The pedestrian navigation system (PNS) based on inertial navigation system-extended Kalman filter-zero velocity update (INS-EKF-ZUPT or IEZ) is widely used in complex environments without external infrastructure owing to its characteristics of autonomy and continuity. However, due to the poor observability of heading errors to ZUPT and the instability of vertical inertial channels, further corrections of the estimated trajectories under the IEZ framework are still needed to obtain higher positioning accuracy.

In order to achieve high performance for PNS in terms of accuracy and robustness, we integrate the micro electro-mechanical system inertial measurement unit (MEMS-IMU) and GPS as shown in Figure 1. In this scheme, MEMS-IMU provides the 3-axis accelerometer, 3-axis magnetometer, and 3-axis gyroscope readings which are [f_x f_y f_z], [mag_x mag_y mag_z], and [ω_x ω_y ω_z] in the body frame, respectively. The main work are as follows.

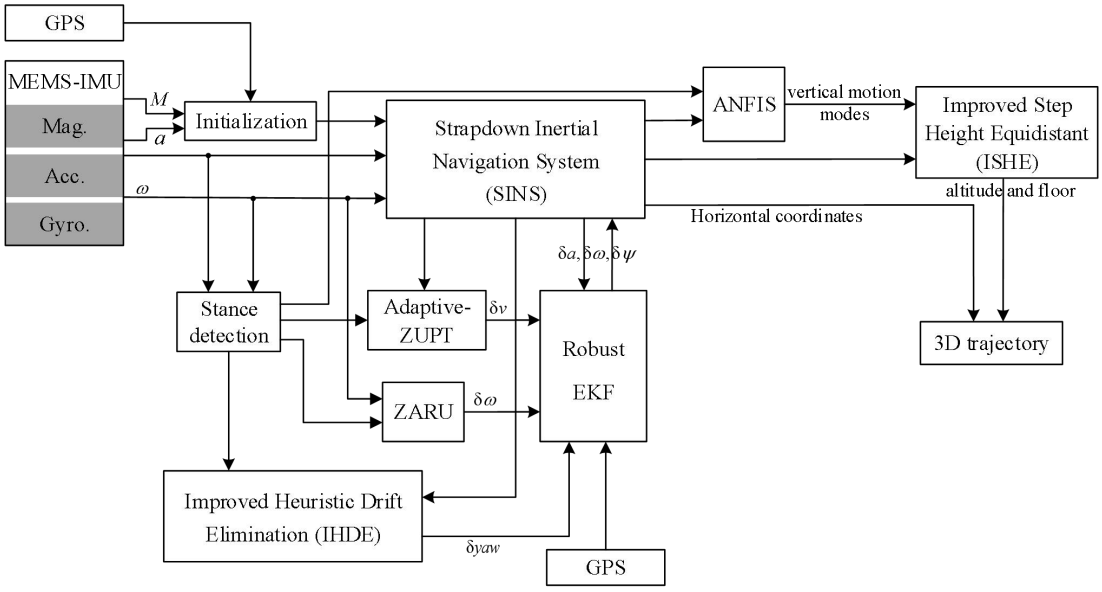

Figure 1. Scheme of proposed positioning system

1. Aiming at the weakly observability of heading drift for MEMS-IMU, the improved heuristic drift elimination (IHDE) algorithm is proposed. The algorithm consists with the following three steps. First,

heading information is extracted from pedestrian's straight-line motion track, which is used to construct eight datum directions of the building. Then, building heading information is utilized to estimate yaw errors of trajectories that satisfy specified rules. Finally, these yaw errors are utilized as the EKF observation to estimate the state error of the navigation parameters.

2. In order to deal with the problem that the inertial vertical channel is unstable under the traditional IEZ framework, which makes it impossible to locate the floor by SINS solutions, the improved step height equidistant (ISHE) is exploited. At the begin, we make use of the adaptive network-based fuzzy inference system (ANFIS) to identify different vertical modes including elevator, escalator and staircase (walking upstairs, horizontal movement, and walking downstairs). Then, the floor information or altitude is estimated by ISHE.

3. To detect the stance phase accurately, we make use of adaptive-ZUPT algorithm based on backward neural network. In conventional researches, positioning performance is easily affected by the ZUPT with fixed threshold, because it is difficult to determine ZUPT conditions for jump, fast walking, running.

4. GPS is fused with MEMS-IMU through Robust EKF (REKF), which can remove the contaminated points of GPS signal. What’s more, GPS can provide global coordinates.

Figure 2 represents: purple triangles and bluetooth boxes represent the starting and ending points, respectively, and the black line represents the estimated 3D trajectory. The positive direction of abscissa and longitudinal represents East and north respectively.

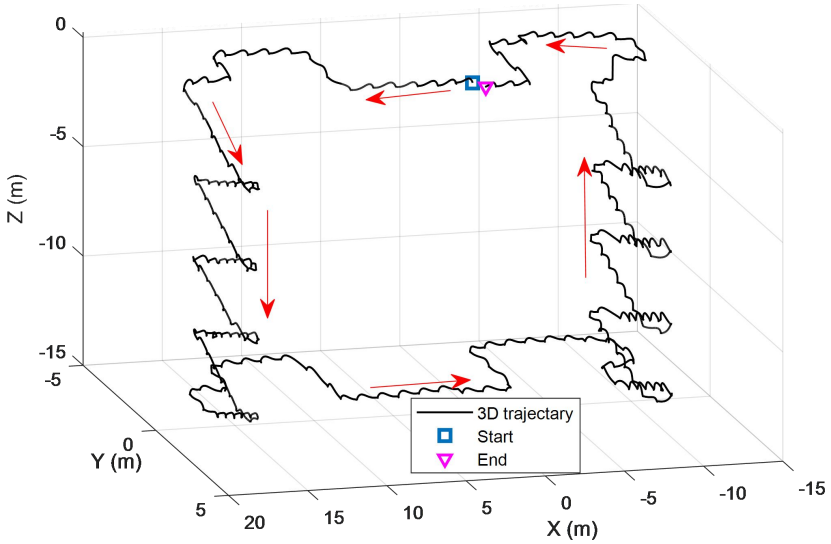

Figure 2. Estimated 3D trajectory at main building of Beihang University