DEEP LEARNING SUCCESSFULLY CLASSIFIES ACOUSTIC EMISSION DATA FROM KNEE JOINTS

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INTRODUCTION

The prevalence of injuries associated with dynamic physical activity has compelled scientists to study changes in body structures after exercise, with degenerative changes to tissues and implications of these of particular concern. The function of cartilage in joints is for bones in motion to evenly transmit loads from one body segment to another at very low friction. During these events it has been shown that cartilage undergoes changes in volume, thickness, and joint space narrowing [1]. In recent years much research has been conducted in developing novel ways of joint degeneration identification and joint health assessment using Acoustic Emission (AE) [2,3].

METHODS

32 adult volunteer participants took part in the study. The participants were assigned in one of the three age groups 18-34, 35-49 and 50+. To calculate kinematic and dynamic variables nine Qualisys Oqus 700+ cameras and a Kistler Force Plate were positioned around the capture area. 28 reflective markers were placed on specific body landmarks [4]. A sensitive condenser microphone connected to the Laryngograph DSP Unit [Laryngograph Ltd., London, UK] was attached on the lateral soft part of the knee. Each participant was asked to perform a set of three sit-stand-sit (S–S–S) cycles three times for each leg on five different days. A custom-made MATLAB code was developed to process and analyse collected data. Two different Deep Neural Networks (DNNs) were used to classify the AE signals. This research project and its methodology were granted ethical approval by the Ethics Committee of Kingston University London.

RESULTS AND DISCUSSION

This project aimed to analyse the AE signal data obtained from the knee joints of people performing an S-S-S cycle. The results indicate that. although no S-S-S cycle is the same, there is a correlation between the obtained AE and the associated kinematic data. The synchronized plot of the knee angle, angular velocity & accelaration, and AE signal shows that there is a relationship between them. The AE events can be seen to coincide with the peak velocities during ascent and descent for each of the three cycles. There are also smaller AE events occuring during a change in angular velocity.

The AE signal was explored in Time & Frequency domains. The findings show that amplitudes differ between participants and within sessions, however a unique AE pattern is evident. The frequency domain indicates that the signal is predominantly low frequency; signal with the most power >1kHz.

Two different Deep Neural Networks (DNNs) were used to categorise the AE signals. These were Recurrent Neural Network (RNN) and Convolutional Neural Network (CNN). CNN was applied to the spectrograms to try to predict the age group of each participant, and overall obtained the best testing accuracy with a score of 81.82% (see figure 1).

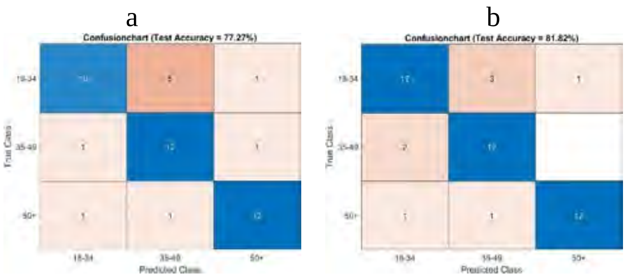

Figure 1 Best trained networks using spectrograms

CONCLUSION

The results of the experiment have shown that the characteristics of the AE signal can vary from one cycle to another, and even more so, from one day to another. However, the AE events appear to be directly correlated with the knee angular velocity. The use of DNNs shows that they can be used to categorise participants into age groups with good accuracy. To improve upon the accuracy of the model the inclusion and exploration of the kinematic features into the MATLAB model is the next step in our research.

REFERENCES

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