Towards an Agent-Based Proxemic Model for Pedestrian and Group Dynamic

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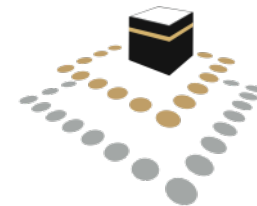
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Outline

- The Crystals project
- Few words about agent-based simulation
- A very brief introduction to proxemics
- A simple agent-based proxemic model
- Extending the model with basic group behaviour
- Towards a 3D visualization of simulated dynamics
- Future directions

CRYSTALS

Proxemic Dynamics of Crowds & Groups

The aim of the research project is to introduce agent-based modeling and simulation as an effective approach to multidisciplinary investigation of complex dynamics that characterize aggregations of pedestrians and crowds.

The main focus is on how this approach can fruitfully be adopted to investigate meaningful relationships between anthropological proxemic constraints, cultural characteristics and crowd dynamics, and how the presence of heterogeneous groups influence emergent dynamics in Hajj and Omrah.
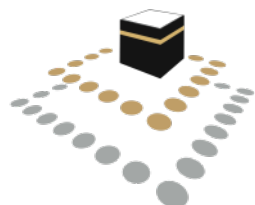
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RCAST

CRYSTALS
Proxemic Dynamics of Crowds & Groups

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experiments & calibration

proxemic distances
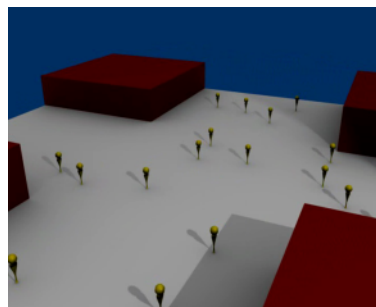
agent based simulation model
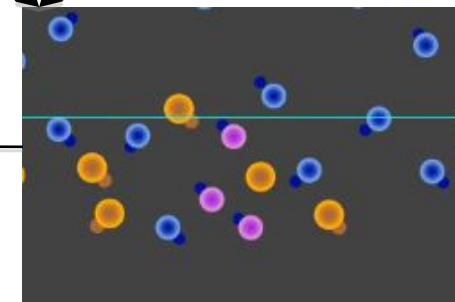
3D simulation

case study

data & expertise

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# Few words about agent-based simulation

Simulation: a definition and motivations

- (Computer) Simulation represents a way to exploit a *computational model*
  - to *evaluate designs and plans* without actually bringing them into existence in the real world
  - to *evaluate theories and models* of complex systems by envisioning the effect of the modeling choices, with the aim of gaining insight of their functioning
- The use of *"synthetic environments"* is sometimes necessary, because the simulated system cannot actually be observed
  - Because it *is actually being designed*
  - For *ethical or practical* reasons
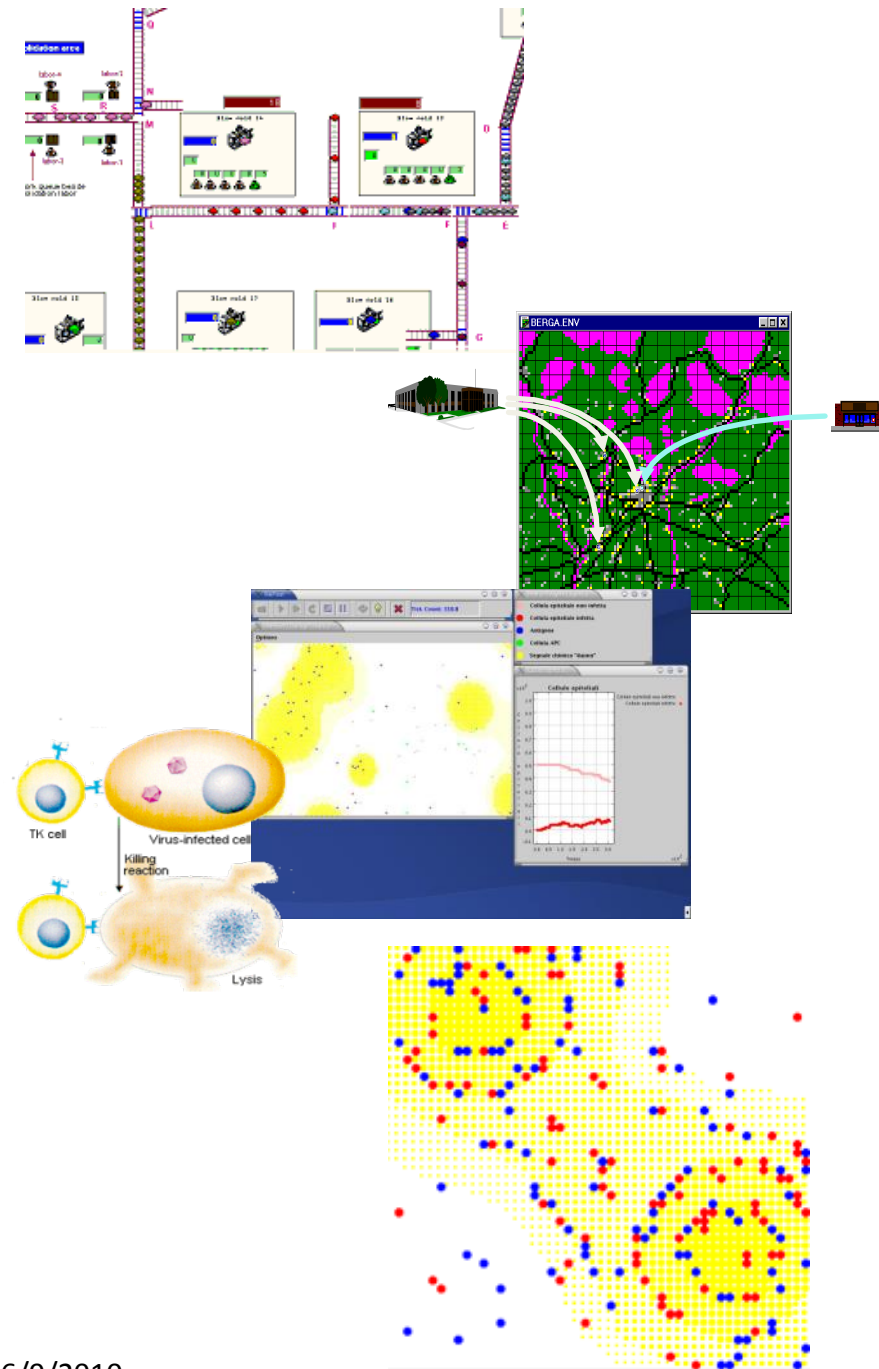
Agent Based Modeling and Simulation

- Several situations are characterized by the presence of *autonomous entities* whose actions and interactions determine (in a non-trivial way) the evolution of the system

- A *growing number* of disciplines are interested in considering and studying effects of
  - *decentralized* decision making
  - *heterogeneity* in the system
  - *local-global* interaction, *self-organization, emergence*

- *Agent based models* are particularly suited to represent these situations, and to support this kind of study and analysis
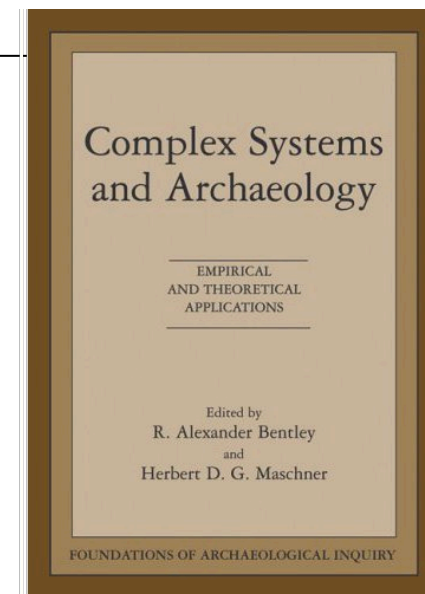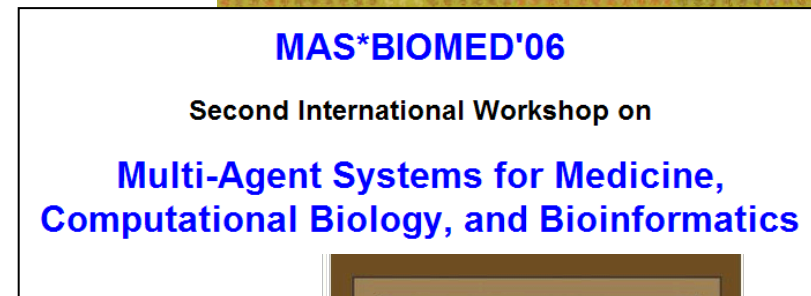
A brief introduction to proxemics

Human distances in space

Proxemics

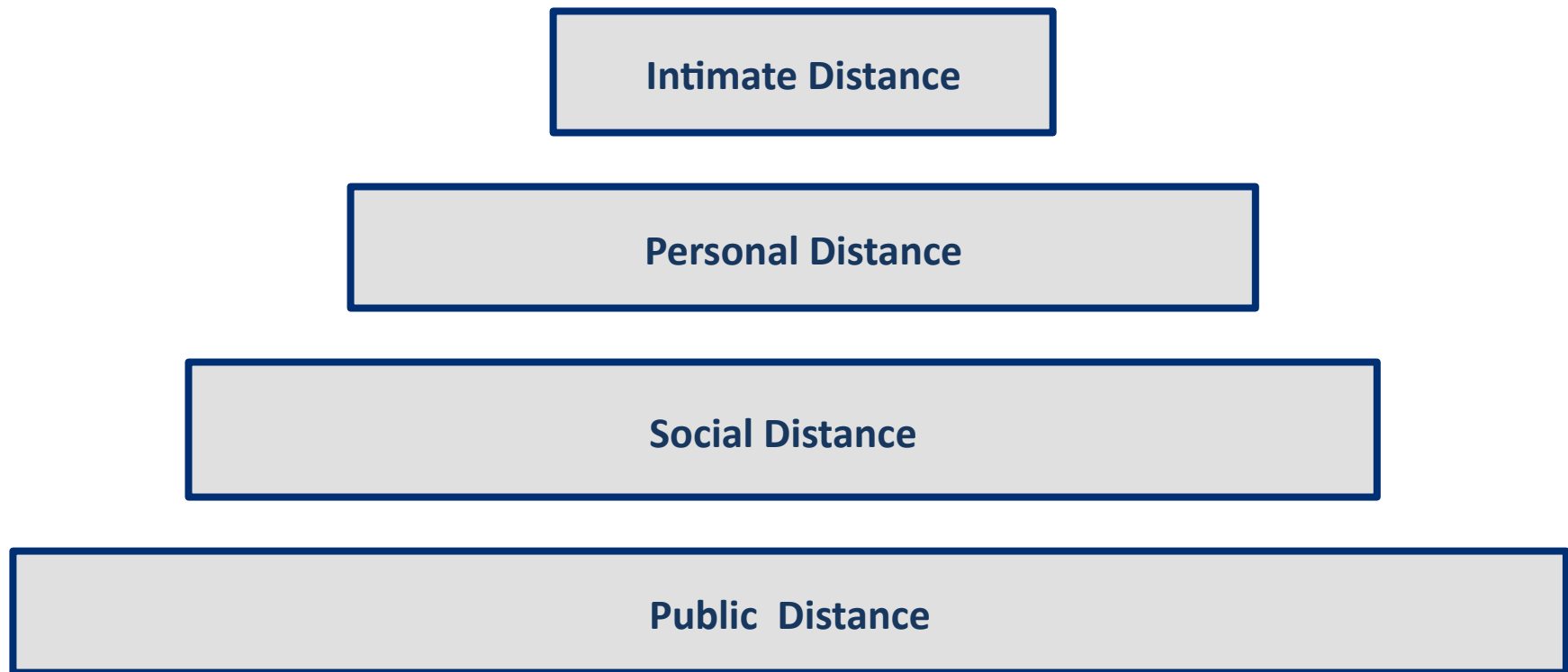"[…] the study of set measurable distances between people as they interact"
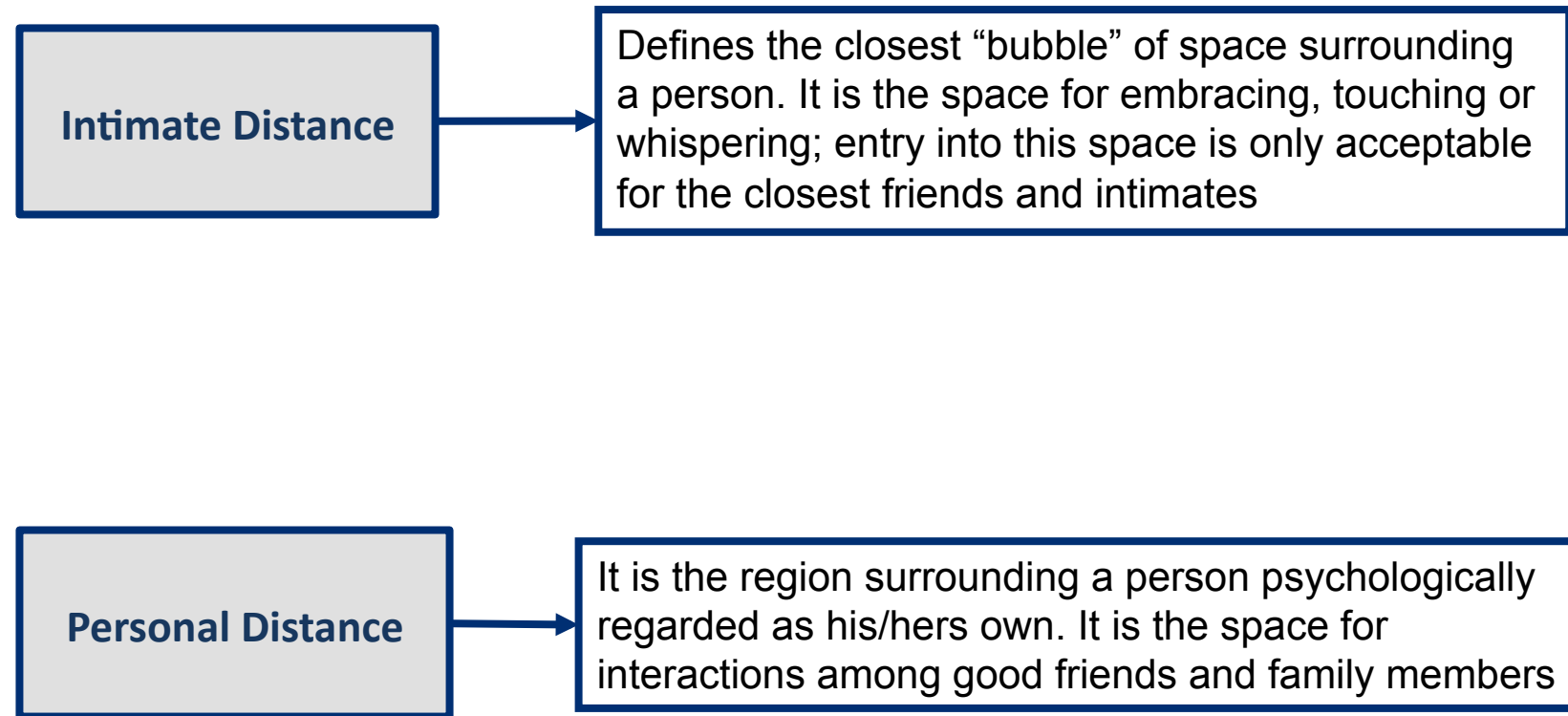
[Hall, *The Hidden Dimension*, 1966]

The theory of proxemics gets into the field of studies dealing with human spaces and their fruition
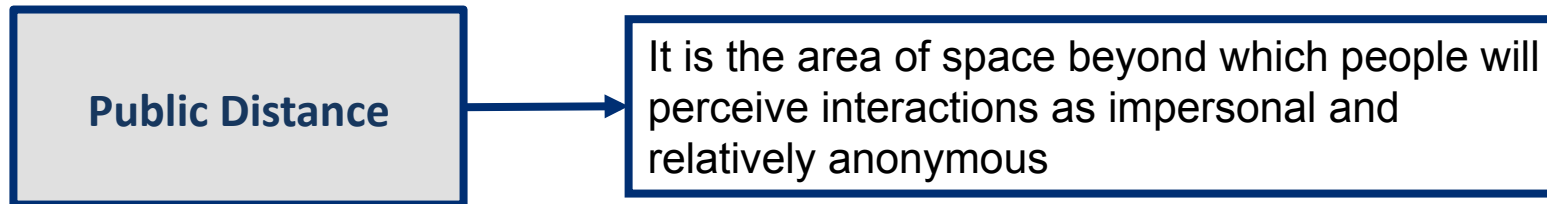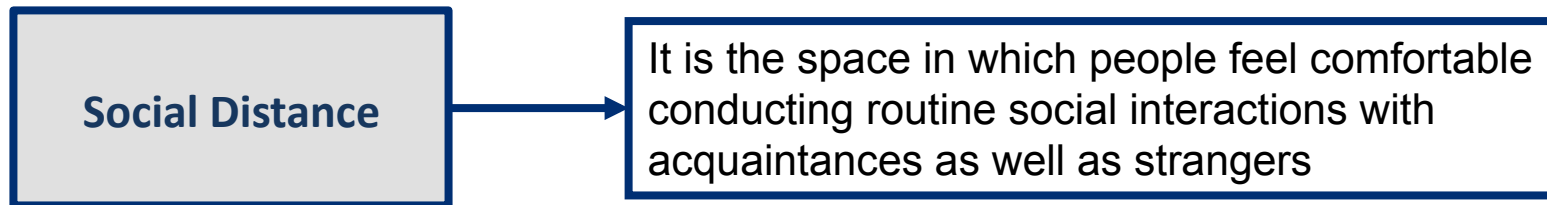
Proxemics distances (1/3)

The following distances indicate the way in which space may be divided and organized on the basis of personal reactions to the external environment

Intimate Distance

Personal Distance

Social Distance

Public Distance

Proxemics distances (2/3)

Intimate Distance → Defines the closest "bubble" of space surrounding a person. It is the space for embracing, touching or whispering; entry into this space is only acceptable for the closest friends and intimates

Personal Distance → It is the region surrounding a person psychologically regarded as his/hers own. It is the space for interactions among good friends and family members

Proxemics distances (3/3)

Social Distance → It is the space in which people feel comfortable conducting routine social interactions with acquaintances as well as strangers

Public Distance → It is the area of space beyond which people will perceive interactions as impersonal and relatively anonymous

A case study
North American Culture (1/2)

According to Hall different cultures maintain different standards of personal space; similarly the level of comfort/discomfort also depend on cultural and social parameters such as class, gender, ethnicity and personal preferences

North American Culture

Observations and interviews to people with the following characteristics:

- **Adults**
- **Strangers to one another**
- **Middle class**
- **In good health**
- **From the Northeastern cost of USA**
- **The majority of them being businessmen, scholars and intellectuals**

A case study
North American Culture (2/2)

- **Intimate distance:**
  - *Close phase* – less than 6 inches (15 cm)
  - *Far phase* – 6 to 18 inches (15 to 46 cm)
- **Personal distance:**
  - *Close phase* – 1.5 to 2.5 feet (46 to 76 cm)
  - *Far phase* – 2.5 to 4 feet (76 to 120 cm)
- **Social distance:**
  - *Close phase* – 4 to 7 feet (1.2 to 2.1 m)
  - *Far phase* – 7 to 12 feet (2.1 to 3.7 m)
- **Public distance:**
  - *Close phase* – 12 to 25 feet (3.7 to 7.6 m)
  - *Far phase* – 25 feet (7.6 m) or more

Proxemics - summary

- Notion of *personal space*, as the region surrounding a person which they regard as psychologically theirs

- Individuals belonging to different cultural groups may have *different points of view* on the amount of space that is considered necessary to be set between themselves and the others

- Most pedestrian and crowd models *implicitly* consider some of these fundamental notions
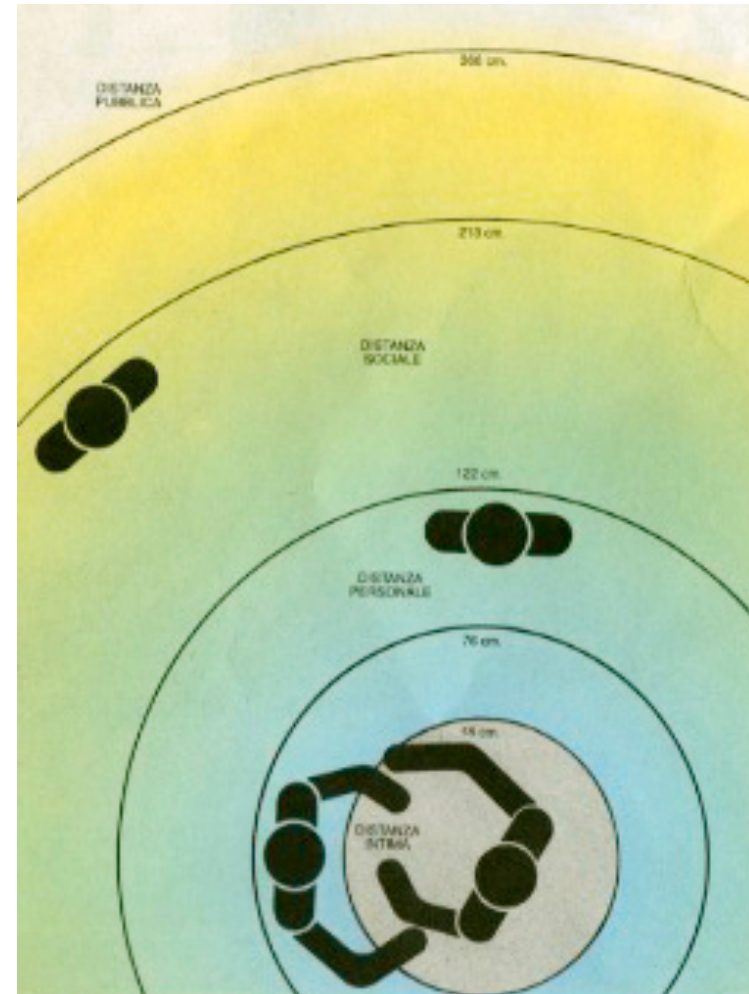
# FEAR OF BEING TOUCHED *(E. Canetti)*

- "There is nothing man fears more than the touch of the unknown. He wants to see what is reaching towards him, and to be able to recognize or at least classify it."

- "All the distance which men place around themselves are dictated by this fear."

# A simple agent-based proxemic model

The pedestrian environment

- Simple euclidean 2D space
- Discrete (coordinates are integers) but not "discretized" (as in a CA)
- Boundaries can be defined
  - e.g. in the example Eastern and Western borders cannot be crossed
- More complex environments can be modeled
  - by means of a list of relevant objects in the scene
  - objects can be perceived and agents can be attracted or repulsed by them, or they can even ignore them

x axis

y axis
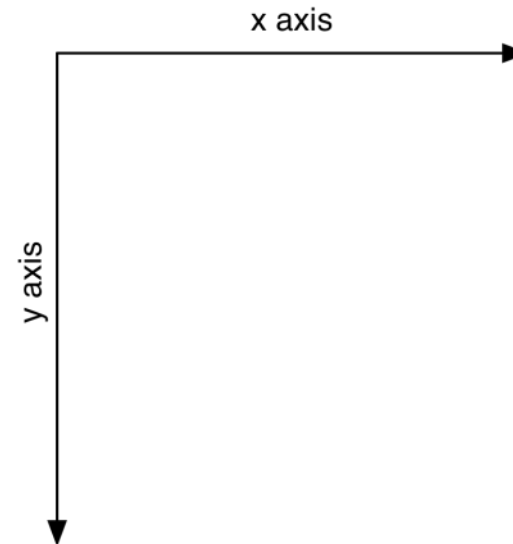
Pedestrians as agents

- Pedestrians can be modeled as agents situated in an environment, characterized by a *state* representing individual properties
- Their behaviour has a goal driven component, a *preferred direction*
- It generally changes in time, generating a path of movement from a starting point to the destination
- The preferred direction is thus the result of a stochastic function possibly dependant on
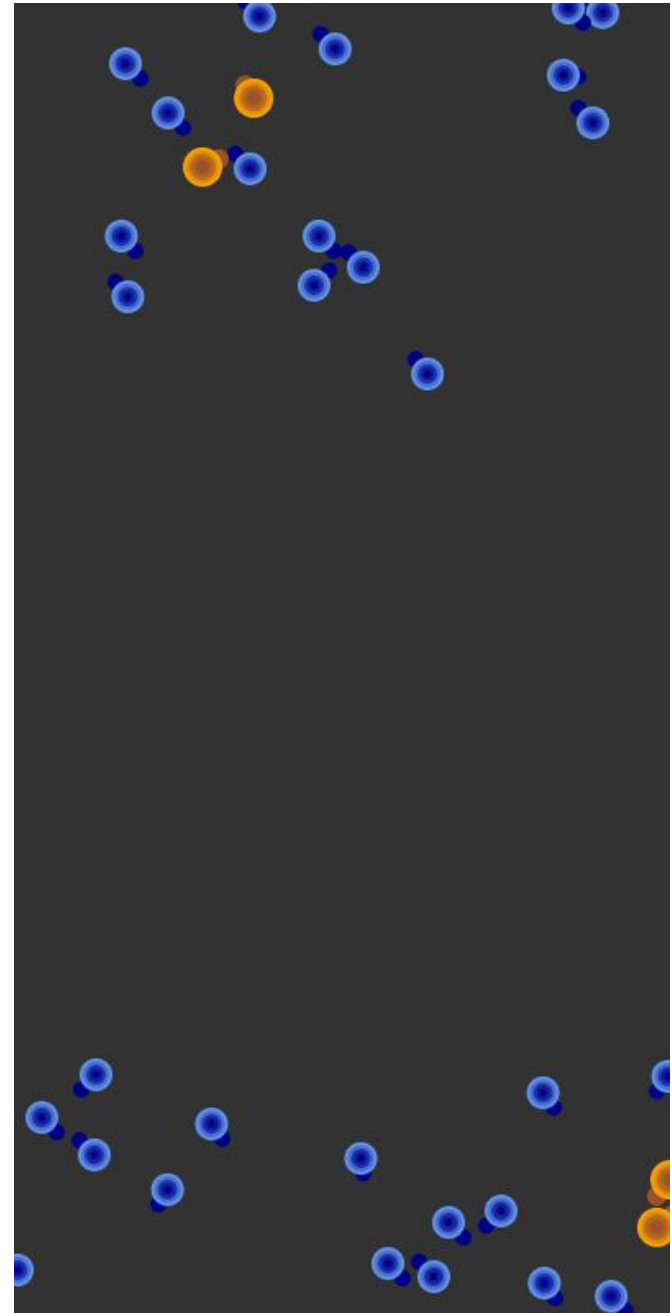 - time
  - position
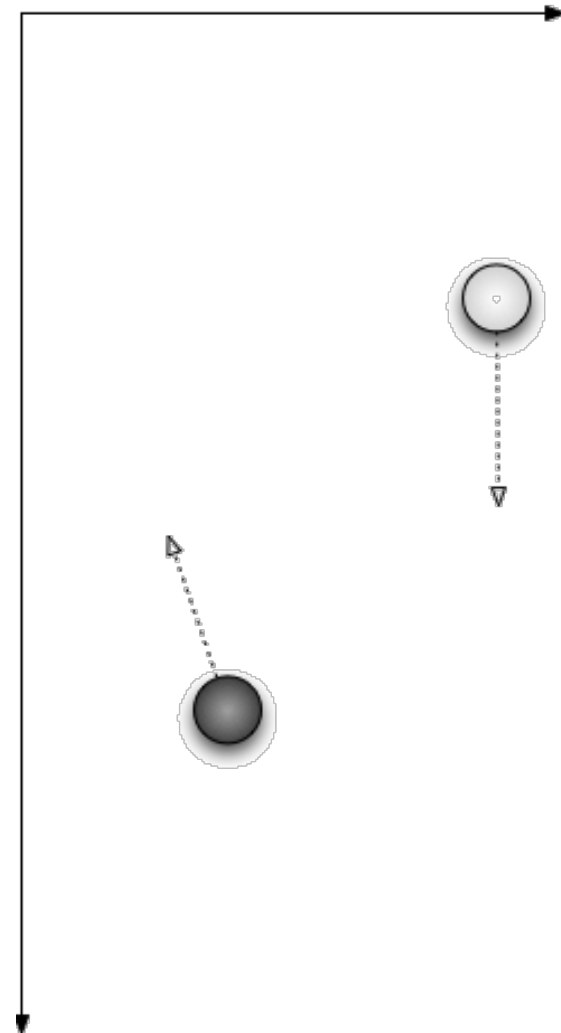
Basic proxemical rules

- Every pedestrian is characterized by a culturally defined proxemic distance p

- Rule P1: the pedestrian moves keeping the minimum distance from the others above p

- Rule P2: whenever the minimum distance between one pedestrian and another drops below p it will try to restore this condition (*fear to be touched*)

p

"fear to be touched"
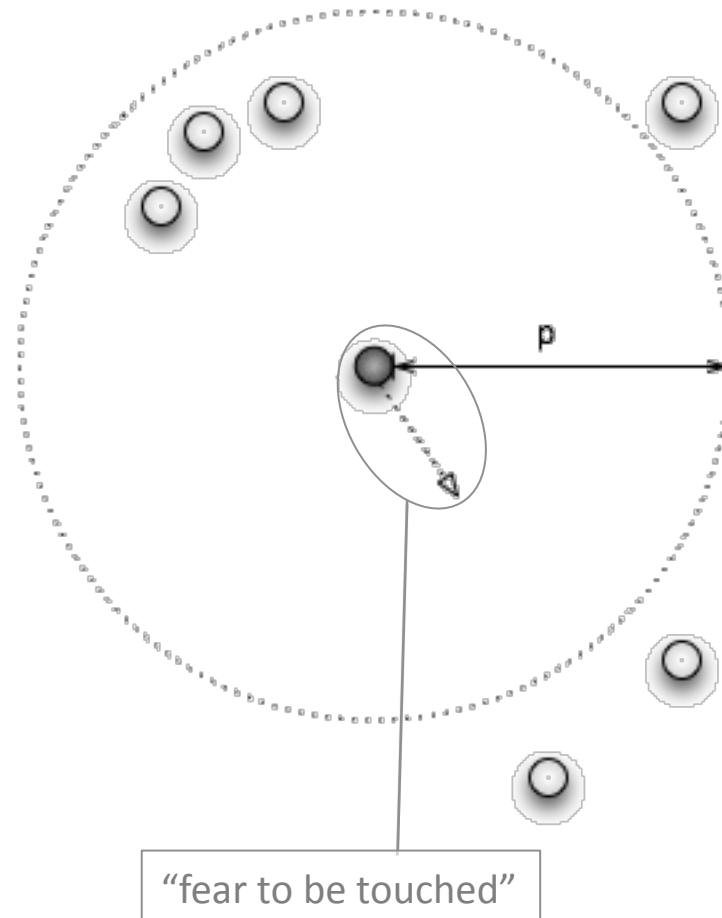
Sample Agent Based Proxemic Dynamics

- These basic rules support the definition and realization of a simple agent based proxemical model
- In this scenario we have
  - 17 peds heading North (blue agents)
  - 17 peds heading South (blue agents)
- Agents for which rule P2 is activated (they are afraid to be touched) turn to orange, to highlight the invasion of their proxemical distance/ personal space

Extending the model with basic group behaviour

CROWD CRYSTALS

CROWD

CROWD CRYSTALS:
small and rigid groups of men,
strictly delimited and of great constancy,
which serve to precipitate crowds.
- unity
- constant
- clarity, isolation, constancy

crowds precipitations: their roles must
be familiar, as with uniforms

unity – constancy – clarity – isolation

small and rigid groups of individuals

Additional proxemical rules - groups

- Every pedestrian may be part of a group
- Every pedestrian is characterized by a culturally defined proxemic distance g
- Rule G1: the pedestrian moves keeping the maximum distance from the other members of the group below g
- Rule G2: whenever the maximum distance between one pedestrian and other members of his group exceeds g it will try to restore this condition (*fear of isolation*)


"fear of isolation"
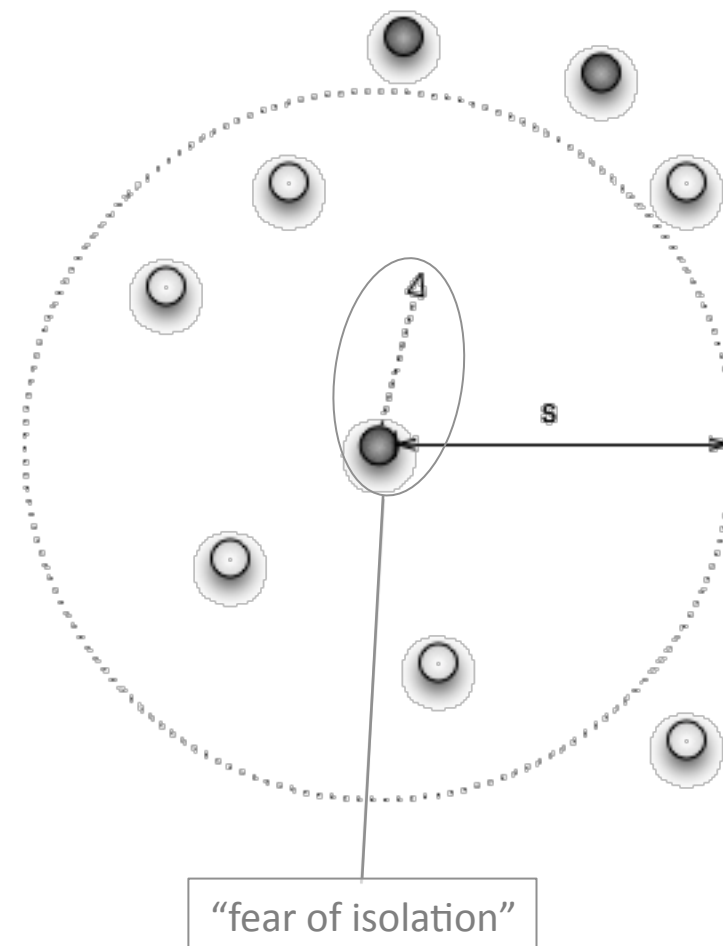
Sample Agent Based Group Proxemic Dynamics (1)

- We can analyze how crowd crystals interact with other pedestrians
- In this scenario we have
  - 12 peds heading North (blue agents)
  - 10 peds heading South (blue agents)
  - a crowd crystal of 4 peds heading south (pink agents)
- The group manages to remain united under these conditions
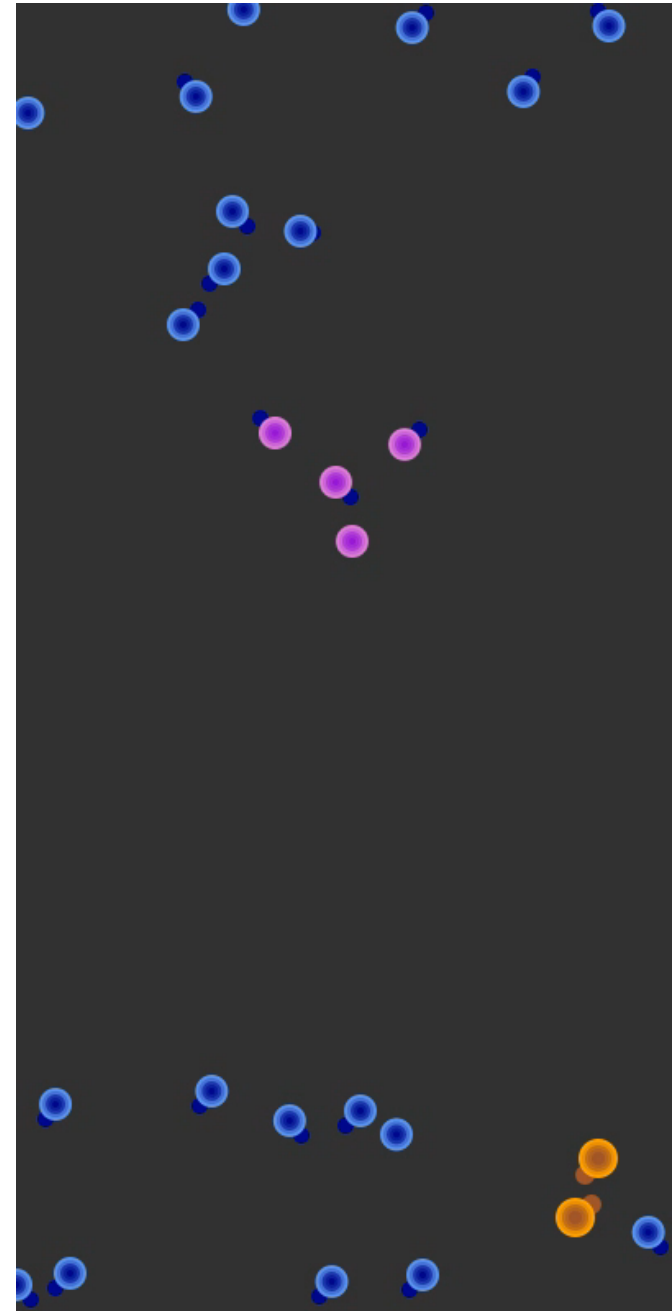
Sample Agent Based Group Proxemic Dynamics (2)

- In this scenario we have
  - 12 peds heading North (blue agents)
  - 10 peds heading South (blue agents)
  - a crowd crystal of 5 peds heading south (pink agents)
- The group manages to remain united under these conditions...
- ... but in some occasions a group splits into subgroups
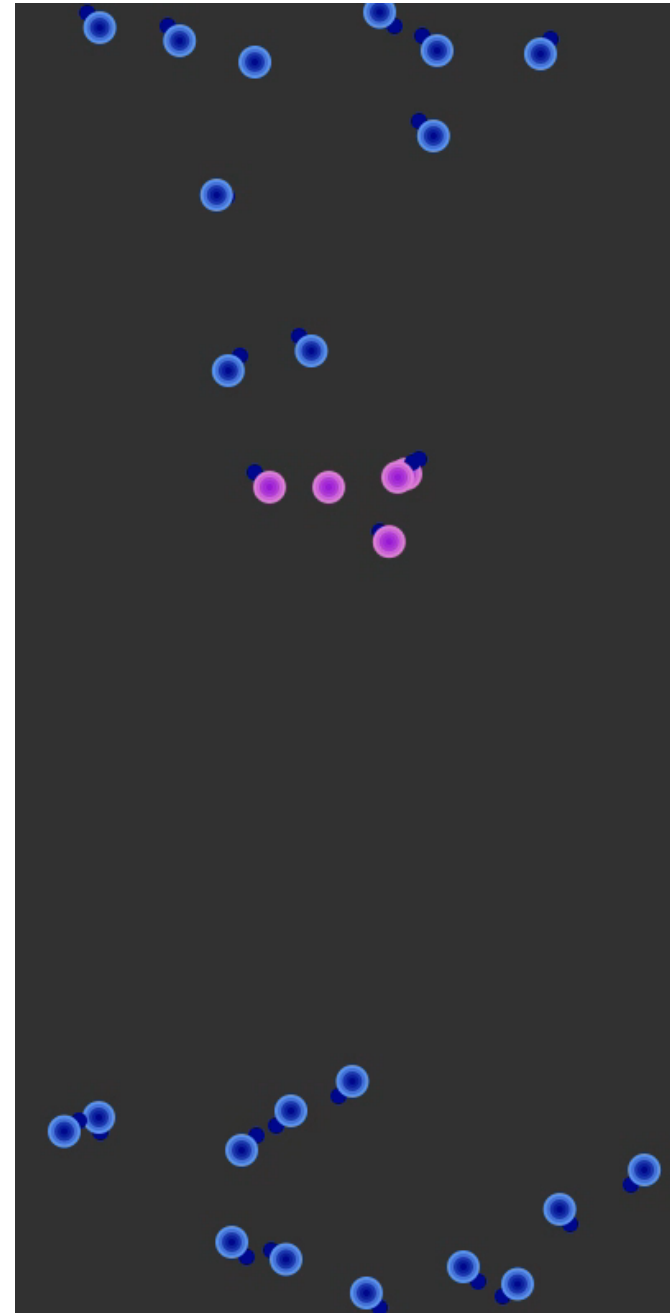
Facing groups

- We can also analyze how crowd crystals interact with other ones
- In this scenario we have
  - 10 peds heading North (blue agents)
  - 10 peds heading South (blue agents)
  - a crowd crystal of 4 peds heading south (pink agents)
  - a crowd crystal of 4 peds heading north (purple agents)
- The group manages to remain united under these conditions...
- ... but in some occasions a group splits into subgroups
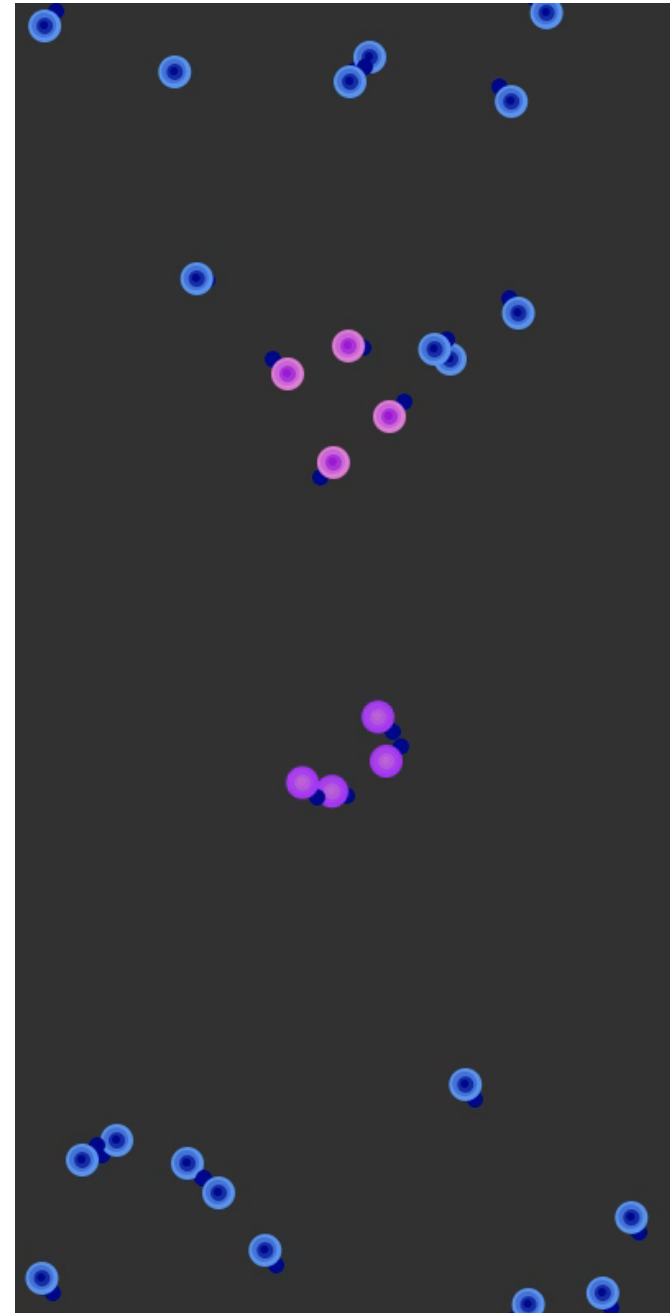
Some experimental results

- Tests were conducted with a variable number of pedestrians to evaluate the plausibility of different proxemic distances
  - Environment: 10 m x 5 m corridor
  - Number of agents: variable from 40 to 150
  - Dynamics: movement velocity 1.5 m/s, 0.1 s time step
- High personal distance (1 m – average personal distance, far phase) leads to good results in low density scenarios
- Low personal distance (75 cm – low end personal distance, far phase) leads to better results in high density scenarios
- … hint of the possible applicability of a more complex and adaptive agent architecture?

Fundamental diagram - velocity

Low personal distance   High personal distance

Fundamental diagram - flow

Low personal distance   High personal distance
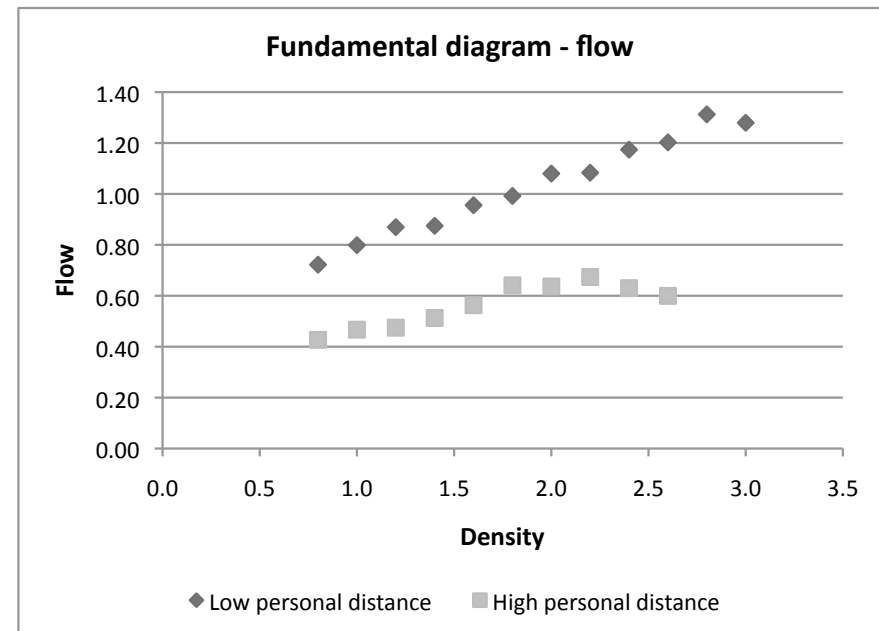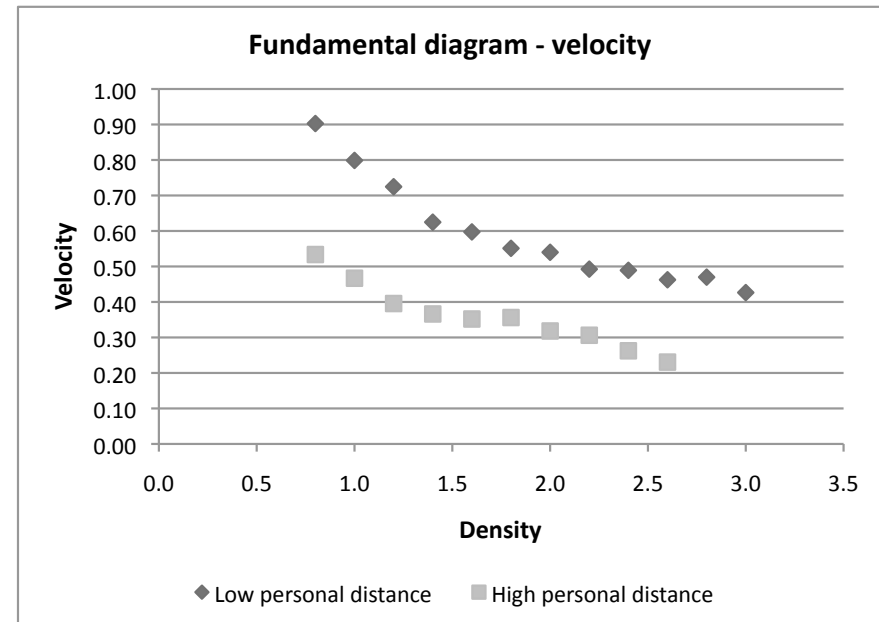
The Simulator Prototype

- Adopts NodeBox as a tool for rapid prototyping
  - Python based library
  - provided with simple tools for UI creation
- Very simple system
  - a main program to setup the simulation, define the simulation cycle and manage visualization
  - a program for the behavioural specification of pedestrians (either individuals or group members)
  - The model we aim to realize is much more sophisticated, precise and cleaner than this
- Various alternative platforms are available for rapid development of MAS simulation
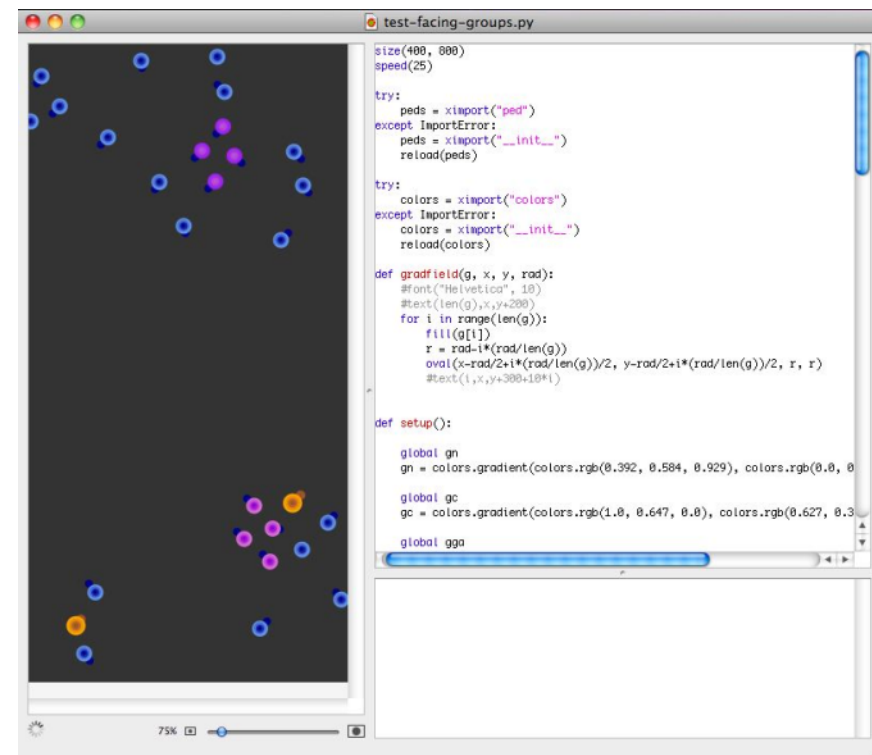
Endowing Blender with an agent-based simulator

- Blender is a 3D graphics application that can be used for a wide range of aplications, from animation and rendering to simulation

- Supports the importing of a large set of formats used in the CAD / 3D modeling context

- Extensible by means of scripts written in Python language

- Produces high quality renderings of simulated dynamics
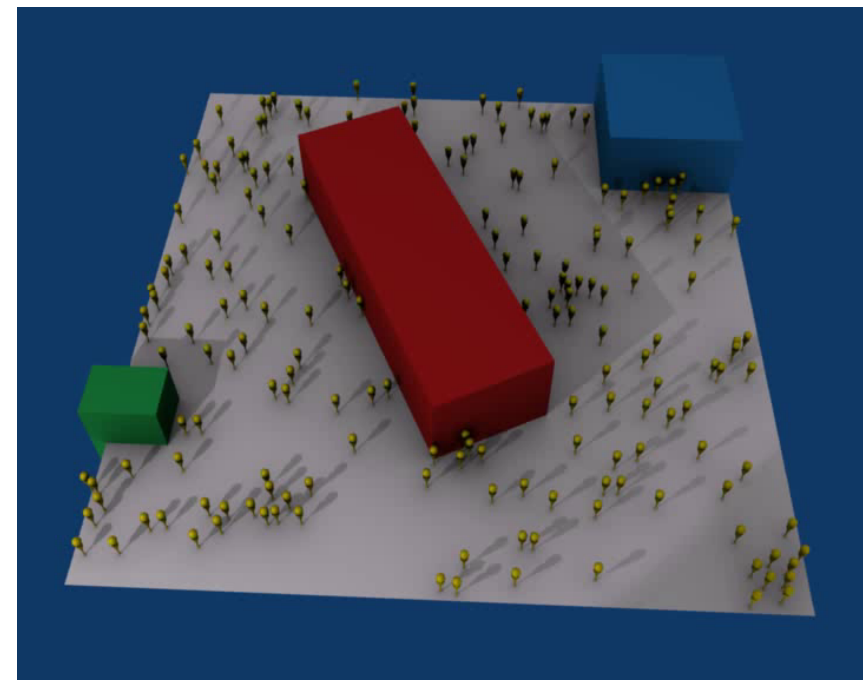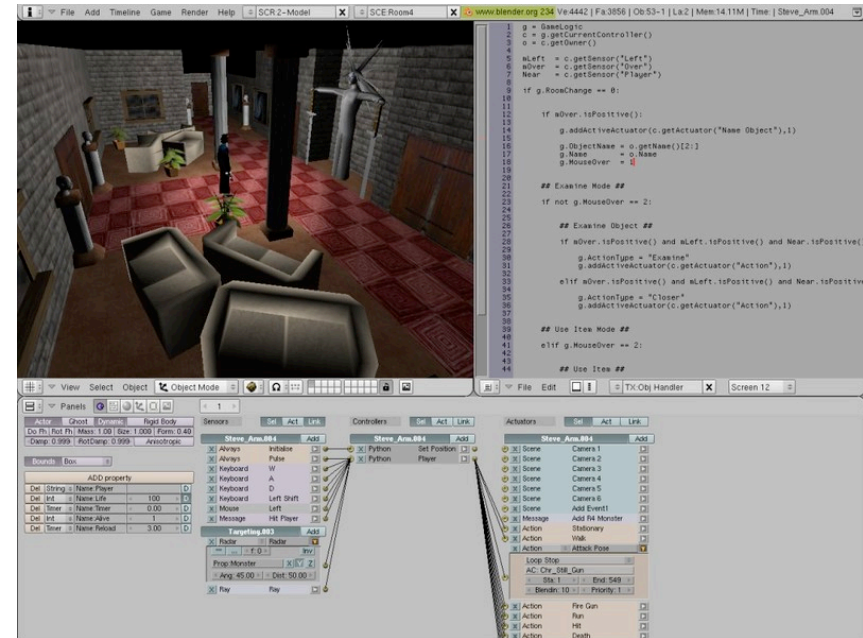
Towards a general model for proxemic group dynamics

- We think that groups can have a deep influence on system dynamics and that studying the effect of the presence of groups is an *innovative and challenging research topic*

- Several ongoing works and open issues
  - *Contribution of anthropology* to the identification of groups and to the definition of a model of groups
  - Internal *structure of groups, leadership* and its effects
  - *Hierarchy* of groups, *relationships and influences* between groups, mutual *influence among leaders*
  - ...

Thank you!

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