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Analysis of Knee Osteoarthritis Ground Reaction Vertical Force During Stair Ascent: A Neural Network Approach

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Abstract:
Osteoarthritis (OA) is the second leading cause of pain and disability, affecting more than 250 million people worldwide. Here, we focus on knee OA, the most common form of OA. To collect data, subjects were asked to ascend a custom-based stair with a force plate (Kistler Type 9286B, Kistler Instrumente AG, Winterthur, Switzerland). Each subject was barefoot and provided 3 trials. We consider the strike of the right foot on the force plate. Trial data where subjects did not cleanly strike the force plate was excluded from the analysis, so a total of 272 trials were recorded. The signal from the force plate was recorded at a sampling rate of 1000 Hz, then normalised to the subject's body weight (N/kg), and time-normalised to the entire gait cycle using linear interpolation. We retain the ground reaction force over the vertical plane. Out of the 96 subjects, 37 have OA at the one knee, 11 at both knees and the remaining 48 are control subjects. To automatically classify the motion patterns into three categories, i.e. normal, knee OA at one knee, and knee OA at both knees, a probabilistic neural network (PNN) was employed. The PNN is based on the theory of Bayesian classification. Regarding the PNN structure, it is a feed-forward neural network with high degree of parallelism. The PNN classifier is a non-parametric classification approach, since we have no guarantee that the data follows a Gaussian distribution. The effectiveness of the PNN for detecting knee OA has been verified previously, but the data analysed were radiographic images, rather that ground reaction forces. Results for 5-fold cross-validation can be seen in the Table below. To conclude, the PNN is able to effectively handle locomotion data that exploit great variability both inter- and intra-subject. Also, the PNN can detect approximately 16% of subjects that claim not to have knee OA, but they present gait patterns similar to those of subjects that suffer knee OA.

		Estimated by the PNN		
		No OA	Has OA (one knee)	Has OA (both knees)
True value	No OA	100	37	8
	Has OA (one knee)	38	60	5
	Has OA (both knees)	9	10	5

Table: The confusion matrix

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