DENOISING OF RFID RECORDINGS USING KALMAN FILTERS

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Background & Significance

Ubisense is a real time location system (RTLS) that tracks and records location data in an enclosed space using radio-frequency identification (RFID) technology. We use it to track the position and orientation of children in a classroom to detect social contacts and interactions. To record their positions, subjects wear a vest containing left and right tags detected by Ubisense sensors. The X and Y coordinates of the tags are recorded at 4 Hz and are then used to determine the orientation of a subject and relative orientation and distances to other subjects. Inspection of raw data, however, indicates that angular velocity occasionally reaches over 1200 degrees per second (> 3 rpm), which is improbable. Such fluctuations may be caused by mismeasurement of the right and left tags on the subject's vest, causing fluctuating orientation calculations. These fluctuations have an effect on our analyses of interactions in the classroom by decreasing interaction (continuous social contact) durations.

Objectives & Approach

Our objective was the creation of a pipeline based on Kalman filters that adjusts for the positions of raw tag locations to provide more realistic angular velocity values. The denoising (artifact elimination) algorithm focuses on two pieces of data, orientation and the distance of right and left tags. Kalman filters were used to limit the angular velocity and acceleration of tags, as well as the distance between the left and right tags (which should be relatively constant). We use the denoised distance of the tags and orientation to estimate new positions of the left and right tags, minimizing fluctuation in orientation. Using this approach, we constructed a pipeline that inputs raw ubisense location data recorded at 10 Hz and outputs adjusted tag locations. The pipeline first interpolates the raw data to synchronize the location recordings of the left and right tags for each subject. Then using the artifact elimination process described above, Kalman filters were used to adjust the XY coordinates.

Outcomes & Future Directions

We applied the denoising algorithm to 36 hours of recordings containing two classrooms with a combined total of 12 class dates with 36 preschool children and 4 teachers. We found that the distribution of angular velocities for both classrooms shifted left (slower angular velocities) after denoising, showing that faster angular velocities moved to slower values. Social contact between two subjects in our analysis is defined as a distance between 0.2 and 2.5 meters and relative orientations to be less than 90 degrees. Interactions (continuous social contacts) are durations where two subjects continuously meet the criteria for social contact. With denoising, the distribution of interaction durations shifted rightward (longer durations). For example, short interactions (≤ 0.5 seconds) decreased, while longer interactions (≥ 1.5 seconds) increased with denoising. Lastly, the count of interactions decreased while the total amount of time subjects were in interactions was roughly the same. This highlights that longer interactions are being interrupted at a slower rate. The pipeline produces more realistic results from Ubisense tracking data increasing the accuracy of further calculations and analysis done with the data.

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