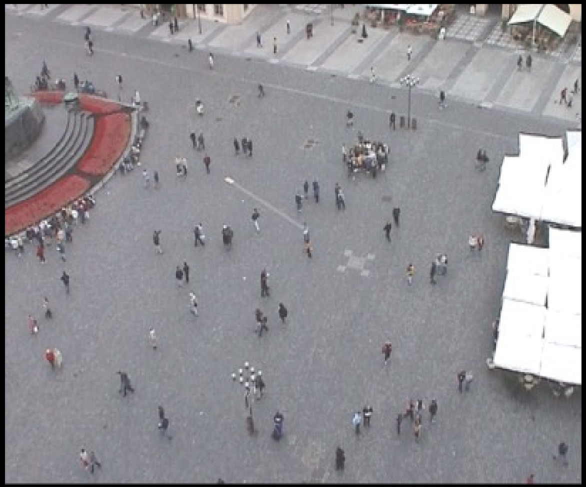
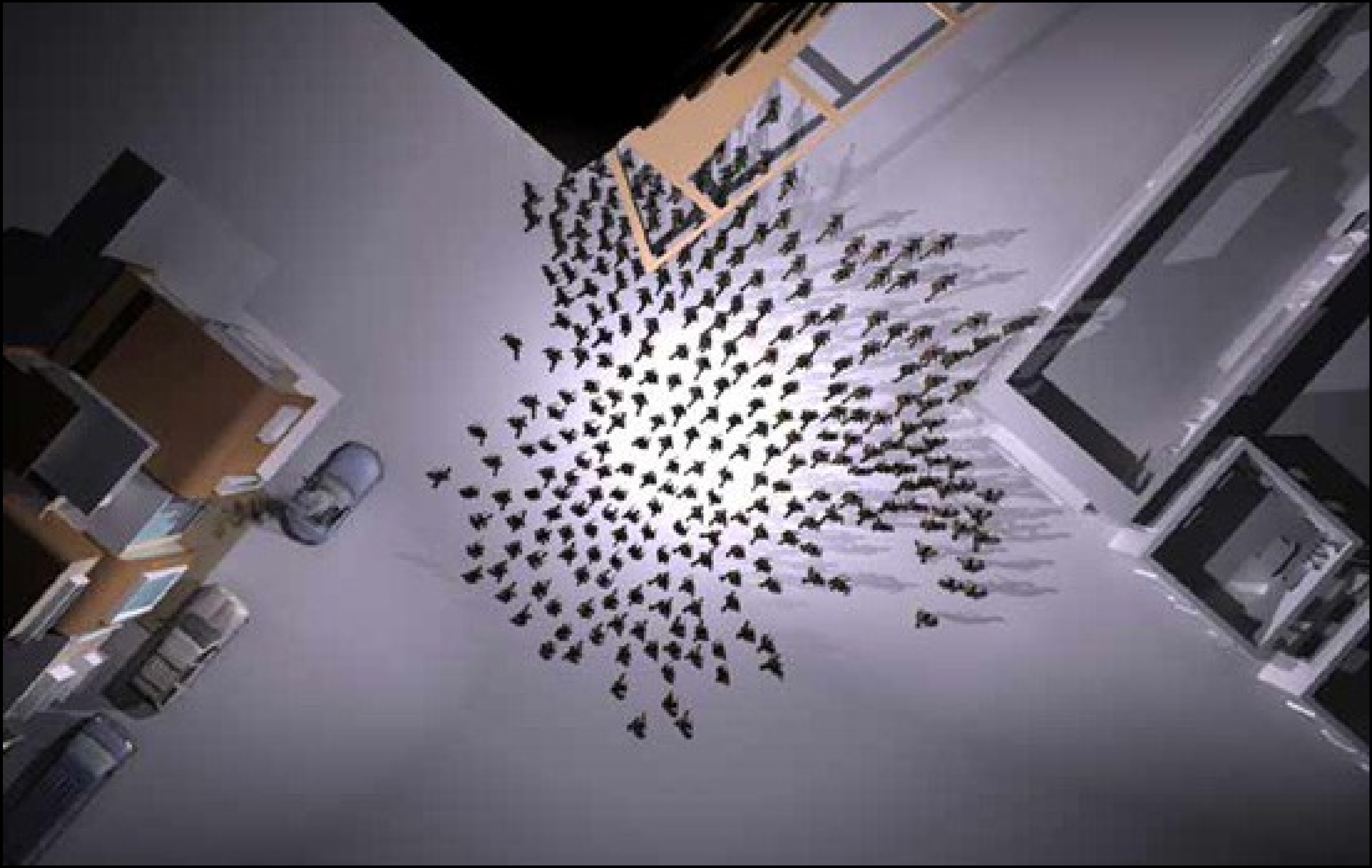
Crowd simulation



Roman Berka
DCGI

pruned.blogspot.com



pruned.blogspot.com

pruned.blogspot.com


ARMA

Motivation

- **Simulation of large group of characters with respect to their individuality**
- Movie industry (Lord of Rings, Avatar, history and wars themes,...)
- Emergency simulations in buildings
- Games
- Military applications

Talk Overview

- Problem specification
- Crowd representation
- Simulation control levels
- Examples

Problem Specification

- Large set of relatively standalone units communicating together
- Control mechanism:
- Representing emotions
- Ability of making decisions
- Computational cost
- Response to the environment changes

Crowd Representation

- Rule based (behavioral) models [Reynolds 87]
- Particle systems [Brogan 97]
- **Social forces model [Helbing 00]]**
- Cellular automata [Kirchner 03]
- Multi-agent models [Pelechano 05]: *Massive*
- Continuum dynamics [Treuille 06]

- Cell and portal graphs
- Potential fields
- Roadmaps

Levels of Control

- Division to two levels of control [Pelechano05]
- Low level
  Motion, Perception
- High level
  Decision making, Communication, Navigation

Low Level Control

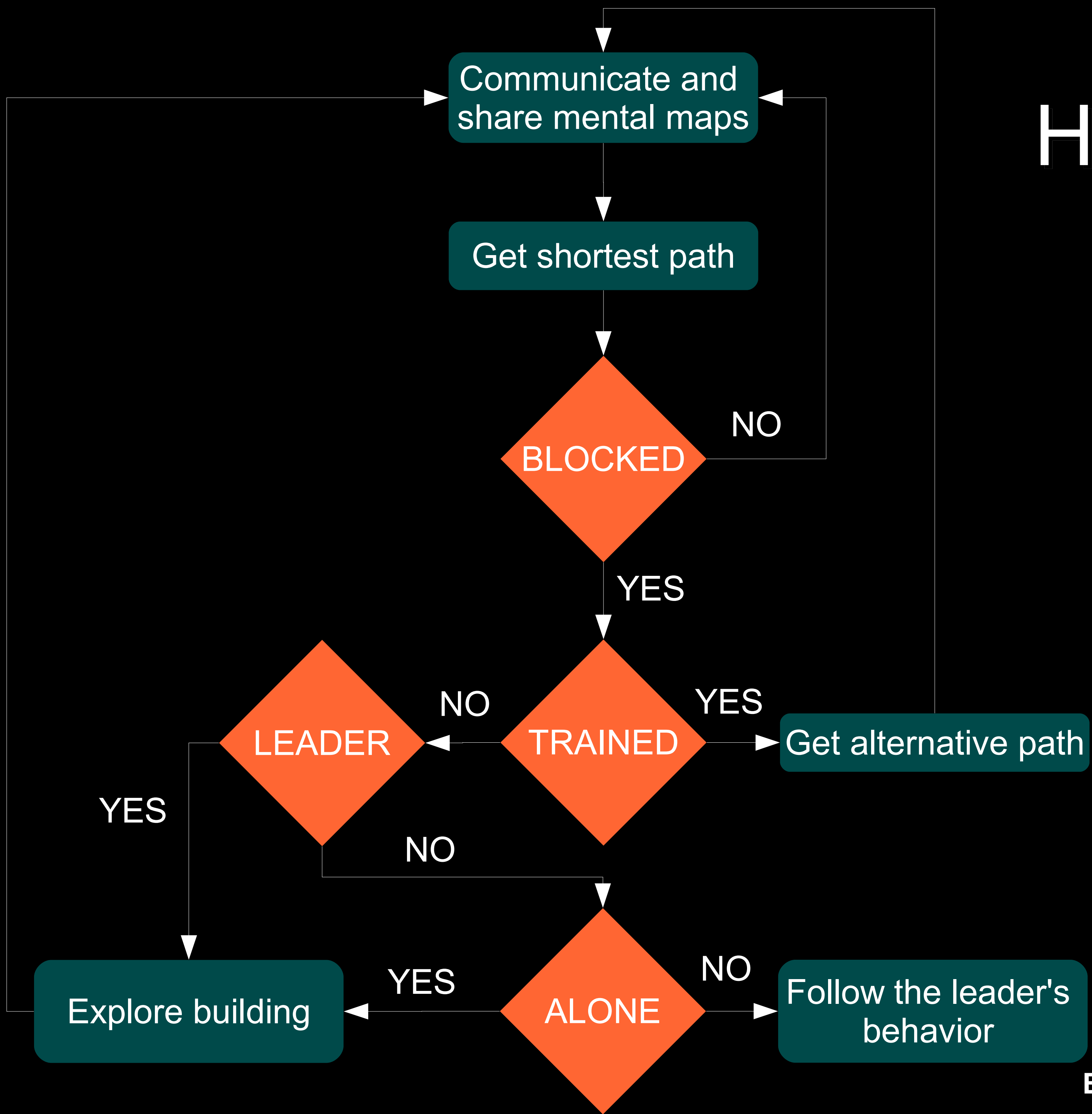
- Social forces model [Helbing 00]

$$m_i \frac{d\boldsymbol{v}_i}{dt} = m_i \frac{v_i^0(t)\boldsymbol{e}_i^{\boldsymbol{0}}(t) - \boldsymbol{v}_i(t)}{\tau_i} + \sum_{j(j \neq i)} f_{ij} + \sum_W f_{iW}$$

Pedestrian with mass m_i and velocity v_i° with direction e_i° tends to have velocity v_i in time interval τ_i with respect to collision forces with other pedestrians and walls.

Examples: http://angel.elte.hu/~panic/

High Level Control



Based on [Pelechano05]

High Level Control

expansion of psychological representation

Long-term memory

- Doctrine ruleset
- Goal Hierarchy
- Standards hierarchy
- Preference hierarchy
- Agent Memory
- Stress thresholds
- Decay parameters

Memory
Relationships
Physical properties

Module scheduler

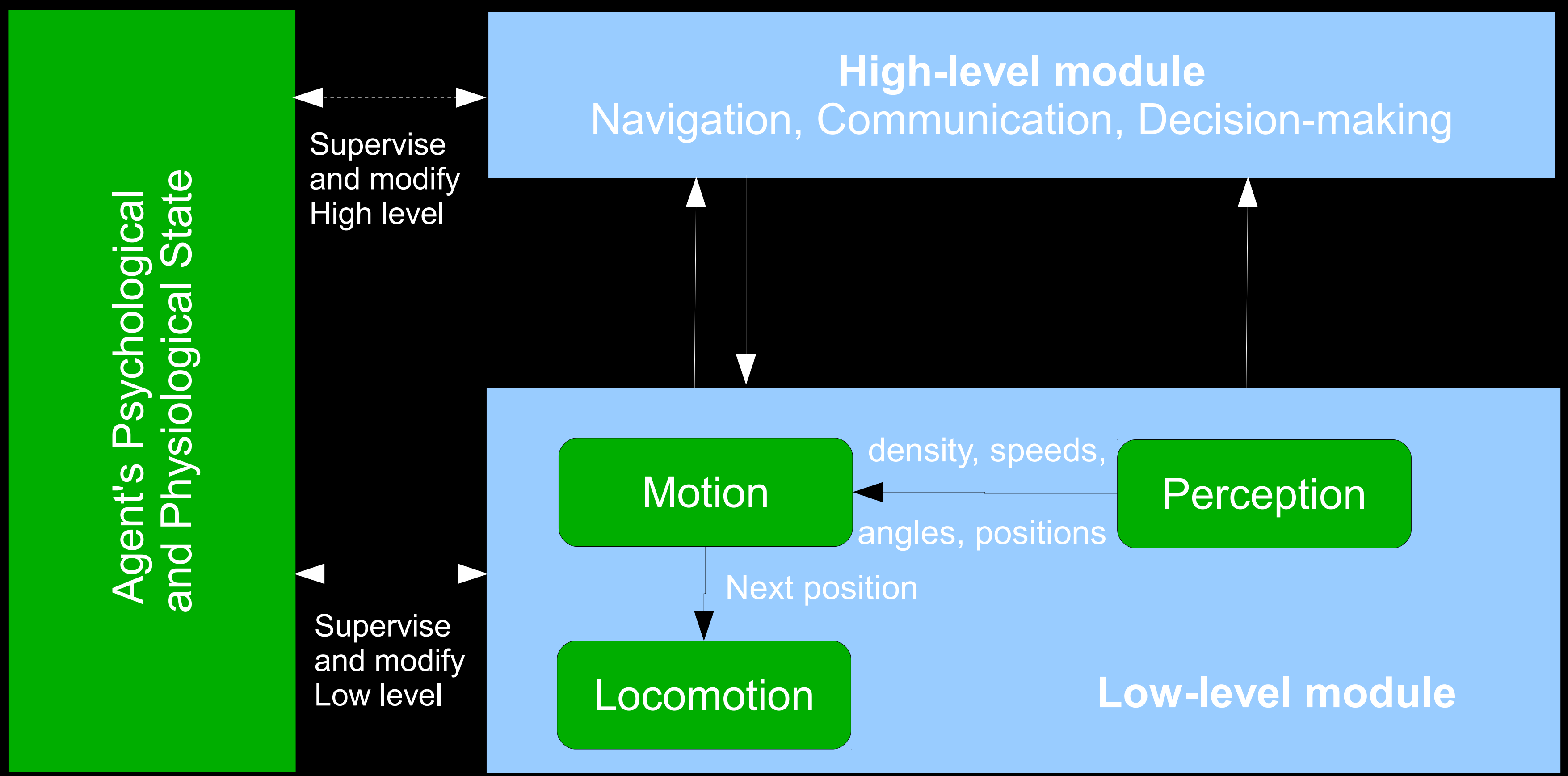
- Decision
- Emotion
- Perception
- Stress

Working memory

- Choosen action
- Calculated Utilities
- Calculated emotions
- Perceived object list
- Need reservoir values
- Copying style
- Stress reservoir
- Physiology reservoir

Based on [Pelechano05] - PMFserv

Another High Level Control Scheme



Based on Pechano07

Low Level Control

The movement of agents expressed by forces

$$F_i^{To}[n] = F_i^{To}[n-1] + F_i^{At}[n]\, w_i^{At} + \sum_w F_i^{Wa} + \sum_k F_{ki}^{Ob}[n]\, w_i^{Ob} + \sum_{j(j \neq i)} F_{ji}^{Ot}[n]\, w_i^{Ot}$$

New position is computed as

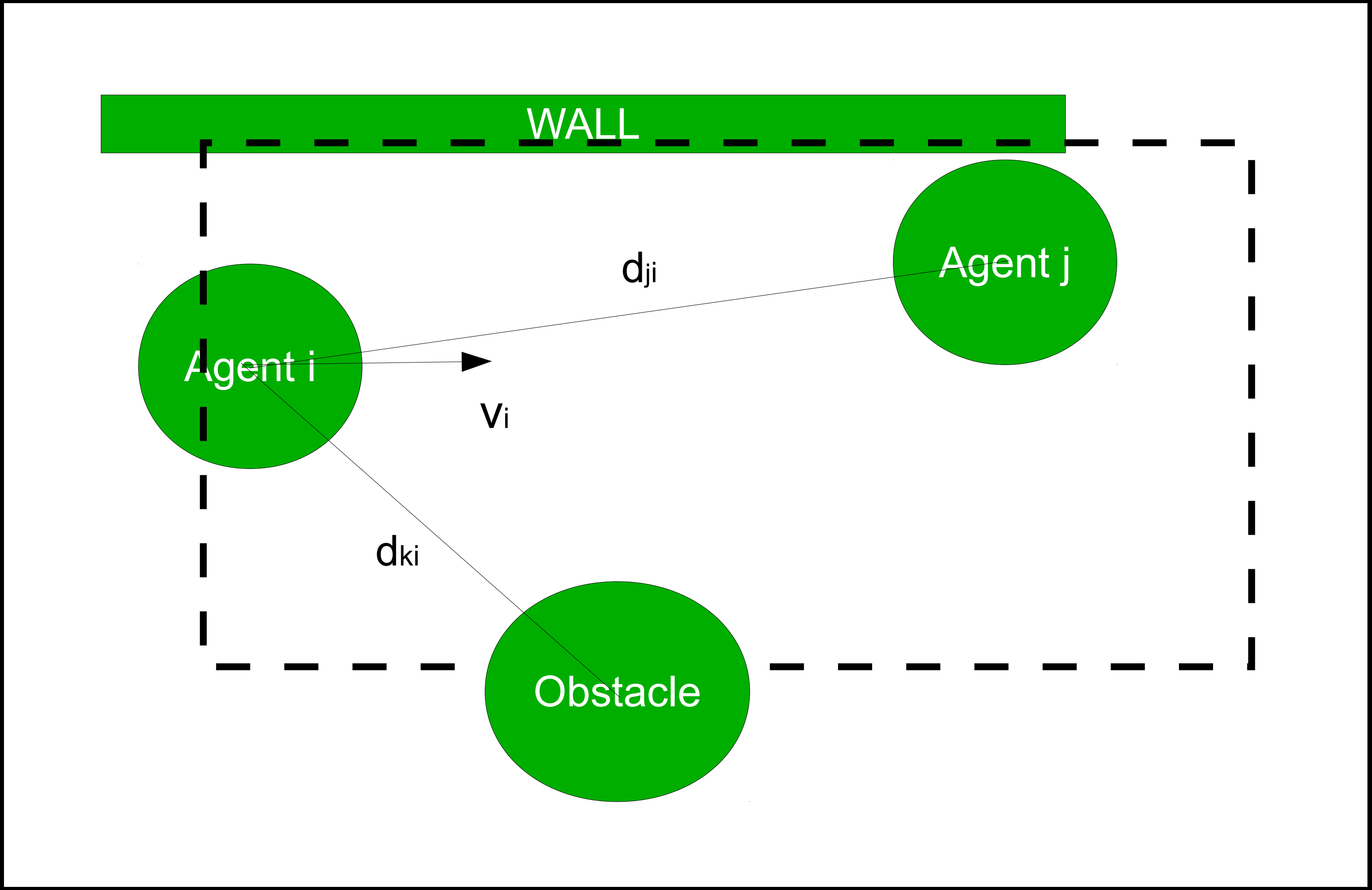
$$p_i[n+1] = p_i[n] + \alpha_i[n]\, v_i[n]\Big(\big(1-\beta_i[n]\big)\, f_i^{To}[n] + \beta_i[n]\, F^{Fa}[n]\Big)T + r_i[n]$$

$$f_i^{To} = \frac{F_i^{To}}{|F_i^{To}|}$$

$$F_i^{Ob} = \frac{(d_{ki} \times v_i) \times d_{ki}}{|(d_{ki} \times v_i) \times d_{ki}|}$$

$$\alpha_i = 0, if\ |r_i| > 0 \vee StoppingRule \vee WaitingRule,\ 1\ othervice$$

Low level Control



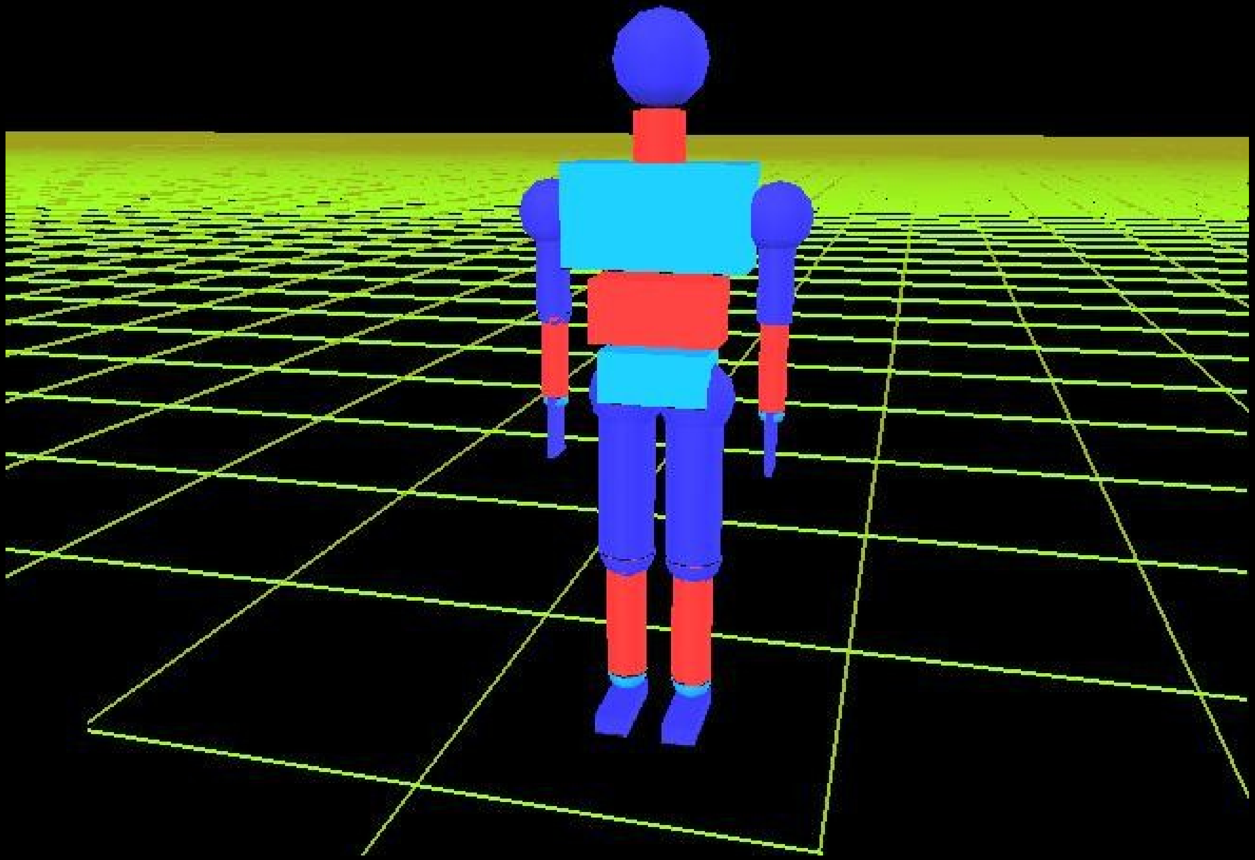
Avoidance forces

Local Motion - Solved Problems

- Avoidance Forces (previous slide)
- Agent avoidance
- Repulsion forces
- “Shaking problem” solution
- Organized behavior
- Pushing behavior
- Falling and becoming obstacle
- Panic propagation
- Avoiding bottlenecks and dynamic changes in the environment

Animation and Visualization

- CA methods, e.g. [Ahn06]



Applications & Projects

- Emergency simulations (HERMES project)
- Games
- Movie industry (Lord of Rings)
- Army training tools

References

- KIRCHNER, A., NAMAZI, A., NISHINARI, K. and SCHADSCHNEIDER, A., Role of Conflicts in the Floor Field Cellular Automaton Model for Pedestrian Dynamics. in 2nd International Conference on Pedestrians and Evacuation Dynamics, (2003), 51-62.
- REYNOLDS, C., Flocks, herds, and schools: A distributed behavior model. in Proceedings of ACM SIGGRAPH, (1987), 25-34.
- HELBING, D., FARKAS, I. and VICSEK, T. Simulating dynamical features of escape panic. Nature, 407, 2000. 487-490.
- BROGAN, D. and HODGINS, J. Group Behaviors for Systems with Significant Dynamics. Autonomous Robots, 4, 1997. 137-153.
- PELECHANO, N., O'BRIEN, K., SILVERMAN, B. and BADLER, N., Crowd Simulation Incorporating Agent Psychological Models, Roles and Communication. in First International Workshop on Crowd Simulation. (VCROWDS '05), (2005).
- TREUILLE, A., COOPER, S. and POPIVIC, Z., Continuum Crowds. in ACM Transactions on Graphics (SIGGRAPH 2006), (2006), 1160-1168.
- J. Ahn, S. Oh, and K. Wohn. Optimized motion simplification for crowd animation: Research articles. Comput. Animat. Virtual Worlds, 17(3-4):155–165, 2006.
- MASSIVE_SOFTWARE_INC. 3D animation system for crowd-related visual effects, http://www.massivesoftware.com, 2005.