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Whose head?: Subject classification through head motion analysis

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Most studies on human motion analysis currently available focus on the potential to classify the movement of an individual [1 2 3], rather than the individual by the movement. The ones that do attempt to classify individuals by their movement tend to focus on a person's gait or other full body forms of movement [4 5]. Even though classification through gait and other large-scale body movements has been shown to be effective, it may be limiting in situations where data of a subject walking, running, or executing other forms of full body motion is unavailable. In contrast, this study focuses on classifying stationary individuals using 3D data analysis. To do so, we compare the subtle similarities and differences between the position and orientation coordinates of individuals as they move their head. This research hopes to establish a proof of concept that individuals have a distinguishable pattern of head movement that can be recognized by data mining algorithms and utilized for classification purposes in addition to human gait and full body movement analysis.

We are using IRB approved data captured through the 3D motion tracking equipment that was made available to us through the Visbox environment at Valparaiso University's Christopher Center. The data tracks three individuals wearing glasses fitted with several markers that have been calibrated to function as a trackable 6 degrees of freedom rigid body that is recognizable to an *ART* infrared optical tracking system. Each subject was instructed to

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[2] Saripalle, S. K., Paiva, G. C., Cliett, T. C., Derakhshani, R. R., King, G. W., & Lovelace, C. T. (2014). Classification of body movements based on posturographic data. *Human Movement Science,33*, 238-250. doi:10.1016/j.humov.2013.09.004
[3] Deng, J., Xie, X., & Daubney, B. (2014). A bag of words approach to subject specific 3D human pose interaction classification with random decision forests. *Graphical Models,76*(3), 162-171. doi:10.1016/j.gmod.2013.10.006
[4] Al Mashagba, E. (2015). Human Identification by Gait Using Time Delay Neural Networks. *Computer and Information Science, 8*(4), 56-63. doi:10.5539/cis.v8n4p56
[5] Duan, D., Gao, G., Liu, C. H., & Ma, J. (2014). Automatic Person Identification in Camera Video by Motion Correlation. *Journal of Sensors,2014*, 1-8. doi:10.1155/2014/838751

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perform a series of movements with each movement lasting five seconds. This research is looking specifically at movement patterns within the five-second segment in which the subject is moving their head towards their right shoulder. We have an accurate estimation of which data frames to utilize from our recordings through the TIMESTAMP attribute produced by the *ART* tracking system. We have approximately 300 rows of data for each iteration of a subject moving their head towards their right shoulder. Each subject was asked to repeat the movement five times. This resulted in about 4,500 instances of movement. Because we needed to account for the difference in starting position of the subjects, we took the value of change between the position x,y, and z values and the three orientation values that are denoted as η, θ, and ϕ, but will be referred to as orientation a, b, and c. This left us with the SUBJECT attribute and the DIFFPOSITIONX, DIFFPOSITIONY, DIFFPOSITIONZ, DIFFORIENTATIONA, DIFFORIENTATIONB, and DIFFORIENTATIONC attributes, making for a total of 31,479 data points.

At this point, we have been able to demonstrate by using the Random Forest and Deep Learning or Neural Network methods that it is possible to predict the identity of an individual based on their head movement. While the confidence of our predictions varies depending on the algorithm used (i.e. Deep Learning/Neural Network versus Random Forest) and its configuration, both validate our hypothesis that individuals have a distinguishable pattern of head movement that makes classification possible. However, while we are able to prove there is a significant difference in the head movement of our subjects when performing the given task, our model is not meant to be used to classify any and all head movement produced by our subjects, as factors like speed, time of day, and surrounding environment could alter their movements and make it inconsistent with the classification models we built for this research.

Therefore, to improve upon our results in a follow-on project, additional testing on a dataset that has instances from additional subjects and incorporates position and orientation measurements from additional movement patterns (e.g. movement to the left shoulder) and under a wider variety of circumstances would be beneficial. This would generate more evidence to support our theory as well as allow for our premise to be applied to data that has not been so tightly restricted by the time, movement, and setting constraints we implemented when collecting the data. This would also help overcome limitations we encountered when running attribute significance testing methods like the Analysis of Variance (ANOVA), which can be inconclusive when too little data is available.