How to drive passenger airport experience: a decision support system based on user profile

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Objective

SEA Aeroporti Milano expressed interest in improving the efficiency of passengers movement.

A system to give information and suggestions with a smartphone application to airport passengers was developed, in order to:

• Improve passengers airport experience
• Increase airport revenues, give airport management useful information for planning

Reduce queueing and waiting time

By

Increase time spent in discretionary activities
Model framework – general overview

- Activity-sequences probabilities
- Micro-simulation
- Queue lengths and densities
- Real-time user position
- Airport management interests
- User profile
Model framework – activity choice (1)

- Activity-choice model
- Activity-sequences probabilities
- Micro-simulation
- Queue lengths and densities
- Real-time user position
- Airport management interests
- User profile
- Suggestion generation model
Model framework – activity choice (2)

- **Activity types**
- **Activity network**

- $A_1$
- $A_2$
- $\vdots$
- $A_k$

- $S$ to $e$

- $1$ to $T$ time units

- $K$ activity types
- $T$ time units
- $G$ passenger groups
- $K^T$ possible paths  \(\rightarrow\) sampling

[Danalet 2015]
Model framework – activity choice (3)

Utility function:

\[ V_\Gamma = \sum_{k=1}^{K} \sum_{t=1}^{T} \sum_{g=1}^{G} V(A) + \sum_{a=1}^{N_a} \sum_{g=1}^{G} V(a) + \sum_{g=1}^{G} V(\Gamma) \]

That includes time-of-the-day preference, satiation effect, repetition effect.

Parameters estimated using passengers’ smartphone traces and interviews.

Logit model

\[ P_{r_{\Gamma g}} = \frac{e^{V_\Gamma}}{\sum_{p=1}^{N_{\Gamma}} e^{V_p}} \]
Model framework – microsimulation (1)

- Activity-sequences probabilities
- Micro-simulation
- Queue lengths and densities
- Real-time user position
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ACTIVITY CHOICE MODEL

SUGGESTION GENERATION MODEL
1. Activity sequence probabilities (from activity-choice model)
2. Location choice probability (from smartphones/interviews)
3. Infrastructure

1. Queue length prediction (check-in, security control)
2. Passenger density in all airport areas
Model framework – suggestions (1)

**ACTIVITY CHOICE MODEL**

- Activity-sequences probabilities
- Micro-simulation
- Queue lengths and densities
- Real-time user position
- Airport management interests

**SUGGESTION GENERATION MODEL**

- User profile

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Model framework – suggestions (2)

The suggestion to the user is given in two levels:

1. Activity suggestion
2. Location suggestion

LEVEL 1

The activity sequence to suggest is obtained by modifying some variables in the activity choice model’s utility function.

Sequences in which security control is performed when queue is low and waiting time in front of the gate is small have their utility increased.

Sequence with the highest utility is the one to suggest to that passenger group.
Model framework – suggestions (3)

LEVEL 2

The locations are suggested with a weight system that takes into account:

- **user position** and **time availability** (base weight),
- **location congestion** (congestion weight)
- **passenger profile** (user weight)
- **airport management preferences** (airport weight).

\[ W_{it} = f(BW_{it}, CW_{it}, UW_i, AW_i) \]
Case study
Case study – activity choice model

- Smartphone traces not available → utility function parameters set by the analyst

- 30 possible activity sequences considered

- Passengers divided into 3 groups: early, in time and late arrivers

- Model implemented using Matlab

- Output: probability for each sequence to be chosen, for every passenger group
Airport case study’s infrastructure
For this simulation, NOMAD was used. NOMAD microsimulation tool was developed at the Delft University of Technology by S. Hogendoorn, W. Daamen and M.C. Campanella.
Case study – microsimulation (2)

Model output: queue length prediction
Case study – microsimulation (3)

Model output: people inside commercial areas

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Case study – suggestions (1)

Suggestion generation model applied to 3 passengers (1 for each passenger group).

Level 1: activity sequence suggestion
Case study – suggestions (2)

Level 2: location suggestion

Location choice model implemented with Matlab.

Output:

**Passenger 1 (early)**
shop2 (40’) \(\rightarrow\) security \(\rightarrow\) eat4 (45’) \(\rightarrow\) shop5 (30’) \(\rightarrow\) boarding

**Passenger 2 (in time)**
security \(\rightarrow\) shop4 (15’) \(\rightarrow\) eat3 (40’) \(\rightarrow\) shop6 (30’) \(\rightarrow\) boarding

**Passenger 3 (late)**
shop1 (5’) \(\rightarrow\) security \(\rightarrow\) eat3 (40’) \(\rightarrow\) boarding
# Case study – behaviour comparison

<table>
<thead>
<tr>
<th></th>
<th>Queue time</th>
<th>Waiting time</th>
<th>Activity time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early arriving passenger</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without suggestion, average on 5 runs</td>
<td>4’35”</td>
<td>22’01”</td>
<td>1h27’58”</td>
</tr>
<tr>
<td>With suggestion, average on 5 runs</td>
<td>27” (-90.0%)</td>
<td>1’07” (-94.9%)</td>
<td>1h54’36” (+30.3%)</td>
</tr>
<tr>
<td><strong>In-time arriving passenger</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without suggestion, average on 5 runs</td>
<td>5’52”</td>
<td>19’45”</td>
<td>51’03”</td>
</tr>
<tr>
<td>With suggestion, average on 5 runs</td>
<td>1’50” (-68.7%)</td>
<td>4’08” (-79.1%)</td>
<td>1h15’40” (+48.2%)</td>
</tr>
<tr>
<td><strong>Late arriving passenger</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without suggestion, average on 5 runs</td>
<td>3’53”</td>
<td>25’02”</td>
<td>19’49”</td>
</tr>
<tr>
<td>With suggestion, average on 5 runs</td>
<td>4’05” (+5.0%)</td>
<td>3’03” (-87.8%)</td>
<td>44’27” (+124.3%)</td>
</tr>
</tbody>
</table>

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Model limitations and future works
Model limitations and future works

This model has two main limitations:

1. Does not consider **dynamics**

2. Does not consider users **compliance**

Next step: apply this system to a real-world scenario (Milano Malpensa)

Once the system is adapted to consider dynamics and users compliancy, the models calibrated and the smartphone application developed, it can be applied in the real-world.
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\[ V(A) = \beta_{ktg} I_{kt} I_g \]

\[ V(a) = \eta_{kg} \ln|a| I_k I_g \]

\[ V(\Gamma) = \beta_{|k|g} I_{|k|} I_g \]
\[ V(A)_1 = (\beta_{1t}gI_{1t} + \gamma_{1g}EQT_t)I_g \]

\[ V(A)_5 = (\beta_{5t}gI_{1t} + \gamma_{5g}I_{info})I_g \]
\[ BW_{it} = \begin{cases} \frac{-BW_{\max}}{T_t - t_{pi}} D_i + BW_{\max} & \text{if } T_t - t_{pi} > 0 \\ 0 & \text{if } T_t - t_{pi} \leq 0 \end{cases} \]

\[ CW_{it} = c \left( -\frac{n_{it+\tau}}{N_i} + 1 \right) \]

\[ UW_{i} = u \times Pr_{i} \]

\[ AW_{i} = \alpha \times af_{i} \]
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