Towards a spatio-temporal model of human movement surfaces for the simulation of best utility trajectories

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Outline

1. Introduction
2. Why movement surfaces?
3. Objectives
4. Spatio-temporal model design
5. Implementation
6. Conclusions
7. Future Work
Introduction

If you stop and observe a moving crowd..

... it could seem to be a chaotic phenomena at first sight
But if you look at this phenomena a little more...

... you will realize that human movements is not a chaotic phenomena but is the result of human intentional behaviour
Then if we infer about this intentional behaviour..

\[
\text{INTENTIONAL BEHAVIOR} = \text{PERSON PREFERENCES} \cap \text{ENVIRONMENT}
\]

... we can make predictions about human movement!!
Why movement surfaces?

- Any movement is the consequence to the forces acting over the person that moves.
- Movement surfaces represent the forces field which generates such a movement.
Movement surface

- It represents the attraction forces over all the environment. (Not only at the destination point)
- It is individualized for each person. (Each person has different displacement preferences)
- It is a dynamic surface, it varies along the time.
Objectives

● Predict the human movement by modelling movement surfaces.
● Demonstrate how to implement a movement surface in different application scenarios.
Spatio-temporal model design

Modelling Phases

   - The acting classes (Main actors)

2. Why? How?
   - The rules of the movement

3. Prediction
   - Movement surface

4. Planning
   - Applications

Applications

Movement surface

The rules of the movement

The acting classes (Main actors)
The acting classes

2. Why? How?
3. Prediction
4. Planning

Who?
What?
Where?
When?

Environment
Event
Person
Preferences

Time
Event
Person
Preferences
The rules

2. Why? How?
3. Prediction
4. Planning

Active

Time

Event

Environment

Person

Preferences

Modifies

Interaction

Haunted by

LatinGE

GeoPKDD

The rules
Each person moves in a way that his satisfaction is maximized according to his preferences.
Movement surface

2. Why? How?
3. Prediction
4. Planing

Active

Event

Time

Environment

Person

Preferences

Movement Surface

Produces

Interaction

Modifies

Highlights

Movement Surface

Active
As a raindrop flows over a surface looking for the maximum slopes, people flow over their correspondent movement surface looking for the maximum utility.
Planning

- **Location-allocation problem:** Find the optimal location for a specific public (stand, supermarket)

- **Optimal routes which are individualized per each person**
Implementation

How can this movement surface be generated?

By assigning a utility value to the environment
Implementation

How can this movement surface be generated?

By assigning a utility value to the environment

<table>
<thead>
<tr>
<th>Different preferences</th>
<th>Environment</th>
<th>Utility value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High utility</td>
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<tr>
<td></td>
<td></td>
<td>Low utility</td>
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<tr>
<td></td>
<td></td>
<td>Medium utility</td>
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</table>

\[ \cap \cap \cap \]
I need to get the village
I am allergic to flowers
I love mountain
I like hot

Attraction forces are proportional to utility

SOURCE

DESTINATION

could
mountains
flowers

Enviroment

Person
Preferences
How is this utility value calculated?

The utility is the measure of the compliment level of the person preferences in the environment.

**EMC techniques**
(Simple Additive Weighting, SAW)

- Person preferences (= criterias)
- Environment

EMC \(\rightarrow\) Utility
How are the preferences defined?

Preferences are represented by using two concepts:

- **Preference matrix**: The weight of each criteria. (= Relevance of the preference)
- **Satisfaction function**: Satisfaction produced to one person by one variable value of the environment.

![Graph showing satisfaction function vs. temperature]

Satisfaction

Temperature
Application Scenario: Emergency Call

Moving Object: Ambulance

Preference matrix

<table>
<thead>
<tr>
<th>Humidity</th>
<th>Slope</th>
<th>Soil type</th>
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</thead>
<tbody>
<tr>
<td>0%</td>
<td>40%</td>
<td>60%</td>
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Satisfaction Functions

<table>
<thead>
<tr>
<th>Slope</th>
<th>Satisfaction</th>
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<td>Level</td>
<td>Maximum</td>
</tr>
<tr>
<td>Slight</td>
<td>Medium</td>
</tr>
<tr>
<td>Scarp</td>
<td>Minimum</td>
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<tr>
<td>Grass</td>
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</tr>
<tr>
<td>Soil</td>
<td>Medium</td>
</tr>
<tr>
<td>Pavement</td>
<td>Maximum</td>
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Moving Object: Mushroom Picker

Preference matrix

Humidity | Slope | Land type |
---|---|---|
30% | 5% | 65%

Satisfaction Functions

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<tr>
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Utility Calculus Example

For the mushroom picker

- Slope value = 5%
- Humidity value = 80%
- Land type = Soil

Satisfaction normalization
- High = > 10
- Medium = > 5
- Minimum = > 0

Environment

EMC (SAW)

Movement

Surface

Calculus for A cell

Utility = \sum (Weight \times Satisfaction) for all criterias

\[
U = \left( \frac{W_{	ext{slope}} \times S_{	ext{slope}}}{\text{Slope value}} \right) + \left( \frac{W_{	ext{humid}} \times S_{	ext{humid}}}{\text{Humidity value}} \right) + \left( \frac{W_{	ext{land}} \times S_{	ext{land}}}{\text{Land type}} \right)
\]

\[
= \left( \frac{5\% \times 10}{5\%} \right) + \left( \frac{30\% \times 10}{80\%} \right) + \left( \frac{65\% \times 5}{100\%} \right)
\]

= 6.75
Flow direction calculus

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<tr>
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</tr>
<tr>
<td>0</td>
<td>3</td>
<td>3</td>
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Satisfaction due to destination point + Satisfaction due to environment

Looking for high satisfaction
Conclusions

• Each singular movement of a person is the consequence of the forces acting over him/her.

• If we know about an environment and the preferences of one person we can simulate his/her movements through the modelling of movement surfaces.

• Movement surfaces are the analogue to surface confluence in flow water phenomena.
Future Work

Model validation
¿Questions?

This research was funded under the GeoPKDD project