Introduction

Motion capture (Mocap) has been involved extensively into education, training, sports, and recently computer animation for television, cinema and video games as the technology matured. Locomotion is the fundamental skill of human beings, and many form of locomotion, like walking, running, jumping and climbing are being studied and used in computer animation.

Different from the optical Mocap, data capture and processing in MMocap are mainly done in the sensor coordinate system and the subject’s body coordinate system. There is no information of subject’s movements with reference to the global coordinate system, which is important for most applications.

System Prototype

Our prototype system mainly consists of three parts:
- **Sensor subsystem:** includes 16-20 micro-sensor nodes (each node contains a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer) and a base station connected by a data bus. Sensor nodes are placed on the segments of the human body (head, shoulders, spine, upper and lower limbs) to collect the motion data. The base station controls the data sampling rate range from 50Hz-200Hz. It also sends data packets via USB or high-speed wireless module to the CPU for data processing by the data fusion and animation subsystems;
- **Data fusion subsystem:** fuses sensory data and biomechanical constraints to get the orientation information using Kalman Filter under Bayesian network theory and obtain the locomotion information by gait analysis;
- **Animation subsystem:** uses the orientations and locomotion information to reconstruct the movements onto the 3D avatar model.

In this demonstration, a subject who wears the sensor nodes performs a set of action, while the 3D avatar reconstructs the movements in real time.

Methods (Cont.)

- We build two sets of the lower body segments, namely, $S_L$={Pelvis, Lfemur, Ltibia, Lfoot} and $S_R$={Pelvis, Rfemur, Rtibia, Rfoot}, and also two sets of the joints $J_L$={Pelvis, Lhip, Lankle, Ltoe} and $J_R$={Pelvis, Rhip, Rknee, Rankle, Rtoe}.
- From the proximal joint, e.g. root joint, to the distal joint, the position of the child joint can be calculated from its parent joint’s position:

$$P_{J_k(i,j)} = P_{J_{k-1}(i,j)} + q_{S_k(i,j)} \bigoplus q_{S_k(i,j)}^{-1}$$

where $i = 1, 2, 3, 4$ and $k = 2, 3, 4, 5$.
- From the distal joint, e.g. right toe, to the proximal joint, the position of the parent joint can be calculated from its child joint’s position:

$$P_{J_k(i,j)} = P_{J_{k+1}(i,j)} - q_{S_k(i,j)} \bigoplus V_{S_k(i,j)}^{-1}$$

where $i = 4, 3, 2, 1$ and $k = 5, 4, 3, 2$.

3. Estimation of CoM displacement

- During walking, the root joint is considered as the CoM of the human body. To estimate the CoM displacement, we need to determine which joint is the reference joint first for kinematic transmission during walking.
- When the right leg is selected as the support leg, the position of the right toe joint, considered as the reference position:

$$P_{Ref,J} = P_{J_{5}(5)}$$

- The positions of other joints, namely, right knee, right hip, root joint, left hip, left knee, left ankle, and left toe can be obtained in turn relative to the reference position.
- When the left leg is the support leg, the reference joint changes to the left toe, the position of the left toe at the previous time slice $t-1$ is considered as the reference position:

$$P_{Ref,J} = P_{J_{5}(5)}^{-1}$$

Results

![Fig. 4 The CoM level position of forward, backward, and sideways walking (CMU Subject 41 trial 2) (Z: upper; X: middle; Y: lower). INT: Integration of the acceleration data from the pelvis; EST: Our proposed method; TRUE: The ground truth. The sampling rate is 120Hz.](image)

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