/second), and magnetic field in (microtesla), and time in (seconds) using a MotionNode IMU set to the ±2g range. The x axis represented side to side movements, y axis represented front to back movements, and the z axis represented up and down movements.

A back-propagation neural network with 1 hidden layer was used analyze the data. It was trained using all 9 axes of data. Training typically took 400 cycles. New gait values for the same subject were presented for feed-forward prediction. The goodness of fit was shown using scatter plots or mean shifted sum of squares calculations.

RESULTS AND DISCUSSION

When considering individual parameters, the resulting y acceleration prediction versus actual data is shown (Figure 1).

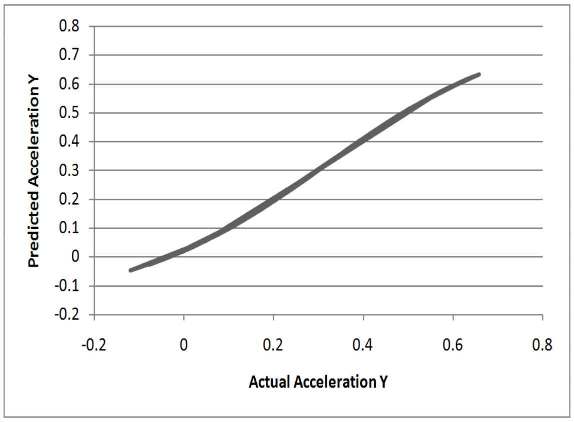

Figure 1 scatter plot shows actual and predicted gait data from a 21y.o. participant.

Similar results are seen in x acceleration. The data showed a mean shifted sum of squares of 0.011 between actual acceleration in x and predicted acceleration in x (Figure 2).

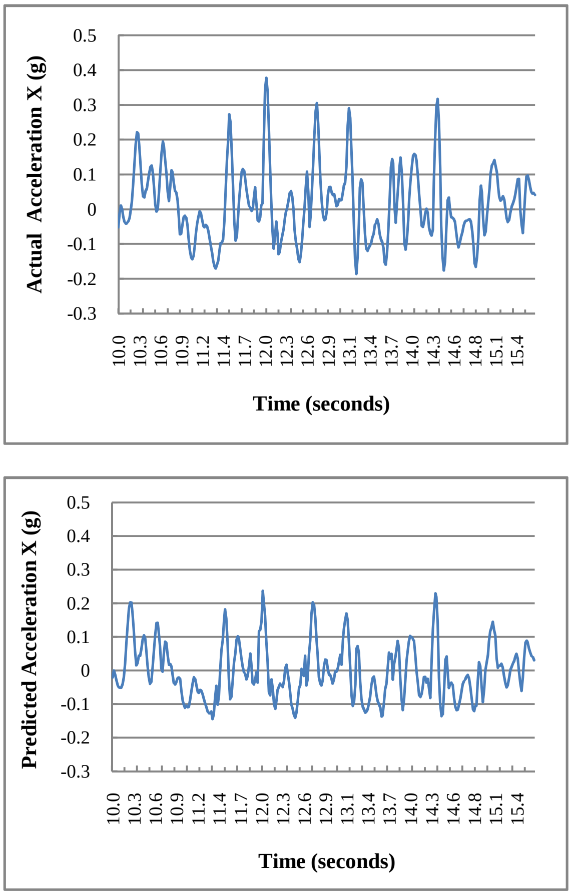

Figure 2 shows actual and predicted gait data from the 21y.o. subject from Figure 1.

Results with y acceleration data showed a mean shifted sum of squares of 0.00913 between actual acceleration in y and predicted acceleration in y (Figure 3).

When considering all participants, the average mean shifted sum of squares for predicted versus actual x and y acceleration values was 0.0094 ±0.0024.

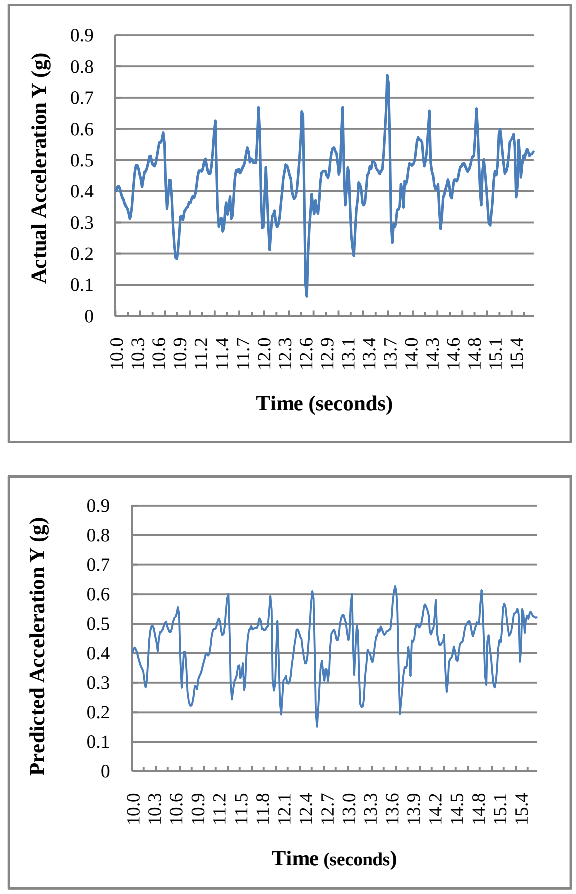

Figure 3 shows actual and predicted gait data from the 21y.o. subject from Figure 1.

CONCLUSIONS

The results have shown that neural networks can effectively be used to model normal gait data. This leads to the ability to model complex non-linear movement data with neural networks.

REFERENCES

Wu G, Journal of Biomechanics 2000, Nov;33(11):1497-1500

Luinge H.J., Veltink P.H., Medical and Biol. Eng. & Computing 2005, 43, 273-282

Giansanti D., Maccioni G., et al, Medical Engineering and Physics 30 (2008) 367-372