Upper Limb Position Tracking based on Kinematic Model and IMU Measurement

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Motivation:

Recently years, commercial Virtual Reality (VR) products such as Oculus, HTC Vive, Sony Playstation VR has drawn extensive public interest and shown potential market success. Real-time upper limb motion and position tracking as a critical complementary information plays an essential role in VR gaming. Different techniques and form factors has been developed and applied on various VR platforms. Time of flight camera and computer vision technique has been used for full DOF hand tracking and finger tracking[2]. Optical sensors and ultrasonic sensors has been used for whole body motion tracking[2]. However, many of these techniques suffer from problems of high cost, vulnerable to occlusion and different environments, computational-consuming. On the other hand, inertial Unit Measurement has been shown as a cost effective alternative for body tracking[1]. Using complementary filter or Kalman filter, the gyroscope and accelerometer can be used for high accuracy orientation tracking[1][2]. However, absolute position tracking using IMU alone is not possible due to nonlinear drift induced by double integration of the accelerometer data[1][2][3]. Recent studies show that using kinematic constraints can eliminate the drift and restore the reliable position data[1][2][3]. In this project, we will implement the position tracking using measurement from two IMUs with constraints from kinematic model of the upper limb.

Project Planning:

The main idea is to put two IMUs on wrist and elbow to measure the orientation of arm and forearm. By pre-measuring the length of upper limb and constraining the connection of arm and forearm with a proper kinetic model, we hope to reconstruct the posture of arm.

The project is based on but not limited to several published papers. The Matlab simulation will be carried out first to verify the algorithm introduced in the papers and as a start point for future improvement. Next, the algorithm will be implemented on IMUs. In the headset, an avatar will be created in the virtual scene and synchronize user's upper limb motion.

Timeline & Milestones:

End of Week 7:

- Finish MATLAB simulation

End of Week 8:
- Finish IMU programming and Scene Rendering

End of Week 9:
- Finish wireless communication, code optimization and experimental test.
- Finish poster & report.

Reference:
[1]. H. Zhou and H. Hu, “Kinematic model aided inertial motion tracking of human upper limb,” *2005 IEEE International Conference on Information Acquisition*.

[2]. X. Yun and E. R. Bachmann, “Design, Implementation, and Experimental Results of a Quaternion-Based Kalman Filter for Human Body Motion Tracking,” *IEEE Trans. Robot. IEEE Transactions on Robotics*, vol. 22, no. 6, pp. 1216–1227, 2006.

[3]. M. El-Gohary and J. Mcnames, “Shoulder and Elbow Joint Angle Tracking With Inertial Sensors,” *IEEE Transactions on Biomedical Engineering IEEE Trans. Biomed. Eng.*, vol. 59, no. 9, pp. 2635–2641, 2012.