Reaction-Diffusion based Autonomous Control of Camera Sensor Networks

Katsuya Hyodo, Naoki Wakamiya, Masayuki Murata
Graduate School of Information Science and Technology
Osaka University
{k-hyodo, wakamiya, murata}@ist.osaka-u.ac.jp

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

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
- Scalable, adaptive, robust
- Large number of nodes
- Random or unplanned deployment
- Dynamic topology changes
- Self-organizing mechanism

Characteristics of Mechanism
- 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
  - Shrink a pattern for closely located targets

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

- $u$ : activator concentration
- $v$ : inhibitor concentration
- $D_u, D_v$ : diffusion rates
Rate Control Mechanism

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

Simulation Results

- 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.