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Abstract

FBG-Based Sensing of the Back during Gait Cycle †

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Abstract: We report on the calibration and testing of a fiber Bragg grating (FBG)-based 2D-shape sensing strip for real-time monitoring of the position and orientation of the human spine during gait. The strip is evaluated for its use as an input for control of an exoskeleton for patients with spinal cord injury. By measuring the torsion and bending of the back, walking movements can be reconstructed. The 3D-printed strip has nine embedded fiber Bragg gratings that are located at specific places with respect to the vertebral column. Three FBGs are placed opposite to the thoracic vertebrae T6–T9, these FBGs are sensitive for measuring the bending of the spine during the gait cycle. Torsion is measured at two locations: at thoracic vertebra, T3 and at lumbar vertebra, L3. At these locations, the width of the strip is reduced to have a larger sensitivity for torsion. The strain at each FBG is measured using an interrogator. This leads to the radius of curvature and torsion as a function of time. The Frenet-Serret formulae are used to calculate the shape of the strip during the gait cycle. We have calibrated this FBG strip for curvature by bending it at known radius of different curvatures. We found a linear dependence between the strain and curvature. For torsion calibration we have rotated the strip with a stepper motor at different angles and monitored the strain. We, again, found a linear dependence with a small hysteresis. We mounted the strip on a healthy test subject and monitored their gait cycle. The FBG strip shows similar results when compared to a motion capture system based on multiple cameras. Although the fixation of the strip to a garment or on the back directly strongly influences the measured response, it does show a periodic and reproducible signal during the gait cycle.

Keywords: photonics; fiber Bragg grating; shape sensing; gait cycle

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