Starting the Simulator

The sequence of steps in the operation of the simulator is described below. Figure A.1 shows the initial screen after invoking the simulator.

Figure A.1: Simulator: Starting Screen
Initial Settings

On selecting a layout from the options provided, the system loads a set of adjacency relationships associated with the layout. A set of scripts capable of generating trajectories, adhering to the zone adjacencies of the selected layout is also prepared. Each of these trajectories consists of a sequence of zones visited by an occupant after his entry into the smart environment and before his exit. The time interval is also assigned to denote the minimum and maximum duration of presence in any zone. On selecting the number of occupants entering the environment, the system loads a subset of their event templates subject to a specified sensor quality from the event template database.
Generation of States

Clicking the ‘Make States’ button, associates a randomly selected event (from the event pool) and a time of occurrence in each zone of the randomly generated occupant’s trajectory (based on scripts from the set). The time of occurrence of an event in a zone is based on the duration randomly assigned in the previous zone. This process is repeated for every occupant and the time-ordered sequence of events are used to generate the corresponding sequence of states of the smart environment. The ‘Show States’ button displays a listing of the Top10 occupants in terms of their probabilities of presence in the zone of occurrence of every event and is illustrated in figure A.3.

![Figure A.3: Top-k Occupants in States](image)

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Estimation of Event Sequence

Once the states are generated the user can select a recognition threshold which is used to perform a recognition step (using ‘Recognize’ button) which estimates the event sequence of the smart environment. The estimated event sequence is compared with the ground truth and the mismatched (misidentified) events are listed. The overall accuracy of the recognition process is also calculated.

Figure A.4: Estimated Events Sequence
Estimation of Valid Tracks

The recognition step also generates a set of valid occupant tracks by filtering the occupants with substantial tracks from the estimated event sequence based on the zone adjacencies and other spatio-temporal constraints of the layout.

Figure A.5: Valid Tracks
Estimation of Spurious Track Events

The set of events from the estimated event sequence that is not associated with any of the valid tracks is classified as spurious track events. Based on the zone adjacencies and other spatio-temporal constraints of the chosen layout, gaps between two consecutive track elements of a valid track are identified. The gaps arise due to missing event (or events) and are sorted on the basis of duration. The spurious track events are candidates for rectification and can be reassigned to the gaps in valid tracks by applying spatio-temporal reasoning.

Figure A.6: Invalid Tracks
Tracking an Occupant

Figure A.7 is a graphical illustration of the actual and the estimated track plots of an occupant $o_3$ generated using the ‘Track Person’ option. The tracks are modeled on the lines of a UML time-sequence diagram [107] with zone location on the x-axis and event time stamps along the y-axis. The actual track (ground truth) of the occupant and time stamps of events are displayed in blue while the estimated track and time stamps of false positive events are displayed in red. The horizontal lines capture the transition between zones and the vertical bars indicate the duration of presence in a zone. The displayed face images correspond to the input faces associated with the randomly selected template events from the event template pool. The estimated event sequence fails to capture the actual track of an occupant, for example, at time stamps 9:26, 12:02, 12:08 and 13:42. In these cases, the smart environment wrongly assumed the continued presence of the occupant in a zone, despite the occupant having left that zone.
Performance Evaluation of a Smart Environment

This overall performance of a smart environment is captured using precision and recall plots at the state level, the variations of these metrics with recognition threshold $\theta$ as well as precision and recall curves generated at different sensor quality $\sigma$.

Figure A.8: Metrics (State based)
Query Formulation

The system can retrieve answers in response to various spatio-temporal queries relating to the presence and movements of occupants within the smart environment. The query interface allows a user to compose a set of simple canned queries.

Figure A.9: Query Formulation
Applying Spatio-temporal Reasoning

Spatio-temporal reasoning is invoked by the ‘Reason’ option in the GUI to reassign the misidentified events listed in the spurious track to gaps in the valid tracks. The knowledge of the neighboring occupants in adjacent zones forms the basis for generation of revised events which triggers a revision in the states. The following screenshots illustrate the recognition results after applying spatio-temporal reasoning - revised estimated event sequence, revised valid tracks and spurious track events.

Figure A.10: Estimated Events Sequence (After Reasoning)
Figure A.11: Valid Tracks (After Reasoning)

Figure A.12: Invalid Tracks (After Reasoning)