D1 Quantifying 3D Gait Reconstruction With a Single Camera

Jungbin Lee, BS, Chung-Ang University, Rm 115, Bldg 207, 84 Heukseokro, Dongjakgu, Seoul 06974, SOUTH KOREA; Cong-Bo Phan, Chung-Ang University, Rm 115, Bldg 207, 84 Heukseokro, Dongjakgu, Seoul 06974, SOUTH KOREA; and Seungbum Koo, PhD, Chung-Ang University, Rm 535, Bldg 310, 84 Heukseokro, Dongjakgu, Seoul 06974, SOUTH KOREA*

After attending this presentation, attendees will understand the usefulness and methodology of reconstructing 3D human movements from sequential images, such as Closed-Circuit Television (CCTV), and of estimating the lengths of body segments and joint angles. Attendees will understand 3D body movement estimation using Principal Component Analysis (PCA) and the effect of the camera angle on the estimation accuracy.

This presentation will impact the forensic science community by providing relevant information on quantifying 3D gait parameters and body segment lengths from 2D images.

Gait has been studied as a biometric parameter useful for identifying individuals. Human gait is influenced by biomechanical and physiological factors such as weight and height as well as injuries associated with the skeleton or the brain. Therefore, by measuring an individual's gait, his or her personal biometrics can be estimated. Thus, it is possible to verify a person's identity using an analysis of his or her gait on CCTV even when the person's face is obscured. Currently, there have been several studies that attempt to recognize gait from single images.[1,2] Recently, 3D gait reconstructions were performed from 2D images using PCA.[3] In some studies, the results of observing 2D images may vary depending on camera angles.[2,4] Also, to reconstruct 3D gait, major joint points should be recorded; however, marking such points on every image frame is time consuming. The objectives of this study were to develop a method to reconstruct 3D body movements from sequential 2D images and to analyze the effect of camera angle on the accuracy of the gait-related movement reconstruction.

3D gait data were collected from each of the 30 recruited subjects using a motion capture system. 3D coordinates of each joint in each image frame were obtained and subjected to PCA analysis to obtain mean posture and principal component data. Following acquisition of the 3D joint coordinate data, the position and orientation of the camera could then be changed to obtain projected 2D images. 3D gait data were used to create 2D images taken from a virtual camera at 0º to 60º elevation and 0º to 180º azimuth angle. The 3D posture of each subject was reconstructed using PCA for the key frame image at each camera angle by optimizing the weight of principal components of posture and the transformation matrix. Also, the study developed a robust method using information from the phase of gait to lessen the effect of camera angle. From the reconstructed posture, segment lengths were calculated by measuring the distance between joints. Major joint angles were extracted from reconstructed full-gait cycle images through movement estimation accomplished by interpolating positions between key frames.

The results of this study confirmed that gait analysis for identification is best performed by viewing subjects from the sagittal plane rather than the coronal plane. Also, the higher the elevation angle of the gait imaging camera, the better the reconstruction accuracy. The phase of subject gait was shown to be an input parameter; consideration of this parameter reduced inaccuracies occurring from varying camera angles. This study was limited by the use of manually identified joint markers and interpolation of gait-related continual images. The results of this study support the argument that individual human subjects can be identified from analysis of their optically recorded 3D gait cycle.

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*Presenting Author