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Sensory Hardware for 3D Motion Capture

Introduction

Collection and analysis of human motion data has become more popular as new technology makes it cheaper and more reliable. The applications of human motion analysis can be found in rehabilitation, computer-generated media, and sports performance analysis. This paper reviews current methods of 3D motion capture and the sensory hardware used in each.

Methods

Depth Imaging

Depth imaging involves the collection of depth data in order to recreate a 3D image. Depth images can be developed using stereo cameras, time of flight cameras, and structured light cameras [1]. Stereo cameras use the same principles as human eyes to infer depth, while time of flight and structured light cameras rely on one camera and the addition of light transmitters and sensors to compute depth. Depth images are then used to segment the body into body parts and estimate the posture of the body [2].

Ultrasonic Measurement

Ultrasonic measurement systems use acoustic signals to compute distances and estimate the relative positions of multiple sensor nodes. Multiple transmitters emit coded signals which are received by a mobile microphone sensor array. Processing of the sensory data received from the microphones can calculate the distance between each transmitter and microphone [3]. This data can then be used to estimate the position and orientation of the sensor array with six degrees of freedom.

Inertial Measurement

Inertial measurement involves the use of linear acceleration and rotation rate to capture six degrees of freedom for a sensor node. Inertial measurement units (IMU) consist of a tri-axis accelerometer and a tri-axis gyroscope to facilitate inertial motion capture [4]. Integration of the raw data is used to calculate position and orientation of the sensor. Sensor arrays can be used to capture the motion of sensors with respect to each other by defining an initial configuration [5].

Technology

Depth Imaging

Stereo camera imaging relies on software processing of standard imagery from cameras. The cost of a stereo camera solution depends on the desired resolution of the resulting depth imagery. Time of flight cameras, such as the SwissRanger SR4000 from MESA Imaging, can cost up to $10,000 [1]. Structured light cameras reached consumer level with the release of the Microsoft Kinect in 2010, and have improved in quality while reducing in cost since. A Kinect currently costs around $100.

Ultrasonic Measurement

A primary benefit of ultrasonic position and orientation calculation is its low cost. The hardware includes a minimum of three ultrasonic transducers to function as transmitters and a minimum of three microphone sensors to receive the transmitted signal [3]. The microphone sensors can cost as little as $1.18 for a basic microphone from CUI Inc. An ultrasonic transducer capable of operating up 40 kHz, the PUI Audio, Inc. UT-1240K-TT-R, costs $4.95.

Inertial Measurement

Inertial measurement units have drastically reduced in price in recent years while continuing to shrink in size. The average cost of an IMU dropped below $1.00 in 2013 and is expected to continue dropping as manufacturing processes improve [6]. The Bosch Sensortec BMI160 IMU can measure up to 16 g in linear acceleration and up to 2000 degrees per second in angular velocity with only a 7.5 mm^2 footprint [7].

Conclusion

3D motion capture can be achieved through various methods that each have trade-offs. Camera and ultrasonic methods require components external to the subject, while inertial measurement suffers from the difficulty of synchronizing data from multiple sensors. From a sensor standpoint, ultrasonic and inertial techniques are much lower cost than any of the camera methods. Hardware selection for motion capture is heavily dependent on the desired application. Ultrasonic and inertial methods provide detailed information about a small number of defined points, while camera methods produce depth data for a given area.

References

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