



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

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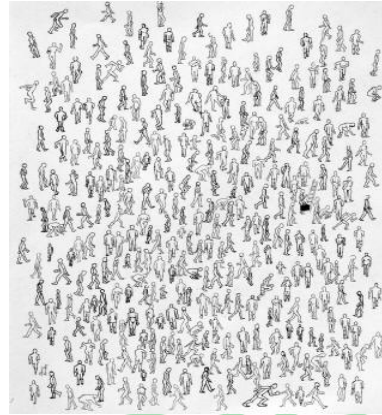
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Outline

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

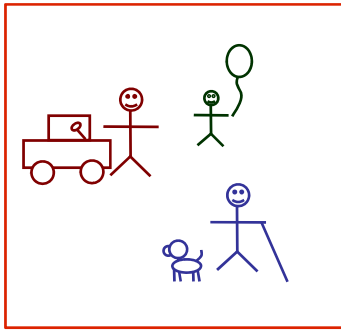
Introduction

If you stop and observe a moving crowd..



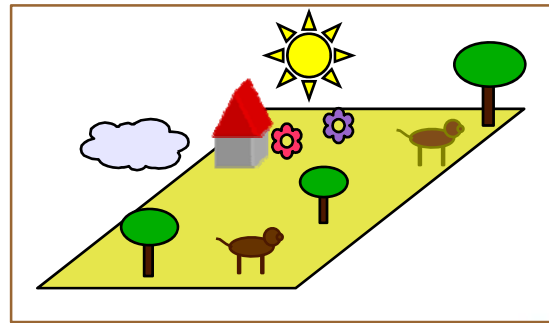
... it could seem to be a chaotic phenomena at first sight

But if you look at this phenomena a little more...



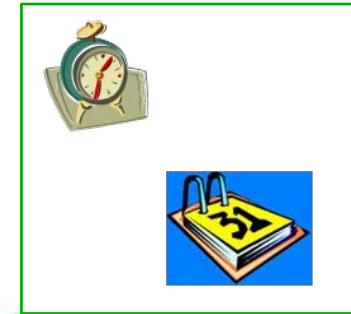
THE
SUBJECTS

&



THE ENVIRONMENT
(and restrictions)

&



THE
MOMENT

... 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..

$$\text{INTENTIONAL BEHAVIOR} = \text{PERSON PREFERENCES} \cap \text{ENVIRONMENT}$$

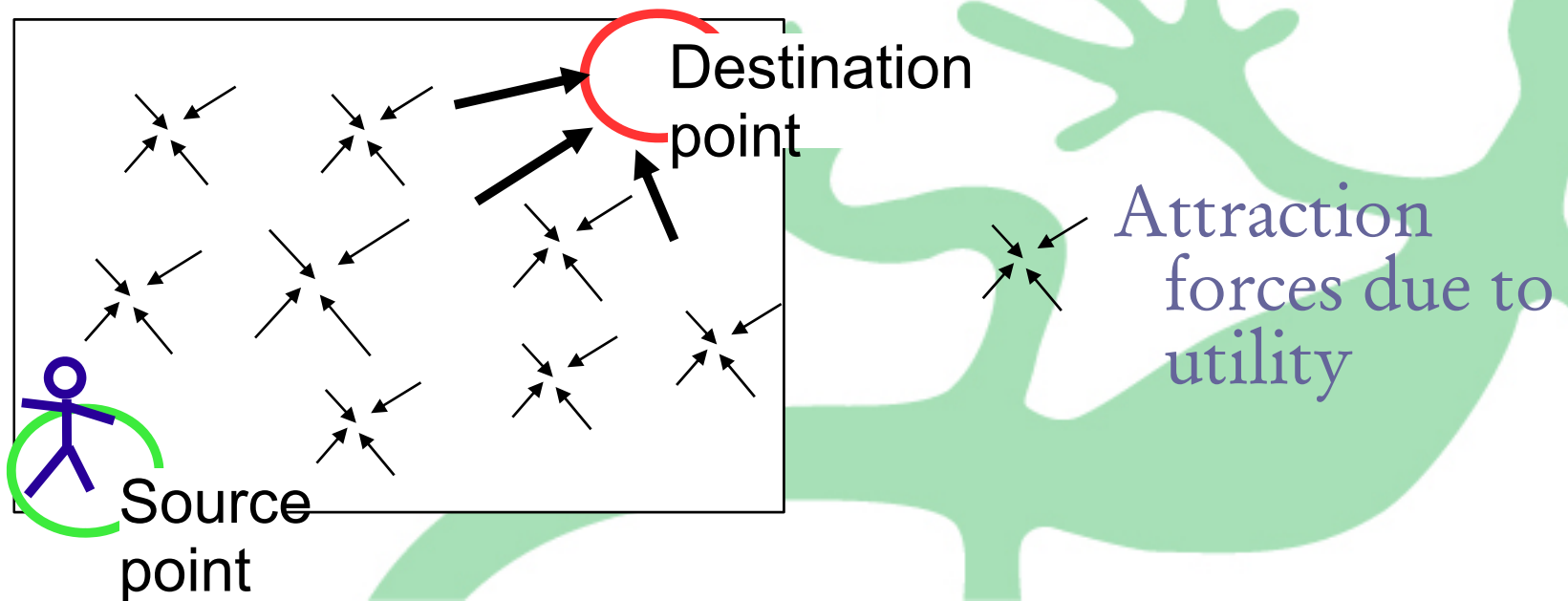
... we can make predictions about human movement!!



Movement Surface

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

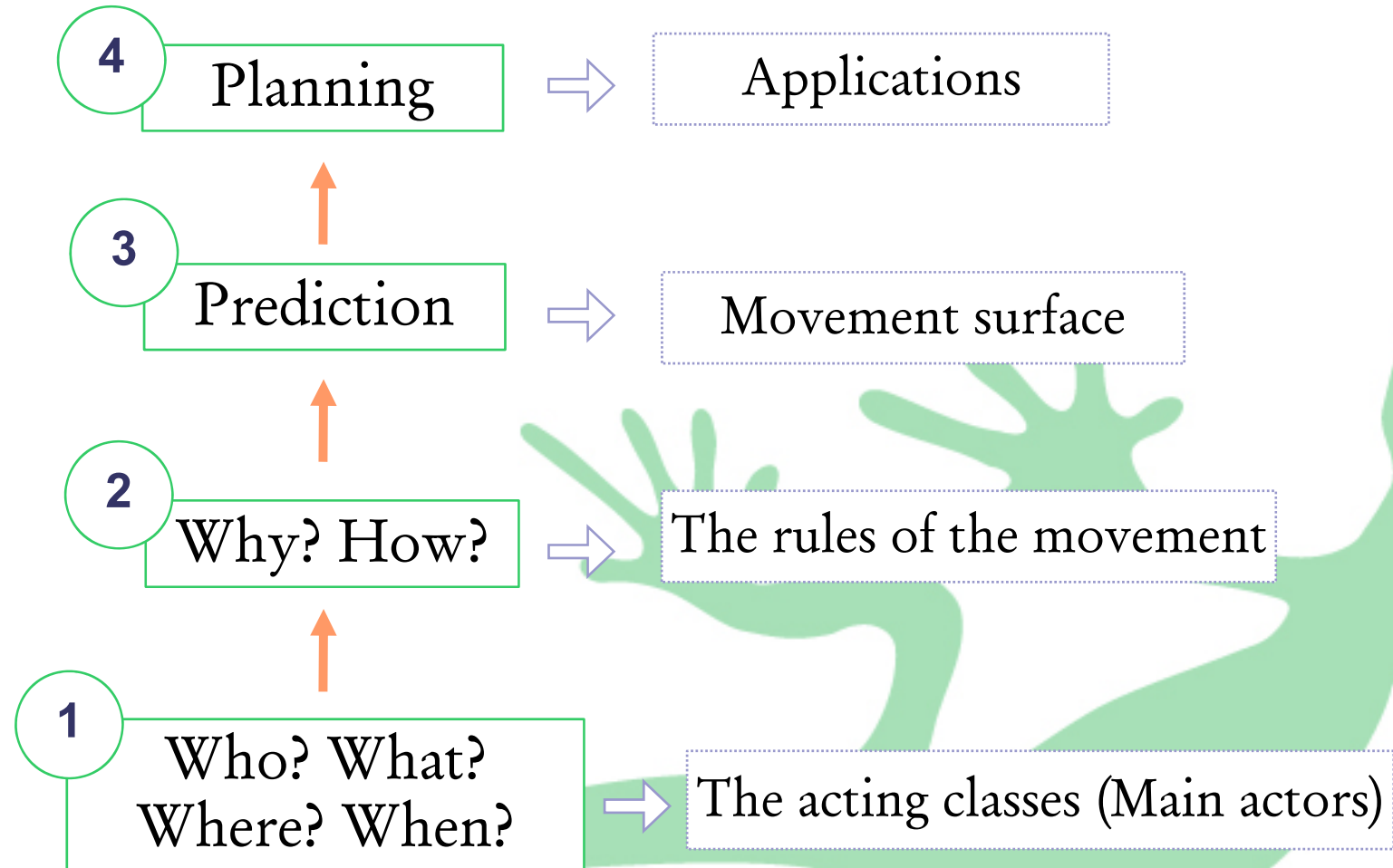
- It represents the attraction forces over all the environment. (Not only at the destination point)
- It is individualized for each person. (Each person has different displacement preferences)
- It is a dynamic surface, it varies along the time.

Objectives

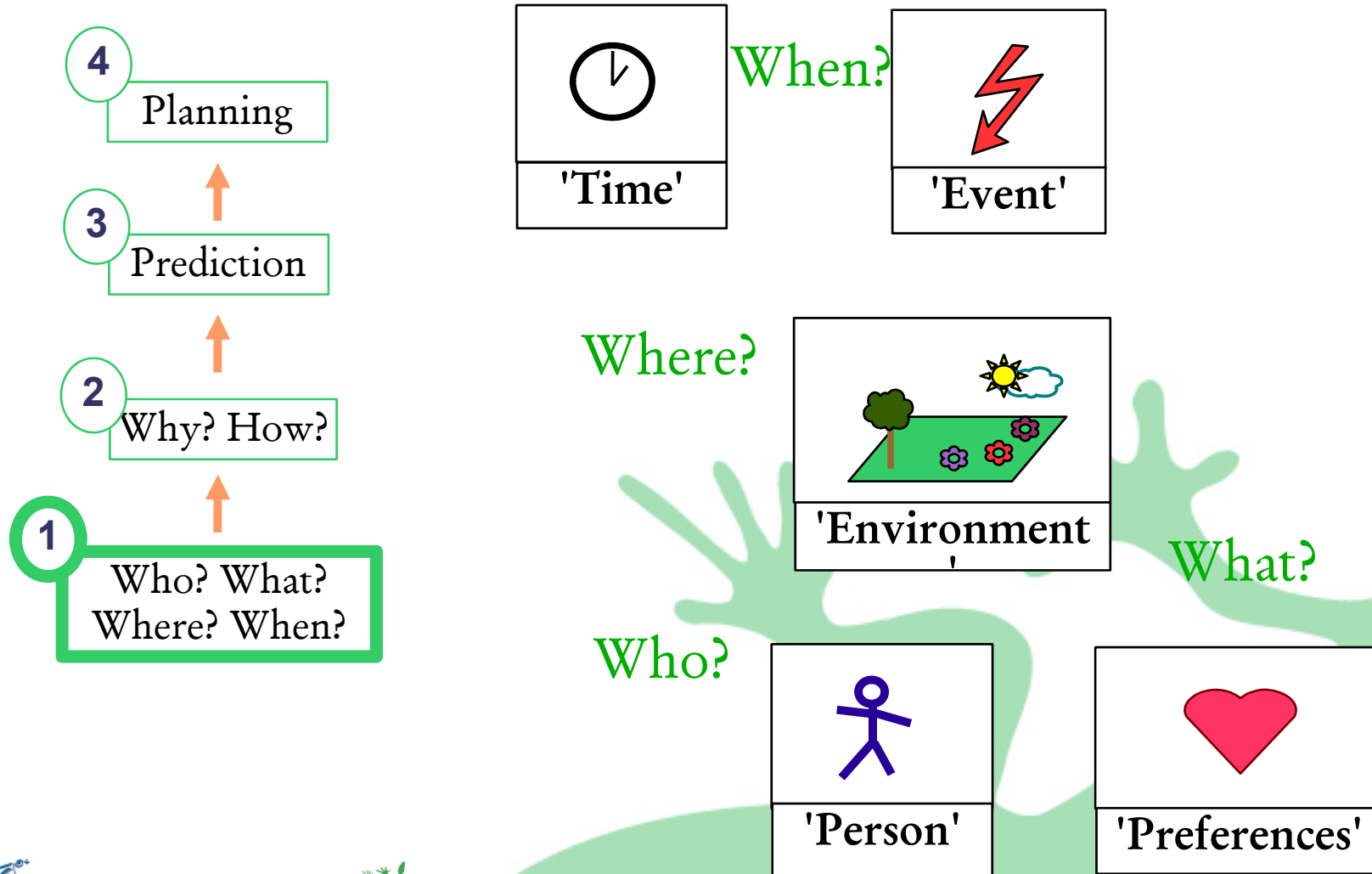
- Predict the human movement by modelling movement surfaces.
- Demonstrate how to implement a movement surface in different application scenarios.

Spatio-temporal model design

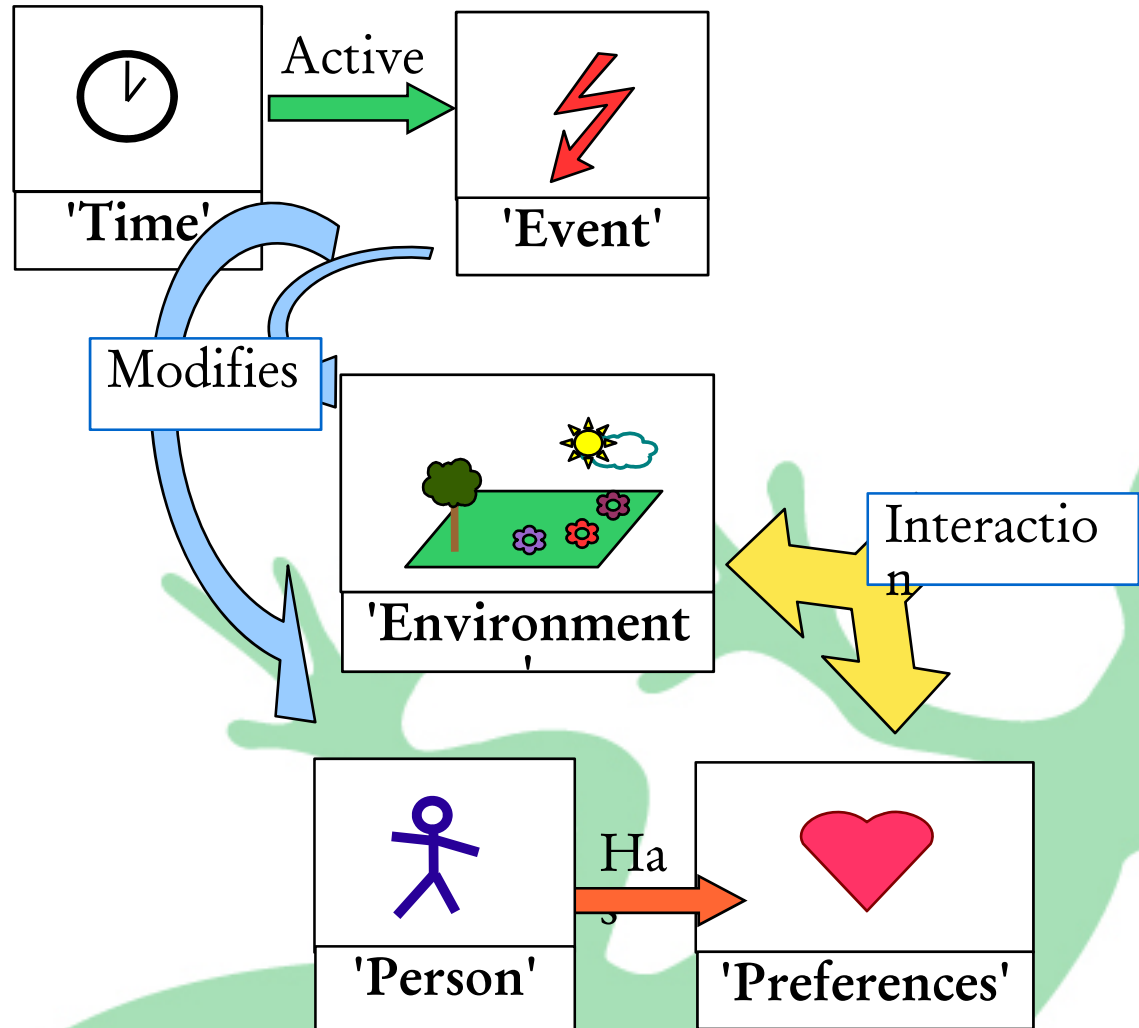
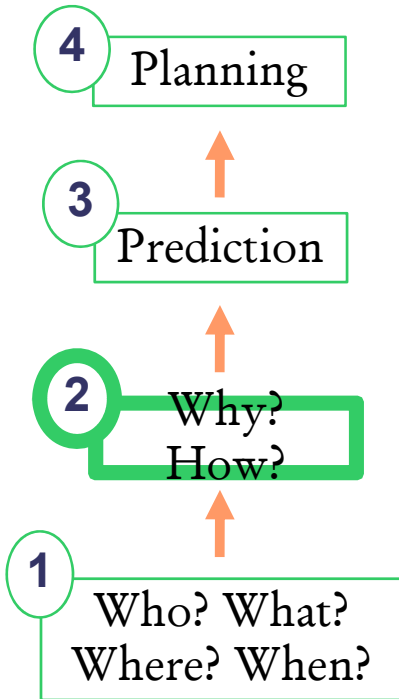
Modelling Phases



The acting classes

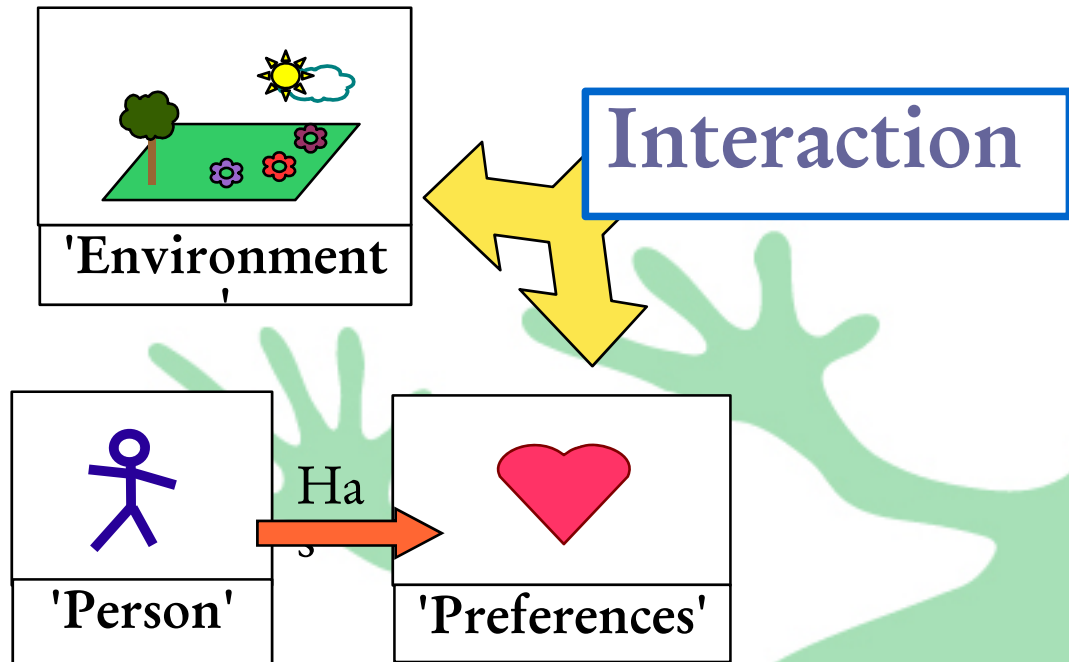
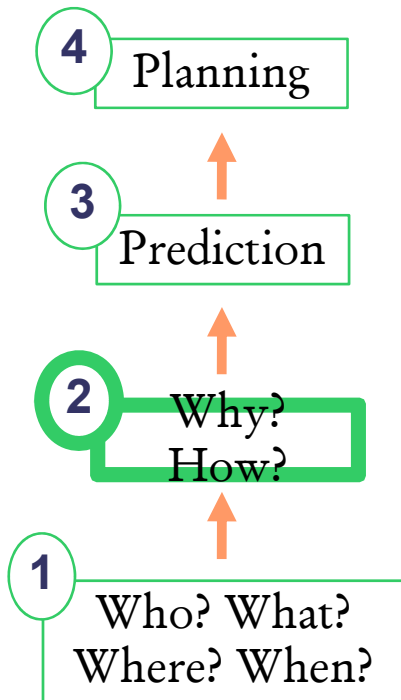


The rules

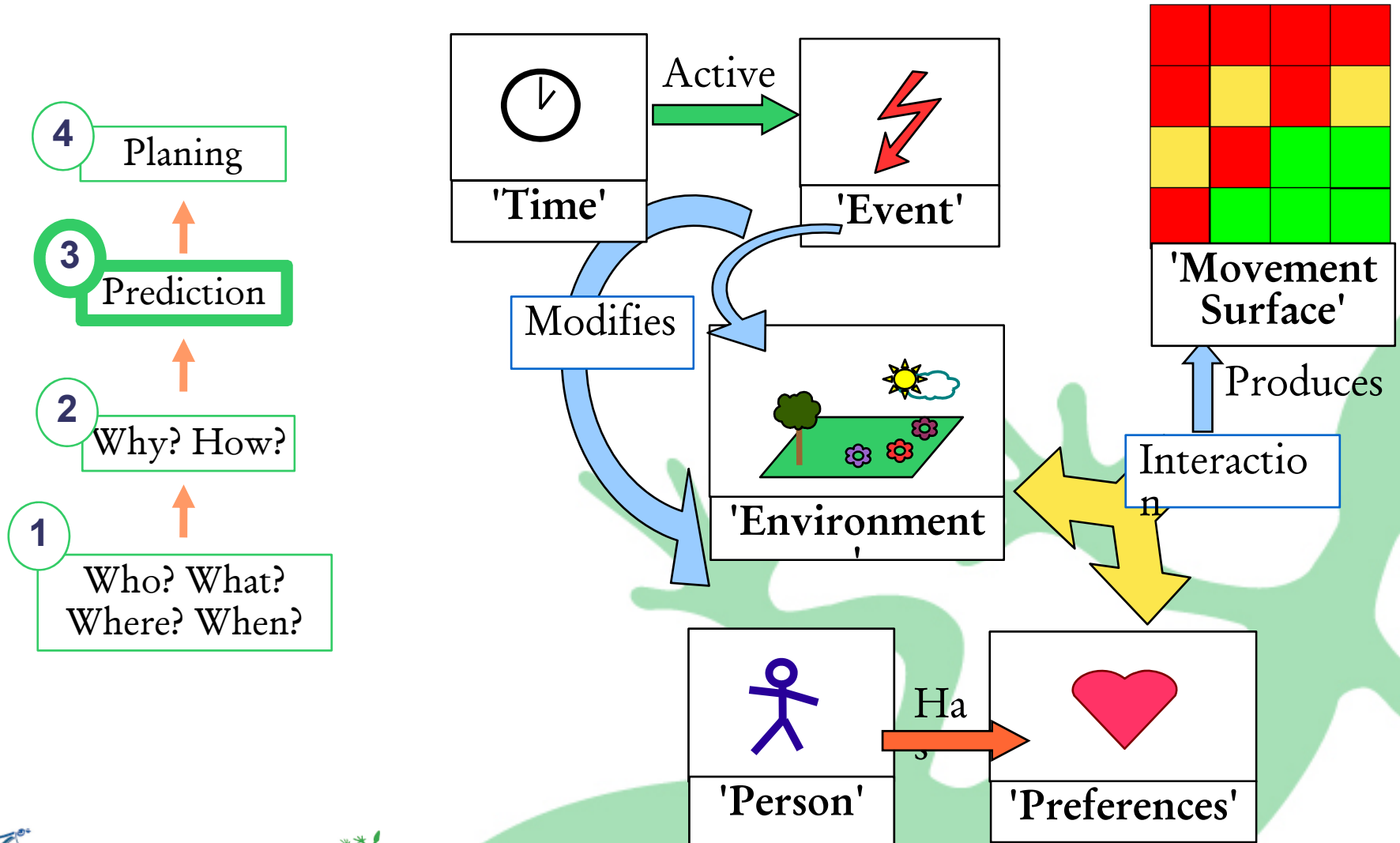


The rules

Each person moves in a way that his satisfaction is maximized according to his preferences.

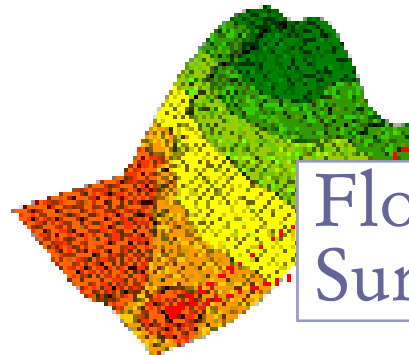
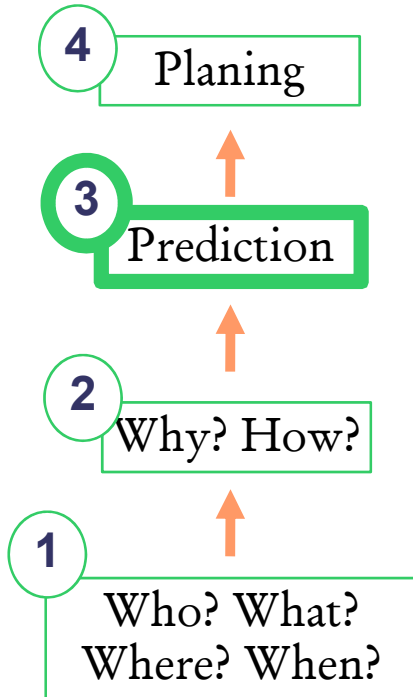


Movement surface



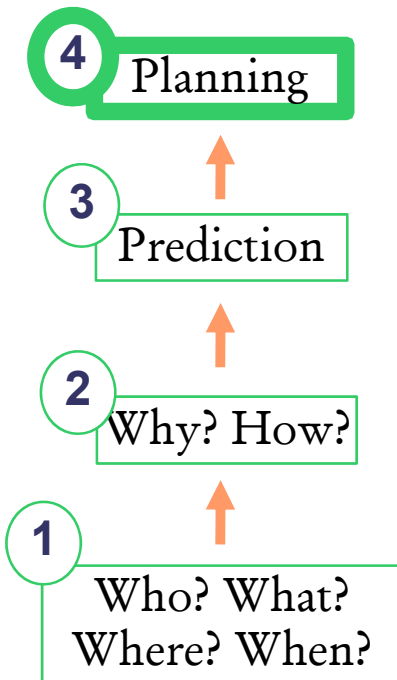
Movement surface

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



Flow Confluence Surface

Planning



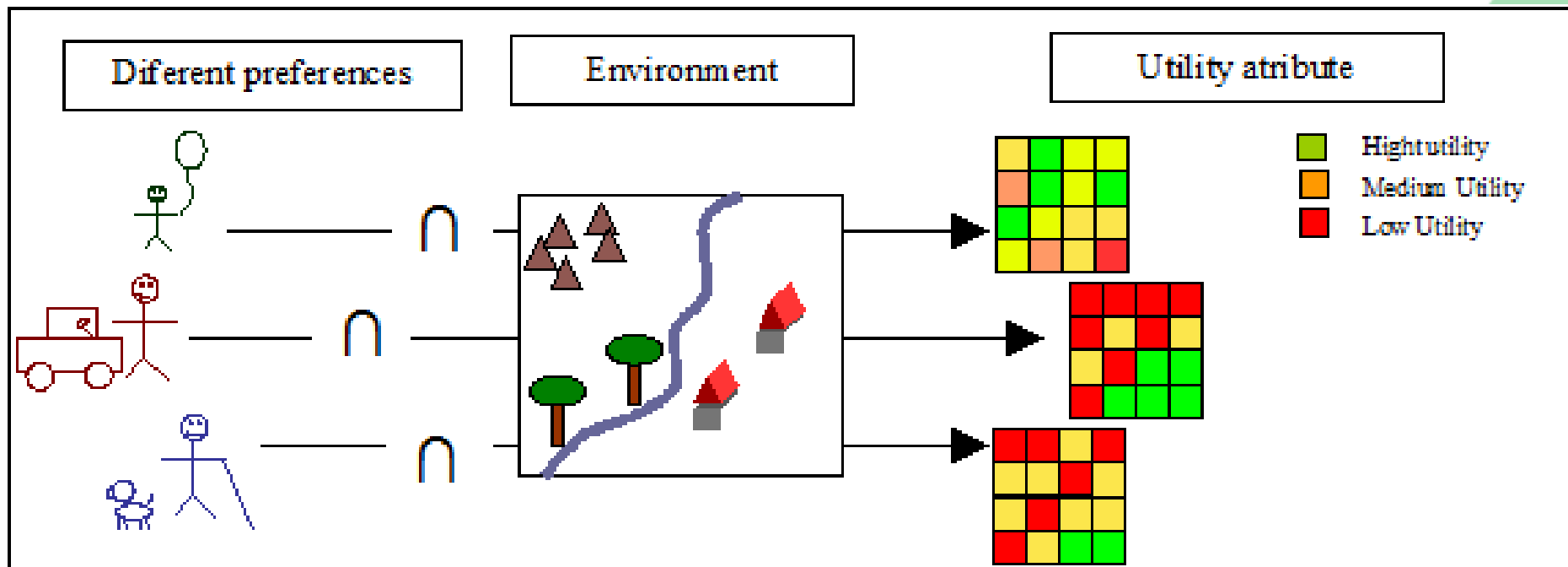
- Location-allocation problem: Find the optimal location for a specific public (stand, supermarket)

- Optimal routes which are individualized per each person

Implementation

How can this movement surface be generated?

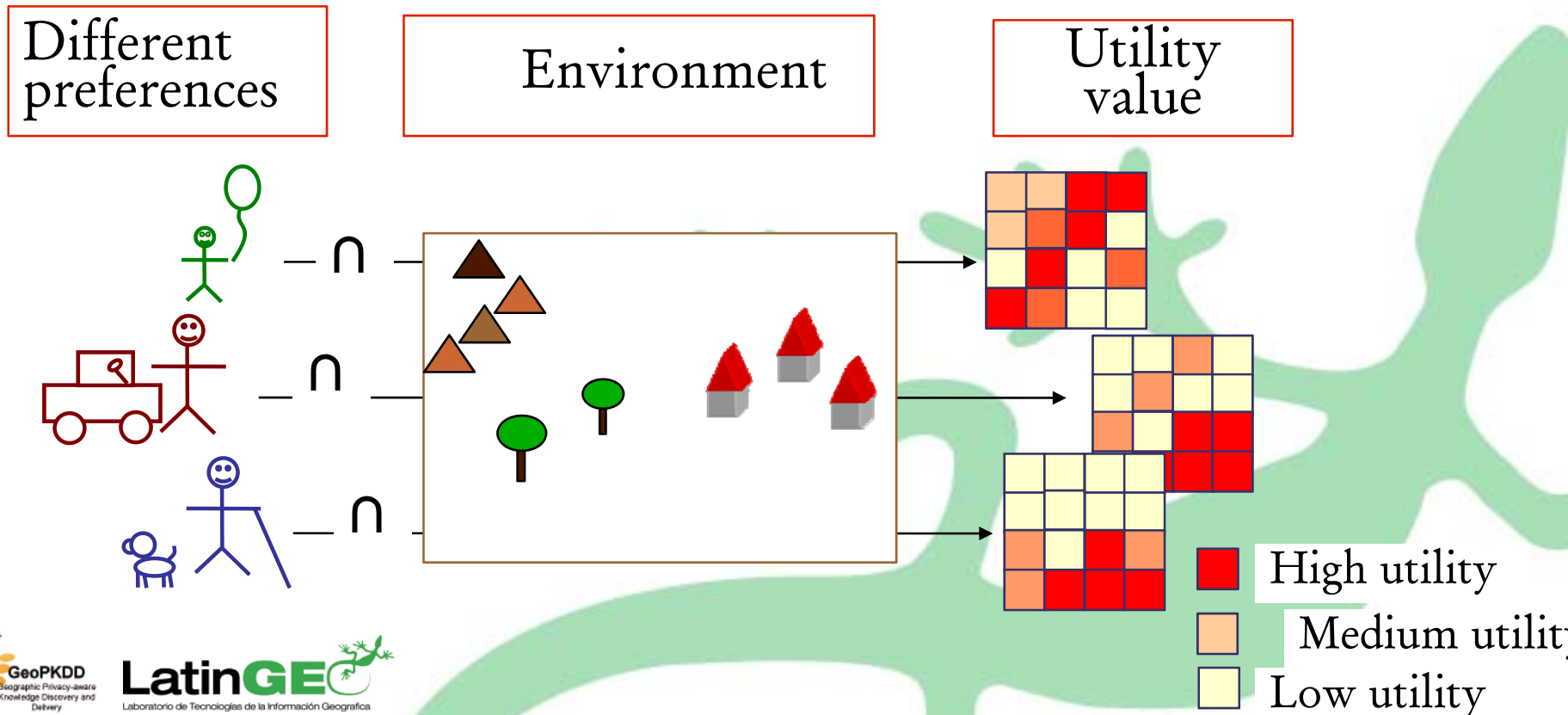
By assigning a *utility value* to the environment



Implementation

How can this movement surface be generated?

By assigning a **utility value** to the environment



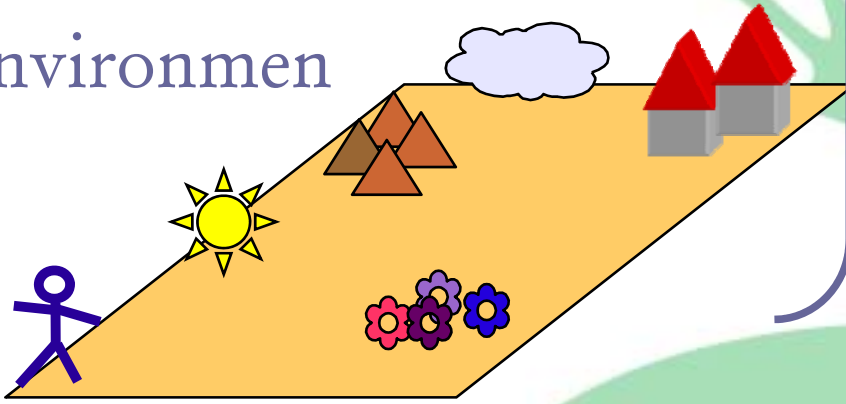
Preferences

- I need to get the village
- I am allergic to flowers
- I love mountain
- I like hot

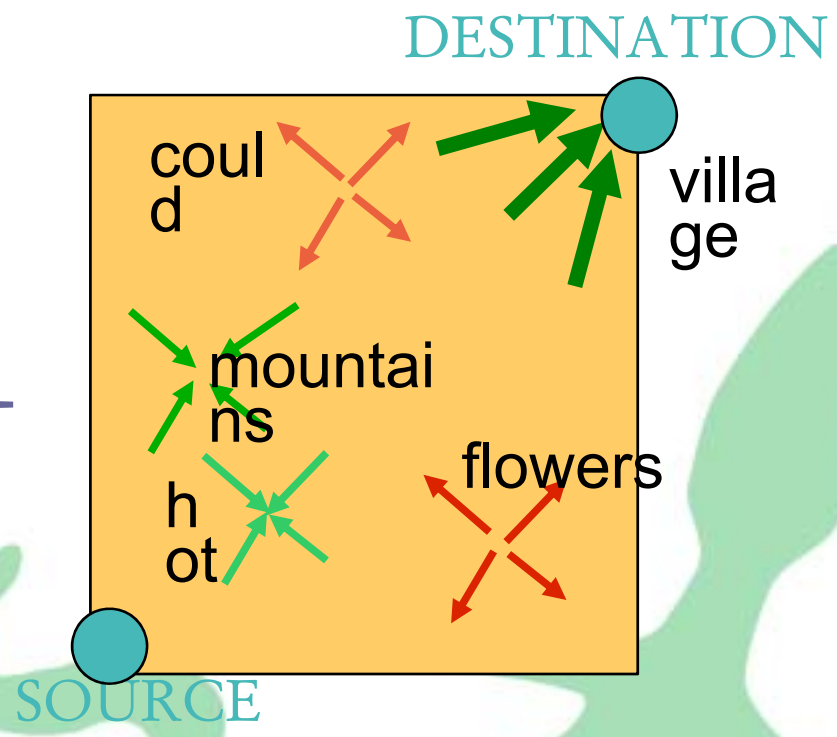


Person

Environment

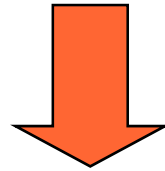


Attraction forces are proportional to utility



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

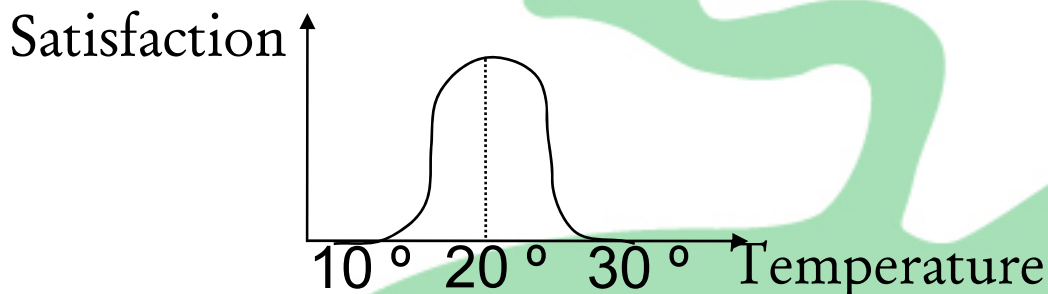
Utility

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.



Application Scenario: Emergency Call

Moving Object: Ambulance

Humidity	Slope	Soil type
0%	40%	60%

Preference matrix ←

Slope	Satisfaction
Level	Maximum
Slight	Medium
Scarp	Minimum

Satisfaction Functions

Land	Satisfaction
Grass	Minimum
Soil	Medium
Pavement	Maximum

Application Scenario: Recreation

Moving Object: Mushroom Picker

Humidity	Slope	Land type
30%	5%	65%

Preference matrix



Satisfaction Functions

Humidity	Satisfaction
Low	Minimum
Normal	Medium
High	Maximum

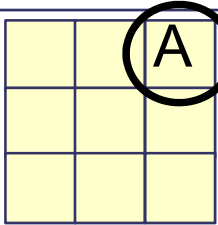
Slope	Satisfaction
Level	Maximum
Slight	Medium
Scarp	Minimum

Land	Satisfaction
Grass	Maximum
Soil	Medium
Pavement	Minimum

Utility Calculus Example

For the mushroom picker

Environment



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

Satisfaction normalization

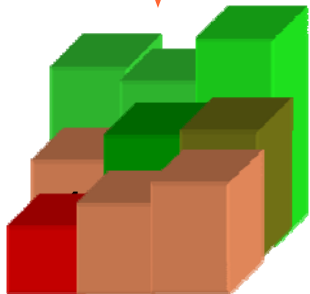
- High = > 10
- Medium = > 5
- Minimum = > 0

EMC
(SAW)

Calculus for A cell

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

$$U = \left\{ \begin{array}{l} (W_{\text{slope}} * S_{\text{slope}}) \\ (W_{\text{humid}} * S_{\text{humid}}) \\ (W_{\text{land}} * S_{\text{land}}) \end{array} \right\} = \left\{ \begin{array}{l} (5\% * 10) \\ (30\% * 10) \\ (65\% * 5) \end{array} \right\} = 6,75$$

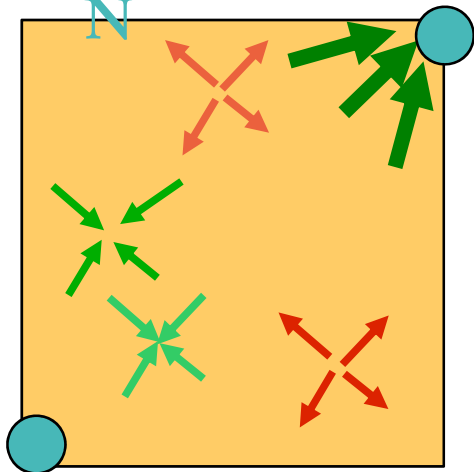


Movement
Surface

Flow direction calculus

DESTINATION

N



SOURCE

1

Satisfaction due to destination point

+

Satisfaction due to environment

4	6	9	10
4	7	5	6
5	2	4	2
0	3	3	3

2

Looking for high satisfaction

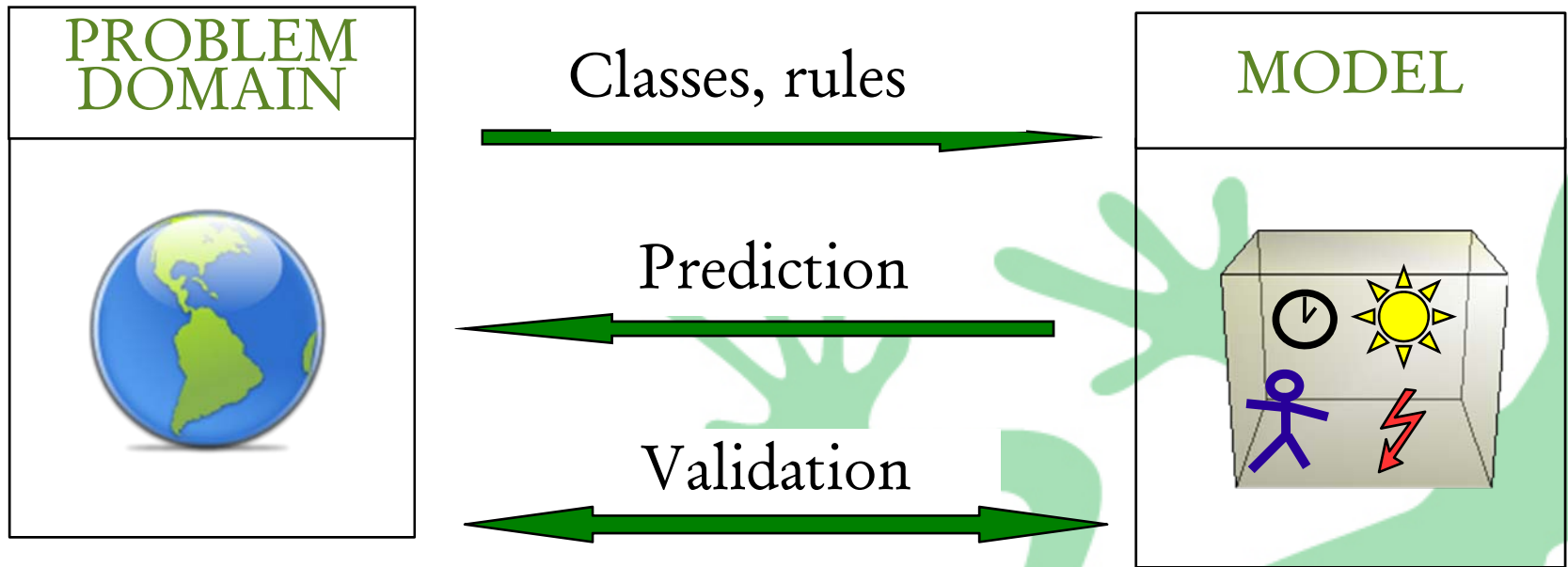
4	6	9	10
4	7	5	6
5	2	4	2
0	3	3	3

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

