Tracking Evacuation of Pedestrians during Disasters

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Motivation

- Increasing use of mobile devices
- Application scenario of theme parks
  - Theme parks in Orlando
  - Crowded areas (e.g., city squares, airports)
Tracking pedestrians and emergent events

- Internet requires certain infrastructure that can be damaged
- Networks resilient to disasters
- Communication and safe evacuation in disaster areas

Contributions
- A networked system with mobile sinks
- Sink placement and mobility approaches
Network model

- Network consists of sensor nodes and mobile sinks

- Sensor nodes:
  - Store, carry, and transmit the messages

- Mobile sinks:
  - Personal electric vehicle (e.g., Segway)
  - Exist in limited numbers
  - Able to move to emergent events

- Routing protocol: Epidemic routing
Routing protocol

- Sensors act as either initiator or replier
- Mobile sinks always act as repliers
Initial sink placement

- Process starts with the creation of a grid layout

- The small-sized grids are located only on top of the roads

- Base points: The set of quasi-random points with the highest distance sum

- Base points are used for marking grids with particular indices

- Each mobile sink is placed on a random point in the subset of grids
Inspired by Newton’s law of universal gravitation
- A pedestrian has a unit mass which attracts the mobile sinks
- Mobile sinks have larger masses causing inverse forces
Each mobile sink allocates a subset of grids (by indices)
Iteratively chooses a random waypoint as the next destination
Aims to divide the workload evenly without intercepting
Each sink allocates one or multiple roads
Grid indices are used for allocating neighbor roads
Sinks decide random waypoints on top of the roads
Simulation study

- Our group’s disaster area mobility model† is used for pedestrians
- Metrics: Intercontact times, recontact rates, number of transmissions, rescue success ratio
- Two mobility models: Random waypoint distribution (RWD), random target location (RTL)

Table: Simulation parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>simulation time</td>
<td>2000 s</td>
</tr>
<tr>
<td>sampling time</td>
<td>2.0 s</td>
</tr>
<tr>
<td>disaster area size (≈)</td>
<td>800x800 m</td>
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<tr>
<td>number of sensor nodes</td>
<td>200</td>
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<tr>
<td>sensing range</td>
<td>20 m</td>
</tr>
<tr>
<td>sensor message storage capacity</td>
<td>100</td>
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<tr>
<td>transmission probability</td>
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<tr>
<td>grid width/height</td>
<td>50 m</td>
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<tr>
<td>number of effected people</td>
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<td>rescue failure time</td>
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<td>sink relative mass constant (λ)</td>
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<td>physical force impact factor (α)</td>
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<td>sink max speed</td>
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<td>pedestrian max speed</td>
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<tr>
<td>pedestrian visibility</td>
<td>50 m</td>
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</table>

The map of the Magic Kingdom extracted from (†OSM) and the processed map with 1300 waypoints

Results: Intercontact times by sink mobility

- PF: Physical force based
- GA: Grid allocation based
- RA: Road allocation based
- RTL: Random target location
- RWD: Random waypoint distribution

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Results: Intercontact times by transmission range

- **PF**: Physical force based
- **GA**: Grid allocation based
- **RA**: Road allocation based
- **RTL**: Random target location
- **RWD**: Random waypoint distribution

![Graph showing intercontact times by transmission range](image)

Transmission range (m) vs. Intercontact time (s) for different algorithms.
Results: Recontact rates by number of sinks

- **PF**: Physical force based
- **GA**: Grid allocation based
- **RA**: Road allocation based
- **RTL**: Random target location
- **RWD**: Random waypoint distribution

<table>
<thead>
<tr>
<th>Number of mobile sinks</th>
<th>PF</th>
<th>GA</th>
<th>RA</th>
<th>RTL</th>
<th>RWD</th>
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</tbody>
</table>
Results: Number of transmissions by range

- PF: Physical force based
- GA: Grid allocation based
- RA: Road allocation based
- RTL: Random target location
- RWD: Random waypoint distribution
Results: Rescue success ratio by number of sinks

- PF: Physical force based
- GA: Grid allocation based
- RA: Road allocation based
- RTL: Random target location
- RWD: Random waypoint distribution

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Thank you

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