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Initiating lane and band formation in heterogeneous pedestrian dynamics

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Abstract. Flows of self-avoiding agents such as pedestrians or road vehicles can describe many types of collective dynamics. Examples are coordinated motion, stop-and-go waves or lane formation in unidirectional and counter flows, or jamming, oscillation, and pattern at bottlenecks and intersections. Collective dynamics and self-organization in flows of agents raise interesting theoretical questions related to stability properties, non-linear effects, phase transition, and metastability. Furthermore, controlling collective performances from individual interaction rules are, besides scientific interests, useful to authorities. In this contribution, we show that heterogeneity of the agent behaviors in unidirectional flows can lead to segregation and formation of lane or band patterns. We use a collision-free agent-based model including a desired time gap parameter. We consider two types of agents and two modeling approaches of heterogeneity: Model 1— We attribute statically two different values for the time gap parameter to the two types of agents. We aim to model heterogeneous individual characteristics; Model 2 — We attribute dynamically two different values for the time gap parameter according to the type of the neighboring agent in interaction. In contrast to model 1 for which the heterogeneity lies in agent characteristics, we aim to model heterogeneity in the interactions. Simulation results show that phase transition and self-organized lane and band formations spontaneously occur when the difference between the two attributed time gap values is sufficiently high. More precisely, we observe the emergence of horizontal lanes when the heterogeneity lies in the agents (model 1, left panel), while vertical bands arise if we assume heterogeneity in the interactions (model 2, right panel). The different organizations of the flow highly influence the system performances. Lane patterns significantly improve the flow, while band patterns result in low performances. The collective dynamics occur in relatively short time intervals and are partly robust to stochastic perturbations.

***Keywords*:** Heterogeneous pedestrian dynamics, static and dynamic heterogeneity, lane formation, band formation, simulation

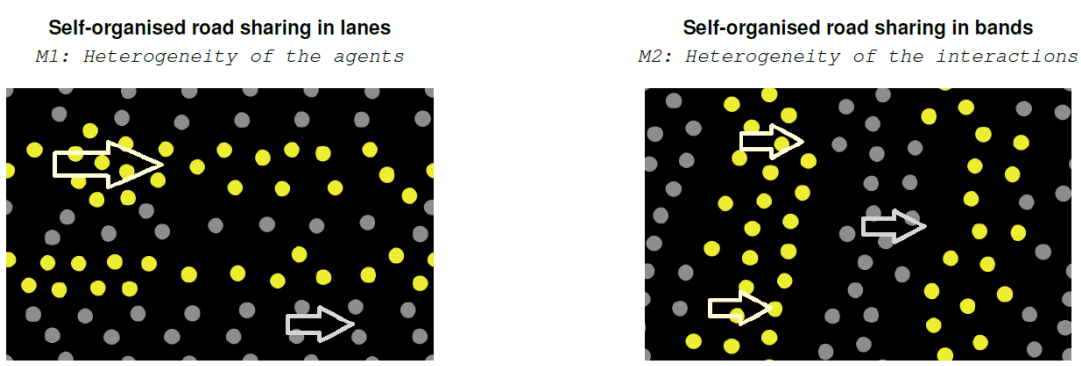

Figure: Screenshots for the model 1 with heterogeneity in the agent characteristics for which lanes emerge (left panel), and for the model 2 with heterogeneity in the interactions where bands emerge (right panel). Flow direction from left to right, periodic boundary. The initial conditions were random. Simulations can be implemented online: https://www.vzu.uni-wuppertal.de/fileadmin/site/vzu/Lane-Formation.html