Detection of Human Walking Posture through a Wearable Camera

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***Abstract*—This study proposes the detection of leg posture, walking trajectory, and walking speed, which are key to monitoring human walking normality in a static indoor environment. A small wearable depth camera installed on the knee was used as a sensor to detect and monitor knee posture, including angle, walking distance, and trajectory. In this method, points of interest (PoI) are determined and tracked in each frame, and the 3D coordinates of the PoI are used to calculate the camera angle and moving distance. The camera angle and moving distance can be used as features for training and testing a classifier for the human walk normality diagnosis.**

I. Introduction

Abnormal walking posture is an important sign of serious diseases such as Parkinson's disease, stroke, and myopathies [1-3]. Walking posture, including gait speed, stride length, stride duration, and cadence, could be used to monitor and detect the possibility of these diseases, especially in the early stages. However, it is difficult to detect abnormal walking in daily life; therefore, automatic systems installed at home and mobile wearable devices are required.

In related work, Sohei Hor *et al.* [4] proposed a data-driven waveform adaptation method for mm-wave gait classification at the edge. This system works based on mm-wave, which can be applied to detect and classify human gait at home or in a limited space, but it may not be suitable for mobile systems. Yao Guo *et al.* [5] presented 3-D canonical pose estimation and abnormal gait recognition with single RGB-D camera, in which the assistive robot follows human, collect video data, and monitor abnormal gait. To monitor gait continuously in daily life, the system should be wearable and move together with humans. Xinyao Hu *et al.* [6] proposed a soft robotic intervention for gait enhancement in older adults. This device was developed to detect abnormal footprints and simultaneously enhance gait to prevent falls. However, wearable systems are complicated and heavy. Wearable systems should be improved in terms of simplicity and light weight.

In this study, we attempted to develop a simple wearable system to monitor gait and detect abnormal gait. In our approach, a walking environment with a landmark was designed, a depth sensor was installed at a pedestrian knee, and landmarks in the walking environment were used to estimate walking postures.

II. System Model and Proposed Method

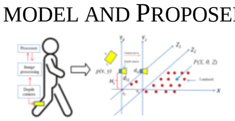

Fig.1. System Model.

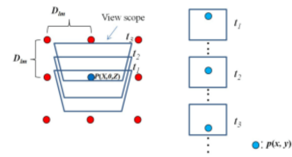

Fig.2. Walking environment set-up and calibration

The proposed method begins by inputting the first and second video frames of a landmark installed on a flat plane in the room. Then, it determines a PoI on those video frames, calculates the walking range, speed, and position, and simultaneously estimates the PoI in the next frame in order to track the PoI in the next frames. The details of the PoI determination, calculation of the walking distance and speed, and calculation of the PoI in the next frame are described in the following subsections.

III. Experimental Results

To evaluate the performance of the proposed method, we used the average walking steps of five participants in the experiments and manually moved the depth sensor according to the human steps. The results are presented in Table 1.

TABLE I. Result of Ambulance Moving Toward Vehicle

Position	Landmark as PoI	Distances (cm.)	Ground Truth			Proposed Method		
			X	Y	Z	X	Y	Z
1	1	5	0	34	15	0	34	15.30
2	2	10	0	34	10	0	34	10.10
3	3	15	0	34	25	0	34	24.90
4	4	20	0	34	20	0	34	19.90
5	5	25	0	34	15	0	34	15.10
6	6	30	0	34	30	0	34	29.80
7	7	40	0	34	25	0	34	25.33
8	8	45	0	34	20	0	34	20.20
9	9	50	0	34	15	0	34	15.10

Conclusion

This study assumed that the walking environment is simply arranged using black floor and white circle landmarks, in which information is initially input into the system. The system determined the PoI based on environmental information, estimated the PoI position in the next frame to correctly track the PoI, and periodically measured the walking distance. Experiments confirmed the effectiveness of the proposed method.

References

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