Motion Capture in Outdoors

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***Abstract*—For motion capture system used at outdoors, this paper presents two contributions. One is a configuration of multiple camera system, of which cameras are synchronized by GPS signal. Thus, the wireless synchronization of cameras does not disturb the pedestrian traffic. Another is a new method to estimate skeleton pose of pedestrian who brings luggage or backs a rucksack. These belonging make it difficult to discriminate body trunk. Our method can infer trunk skeleton from shoulder and hip joints.**

I. Introduction

Marker-less motion capture system based on video camera can measure motion of human body as it is. To capture 3D motion exactly, it is necessary to allocate several synchronized video cameras around the subject. We make these video cameras synchronize by GPS signal. This wireless synchronization does not disturb traffic of pedestrian and vehicle.

When pedestrian sometimes wears loose clothes and brings luggage, it is difficult to measure a skeleton of the trunk. Compared with measurement of the trunk, it is easy to measure positions of limbs. We propose a method to estimate the skeleton of trunk from positions of limbs.

II. Cameras system and camera calibration

We shoot a walking pedestrian in outdoor. A sync generator (GVS-0710, Totsusangyo co.) supplies a video camera (XH-G1, CANON co.) with a synchronized signal and time code generated from a GPS signal. Two video cameras are arranged at one lane side, and are connected with the sync generator by cable. Also, a set of two video cameras with the same configuration is located at the opposite lane side. The four cameras are synchronized via GPS, and can shoot a pedestrian walking without disturbing the traffic. Fig.1 left shows an arrangement of four cameras at lane sides.

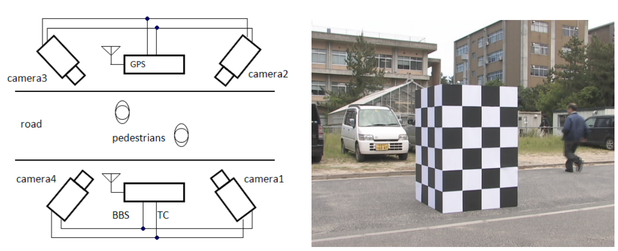

Fig. 1. Right:The 4 cameras outdoors are synchronized by GPS. Left:Reffrence box for camera calibration.

The video camera records the image sequence on DV tape. A video editing system (Rexceed model 3100, Grass Valley co.) produces a sequence of a set of 4 images from the DV tapes. All cameras are calibrated by the Tsai algorithm [3]. As reference objects for calibration, we use a box shown in fig.1 right.

III. Inferring skeleton of trunk

Fig.2 left shows a skeleton model together with its joins. A length of the link is set as a length of the corresponding part of a real body.

Given positions of shoulder and hip joints, a problem is to infer a central joint of a two-link model of the trunk. The joint should satisfy the following three constraints.

First one is a constraint on DoF. The chest part has only one DoF, i.e. rotation around a line passing through the shoulder joints. Similarly, the waist part has only one DoF. Therefore, the both parts have a unique joint. Second, taking an intersection between upper sphere with its center at a midpoint (corresponding to spinos process of the 7th vertebra) of shoulder joints and with a radius of the chest height and lower sphere with its center at a midpoint (corresponding to pubic symphysis) of hip joints and with a radius of the waist height, the central joint is on the intersection, i.e. a circle (see fig.2 right). Third, if a person is slouchy, the central joint is biased backward, otherwise i.e. recurvate, it is biased forward. We infer that if the both wrists are located behind the body, it judges as recurvate pose, otherwise, it judges as slouchy pose.

The 1st and 2nd constraints are not satisfied simultaneously due to the measurement noise of shoulder and hip joints.

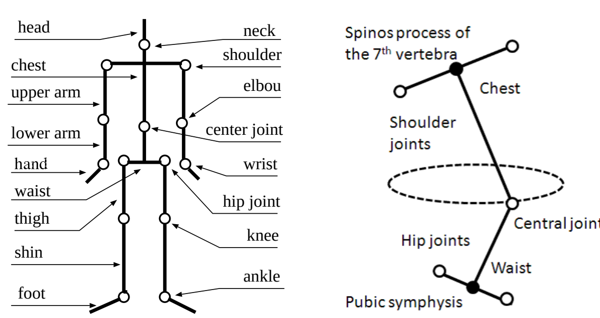

Fig. 2. Links and joints of a skeleton model of human body, and Two-link skeleton model of trunk.

We slightly shift the shoulder and hip joints while keeping the positions of the midpoint of shoulder joints and midpoint of hip joints. We determine the central joint under the 3rd constraint so that it should minimize the magnitude of the shifts subjected to the 1st and 2nd constraints.

IV. Determining skeleton of limbs

When a pedestrian brings some pieces of luggage, it will be difficult to discriminate body parts from the bringing. We describe a manual-aided method to give the positions of the shoulder and hip joints.

First of all, we specify both end point of central axis of limb part image. Fig.3 shows the central axes given on images viewed from 4 cameras. When a body part is observed from two and more cameras, a principal axis of the body part is obtained as an intersection among the planes containing the central axis and the camera center. An elbow joint is an intersection of principal axes of upper and lower arms. This implies that an elbow joint is obtained as an intersection of the planes containing the central axis of arm part and camera center. From the elbow joint, we reach a shoulder joint by moving in the direction of principal axis of upper arm with its length. Similarly, we can determine hip joints.

Fig. 3. A center axis of each body part is manually specified in 4 camera views.

V. Pedestrian outdoors

We infer skeltons of two pedestrian outdoors. The first pedestrian is a man who wears a light gray loose jacket and has a big rucksack on his back. The central axis of each limb can be easyly specified as shown in fig.3, while it is difficult to find his trunk silhouette due to the occlusion by the rucksack and his clothes. Fig.4 shows his estimated skeleton.

The second pedestrian is a woman who backs a black and big tube and brings two pieces of luggage. This is also an example difficult to find the trunk silhouette from the appearance. Fig.5 shows the estimated skeleton. The skeleton is slightly shifted from the central axes of body parts. We have not measured body size of this woman, and use an average size in the body database. The difference between the average size and real size may affect the skeleton drift.

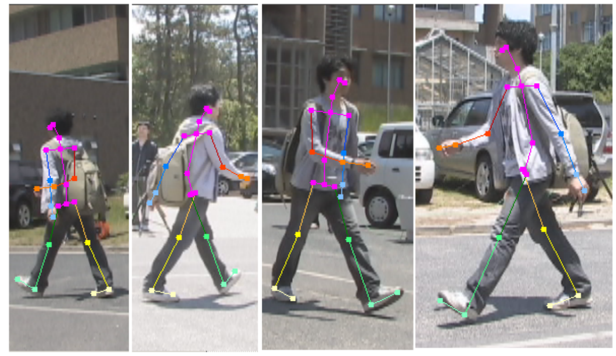

Fig. 4. The estimated skeleton of a man pedestrian with a big rucksack

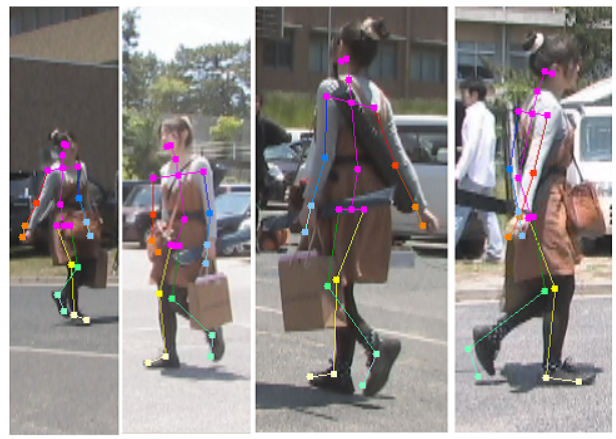

Fig. 5. The estimated skeleton of a woman pedestrian with a big luggage

VI. Conclusion

We proposed a simple and robust method to estimate a skeleton of the human trunk from shoulder and hip joints. In our experiments, the joints of limbs were manually given. We will try to real-time capture of the whole skeleton by our method with aiding automatic skeleton capturing methods [1], [2] of limbs.

Acknowledgment

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