Flow aproximation in cellular models of pedestrian dynamics

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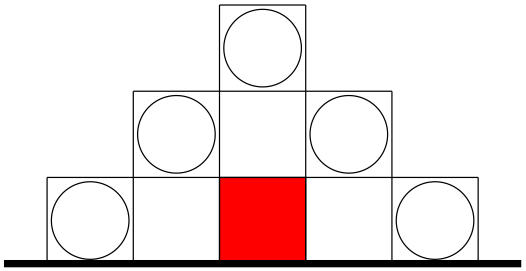
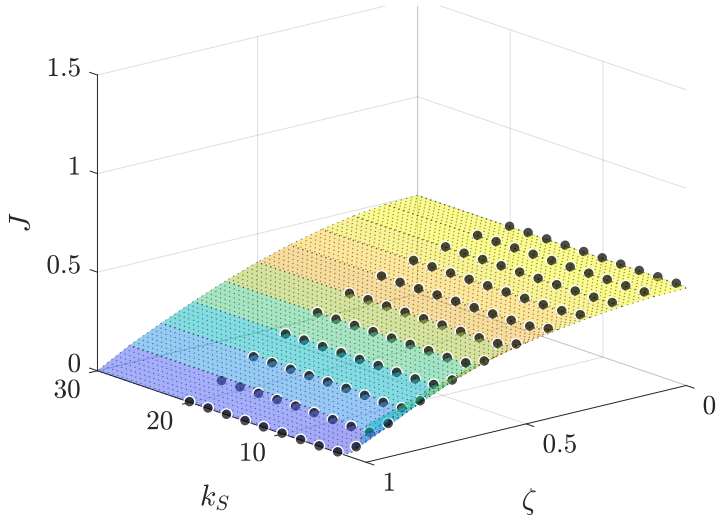
Overview

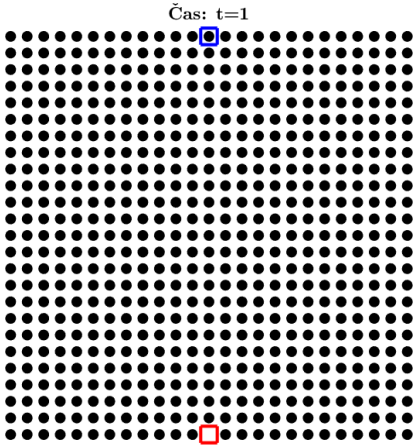
Approximation



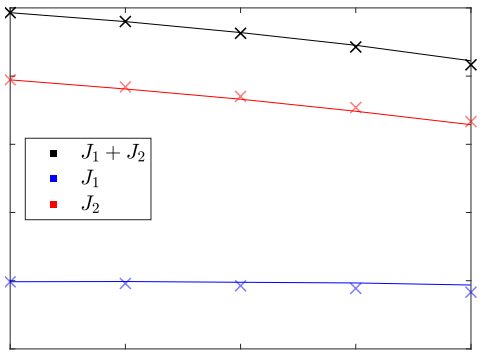
Validation



Model $H = 1$



Model $H = 2$



Approximation

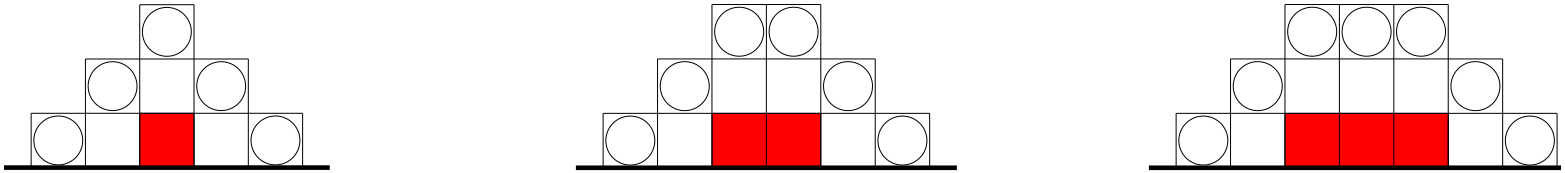
Markov Chains

- $\{X_t, t \in T\}$
- $\boldsymbol{P}: \quad p_{i,j} = \Pr(X_{t+1} = j \mid X_t = i)$
- $\boldsymbol{\pi} = \boldsymbol{\pi}\boldsymbol{P}$
- $J = \sum_{s \in S} j_s \, \pi_s$

Edge Occupancy

- $H \geq 1$
- $r_i = \Pr([b_{\text{edge}}] = i), \; i \in \widehat{H}$
- $\sum_{i \in \widehat{H}} r_i = 1 - r_0$

Approximation Model Lattice



Floor-filed model, $H = 1$

Target Cell Selection

- $S_b = \mathrm{Dist}(b, b_{\mathrm{exit}})$
- $\Pr(b_{\mathrm{desired}} \mid b_{\mathrm{now}}) \propto \exp(-k_S S_{b_{\mathrm{desired}}})$

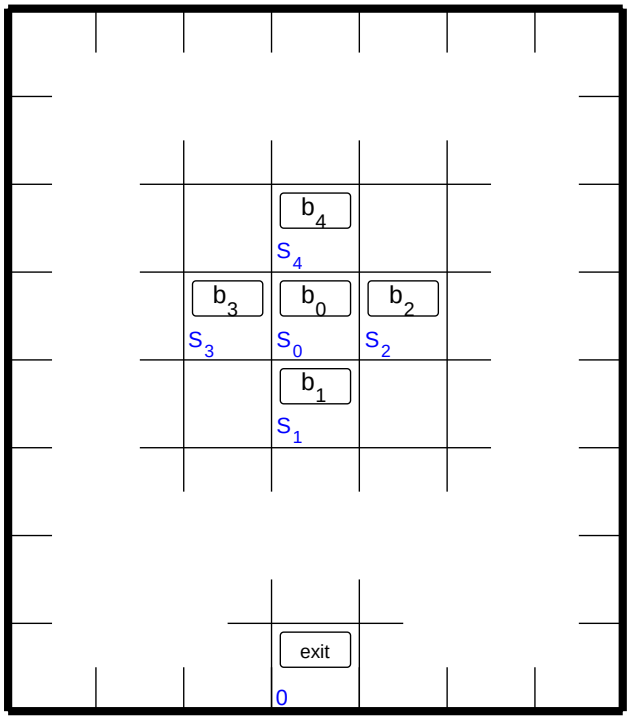
Agent Friction

- $\phi(\zeta, k) = 1 - (1-\zeta)^k - k\zeta(1-\zeta)^{k-1}$

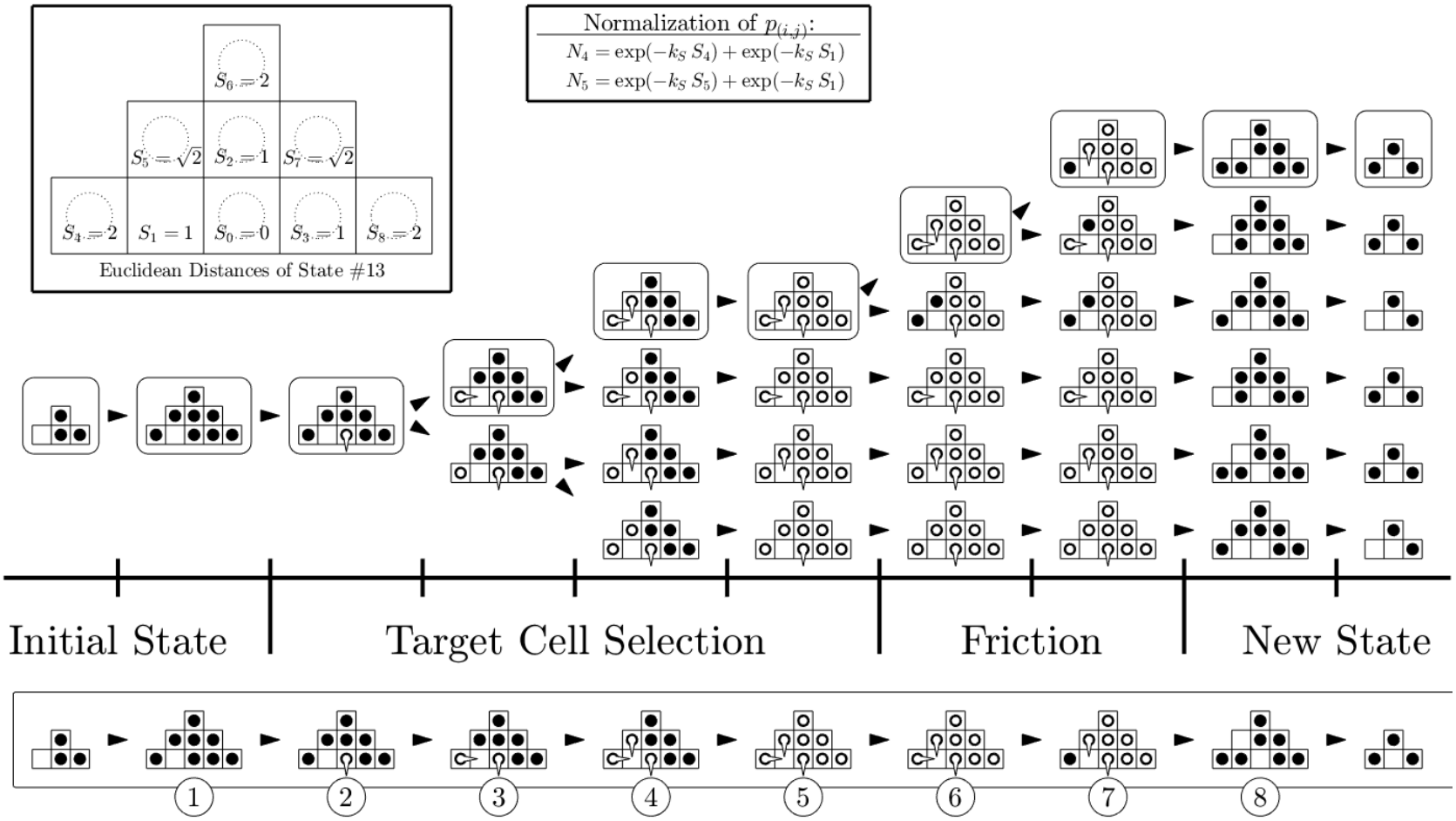
Parameters

- $H = 1$
- $k_S \in [0, +\infty)$: sensitivity to field
- $\zeta \in [0, 1]$: friction parameter

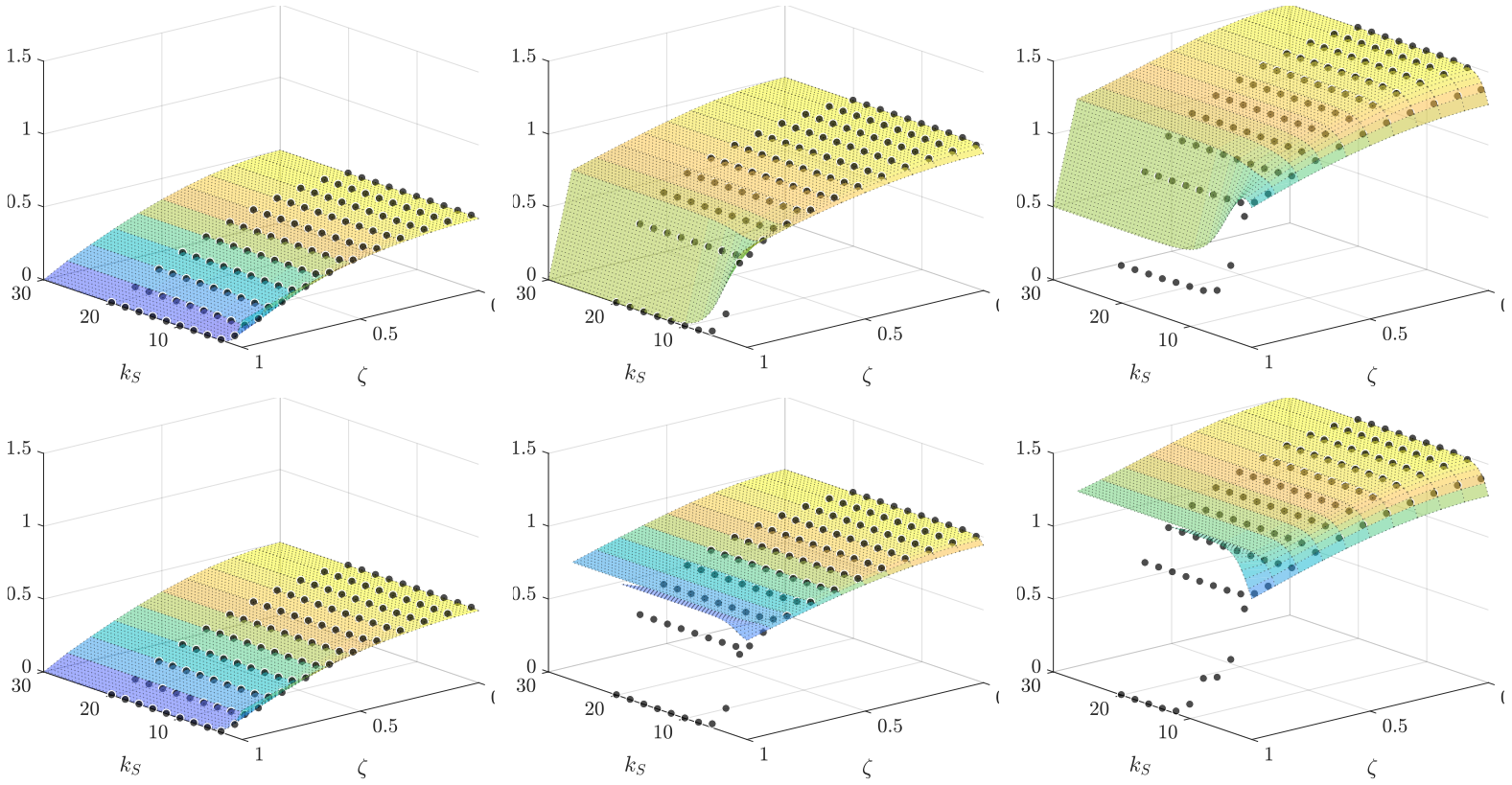
Single Cell Neighborhood

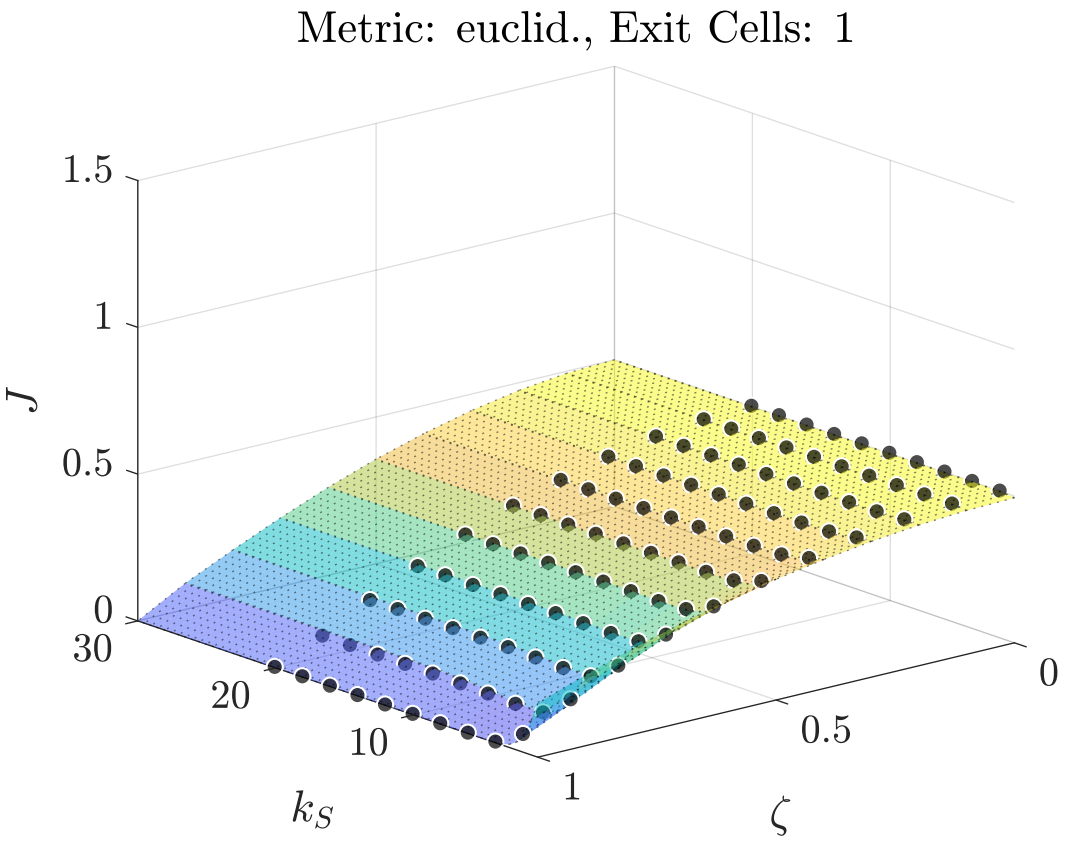


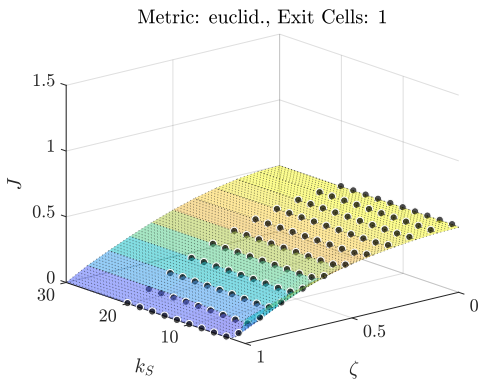
Algorithmization

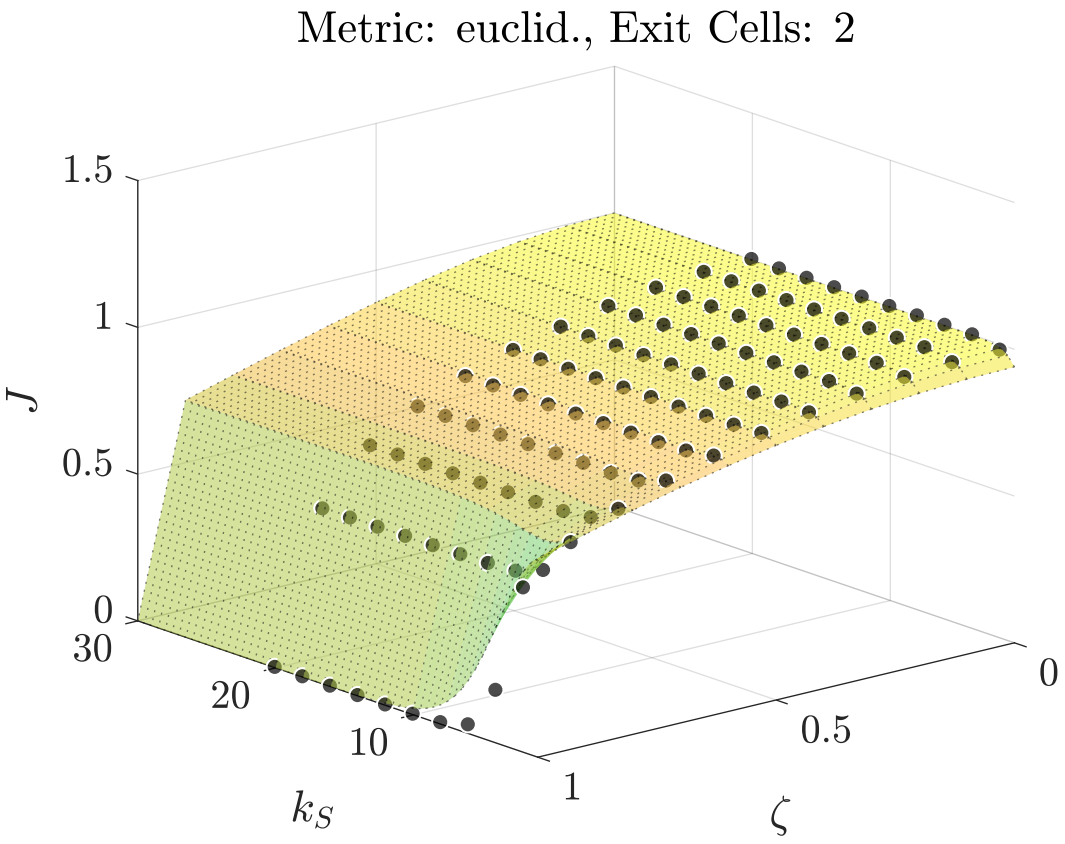


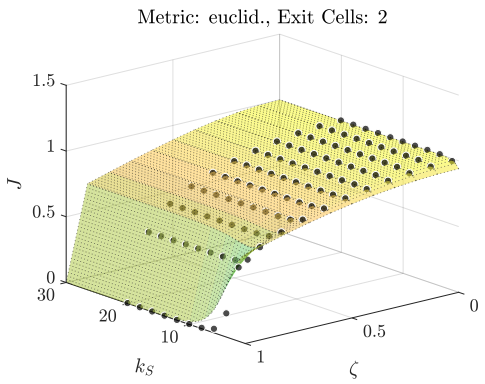
Validation

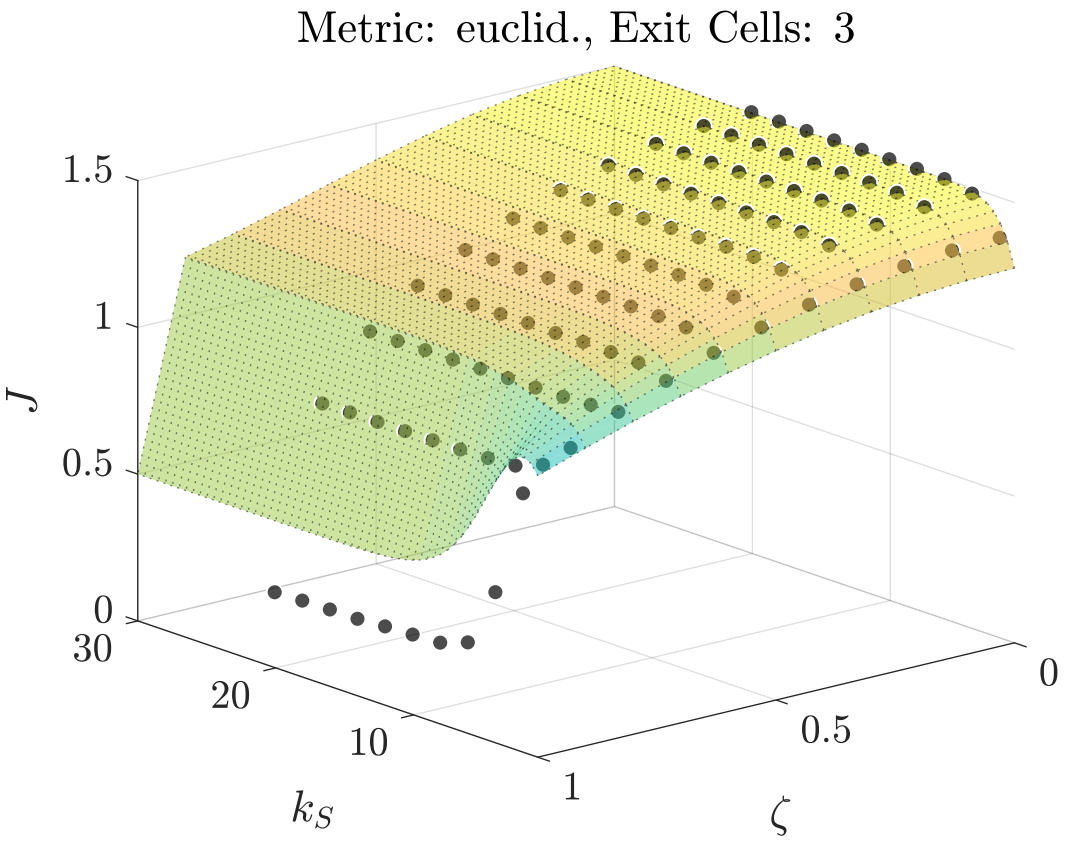


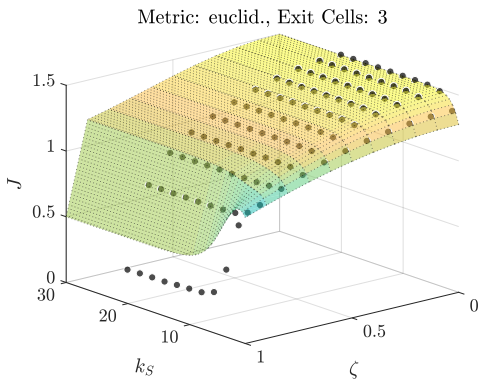

Metric: euclid., Exit Cells: 1
1.5
1
0.5
0
J
30
20
10
k_S
1
0.5
0
ζ


Metric: euclid., Exit Cells: 1
1.5
1
0.5
0
J
30
20
10
k_S
1
0.5
0
ζ

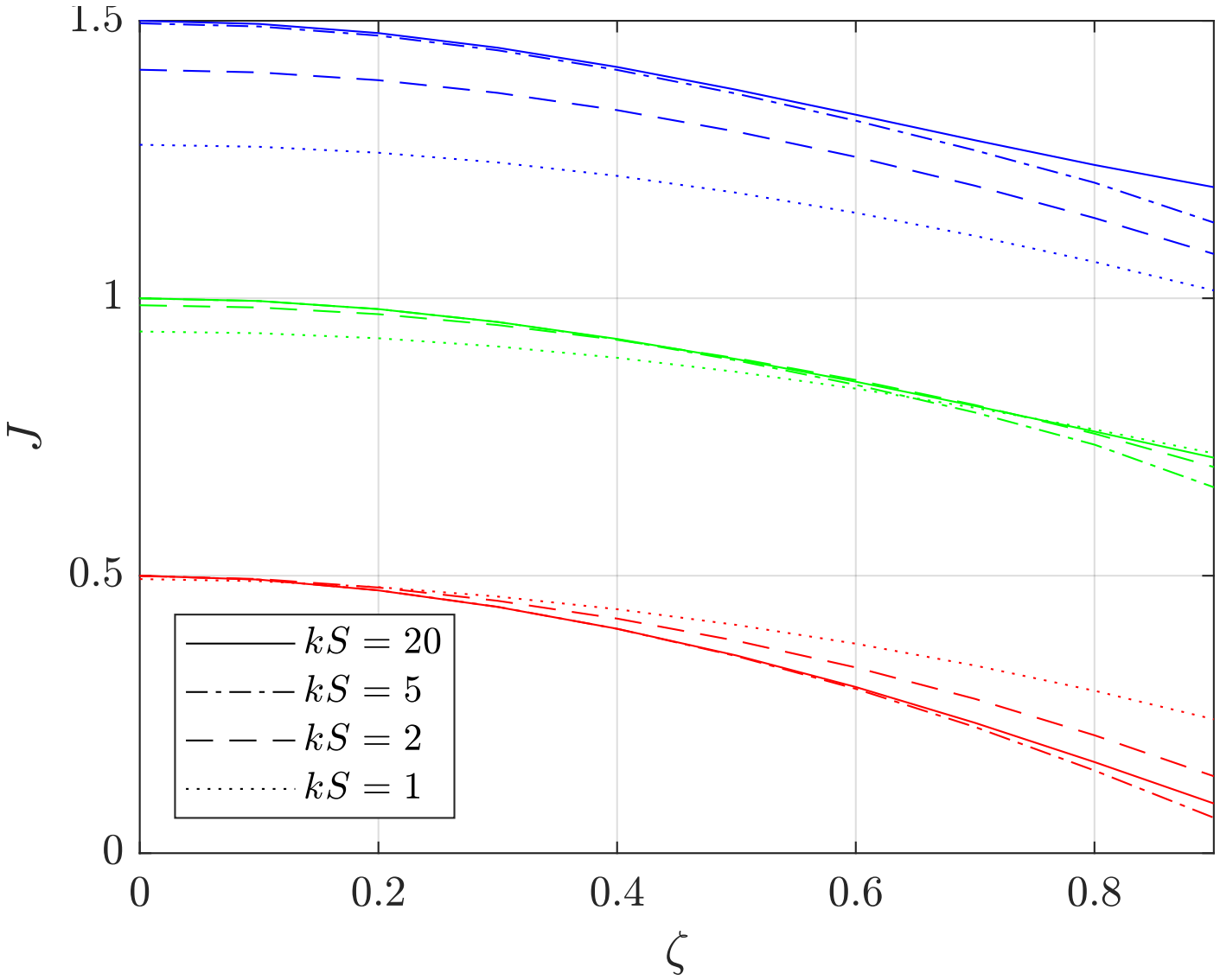

Metric: euclid., Exit Cells: 2
1.5
1
0.5
0
J
30
20
10
1
0.5
0
k_S
ζ


Metric: euclid., Exit Cells: 2
1.5
1
0.5
0
J
30
20
10
1
0.5
0
k_S
ζ

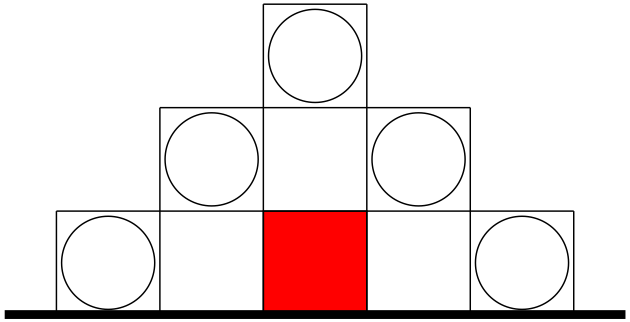

Metric: euclid., Exit Cells: 3
1.5
1
0.5
0
J
30
20
10
1
k_S
0.5
0
ζ

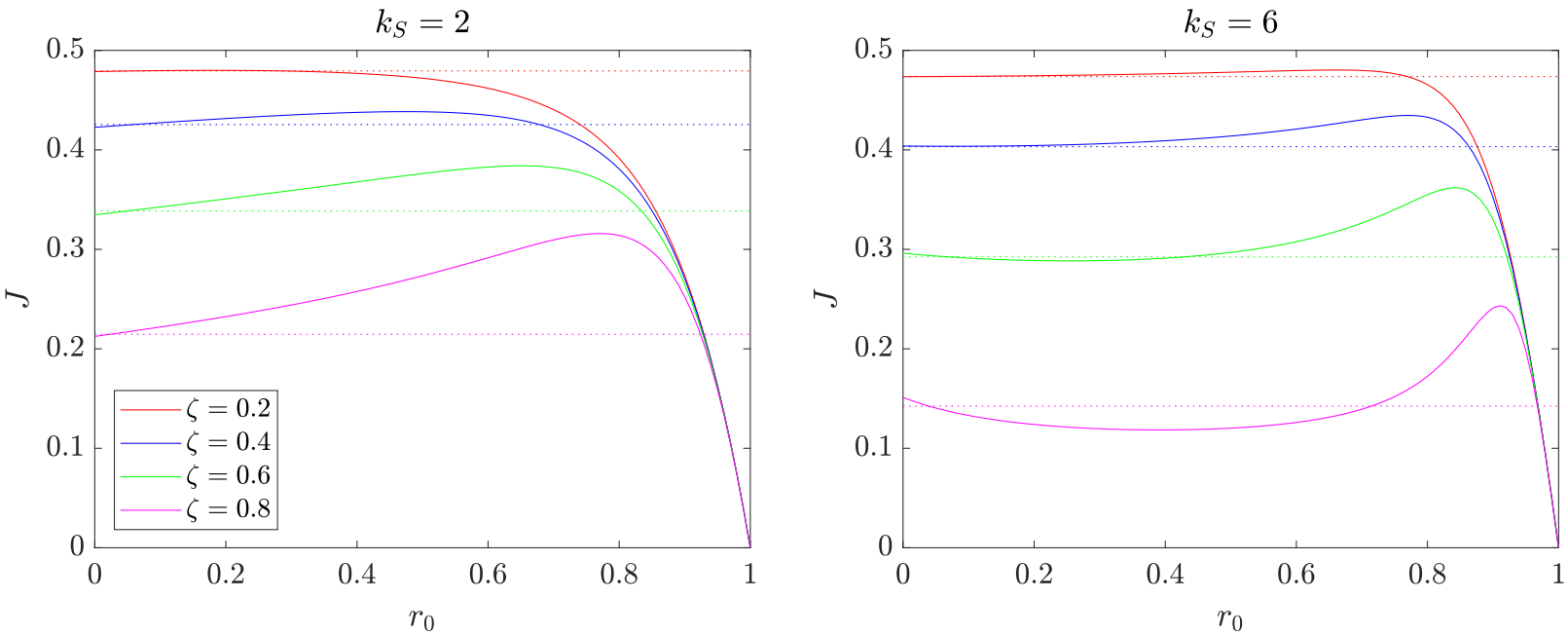

Metric: euclid., Exit Cells: 3
1.5
1
0.5
0
J
30
20
10
1
k_S
0.5
0
ζ

Model Calibration



Edge of Exit Neighborhood





Floor-field model, $H \geq 1$

Parameters

- $\boldsymbol{k_S} = (k_{S1}, \ldots, k_{SH})$
- $\boldsymbol{\zeta} = (\zeta_1, \ldots, \zeta_H), \;\; \phi(\overline{\zeta}, k)$
- $\boldsymbol{A} = (A_1, \ldots, A_H),$
  $\Pr(\text{"winner\_type}{=}i\text{"}) = \dfrac{A_i}{\sum_j A_j}$
- $\boldsymbol{\beta} = (\beta_1, \ldots, \beta_H), \;\; \sum_i \beta_i = 1$

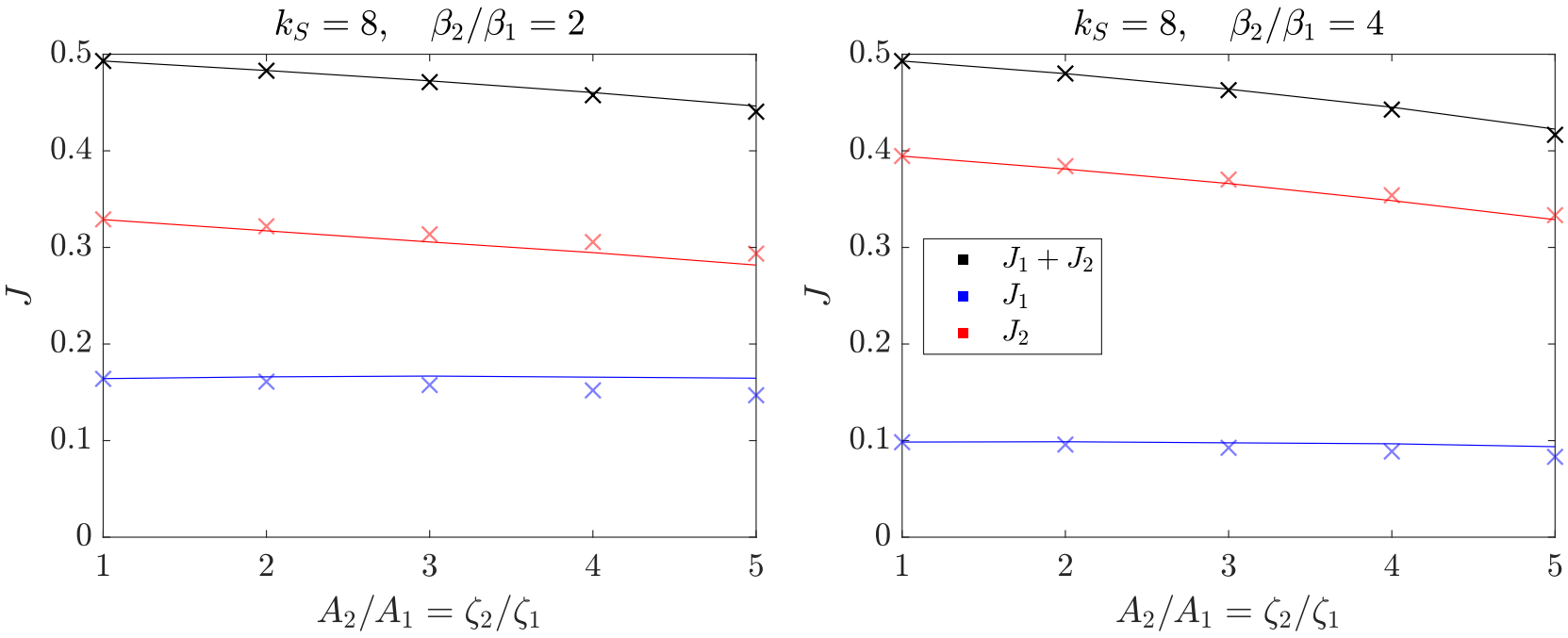
Flow

- $J = \sum_i J_i$
- $J_{\text{aprox.}} = J(\boldsymbol{k_S}, \boldsymbol{\zeta}, \boldsymbol{A}, \boldsymbol{r}, r_0)$

Selected Configuration

- $H = 2$
- exit_width $= 1$
- $A_1 = 1, \; \zeta_1 = 0.1, \; \beta_2 = 1 - \beta_1$
- $A_2 = \dfrac{A_2}{A_1} = \dfrac{\zeta_2}{\zeta_1}$
- $k_{S1} = k_{S2} = k_S$
- $J_{\text{aprox.}} = J(k_S, A_2, r_1, r_2, r_0)$

Validation


$k_S = 8, \quad \beta_2/\beta_1 = 2$
$k_S = 8, \quad \beta_2/\beta_1 = 4$
J
$A_2/A_1 = \zeta_2/\zeta_1$
$J_1 + J_2$
J_1
J_2
0
0.1
0.2
0.3
0.4
0.5
1
2
3
4
5

Thank you for your attention

Main References

Takahiro Ezaki, D. Yanagisawa, and K. Nishinari.
Analysis on a single segment of evacuation network.
Journal of Cellular Automata, 8(5-6):347–359, 2013.

Andreas Schadschneider, Debashish Chowdhury, and Katsuhiro Nishinari.
Stochastic transport in complex systems: from molecules to vehicles.

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