Wearable Wireless Ultrasonic Sensors for Human Gait Analysis

Human motion capture has been used in rehabilitation clinics for evaluating the severity of various neuromuscular and musculoskeletal diseases. Gold standard for gait analysis is optical system using multiple high-speed cameras which is complex, costly and require controlled lighting conditions and dedicated laboratories due to the sensitivity to variations in the intensity of light, occlusion and shadow. Narrow band ultrasonic sensors can be used for accurate ranging with considerably cheaper hardware. We propose a scalable, cost-effective, wearable ultrasonic gait analysis system, which is easy to use, portable and does not require complex calibration procedures. The Time of Arrival (TOA) of ultrasonic pulses were used for localization with the help of Unscented Kalman filter. We employ chirp signals, a novel multi-path compensation and multiple-access along with simultaneous Doppler-correction to increase the accuracy and number of markers. The system was tested on healthy subjects. The results were compared with Motion Capture system.

List of Publications

[1] Karalikkadan Ashhar, Mohammad Omar Khyam, Cheong Boon Soh, and Keng He Kong (2018). A Doppler-Tolerant Ultrasonic Multiple Access Localization System for Human Gait Analysis. *Sensors, 18(8), 2447*.

[2] Karalikkadan Ashhar, Mohammad Omar Khyam, and Cheong Boon Soh (2019). A Multi-Path Compensation Method for Ranging in Wearable Ultrasonic Sensor Networks for Human Gait Analysis. *Sensors, 19(6), 1350*.

[3] Karalikkadan Ashhar, Md Noor-A-Rahim, Mohammad Omar Khyam, and Cheong Boon Soh. A Narrowband Ultrasonic Ranging Method for Multiple Moving Sensor Nodes. IEEE Sensors Journal (2019).

[4] Karalikkadan Ashhar, Cheong Boon Soh and Keng He Kong, A Wearable Ultrasonic Sensor Network for Analysis of Bilateral Gait Symmetry, *39th Annual International Conference of the IEEE Engineering in Medicine \& Biology Society (EMBC'17), JeJu Island, S. Korea*.

[5] Karalikkadan Ashhar, Cheong Boon Soh, and Keng He Kong (2018, October). Wireless Ultrawideband Sensor Network for Gait Analysis in Rehabilitation Clinics. *In 2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC) (pp. 1524-1529). IEEE*.