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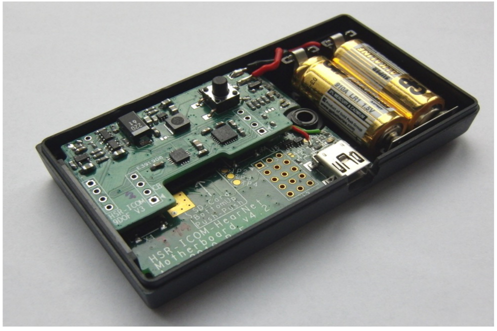
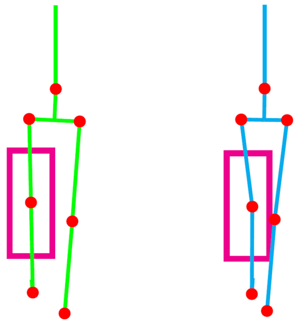
Subject Area	Sensor, Actuator and Communication Systems

Human Motion Tracking Using Inertial and Magnetic Sensors

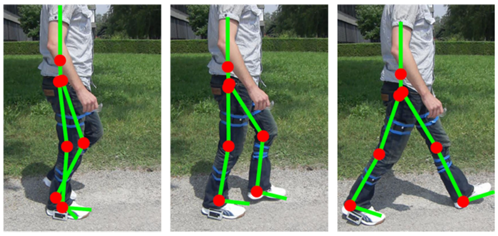
with Quaternion-Based Extended Kalman Filter for Orientation Determination and a Human Body Model Incorporating Anatomical Constraints



Module containing inertial and magnetic sensors



Stickfigure with constrained body model applied (green) and without body model (blue)



Visualization of a recorded gait sequence

Human motion tracking is applied in many areas for example in surveillance, control or diagnostics. It is the tracking of human movements such as the motions of the limbs. Inertial and magnetic sensors attached to the body segments can be used to recover the performed motions. The task of this thesis was to implement a motion tracking algorithm which uses the measurements of an existing inertial and magnetic sensor system.

The inertial and magnetic measurements of each sensor are fused in an Extended Kalman Filter to determine the sensor orientation, the so called attitude. An initial attitude estimate is given by the integration of the angular rate measurements. In non-moving sequences, the acceleration measurement coincides with the gravity vector and can be used to improve the estimate. The magnetic field sensor also includes information about the sensor attitude by measuring the earth magnetic field vector. An adaptive covariance is implemented to ensure that only reliable and undisturbed measurements of the accelerometer and magnetometer are taken into account. Under realistic conditions for human motion, the achieved accuracy in the attitude determination is below 4.3° RMSE and below 0.5° RMSE under optimal conditions.

The estimated sensor attitudes are fused in an Unscented Kalman Filter to enable a visualization of the recorded motion. Known information about the human motion such as reduced degrees of freedom of joints and limited joint flexion is incorporated in the processing of the sensor attitudes. A simple kinematic tree model is implemented in the constrained Unscented Kalman Filter. The recorded human motion can be visualized by a stickfigure animation. The visualization is based on the lengths of the body segments, and on the joint angles estimated by the body model. Anatomical constraints are satisfied and the visualization gives a realistic representation of the recorded motion.