

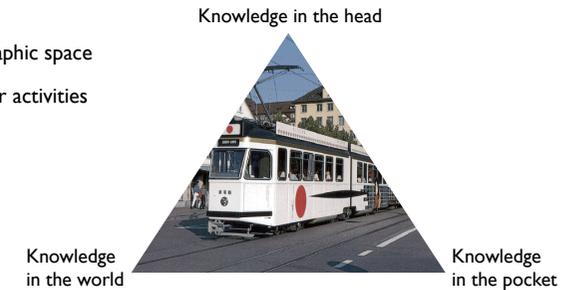
Modelling spatial behaviour for agent-based simulations

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You are going places...

- ...every day
- ...interacting with geographic space
- ...while carrying out your activities



- What does your immediate environment contribute to your activities?
- How much information do you need to have in your head to carry out your activity?
- How much information is needed in addition to these knowledge sources?

Human-environment interaction

- modeling the knowledge sources and their structures but also their interplay
- modeling activities carried out in geo-space that lead to human behavior
- using an (embodied) agent perspective -> agent-based modeling



How activities structure space

- Human activities take place in space
 - there are different types of spaces: room, building, street, neighborhood, city, country...
 - an agent assigns meaning to these spaces and make them her own - she appropriates them and thus construct her own environment
- an agents complements his environment with mental representations to act effectively
- he constructs/selects the best environment to go with the activity at hand (Timpf et al. 1992)
- activities engender environments, i.e., they partition reality and guide attention

Activities engender environments



driving

Activities engender environments



biking

Activities engender environments



walking

Activities engender environments



driving

biking

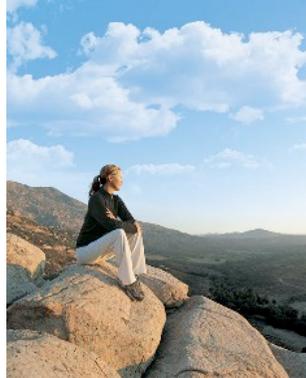
walking

- assigning meaning to what an agent sees
- allowing actions to be performed
- activities engender environments

but the reverse is also true

How space structures activities

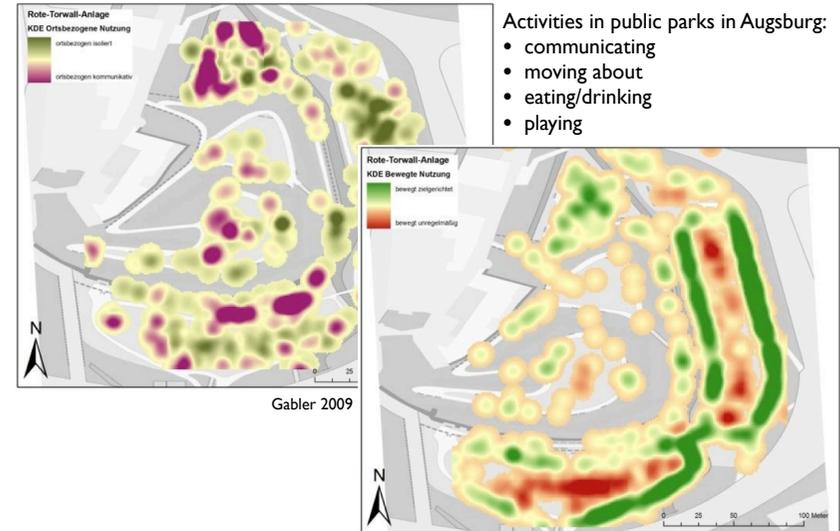
- environments elicit actions (home, office)
- environments and their parts can afford an action (Gibson 1979)
- environments offer actions to agents who can perceive that the environment affords these actions
- Example: this rock affords sitting
- an affordance is a quality of an object, or an environment, which allows an agent to perform an action
- environment - agent - action



How space structures activities

Activities in public parks in Augsburg:

- communicating
- moving about
- eating/drinking
- playing



Gabler 2009

Schematic Geometry (Rüetschi & Timpf 2004)

- partitions space into different types of image schemata (Johns) -> schematizing space
here: surface schema, container schema, gateway schema
- produces a stratified part-of hierarchy of partitions of space
- represents general knowledge about an environment as we

An **image schema** is a recurring structure within our cognitive processes which establishes patterns of understanding and reasoning.

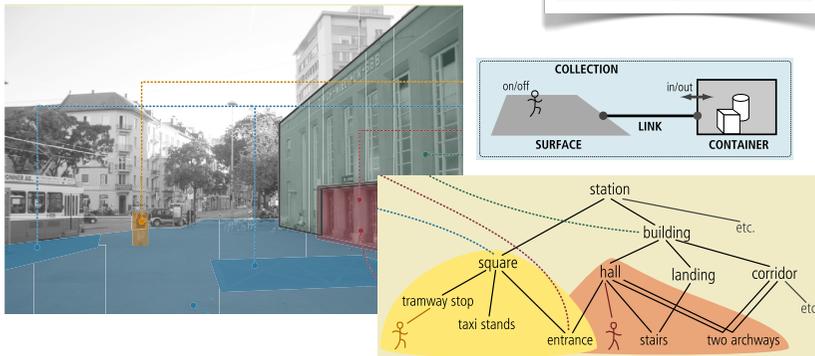
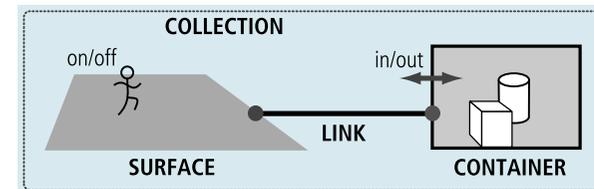


Image schemata afford actions

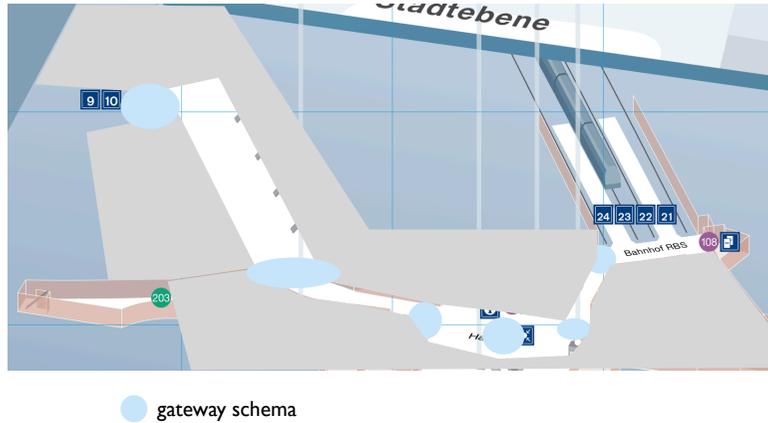
- a gateway schema affords entering/leaving a space
- a container schema affords sheltering, being inside
- a surface schema affords walking

=> this interpretation of image schemata is dependent on the size of the human body and on the activity being carried out -> environments elicit actions



Environments elicit actions

- activity: walk from platform 10 to platform 21
- requires actions to be carried out in a sequence given by partitions of space



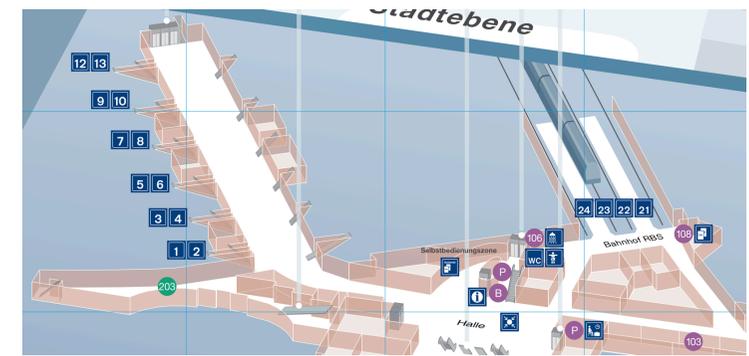
● gateway schema

Actions at different levels of granularity

Activity: go from platform 10 to platform 21

Actions: go down to pedestrian passage
walk towards connecting corridor
walk towards station hall
cross hall using the same heading
turn left into passage
walk to last platform

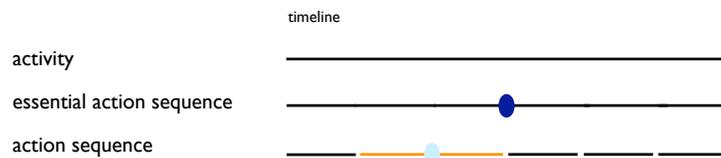
Essential Actions: walk towards station hall
turn left



Actions at different levels of granularity

each spatial partitioning corresponds to an action/activity

can be seen at different levels of granularity -> activity theory (Nardi 1996)



action here:

walk towards the place where you will have the next decision to make

Environments elicit actions

- space subdivides activity into
 - a decision being made at specific places
 - actions being carried out between places
- the segmentation of activities into actions produces a spatial partitioning
- spatial structure affords action sequence
- spatial partitioning
 - is an easy way to reduce the amount of needed information
 - is one of the schematization processes going on while perceiving the world

Research goal

- modeling human activities, e.g., navigation or outdoor recreation, and the necessary affordances of the environment
- reproduce human navigation behavior in an agent-based simulation in order to
 - learn how low-level and high-level actions fit together
 - learn about the influence of different models of space and their representations
- use the resulting model for assisting humans when they navigate (planning and executing the plan, e.g. as a mobility assistance)
- use the resulting model for prediction of human behavior in changing environments (designer's aid)
- goal 1: plug and play system (plug in new environment or new model or new algorithm and see how this changes the behavior of the agent)
- goal 2: identify a small set of basic actions that are needed for interacting with the environment

Agent simulation: change of perspective



- bottom-up
- immersed
- dynamic
- limited knowledge
- distractions
- obstacles
- other agents
- bounded rationality

Walking Behaviours: different modes

- goal directed navigation
- explorative navigation (undirected, wandering around)

- walking while avoiding stationary obstacles
- walking while avoiding dynamic obstacles
- walking in a group or in pairs (social context)
- climbing stairs, using the elevator or escalator
- crossing the street or a park
- jogging, running (following a path)

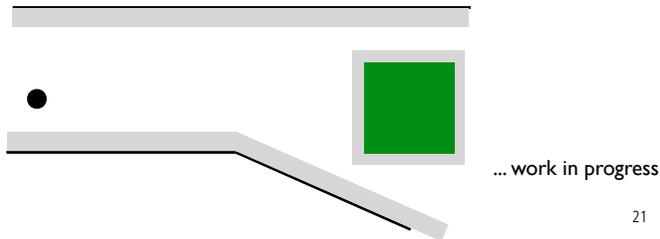
Walking around an obstacle

- humans often automatically walk around an obstacle (part of locomotion)
- the moment when the evasion process starts is difficult to determine
- there are also very different avoidance processes: sidestepping, swerving, dodging
- dependent on speed of agent



Walking around an obstacle

- partitioning according to
 - type of obstacle
 - size of obstacle (extension in several dimensions)
 - speed of agent
 - relative size of agent with respect to obstacle (comfort zone)
 - relative size of obstacle with respect to neighborhood
 - planned path relative to the obstacle
 - shape of obstacle



Movement behaviours

- how much schematization is possible?
- differentiation between agents
 - > variation on a basic behaviour or different behaviour?
 - agent in wheelchair
 - blind person using cane
- differentiation between modes of movement
 - bikes
 - cars
- groups of agents

... work in progress

Summary and conclusions

- interdependence between agent, environment and activity
- activities engender environments in the mind of the agent
- environments elicit actions to be carried out by the agent
- *goal*: identify a small set of actions needed for interaction with the environment
- an agent based perspective
 - gives us a closer look at actions and their parameters
 - provides us with a means to model the agent as well



Future work

- continue with agent-based modeling of walking behaviour; extend to other modes
- observe activities and their actions in the environment (human subject studies)
- design a suitability model for affordances (PhD student David Jonietz)



Thank you for you attention !



send comments and questions to
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