Reaction-Diffusion based Autonomous Control of Camera Sensor Networks

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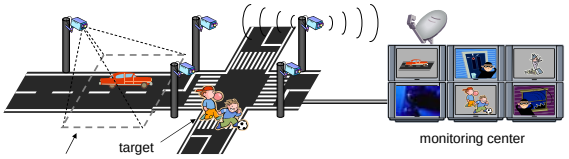
Camera Sensor Network

- Composed of nodes equipped with cameras
- Application examples:
  - Remote surveillance
  - Home security
  - Tracking (urban monitoring, wildlife monitoring)



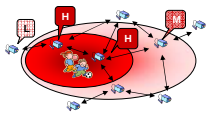
urban monitoring system

Problem and Solution

Problem
- Delay and packet loss due to congestion
  - High volume traffic of video data
  - Limited network capacity

Solution
- Adjust the video coding rate, considering the network capacity and the importance of the video data

Spatial pattern of coding rate



Requirements
- Large number of nodes
- Random or unplanned deployment
- Dynamic topology changes

- Scalable, adaptive, robust

➡ Self-organizing mechanism

Problem and Solution

Problem
- Delay and packet loss due to congestion

To accomplish these goals, we propose an autonomous mechanism based on a reaction-diffusion model to control the coding rate.

A mathematical model for autonomous pattern generation

- Scalable, adaptive, robust

➡ Self-organizing mechanism

Reaction-Diffusion Model

- Mathematical model of pattern generation on the surface of body of fishes and mammals
- Patterns emerge through local interactions among neighboring cells

Reaction-diffusion equation

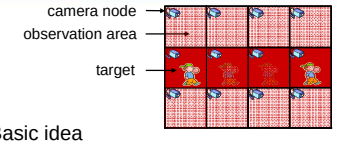
$$\frac{\partial u}{\partial t} = F(u,v) + D_u \nabla^2 u + E$$
$$\frac{\partial v}{\partial t} = G(u,v) + D_v \nabla^2 v$$

Stimulus

zebra leopard emperor angelfish

u : activator concentration
v : inhibitor concentration
Du, Dv : diffusion rates

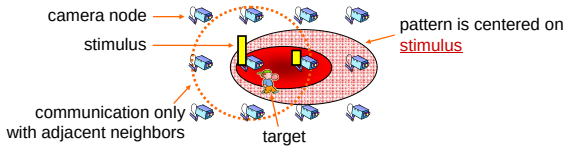
Characteristics of Mechanism



darker squares correspond to higher video coding rate

- Basic idea
  - Generate a spot pattern with its center on the target
  - Adjust the video coding rate based on this pattern
- Additional features
  - Spread a pattern towards the predicted path of the target
    ➔ prepare neighboring cameras for future detection
  - Shrink a pattern for closely located targets
    ➔ keep low total coding rate to preserve wireless capacity

Rate Control Mechanism

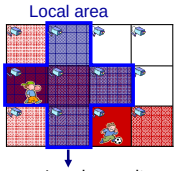


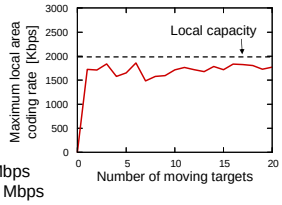
The node behavior at regular control intervals

1. Determine stimulus from target location
2. Adjust stimulus based on received messages
3. Calculate the reaction-diffusion equations
4. Change the video coding rate
5. Broadcast a status message

Simulation Results

- Local area coding rate against the number of randomly moving targets





e.g. Local capacity : 2 Mbps
Local area coding rate : 1.8 Mbps

Local area coding rate is kept constant and below the local capacity of the network

Conclusion/Outlook on Poster Session

- Conclusion
  - We proposed a reaction-diffusion based autonomous control mechanism of the video coding rates in camera sensor networks
- Poster session
  - More detailed explanation of proposed mechanism
    - Propagation of the stimulus attenuation
    - Adjustment of the stimulus inhibition from neighbors
  - Further results from simulation
    - System behavior with one stationary target
    - System behavior with two stationary targets
    - Comparison with an alternative tracking method

Thank you.