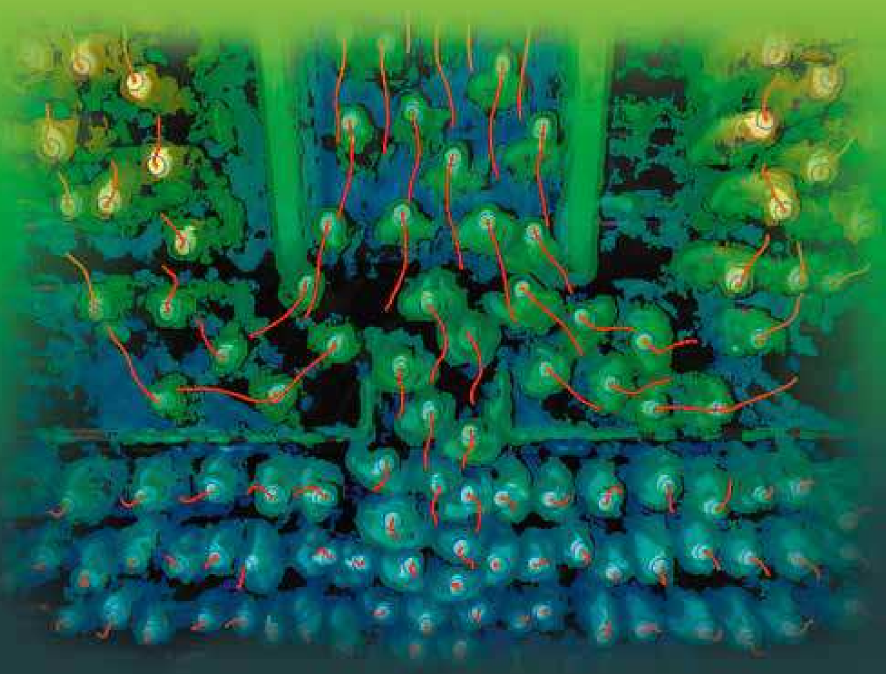
Traffic and Granular Flow '13

25 – 27 September 2013
Forschungszentrum Jülich, Germany



BOOK OF ABSTRACTS

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PREFACE

For its tenth edition, the international workshop TGF "Traffic and Granular Flow" will return to the location of the very first conference held in 1995. From 25 - 27 September, 2013, the international conference will be organized by the Jülich Supercomputing Centre at the Forschungszentrum Jülich. The purpose of the TGF'13 is bringing together international researchers from different fields ranging from physics to computer science and engineering to stimulate the transfer between basic and applied research and to discuss the latest developments in traffic-related systems.

In 1995 the TGF was probably the first conference with this objective. The workshop was attended by about 130 participants from 14 countries. My colleagues – D. E. Wolf and M. Schreckenberg – and I conceived the workshop to facilitate new ideas by considering the similarities of traffic and granular flow. To develop a unified view of flow instabilities like traffic jams or clogging of a hopper by powder was a purpose of the international workshop. Traffic as well as Granular Flow have both intriguing conceptual analogies. Traffic jams can be described by the same equations as density waves in granular pipe flow, and efficient simulation tools like cellular automata have been developed along similar lines in both fields, just to name two examples.

I am pleased to see that after so many years the field of traffic and granular flow is still progressing and that numerous problems could be solved by new facilities. Nevertheless, we are facing plenty of new challenges in these research fields. In 2013 the international conference covers a broader range of topics related to driven particles and transport systems. Besides the classical topics of granular flow and highway traffic, its scope includes data transport (Internet traffic), pedestrian and evacuation dynamics, collective motions in biological systems (swarm behaviour, molecular motors, social insects,…), complex networks and their dynamics (transportation network, Internet, epidemics, social networks,…) and intelligent traffic systems.

Supercomputing is one of the instruments in traffic and granular research, and Forschungszentrum Jülich, as one of the largest national centre for supercomputing and part of PRACE, is proud to play an important role in security research. In the Jülich Supercomputing Centre a division focuses on models of self-driven systems with applications in civil security and traffic planning. Experiments are performed and methods of data capturing are refined to support the developments of reliable models usable for security-related applications. In combination with high performance computing we are able to tackle challenges in the simulation of large systems using high fidelity models.

I would like to thank the entire Organizing Committee and the Scientific Committee of the conference for their intensive and excellent work.

Jülich, August 2013

A. Bachem

TIMETABLE 24.09/25.09

	Tuesday, 24.09.	Wednesday, 25.09.	
	Elisenbrunnen	**Lecture Theatre**	**Seminar Room**
09:00		Registration	
09.30		Greeting by Sebastian M. Schmidt, Member of the Board of Directors of Forschungszentrum Jülich	
09:45		Jens Krause *Collective Behaviour and Collective Cognition* ☞9	
10:10			
10:35		Coffee	
11:00		J. Cividini ☞10	H. Rehborn ☞20
11:25		M. Treiber ☞11	H. Weber ☞21
11:50		S. Hoogendoorn ☞12	A. Chechina ☞22
12:15		W. Daamen ☞13	B. S. Kerner ☞23
12:40		Lunch	
14:00		T. Kretz ☞14	V. Knoop ☞24
14:25		F. Dietrich ☞15	B. Goni Ros ☞25
14:50		G. Köster ☞16	I. Neri ☞26
15:15		J. van Den Heuvel ☞17	J.-P. Lebacque ☞27
15:40		Coffee	
16:00		G. Vizzari ☞18	J. Ma ☞28
16:25		M. Bukáček, ☞19	X. Mai ☞29
16:50		Poster Session	
18:00	Welcome Reception in Aachen	Barbeque in Jülich	

THEMES: Pedestrian Dynamics (pink) Traffic (blue)

TIMETABLE 26.09/27.09

	Thursday, 26.09.		Friday, 27.09	
	Lecture Theatre	Seminar Room	Lecture Theatre	Seminar Room
09:00 09:30	Cecile Appert-Rolland *Pedestrian Dynamics: Experiments and Models* ☞31		Marc Barthelemy *Evolution of Road Networks* ☞53	
09:45	I. Zuriguel ☞32	R. Shaebani ☞42	J. Starke ☞54	P. Hrabák ☞64
10:10	A. Singh ☞33	S. Klein ☞43	A. Marroquin ☞55	R. Rao ☞65
10:35	Coffee		Coffee	
11:00	J. Kaupuzs ☞34	L. Ciandrini ☞44	N. Bode ☞56	M. Khoshyaran ☞66
11:25	E. Kirik ☞35	I. von Sivers ☞45	S. Pathan ☞57	Y. Taniguchi ☞67
11:50	J. Porzycki ☞36	L. E. O. Sánchez ☞46	K. Suzuno ☞58	A. Tordeux ☞68
12:15	T. Kretz ☞37	S. Belbasi ☞47	D. R. Parisi ☞59	D. Yanagisawa ☞69
12:40	Lunch		Lunch	
14:00	N. Ding ☞38	C. Marschler ☞48	A. Tomoeda ☞60	J.-P. Lebacque ☞70
14:25	T. Chen ☞39	A. Buslaev ☞49	W. Lv ☞61	Y. Sugiyama ☞71
14:50	M. Davidich ☞40	V. Kurtc ☞50	T. Ezaki ☞62	S. Hamdar ☞72
15:15	T. Matsuoka ☞41	P. Zhang ☞51	R. Mahnke ☞63	D. Greenwood ☞73
15:40			End	
16:00				
16:25				
16:50				
18:00	Social Event in Aachen			

Molecular Motors   Granular and Misc

6 SCIENTIFIC COMMITTEE

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WEDNESDAY, 25.09.

Collective Behaviour and Collective Cognition

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Many group-living species exhibit complex and coordinated spatio-temporal patterns from the motion of locust swarms and fish schools to bird flocks, ungulate herds and human crowds. The common property of these seemingly unrelated biological phenomena is that of inter-individual interaction, by which individuals can influence the behaviour of others. Individual-based models provide predictions regarding collective processes which we tested in a set of experiments that explore human crowd dynamics and fish schooling behaviour. In particular we designed a robotic fish that can be used to manipulate decision-making processes in live shoals of fish. Finally, I will discuss the phenomenon of swarm intelligence using examples from both humans and animals.

ABSTRACT

Generic instability at the crossing of pedestrian flows

Julien Cividini, Cécile Appert-Rolland, and Hendrik-Jan Hilhorst

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Crossing pedestrian flows have been observed to self-organize into a diagonal pattern experimentally [1] and numerically [2, 3], but this instability has never been systematically studied. Our goal is to understand its origin through the study of a model system. A pedestrian is modeled as a particle having a preferred direction, say east or north, and moves in that direction on a square lattice, each site being occupied by at most one particle. The jamming transition of this model has been widely studied on a torus in the context of road traffic in cities [4]. In this work we will stay below this transition.

We will first show how the diagonal pattern emerges on a torus from a linear stability analysis of some mean-field equations, then we shall generalize this model to open boundary conditions.

Particles will be shown to self-organize not exactly into diagonals but into 'chevrons', a slightly tilted pattern. This property seems quite robust as it will be shown to emerge from the mean-field equations as well as for several variants of the particle model. We will provide a simple picture by isolating the dominant propagation modes of the particles. The formation of these modes can be explained considering that each particle leaves a wake behind it which traps the other particles of the same type. As we shall discuss in the conclusion, the chevron effect should also be observable in more sophisticated pedestrian models.

11:00

References

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Crowd Flow Modeling of Athletes in Mass Sports Events - a Macroscopic Approach

Martin Treiber[1]

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Mass-sport events for runners, cross-country skiers, or other athletes, are increasingly popular. Prominent examples include the New York Marathon, the Vasaloppet cross-country ski race in Sweden, and the nightly inline-skating events taking place in nearly every major European city. Due to their popularity (the number of participants is typically in the thousands, sometimes in the ten thousands), "traffic jams" occur regularly. They are not only a hassle for the athletes (since the time is ticking!) but also pose organisational or even safety threats. Scientific investigations of the athletes' crowd flow dynamics [1] are virtually nonexisting.

We propose a macroscopic model in form of a dispersion-transport equation for non-congested flow which is coupled to a LWR model for congested flow of the athletes. The model takes into account the observed performance (i.e., free-flow speed distributions) of the athletes in the different starting groups. The model is calibrated and validated on microscopic data of the *Vasaloppet 2012* and the *Rennsteig Half Marathon 2012* (a German running event) at several stationary locations.

Simulations of the model allow the event managers to improve the organization of existing races by determining the optimum number of starting groups, the maximum size of each group, or whether a staggered start with a certain starting delay between the groups is necessary or helpful. Moreover, the model allows to anticipate the effects of route changes or to plan completely new events by predicting when and where obstructions during the race are likely to occur, how they develop spatiotemporally, and which maximum delay they impose on the athletes. As example, we simulate several organisational and route changes planned for the *Rennsteig Half Marathon 2013*.

References

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ABSTRACT

Pedestrian evacuation optimization
Dynamic programming in continuous space and time

F.L.M. van Wageningen-Kessels[1], W. Daamen[2], and S.P. Hoogendoorn[3]

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11:50

Efficient pedestrian evacuation plans are important for areas where large crowd are present, e.g., events and train stations. Currently, the development of evacuation plans is tailored to a single area and based on scenarios of a limited number of calamities. We propose an innovative framework within which efficient evacuation strategies can be developed for any area and calamity. The framework consists of a coupled dynamic travel choice model and dynamic pedestrian flow model. The travel choices of the pedestrians, including route, departure time and destination, are optimized for efficient evacuation.

The main challenge for both the choice model and the flow model lies in the fact that pedestrians move in a continuous 2 dimensional plane. Furthermore, people make different choices in an evacuation than in normal situations: e.g., travel times are more important, comfort is less important.

We develop a route choice model that deals with these challenges by applying the concept of maximizing utility. The utility of a travel choice is determined by, e.g., its travel time. In turn, the travel time is largely influenced by the number of other people on the route and thus on their travel choices. The resulting bi-level optimization problem is solved using a dynamic programming approach [1]. Our main contribution is the development of a generic framework for such problems and its application to evacuations.

In the full paper we describe in more detail the framework consisting of a simple choice model, a simple flow model and a coupling between the two. Furthermore, a test case with results is shown. Other (improved) choice models and flow models will be implemented in the future. In applications, the optimized travel choices can be translated into an optimal evacuation plan.

References

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Generalized Network Fundamental Diagram for pedestrian flows

Winnie Daamen[1], Victor L. Knoop[2], and Serge P. Hoogendoorn[3]

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It has been shown that a relation exists between the number of pedestrians in an area and the average flow in that area (production); this is called the Network Fundamental Diagram (NFD). Using this relation, we can express the average performance of a network as a function of the average density (or accumulation) of the network. One of the assumptions under which a proper shape of the NFD is found, is that the congestion is spread homogeneously over the network. In vehicular traffic, it is shown that when this assumption is relaxed, the spatial variation of density within the network plays a role. This paper shows to which extent a function of the number of pedestrians and an aggregated variable of the spatial spread can predict the performance of a large scale pedestrian traffic flow.

To this end, the metro station Jardim Oceanico in Rio de Janeiro is modeled using the microscopic simulation tool Nomad. It represents a layout of around 10,000 m2 with mainly walking area, but it also includes the turnstiles leading towards the platforms. We have generated in total 36.500 passengers during a simulated time period of 1.5h. Since the definition of flow and density is not straightforward for a multi-directional pedestrian flow, we propose relationships for NFDs using the common relation between flow and density (or accumulation), but also use other characteristics (such as generalized speed).

The existence of smooth NFDs can be important for (on-line) applications such as pedestrian traffic control. Busy pedestrian facilities (e.g., metro and train stations, airports and shopping centers) need to be monitored for safety and operational performance. The use of pedestrian counting devices combined with a reliable NFD could provide a good estimator for the traffic state in real time applications.

12:15

ABSTRACT

Pedestrian Route Choice by Iterated Equilibrium Search

Tobias Kretz, Karsten Lehmann, and Ingmar Hofsäß

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In vehicular traffic planning it is a long standing problem how to assign demand such on the available road network that an equilibrium with regard to travel time (Wardrop 1952) or generalized costs is realized. For pedestrian traffic this question can be asked as well. However, as the infrastructure of pedestrian dynamics is not a network (a graph), but two-dimensional, there is in principle an infinitely large set of routes. As a consequence none of the iterating assignment methods developed for road traffic can be applied for pedestrians. Either one has to come up with an assignment algorithm that works in two-spatial dimensions (Hoogendoorn and Bovy 2004) or one extracts from the infinitely many routes – which then better are called *trajectories* – the relevant routes (than just called *routes*), those which pose actual route choice alternatives. In this latter way – which is the approach of this contribution – a network structure is extracted from the pedestrian areas. The proposed assignment algorithm for this is general: it delivers a meaningful solution for any geometry. And it does not introduce artifacts into the movements of pedestrians: navigation elements which are required to make pedestrians detour spatially for an earlier arrival are introduced such that their existence is locally not visible in the movement of the pedestrians. The ability of the combined approach (network extraction and iterated assignment) will be demonstrated with one or two examples.

14:00

How navigation according to a distance function improves pedestrian motion in ODE-based models

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We present a new ODE-based model for pedestrian motion where a superposition of gradients of distance functions changes the direction of the velocity vector: the Gradient Navigation Model (Dietrich, BA thesis, 2013). The approach differs fundamentally from force based models where the accelerative term is affected by forces and in turn changes the velocity.

By directly changing the direction of motion, the behavior of individual pedestrians can be controlled in greater detail. This leads to several advantages over the force based approach: Model induced oscillations are avoided completely since no actual forces are present. The use of fast and accurate high order numerical integrators is possible through smooth derivatives in the equations of motion. The concise mathematical formulation of the model allows a proof of existence and uniqueness of the solution to the ODE system. Furthermore, the parameter calibration is performed by theoretical arguments based on empirically validated assumptions rather than numerical tests. The accurate integration methods combined with the theoretically determined parameters lead to a model with almost no overlappings of pedestrians. In sum, this leads to the emergence of several empirically observed system phenomena in various geometries such as obstacle avoidance and congestions at bottlenecks without the need to recalibrate the parameter set. The dependence of the pedestrians velocity on the local crowd density, as well as queing behaviour are also present and quantitatively similar to controlled experiments.

The Gradient Navigation Model is compared quantitatively and qualitatively to Helbing's Social Force Model (Helbing et al., 1995). The comparison focuses on three major difficulties in force based models for pedestrian motion: oscillations induced by their physical nature, overlapping of pedestrians due to weak repulsion forces and numerical inefficiency from low order integrators.

Avoiding numerical pitfalls in social force models

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14:50

Helbing's and Molnár's social force model is one of the best known approaches to simulate pedestrian motion. It is based on the idea that the Newtonian laws of motion mostly carry over to pedestrian motion so that human trajectories can be computed by solving a set of ordinary differential equations for velocity and acceleration. However numerical implementation is not without pitfalls. Oscillations, collisions and instabilities occur even for very small step sizes. Looking at the model through the eyes of a mathematician we realize that the right hand side of the differential equation is discontinuous at critical locations such as intermediate targets. This produces undesirable behavior in the exact solution and, at best, severe loss of accuracy in efficient numerical schemes.

We remove the discontinuities thus defining a mollified SFM which conserves all desired dynamic properties of of the SFM but allows the use of high-order fast converging numerical solvers increasing the computational speed by at least a factor of 100. In addition, we observe less oscillations, less collisions and no complete failures. We demonstrate this for a deliberately symmetric bottleneck scenario. The wide-spread but slow Euler scheme fails for the SFM when pedestrians evacuating a room approach an intermediate target. A $5th$ order Runge-Kutta scheme for the mollified SFM encounters no difficulties.

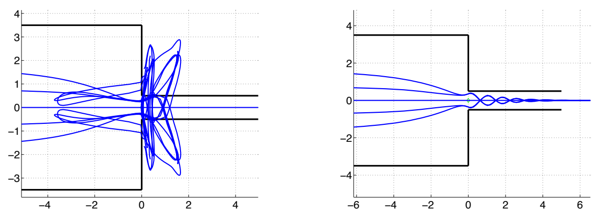

Fig. 1. Pedestrians move from left to right through a bottleneck, $\Delta t = 0.1$. Left: Euler's method fails for SFM. Right: 5th order Runge-Kutta method for MSFM.

Using Bluetooth to estimate the impact of congestion on pedestrian route choice at train stations

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For the design and operations of a train station, it is important to understand the dynamics of bottlenecks in pedestrian facilities. These are the result of pedestrian demand exceeding capacity of a specific point at a certain moment in time. It causes inconvenience for its users because of the waiting time due to queuing. In their response, some pedestrians choose to wait, while others try to find alternative routes.

At train stations escalators and stairs are common bottlenecks, typically after train arrivals which cause a peak in pedestrian traffic. In previous research the impact of waiting time and type of height bridging infrastructure on pedestrian route choice behaviour has been identified, and to a limited extent quantified.

The contribution of this paper is twofold. Firstly, it presents the impact of the relative position of congested stairways and escalators in sets of alternative routes. Secondly, Bluetooth tracking of pedestrians has been used as the main source of data. Bluetooth allowed large sampling of pedestrian movements, including an accurate time registration. Local data of several points in Utrecht Central station - a main railway hub in The Netherlands - have been combined to interpolate pedestrian routes and route times.

This paper shows that the preference of escalators over stairways is statistically significant for pedestrian route choice. Moreover, congestion upstream of escalators and stairways has a measurable impact on pedestrian route choice. Several route choice models have been estimated to describe the probability of choosing a congested escalator route over alternative uncongested stairway routes. The best model only includes waiting time due to congestion at the congested escalator. The results can be used to resolve bottlenecks in train stations, which improves station efficiency and rail passenger experience.

ABSTRACT

Empirical Investigation on Pedestrian Crowd Dynamics and Grouping

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16:00

The definition and implementation of pedestrian simulation models requires empirical evidences, acquired by means of experiments or field observations, for sake of model calibration and validation. This paper describes a on-field observation carried out in an urban commercial-touristic walkway (Galleria Vittorio Emanuele II, Milan, in collaboration with the Municipality of Milano). Although the analysis considered traditional metrics for describing pedestrian flow, such as the *level of service*, the main aim the work was to quantify and characterise the presence, impact and behaviour of groups in the observed population. In particular, we had confirmatory results on the frequency of groups in the observed population, but we also achieved innovative results on trajectories and walking speeds: the walking path of individuals was 4.5% longer than the average path of groups (on average, considering members of groups of different size) but the average walking speed of group members was 37.2% lower the the one of single pedestrians. Finally, a metric for characterising group dispersion was defined and applied to the observed scenario: relatively large groups (size 3 and 4) occupy more space in their movement when compared to couples. The achieved results represent useful empirical data for the calibration and validation of models for the simulation of pedestrian and crowd dynamics [2] but also for the development of automated techniques for data collection and analysis employing computer vision techniques [1].

References

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Experimental Analysis of Two-Dimensional Pedestrian Flow in front of the Bottleneck

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This contribution presents elaborate experimental study of two-dimensional pedestrian flow. It extends the unidirectional flow [1], the T-junction [2], or intersecting studies, which deal with situations that are essentially one-dimensional. The goal of presented experiment was to capture the pedestrian behaviour within the cluster formed in front of the bottleneck.

Two experiments were arranged according to the model presented in [3]. The room 6 m wide and 10 m long was equipped by one entrance and one exit. The inflow rate was regulated to obtain three different walking modes. In the free flow no congestion appeared, in metastable state with balanced inflow and outflow only temporary congestions appeared, in jammed state permanent congestion was formed.

By means of automatic image processing, pedestrian path were extracted from camera records to obtain actual velocity, direction, and local density. For those purposes methods based on Voronoi cells [4] were used. From these data, the fundamental dependence of velocity and density is analyzed. The stated three phases are recognized in the obtained fundamental diagram. Furthermore, we present the method for detecting congested state by means of trajectory curvature and deviation from the exit direction.

16:25

References

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Spatiotemporal traffic pattern recognition based on probe vehicles

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Ubiquitous mobile probe data give new opportunities for the precise reconstruction of congested traffic situations. The three-phase traffic theory [1],[2] is the theoretical fundament for the probe data analysis shown in the paper. The methodology of the approach developped in, e.g., [3], will be illustrated and evaluated with empirical examples from a German field trial. The mobile probes are processed with a three-phase traffic state recognition while the vehicles drive through a spatiotemporal traffic pattern, i.e., they pass synchronized flow regions and/or wide moving jams. In the traffic center, the traffic states from the total number of communicating mobile probes are fused depending on the related traffic phase. The quality of the recontructed traffic pattern with the mobile probes can be correlated with the reconstruction based on stationary detectors. Therefore, we can conclude which number of mobile probes give the same information accuracy as roadside detectors at certain distances. A microscopic traffic simulation based on Kerner-Klenov-Wolf-traffic model have given us an environment for developping, testing and evaluation of traffic reconstruction algorithms. The car-to-infrastructure field trial with more than 120 vehicles communicating with the traffic control center for the duration of six month in the German federal state of Hessen produces a huge amount of empirical data. The paper illustrates the results of the congested traffic recognition and jam front detection. We will show that 2% communicating probe vehicles of the total flow rate give the opportunity of precise jam front warnings and, in addition, the same data quality as detectors of 1-2km distances.

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From Random Walker to Vehicular Traffic: Motion on a Circle

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Summary. Driving of cars on a highway is a complex process which can be described by deterministic and stochastic forces. It leads to equations of motion with asymmetric interaction and dissipation as well as to new energy flow law already presented at previous Traffic and Granular Flow meetings [1].

Here we consider a model, where motion of an asymmetric random walker on a ring with periodic boundary conditions takes place. It is related to driven systems with active particles, energy input and depot. This simple model can be further developed towards more complicated ones, describing vehicular or pedestrian traffic. A particular case, where the coordinate is discrete but the time is continuous, is studied in some detail. In this case we obtain a master equation, which is solved exactly by means of the Fourier transformation. A drift–diffusion equation is derived in a continuum limit. For an infinitely large ring, the solution has a simple form of a spreading–out Gaussian distribution with moving mean value.

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ABSTRACT

Different approaches to the multilane traffic simulation.

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The paper deals with development of both macroscopic and microscopic approaches to the mathematical modeling of multilane vehicular traffic on city roads and highways.The macroscopic model considers synchronized traffic flow, uses the continuum approach and is based on the original quasi-gas-dynamic (QGD) system of equations [?]. The distinguishing feature of the model is the variable transverse velocity reflecting the speed of lane changing. The numerical implementation is explicit, the similarity with kinetically inconsistent finite differential schemes is used.The microscopic model is based on the cellular automata theory and presents generalization of Nagel-Schreckenberg model to the multilane case [?]. The computational domain is the 2D lattice where two directions correspond to the road length and width. The number of cells in the transverse direction corresponds to the number of lanes. Each cell of the lattice can be either empty or occupied by one vehicle. Such a model allows vehicles to change lanes and to overtake one another. The algorithm of cell state update is formed by two components: lane change (if it is necessary and possible), movement along the road by the rules of N-S model.The set of test problems was solved using both approaches to verify the results. The comparison with Aimsun TSS [?], widely used traffic simulation system, was carried out.Both models possess inner parallelism and can be easily adapted to multiprocessor computer systems of different architectures. Parallelization is based on the domain decomposition (data partitioning) technique and message passing between nodes of the cluster. Parallel implementation provides the description of vehicle behavior in details and the real time forecast of big city traffic states.

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Criticism of generally accepted fundamentals and methodologies of traffic and transportation theory

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Summary. It is explained why the set of the fundamental empirical features of traffic breakdown (a transition from free flow to congested traffic) should be the empirical basis for any traffic and transportation theory that can be reliable used for control and optimization in traffic networks. It is shown [1] that generally accepted fundamentals of traffic and transportation theory like Lighthill-Whitham-Richards (LWR) theory, the General Motors model class (models in which traffic breakdown is explained by a free flow instability through a driver reaction time, for example, Herman, Gazis, et al. model, Gipps's model, Payne's model, Newell's optimal velocity (OV) model, Wiedemann's model, Bando et al. OV model, Treiber's IDM, Krauß's model), principles for traffic and transportation network optimization and control (e.g., Wardrop's user equilibrium (UE) and system optimum (SO) principles) are not consistent with the set of the fundamental empirical features of traffic breakdown at a highway bottleneck. Alternatively to these generally accepted fundamentals and methodologies of traffic and transportation theory, we discuss three-phase traffic theory as the basis for traffic flow modeling as well as briefly consider the network breakdown minimization (BM) principle for the optimization of traffic and transportation networks with road bottlenecks.

Keywords: transportation research, highway capacity, traffic flow models, traffic network optimization and control, Wardrop's principles, breakdown minimization (BM) principle, three-phase traffic theory

12:15

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ABSTRACT

Simulation Model for Traffic using Network Fundamental Diagrams

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Traditionally, traffic is described at the level of individual vehicles (microscopic) or at the level of a link (macroscopic). Recently, it has been shown that traffc operations can also be described at the level of a network, using the relationship between accumulation (average density) and production (average flow). This is called the Network Fundamental Diagram (NFD). This paper introduces a traffic flow simulation model, including the numerical scheme, which uses this relationship.

We propose to split a network in cells, and for each of the cells the NFD is determined. The OD is specified. In the model, it registered which fraction of the density in each cell is heading each of the destinations. In each time step, the flow from one cell i to cell j is basically determined by the minimum of 3 elements: (1) the physical road capacity at the border between cell i and cell j, (2) the demand from cell i towards cell j, (3) the supply in cell j in relation to the total demand to cell j. Similar to the cell transmission model (CTM), the supply is at capacity for undercritical values for the accumulation. However, opposed to the CTM, the demand is reducing for overcritical accumulation in cell i due to accumulation effects. The full paper will show the description of the full network propagation model.

The proposed model provides a very powerful tool to quickly predict the traffic states for large area with many roads. This is useful to coordinate traffic control measures over a large area. The full paper will show examples the use of in perimeter control and routing (see below).

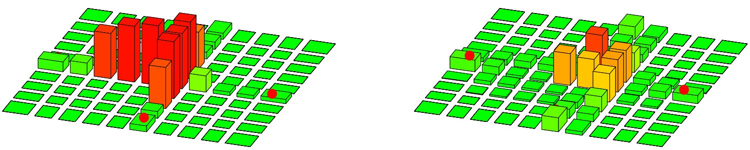

Figure 1: Representation of the traffic states in per area – bar height is accumulation, color is speed. Left: fixed routing, right: adaptive routing

A model of car-following behavior at sags

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Sags are freeway sections along which the gradient changes significantly from downwards to upwards. Sags are often bottlenecks in freeway networks. The main cause is that the change in slope has a negative effect on vehicle acceleration, which influences longitudinal driving behavior at the beginning of the uphill section and reduces traffic flow capacity. Available car-following models are not capable of reproducing vehicle dynamics at sags in a sufficiently realistic way. This paper presents a car-following model that aims to fill that gap. In our model, acceleration ($\dot{v}$) is determined by a two-term additive function. The first term is based on the *Intelligent Driver Model* and accounts for the influence of speed (v) and spacing (s). We added the second term to account for the influence of changes in gradient.

$$\dot{v}(t) = a \cdot \left[1 - \left(\frac{v(t)}{v_0(t)}\right)^4 - \left(\frac{s^*(t)}{s(t)}\right)^2\right] - g \cdot [G(t) - G_c(t)] \tag{1}$$

In the second term, g is the gravitational acceleration, $G(t)$ is the road gradient at time t, and $G_c(t)$ is the compensated gradient at time t. The *compensated gradient* (G_c) is a variable that accounts for the fact that drivers have a limited ability to compensate for the negative effect that an increase in gradient has on vehicle acceleration. Drivers are assumed to compensate for that negative effect linearly over time (the maximum gradient compensation rate is defined as a parameter).

The paper presents the results of a microscopic traffic simulation study using the proposed car-following model. The simulation output data are compared to empirical traffic data from a sag on the Tomei Expressway (Tokyo, Japan). Similar vehicle dynamics and traffic flow patterns are observed in the simulation output data and the empirical data. Particularly, the model is capable of reproducing the decrease in traffic flow capacity and the bottleneck location at the study site. The proposed car-following model could be used to evaluate the effectiveness of possible control measures aimed at reducing congestion at sags.

Exclusion processes through networks

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Exclusion processes are models of active transport of particles in a dissipative environment. These models predict collective effects such as the occurrence of jams and the presence of phase transitions in the overall density. In the literature, exclusion processes have been mainly studied in the geometry of a single segment connecting two reservoirs [1]. Transport is often organized along complex networks: vehicles move along a highway network, motor proteins along the cytoskeleton, information packages move through the Internet, etc. Does the organization of matter depend on the overall topology of these networks? Which collective effects emerge on the network scale due to microscopic interactions? We present a method which allows to reconstruct the stationary state of transport through large complex networks from the phase diagram of a single segment [2, 3]. We demonstrate this approach on several network ensembles (Bethe lattices and Erds-Rnyi graphs) and dynamical models (the totally asymmetric simple exclusion process, the partially asymmetric simple exclusion process and the totally asymmetric simple exclusion process with Langmuir kinetics). We show how one can characterize different regimes of stationarity based on the scale at which heterogeneities in particle densities arise. Such a classification allows for a unified understanding of the phenomenology of exclusion processes through networks. The different regimes are put into the biological context of motor proteins moving along the cytoskeleton. We argue that the transitions between the different regimes of density heterogeneities appear in biological relevant parameter regimes and could therefore play a role into the spatial organization of matter in cells.

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Multi-anticipative car-following behaviour: new empirical investigations

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Abstract. In this work we will deal with multi-anticipative car-following i.e. driving behaviour taking into account many vehicles ahead. Some recent studies have suggested that drivers not only react to the closest leader vehicle but also anticipate on traffic conditions further ahead. Using a recent result of homogenization for a general class of car-following models (and also available for multi-anticipative models), we will deeply investigate the effects of multi-anticipation at the microscopic level on the macroscopic traffic flow. To understand well multi-anticipation behaviour may be fundamental to anticipate cooperative traffic flow dynamics.

The study will be based on the analysis of individual trajectories extracted from the NGSIM database and we hope to compare them with also the MOCoPo dataset. We want to recover and to extend the results of previous studies which state that the multi-anticipative car-following models improve the representation of individual driving behaviour. While the existing experiments only took into account already congested situations (e.g. afternoon peak hour measurements), the present work should be conducted for congested and also for fluid traffic situations.

Notice that NGSIM or MOCoPo datasets come from the analysis of video records. The main difficulty to deal with such data is to counterstrike the process errors. The solution that we will consider is to integrate the expression of the considered multi-anticipative model according to time. For example, if we assume that the considered model has the following form

$$\dot{x}_i(t+\tau) = V\left((x_{i+j}-x_i)_{j=1,\dots,n}(t)\right), \quad \text{for any} \quad t \geq 0,\ i \in \mathbb{Z},\ n \geq 1, \tag{1}$$

where x_i denotes the position of vehicle i, τ is the reaction time and n le number of considered leaders, then by integrating (1), we can deal with the vehicles trajectories that avoid to take into account the classical errors on evaluated instantaneous speeds. We will then calibrate the model by using a maximum-likelihood estimation. In a last step, we will compare multi-leaders and single-leader car-following models by using the Akaike information criterion. Roughly speaking, this test has the advantage to estimate the accuracy of a model compared to its complexity e.g. its total number of parameters.

Simulation of crowd-quakes with heterogeneous contact model

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Abstract: Serious pedestrian trampling in crowd disasters such as the Love Parade happened almost every year around the world. Recently, analysis of video recording of Love Parade disaster indicated that, as shown in Fig.1a, there were different kinds of contacts among pedestrians. Thus to investigate its effect on the massive crowd disaster, pedestrians in the present study are modeled as active and inactive soft particles. Some of those active pedestrians would follow other active ones' movement. As a consequence of this special contact, lane formation in densely packed pedestrian crowds can be observed, as shown in Fig.1b. It was further found that the crowd-quakes has direct relation with the pedestrian type and packing status.

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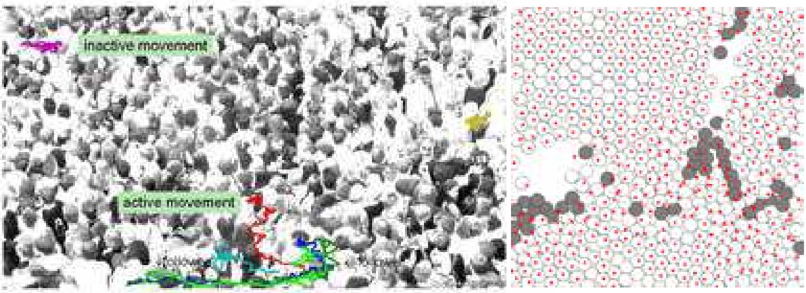

Fig. 1. Snapshot of the Love Parade disaster (a) and the simulation result of the proposed model (b).

New definition and analysis of spatial-headway in two-dimensional pedestrian flow

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Abstract

In this study, two-dimensional experiments are carried out to study pedestrian movement behaviors in a circular passageway. Here we redefine the spatial-headway in two-dimensional following behavior and now we have a vivid visual filed as showed in Fig. 1. The results show that the two-dimensional spatial-headway is distinctly different from that obtained from single-file movement. The velocity in every ligature is also extracted to get the relationship between velocity component and distance in different angles. Results of the more crowded situation show that the pedestrians turn into three steady lanes and the spatial-headway also keeps in a stable state. The findings may be useful for model calibration.

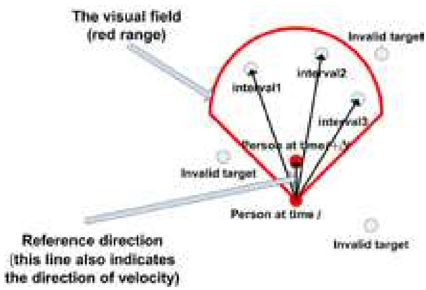

Fig. 1. Diagrammatic sketch of the new definition

THURSDAY, 26.09.

Pedestrian dynamics: experiments and models

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Understanding pedestrian dynamics has become a key issue, not only regarding evacuation safety, but also for the design of buildings or urban equipments, or the animation of movies or games. The dynamics of pedestrians involves various scales, ranging from the detailed stepping behavior to the emergence of large flow structures in crowds. It is a challenge to understand how these scales can be related, and which parameters govern the overall behavior of crowds.

In the frame of the PEDIGREE Project [1], we have realized some experiments that give access to these various scales. Data analysis has revealed some unexpected features. Besides, these experimental results have inspired several modeling approaches that I will review, ranging from IBM to continuous models.

[1] PEDIGREE project (www.pedigree-project.info) involves 4 French teams:
- IMT (P. Degond)
- MimeTIC Project at INRIA Rennes (J. Pettré)
- CRCA (G. Theraulaz)
- LPT-Orsay (C. Appert-Rolland)

Last papers:

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ABSTRACT

Clogging in bottlenecks: from vibrated silos to room evacuation.

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When particulated materials pass through a bottleneck, spontaneous development of stable structures may lead to suddenly arrest of the flow: clogging. Clogging is a generic phenomenon with important consequences in a wide variety of systems, such as crowd evacuation [1, 2] and inert particles discharged from a silo [3, 4]. Interestingly, despite the different nature of the constituent particles, these systems share notable resemblances. In this work we will compare the experimental results obtained for the clogging dynamics of vibrated silos and sheep evacuated from a room.

First, we will analyze the distribution of time lapse between the passage of two consecutive particles. In all the situations the distributions display similar trends revealing a power law decay for time values above a certain well defined cutoff. Smaller times than the cutoff are associated to the flowing dynamics whereas higher times are related with the unclogging mechanisms. Then, the cutoff time can be naturally used to identify the clogs: namely, all these events where the clogging time exceeds the cutoff. Subsequently we can measure the burst (avalanche) size which is defined as the number of sheep (beads) passing through the bottleneck between two consecutive clogs. The distribution of these avalanche sizes is found to be exponential both, for sheep evacuation and vibrated silos.

All these results suggest that, when studying these intermittent flows, one should differentiate among clogging (related with the avalanche size) and unclogging (associated with the clogging times above the threshold).

09:45

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How does gravity affect the dense granular system under shear?

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Discrete Element Method (DEM) simulations of particles in a split-bottom ring shear cell [1, 2] allows studying the non-equilibrium behavior of granular materials close to jamming (the transition between solid and liquid-like behavior), when subjected to an external rotation. From a single simulation, by applying time and (local) space averaging on the steady state, continuum quantities like density, velocity and deformation gradients, as well as structure and stress tensors can be computed. For low rates of rotation, local volume fractions and shear stresses are found to depend on the pressure only, a property of the quasi-static regime. On the other hand, for higher rates of rotation i.e. in the inertial regime, the quantities depend on both local shear rate and pressure. Recent studies have shown the steady state angular velocity profiles to be independent of gravity in the quasi-static regime [3]. That is, the width of shear bands in a weak gravity field is almost same as on Earth. Starting from this interesting observation, we explore the effect of gravity on the granular assembly in both the quasi-static and inertial regime. In the former, an expected relation between the shear stress and gravity is confirmed. But, the additional dependence of shear stress on strain rate in the inertial regime, leads to a non-trivial scaling with gravity. Finally, the dependence of microscopic (velocity profiles, normal and tangential forces) and macroscopic (stress, fabric and volume fraction) quantities on gravity is explored, showing how the role of gravity evolves with the strain rate.

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ABSTRACT

Correlation Functions and Finite–Size Effects in Granular Media

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Summary. A model is considered, where the local order parameter is an n–component vector. This model allows us to calculate correlation functions, describing the correlations between local order parameter at different spatial coordinates. The longitudinal and transverse Fourier–transformed two–point correlation functions $G_{\parallel}(\mathbf{k})$ and $G_{\perp}(\mathbf{k})$ in presence of an external field h are considered in some detail. In the thermodynamic limit, these correlation functions exhibit the so-called Goldstone mode singularities below certain critical temperature at an infinitesimal external field $h = +0$. The actual model can be applied to granular media, in which case it describes a small particle and, therefore, the finite–size effects have to be taken into account. Based on Monte Carlo simulation data for different system (lattice) sizes, we have found that the correlation functions are reasonably well described by certain analytic approximation formulas.

On validation discrete-continuous model with bottleneck flow

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A connection of a width of a bottleneck and unidirectional virtual people flow by the discrete-continuous pedestrian movement model [1] is investigated. Specific and full flow rates for initial densities and bottleneck width are presented and discussed.

Bottlenecks on pedestrian facilities gives the most considerable contribution to the upper limit of evacuation way capacity. Up to now literature on pedestrian dynamics does not give one quantitative answer on bottleneck questions. Qualitative descriptions have common points. Many authors investigated bottleneck flows in experimental environments ([2, 3], web resource http://ped-net.org). It was considered case study from [3] and shown that model flows are in the spirit of available experimental data.

11:25

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Dynamic data driven simulation of pedestrian movement with automatic validation

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Paper presents a dynamic data driven simulation of pedestrian movement based on Social Distances Model, where simulation system is continuously synchronized with current fow data gained from Microsoft Kinect depth matrix. Both simulation and data analysis are real time processes. Agents appears in simu- lation as soon as new pedestrian is detected in Kinect depth matrix stream. Social Distances Model is efficient and scalable method of real time simulation of crowd evacuation. It is discrete, stochastic, based on cellular automata model using more detailed representation of spatial relation. Depth matrix from Microsoft Kinect let us not only detect upcoming pedestrian but also allow to short term tracking. In result, we are able to determine basic movement parameters. Pedestrian detection is also used for model validation and simple calibration. Paper describe in details algorithms we use and show an illustrative experiment.

Crowd Research at School: Crossing Flows

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The Science Exchange Program Shanghai - Karlsruhe is jointly organized bianually by the Schülerakademie Karlsruhe and the Karlsruhe Institute of Technology (KIT). Participants are at an age of 16 to 17 years and come from various high schools from Karlsruhe as well as Shanghai's Jingye high school. In two weeks of which one is held in Karlsruhe and one in Shanghai teams of four to eight pupils (half Chinese and half German) work on particular projects which are supervised by University groups, companies or research centers. In 2012 one group decided to investigate crossing pedestrian flows. In 1974 Naka found that in crossing pedestrian flows stripes form which are orthogonal to the sum of the velocity vectors of the two main walking directions. This was confirmed in 1988 by Ando, Ota, and Oki. However, while in the paper by Naka the stripes are sketched (and most readers outside Japan will only have understood the sketches in both papers, as the papers are written in Japanese) more as extended bubbles, with a rather organic appearance, in the later paper the sketch is drawn with straight lines, strictly and clearly separating pedestrians of the two walking directions. This sketch was used in English language papers for example by Hughes (2002) or Helbing, Buzna, Johansson, and Werner (2005). In this way the idea of strict and straight stripes spread and was eventually even popularized (e.g. Fisher 2009). The participants were 80 pupils of an age between 11 and 14 years. The crossing area was 3X3 m^2 and the participants walked on an 8-like path so the experiment could continue indefinitely. The access width to the crossing area was restricted below 3 m. Among the main findings is that mainly "bubbles" of persons walking in one direction formed and that stripes appeared only rarely and if then they disappeared again only after seconds. In simulations a similar behavior can be generated if a wide distribution of desired speeds is applied. If the distribution is narrow then stripes can be seen much more clearly. If we assume that the German pupils adapted their speeds much less one to another than the participants in Japan the simulation is in qualitative agreement with the observations.

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Pedestrian Flow Simulation in Staircases during Evacuation Based on Jerk Cellular Automata Model

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Building evacuation in case of emergencies such as fire and smoke has long been recognized as a crucial issue, and staircases are the main egress. Whether the staircases meet the criterion of building safety is thus important, but it is difficult or even impossible to test staircases in actual emergency events. In view of this, simulation is a proper method. However, traditional transition rules in cellular automata model are introduced by experience and some important pedestrians' physical and psychological status are ignored. The problem is how to improve pedestrian flow simulation in staircases during evacuation. In this paper, a new cellular automata model is established bridge the gap between discrete models and continuous models. A split-and-recombine grid map is introduced based on the three-dimensional structure of staircases, and three kinds of neighborhoods are discussed according to pedestrians' psychological status. To make transition rules more reasonable and demonstrate pedestrian moving uncertainties more clearly, jerks (accelerated accelerations) of pedestrians are introduced. The movement of a pedestrian is affected by several jerks such as attraction jerks, repulsion jerks and inertia jerks. As all the pedestrians are not acted upon the same jerks, some of these jerks are introduced in a probabilistic way. A new update rule, which enables pedestrians' various speeds in this model, is established. Then, an important pedestrians' physical status such as fatigue, which is ignored by other studies, is considered in this model. How the environment and other pedestrians influence a pedestrian's psychological status is introduced. Furthermore, the jerks, pedestrians' physical and psychological status will determine a pedestrian's speed.

Simulation of evacuation process considering information flow

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Abstract. In most building evacuation models, occupants are assumed to have perfect and static information such as the positions of exits, immediately after the evacuation begins. However, in reality, the information occupants have is neither perfect nor static. In the beginning of the evacuation, occupants may not know the layout of buildings perfectly. In fact, they may not even know the emergency and the need to evacuate from the current places. However, gradually they are able to obtain information from alarms, exit signs or other occupants, and the information they get changes the movement of them. This paper considers the flow of information during evacuation: occupants who have incomplete knowledge (e.g., on the layout of the building) in the beginning of the evacuation keep on getting information from their surroundings and updating local strategies based on the information. We also combine the information flow model with social force model. This framework can describe individual occupants more precisely and more realistic. Section II reviews relevant literature on evacuation models and information flow models, and then points out the importance and the lack of study on the combination of them. Section III provides a model that combines the information flow model with the social force model, so occupants can obtain dynamic information from their surroundings and update their strategies of movement by changing their desired velocities. Several cases are studied in Section IV: occupants in different parts of a building evacuate and information provided to them by loudspeakers or exit signs are asynchronous. Simulation results show that the different ways to provide information significantly affects the evacuation process. It reflects the importance of information flow during the evacuation. It is concluded that with a proper control of information, we can reduce the congestion and speed up the evacuation.

Predictive simulation for real-life rush hour scenarios at a German railway station

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There are more and more known pedestrian motion phenomena discovered during experiments and models that are calibrated and validated according to these experiments. The main challenge is to calibrate and validate models against large real-life scenarios, because they are much more complex than controlled experiments. In this work we build on our previous investigations on calibration and validation of models against real-life scenarios and move from qualitative to quantitative measures of simulation accuracy. We complement the calibration by a sensitivity study to identify parameters where small changes lead to significant changes in the prediction outcome.

The real-life data is gathered from video recordings of typical morning and evening rush-hour scenarios at a major German railway station. Velocity distribution, density-flow relationship, schedule of appearance and disappearance of pedestrians, sources-target distribution and positions and shapes of sources, targets and obstacles are taken as input parameters for the pedestrian stream simulation.

The model is validated by comparing simulated local density evolution to that recorded on video. For a quantitative comparison we introduce a simulation accuracy measure, fitness, which is defined as an inverse of a sum of squared local density deviations over all simulation steps. A sensitivity analysis of input parameters of the simulation is conducted that shows that the source-target distribution, pedestrian appearance and disappearance schedule, and free-flow velocity are the most sensitive parameters and should be considered very carefully.

The qualitative and quantitative comparison of video recordings to the corresponding simulation shows that the model is capable of reproducing complex real-life scenarios and can be used for predicting critical densities.

Effects of an Obstacle Position for Pedestrian Evacuation: SF Model Approach

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Pedestrian dynamics is important subject and has been well studied. Especially, there are many study finding using mathematical models, for example, the social force (SF) model [1] and a cellular automaton model [2]. It is well-known that these models exhibit clogging or “faster-is-slower effect”. More precisely, pedestrians with a high speed spend more time to evacuate from a room than with a low speed when the clogging is observed in a numerical simulation. It is reported that an obstacle, in some cases, placed central in front of an exit enables pedestrians to evacuate faster with cellular automaton model [3]. More interestingly, the authors show in [3] that the total time of evacuation is short in the case that there is the obstacle slightly at the left or right side of the exit. While a cellular automaton model was used in [3], we investigate the details of effects of an obstacle focused on its position using SF model. It is reasonable to use SF model which has a gridless algorithm because we can control the position in detail, although it is difficult for cellular automaton model which has a grid structure. Hence we start to investigate the effects that pedestrians can evacuate faster which are caused by the presence of an obstacle in room evacuation and we will show that SF model with an obstacle can exhibit the same results as in [3]. Finally, we determine the optimal position of the obstacle in evacuation.

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Diffusive Transport on Directed Random Networks

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We study diffusive properties of non-interacting particles on directed random networks, motivated by the structural polarity of the actin filamentous structures in biological systems. We consider a static complex network consisting of N directed intersecting filaments distributed on a plane of area A. Denoting the segment length between two neighboring intersections by ℓ and the angle between two intersecting filaments by θ, the network structure can be characterized by $F(\ell)$ and $R(\theta)$, the distributions of the step length and the rotation angle, respectively. The transport problem is studied by introducing a master equation for the probability $P_n(x, y|\theta)$ of arriving at the vicinity of position (x, y) along the direction θ after the n-th step. Using an analytical Fourier-$z$transform technique, we present expressions for the diffusion constant and the transport mean free path in terms of the moments of $F(\ell)$, and the rotation and persistence probabilities for arbitrary $F(\ell)$ and $R(\theta)$. The method enables us to investigate the influence of structural inhomogeneity of the network on the transport properties. The analytical results are compared with numerical simulations of random walk on diluted lattices as well as random filamentous networks. The approach can be more generally applied to other problems which can be described by a similar master equation, such as light transport in disordered media.

Stochastic cargo transport by teams of molecular motors.

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Many different types of cellular cargos are transported bidirectionally along microtubules by teams of molecular motors. The motion of this kind of objects has been experimentally characterized *in vivo* as processive with rather persistent directionality.

By means of an effective theoretical approach, introduced by Müller et al. [2], it has been argued that the dynamics of these object are the result of a tug-of-war between different kinds of motors. This picture has been questioned in a recent article by Kunwar et al. [1], who considered the coupling between motor and cargo in more detail.

In this contribution we discuss the effect of different motor properties and external forces on the cargo. We compare the model results with experimentally observed dynamic patterns of bidirectional cargo transport.

10:10

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Fluctuations and cooperative properties of molecular motors: from theory to experiments

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11:00

As a result of the recent breakthroughs in high-resolution single-molecule techniques, it is nowadays possible to reliably observe and quantify fluctuations in the completion time of an individual enzymatic cycle and, from the statistics of these variations, extract information on the enzyme's features. However, the complicated interplay between different enzymes and their cycles could determine unexpected outcomes when the molecules are not in an isolated contest, e.g. when tracking molecular motors *in vivo* or when studying the movement of ribosomes translating an mRNA. In fact, although cooperative effects of processive molecular motors have been largely studied in the literature [1], the role of their kinetic cycles has often been neglected. As a consequence, most of the models cannot capture the collective properties emerging from the intrinsic particle kinetics.

We extend the standard exclusion process describing the movement of motors on a linear substrate by considering particles with an internal degree of freedom mimicking their enzymatic (stepping) cycle [2]. Furthermore, here we explain how the kinetic states induce non trivial collective behaviours of processive motors and therefore strongly influence the fluctuations of the system [3]. We finally compare the efficacy and reliability of the proposed method with experimental results related to mRNA translation [4].

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Realistic Stride Length Adaptation in the Optimal Steps Model

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The Optimal Steps Model (OSM) (Seitz & Köster, 2012) uses local optimization on a circle around a virtual pedestrian to determine the next position on a navigational field. The navigational field is given by a superposition of attracting and repelling forces. Each pedestrian seeks the most advantageous position on the surrounding circle. The stride length, that is, the circle radius is adapted to each pedestrian's speed according to the near linear interdependency between walking speed and stride length given in (Seitz & Köster, 2012). The model performs well in typical test scenarios: e.g. the dependency of velocity on the crowd density (Weidmann, 1993) and queuing at a bottleneck (Liddle et al., 2011) are well captured.

The current handling of the stride length as a function of the speed, however, introduces a delay in adaptation, because the speed can only be measured in the past. As a result, pedestrians emerging from a dense crowd continue to walk with tiny steps for a short while. Pedestrians approaching a location that is difficult to navigate do not always find a better position when they try to use a long stride and may be forced to stay put for one simulation step before they adapt the step size.

A real person is more likely to reduce his or her normal step length when there is no room or navigation is difficult. The speed reduction is a result of the current navigational situation. This can be modeled effectively if the next pedestrian position is determined on a disk instead of a circle. The radius of the disk is chosen to be the stride length that corresponds to the pedestrian's free flow velocity. This leads to a two dimensional continuous optimization problem that must be solved efficiently to maintain fast computational speed. We describe the emerging numerical problem and its efficient solution.

Then we demonstrate how the position search on a disk leads to a closer match of real walking behavior. We show navigation around a column in a narrow corridor, a bottleneck scenario, and the emergence of single pedestrians from a dense crowd.

ABSTRACT

A simple statistical method for reproducing the highway traffic

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Some of the most important questions concerning the traffic flow theory are centered around the correct functional form of the empirical flow-density fundamental diagram. The macroscopic and microscopic spatio-temporal properties of highway traffic have usually been reproduced by the dynamic behaviour of simple cellular automata. Nevertheless, a random mechanism to find the equilibrium states just from the driving rules remains unknown.

Here we implement a simple Monte Carlo sampling from the driving rules to generate at random the traffic states on the road and, the equilibrium states are found as the most likely configurations at a given global density. The method consists of randomly throwing cars into the road, then give them the maximum velocity which is defined by the rules of cellular automata and by the distance headway. The highway traffic state is obtained by measuring the spatial variables for these random configurations, each of these correspond to a point in the fundamental diagram . Finally, we constructed a frequency histogram for these states and we identified the most likely regions as the equilibrium states.

The most important finding is that without any dynamical simulation, the method is able to reproduce the fundamental diagram for two cellular automata: the deterministic STCA model and the Olmos-Muñoz model developed for Bogotá [1] (this one also including experimental data).

This Monte Carlo approach to the traffic problem may be an interesting and enlightening alternative for the study of traffic flow.

11:50

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Controlling of vehicular traffic flow at a intersection via two schemes of traffic lights

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By means of extensive Monte Carlo simulation, we have investigated the flow characteristics in a signalized intersection via developing Nagel-Schreckenberg cellular automata model for two perpendicular one-dimensional closed chains each having L sites. The chains represent urban roads accommodating unidirectional vehicular traffic flow from south to north in the first chain and from east to west in second chain. Vehicles are not allowed to turn. The discretization of space is such that each car occupies an integer number of cells denoted by L_{car}, so we are able to reproduce the realistic acceleration. A set of traffic lights is used to control the traffic flow. We have obtained the fundamental diagrams which show that hindrance of vehicles upon reaching the red light gives rise to the formation of plateau region. The plateau region has role as a single impurity in one-dimensional out of equilibrium systems. The overall flow exhibits the significant dependence on the cycle time of traffic lights and on the queue-length. Moreover, we have sketched the space-time plots which show the car spatial distribution is more homogeneous in traffic responsive scheme in comparison with fixed time scheme, which is due to the randomness in cycle times.

Coarse Analysis of Traffic Jams in a Microscopic Traffic Model

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Traffic flow including traffic jams has been modelled with different methods reaching from individual car models to a description by car density using partial differential equations (PDE), e.g., Burgers equation. On the one hand, a lot of progress has been made in understanding and analyzing traffic jams as travelling waves in PDE models. A disadvantage of these models is the difficulty to investigate the influence of driver behavior on the formation of traffic jams. On the other hand, a detailed model for each car allows for the study of driver parameters, e.g., distribution of desired target velocities or typical agressiveness. The drawback here is, that these models usually require a large number of cars to study traffic jam phenomena and therefore result in dynamical systems with a large degree of freedom. This increases the effort to run numerical simulations and makes the understanding of macroscopic phenomena, i.e., traffic jams, complicated. As a microscopic model, we use the optimal velocity model, introduced by Bando et al., to study traffic jam formation on a ring road. Depending on two parameters in the optimal velocity function, i.e., desired velocity and typical headway, the system shows either a uniform car flow or a one-pulse traffic jam, i.e., a travelling wave. The traffic jam formation is studied on a coarse level using so-called equation-free methods, introduced by Kevrekidis et al. In order to apply equation-free methods it is necessary to define two operators, called lifting and restriction. The restriction operator is defined by the choice of a macroscopic variable, i.e., the standard deviation of headway profiles in our case. The lifting operator is used to initialize the system at a microscopic state, i.e., a headway profile, from a macroscopic state. We recently introduced implicit equation-free methods to study the system with tools known from the theory of dynamical systems, namely bifurcation analysis and coarse projective integration. The stable branch of a traffic jam is continued using pseudo-arclength continuation to a set of critical parameters, where the solution becomes unstable in a coarse saddle-node bifurcation.

Mathematical problems and theorems on saturated flows on chainmail

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- The study objects are complex socio-technical systems with functions of various kinds of communications: the transportation of mass, society, and information. In particular, one kind of such systems are saturated flows of road and rail transport.
- In this paper the substance transport model is presented in the form of homogeneous clusters, moving according to Newton's first law without interaction. Interaction scenario is postulated, for example, based on the classic studies of Lighthill-Whitham (Renkine-Hugoniot condition), [3], and the modern physical concepts, [2]. In the case of a single-lane movement of homogeneous cluster is the limit state of the chain following the leader, [1].
- Communications networks are considered as the unit cells construction, i.e. circuits allowing the decomposition of real complex networks. Chain-mail is a multi-dimensional network of engagement rings. In the early Russian history one of the options of the network used defenders Russia as an outer garment. Chailmail, as the shape of transportation network, allows to divide into local and global components.
- We study some basic constructions based on the deterministic and stochastic approaches. For exactly posed problems the mathematical results were obtained, i.e. theorems with proofs.

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Local stability conditions and calibration procedure for new car-following models used in driving simulators

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The intelligent driver model (IDM) [2] has been studied with linear analysis for local stability. Necessary and sufficient conditions are obtained which guarantee a non-oscillating solution about the equilibrium for the case of n vehicles moving one by one. The calibration procedure suggested is based on a numerical solution of the constrained optimization problem. Nonlinear constraints are generated by the numerical integration scheme. The suggested procedure incorporates the obtained local stability conditions and takes into account vehicle dynamics, drivers behavior, weather conditions.

Several drawbacks of the IDM with respect to driving simulators are outlined and two modifications of the IDM are presented. The first one gives any predefined distance $d^* = d^*(v)$ to the leading vehicle in a steady state. The acceleration of the ith vehicle is as follows:

$$\dot{v_i} = w(h, d^*, D)a\left(1 - \left(v_i/v^0\right)^\delta\right) + (1 - w(h, d^*, D))a\left(1 - \left(d^*/h_i\right)^2\right) \quad (1)$$

Here w is the continuous weight-function, which depends on headway h_i and parameter D. The second modification is a combination of the first one and the optimal velocity model [1]. This modification takes into account drivers reaction time τ explicitly and is described by delay differential equation. Suggested model always results in realistic vehicles accelerations what allows simulating real traffic collisions. Stability analysis and suggested calibration procedure have been carried out for both modifications.

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Physically bounded solution for a conserved higher-order traffic flow model

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The higher-order model of traffic flow has been intensively studied. Although the system takes the form of mass and "momentum" conservations, the solution does not share the total variation diminishing (TVD) property with those for most hyperbolic conservation laws. This is mostly because of a relaxation source term by which the solution to the system is often unstable with oscillations. Thus, physically bounded solutions to higher-order traffic flow models should be a great concern. The first concern might be associated with Daganzo's critics [2] of so called "isotropic" models, e.g., the PW [5, 7] and KK models [3], which were believed to result in reverse flow mainly because the second characteristic speed is greater than the motion speed. The concern was followed by the proposition of so called "anisotropic" models [1, 8], of which the second characteristic speed is equal to the motion speed. Although reverse flows seem to be avoided in these models, the belief is only based on simple analysis and numerical simulation. Regardless of "isotropic" or "anisotropic" models, another concern should moreover be associated with an equilibrium constant solution which suggests congestion and thus is unstable with oscillation and evolution into stop-and-go waves. Actually, that the density is over the maximally allowed value in such evolution is possible if the parameters of the model are not confined to certain regions; the overflow was indicated in [9, 6]. Zhang et al. [4] proposed a conserved higher-order (CHO) model in a concern with physically bounded solutions based on the study of characteristics of the model equations. However, the investigation was limited and the conclusions were incomplete.

The present paper serves as supplement to the reference [4] by implementing a systematical and concentrical study of the physically bounded solution to the CHO model. The discussion is associated with the stability of an initial state by dividing the velocity-density (or flow-density) phase plane into several regions.

15:15

FRIDAY, 27.09.

Evolution of road networks

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The road network is a crucial component of urban systems: its growth and evolution reflect how a city changes in time. This network is both embedded in space and evolves in time, and we thus have to face the difficulty of measuring and characterizing its evolution, and to extract useful information. I will illustrate in this talk these various problems and present some recent results on empirical case studies. If time allows, I will also mention various directions for modeling these systems.

ABSTRACT

Equation-Free Analysis of the Collective Behaviour of Microscopic Pedestrian Models

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In many relevant applications microscopic models are given but one is interested in their macroscopic behaviour. For cases where it is difficult or even impossible to obtain by analytical methods equations which describe the macroscopic behaviour, an equation-free approach can be used. We consider two situations of pedestrian crowds as examples where the pedestrians are modelled by pairwise interacting particles. First, pedestrians move along a corridor and two crowds are aiming, from opposite directions to pass through a narrowing doorway perpendicular to the corridor. The collective behaviour of the pedestrians is investigated in two parameters, the width of the doorway and the ratio of the pedestrians velocities of the two crowds. A Hopf bifurcation point is found and continued with equation-free methods in these two parameters. The resulting line of Hopf points in the two-dimensional parameter space separates oscillatory from non-oscillatory net flux through the doorway. Second, the evacuation of a room with one exit is investigated. In particular we focus on the question to which extend obstacles in front of the emergency exit influence the pedestrian flux through the exit. Detailed parameter studies obtained by continuation methods will be presented and show clear and sometimes counterintuitive effects of the obstacle.

09:45

Simulation of panic-driven pedestrian dynamics in Madrid Arena

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This study of pedestrian dynamics under panic responds to a tragic incident in Spain on 31 October 2012, at the Madrid Arena. Security personnel failed to control distribution of the crowd, leading to the crushing death of five teenagers when the passageway to the central court was blocked. A few people attempted to leave the court; but a larger number - excited by the music, a desire to be a part of the action, and alcohol - were moving in the opposite direction. In the semi-darkness, people were unable to see what lay in front or behind. Security cameras recorded as many as five avalanches of people at the three-meter-wide passageway that ended with a deadly bottleneck lasting for many minutes. The cameras revealed that one of several fireworks explosions set off the panic, with smoke and sparks triggering the disastrous final bottleneck. The incident was characterized by shoving, inability to move in any direction, rising temperatures, screams and general panic. Some found themselves lifted off the ground, supported by elbows against their ribs. Those of smaller build, particularly girls, were drawn down under the crush of bodies. Autopsies on the five found suffocation and consequent brain damage due to anoxia.

We developed a method for simulating various hypothetical scenarios in the Madrid Arena, to determine force distribution and evacuation rates among pedestrians. Pedestrian velocity was determined from Newton's equation of motion, taking into account visco-elastic contact forces, contact friction, and desired velocity. In our computer simulation, non-spherical shapes (spheropolygons) modelled the arrangement of the chest and arms in the packing arrangement of pedestrian bodies - based on a cross-sectional profile using data from the US National Library of Medicine. Motive torque was taken to arise solely from the pedestrians' orientation toward their preferred destination.

Individual-specific risks in crowd evacuations

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1 Abstract

Safely evacuating large numbers of people from vehicles or buildings poses a considerable challenge and unfortunately crowd disasters that claim dozens or even hundreds of victims are still a sad reality. Most research considers crowds of people as a whole and investigates, for example, how long it takes an entire crowd to evacuate. We shift the focus from the crowd to the individual and use three complimentary approaches to investigate the relative risks individuals experience as a result of their physical, cognitive or social circumstances.

First, we use individual-based simulation models to assess how the crowd pressure forces experienced by agents and their evacuation times depend on individual characteristics, such as stamina and position at the onset of the evacuation. We find that the initial distribution of agents with different characteristics ('seating plan') can have a profound effect on the evacuation of the entire crowd and of individuals within crowds. These findings enable us to develop optimal seating plans.

Second, we explore 'tactical level' individual behaviour that is not an immediate response to the local environment. We use an interactive virtual environment in which human subjects have to escape from a building in simulated evacuations. We find that under stress, subjects are more likely to evacuate via a known route even if it is jammed by simulated agents, a behaviour detrimental to their evacuation time. We also test subjects' adherence to known routes as well as the effect of being part of a social group, signage and crowd dynamics on subjects' decisions regarding exit routes or evacuation timing.

Third, we conduct evacuation trials with volunteers to investigate visual attention in evacuations. Visual cues are an important source of information to humans. We explore the dynamics of how humans acquire information in known and unknown environments and the relative importance of social and environmental signals in shaping individuals' decisions. For example, individuals are more successful in detecting visual signals in unknown environments, but in known environments, groups react faster to visual signals.

Pedestrian Behavior Analysis with Image-Based Method in Crowds

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In this paper, we aim to investigate the image-based approaches and propose a novel technique to examine the pedestrian flow on various real situations. This research is inclined on two main aspects: first, an in-depth analysis of image-based approaches is given particularly for the situation containing large number of pedestrians (i.e., crowd) and second, our proposed approach which mainly focus on integrating the low-level features with dynamic data, modeling, and classifying the corresponding behaviors of pedestrians. The objective is to compute the dynamic contents depicting the self-evolving characteristics of pedestrians during normal behavior and emergency situations. But, how can we first glean the meaningful information prior to modeling and classification of these behaviors. The resulting dynamic data establishes a large cloud of information (i.e., correlated or un-correlated data) especially in video streams. Therefore, it is essential to extract the meaningful information from the data cloud however the selection of criteria is a crucial task which is answered in the first part of our paper.

In particular to video streams, it is challenging to extract individual characteristic (e.g., head, torso, or leg count) of every pedestrian forming crowd. Because, the pedestrians do not own these characteristics while moving in the form of groups with consistency. Therefore, we can not rely on such individual information of every pedestrian for longer time instances. Based on this fact, in this research, we exploit the saliency features over a time window T. Further, we measure the dynamic contents for these computed saliency features. After this, we model this information by computing the histogram of flow (HOF) for each time instance which is the main feature. Later, we classify these HOF features according to our behavior-specific classes. We have tested the proposed approach on "Angry Rooms" scenario. The dataset is recorded with the help of approximately 30 volunteers. In the context of characterization of pedestrian behaviors, we have employed Support Vector Machines on our recorded dataset and achieved 97% classification rate.

Dynamic Structure in Pedestrian Evacuation: Image Processing Approach

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We show that there exists a dynamic lattice structure in pedestrian evacuation system which is governed by social force (SF) model [1] by using image processing. It is well known that the simulation of pedestrian evacuation from a room with SF model shows "faster-is-slower effect"[1]. We are investigating the phenomenon from the viewpoint of "dynamic arch" [2] to understand the physical property of the system. Inspired by the works that visualize the particle flow [3, 4], we show the existence of "dynamic arch" or the state of dynamic equilibrium in the evacuation system of SF model combined with image processing. We generate the time averaged image from snapshots of the simulation. The resulting image can be interpreted as the probability distribution of the presence of a particle. This method is analogous to the one for "static arch" [4], but the aim here is to visualize the dynamic structure in the system. Note that the number of particles in the system is fixed in this simulation, which means particles are added in an appropriate manner to investigate equilibrium state [5] . The specific flow structure for each time scale is observed. For more application, we are planning to discuss the stiffness of arch and efficient geometry of wall or a position of an obstacle for faster evacuation.

11:50

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Human-Ant Behavior in Evacuation Dynamics

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During a life-and-death situation a highly competitive crowd could rush towards the exit causing a blockage. An example of this phenomena was observed at "The Station" nightclub fire (2003, USA).

On the contrary, social insects do not follow this behavior. Recent experiments [1, 2, 3] have shown that ants (*Camponotus mus* and *Linepithema humile*) do not cause jams near the exit for none of intensities of the different aversive stimuli considered (chemical repellent and heat). The ants maintain their cooperative behavior even in situations of "emergency".

From these results it is clear that the information obtained from ants should not be extrapolated directly to human systems. However, keeping in mind the opposite behaviors displaying by ants and humans, some valid questions can be asked:

- How the evacuation performance of a crowd can be enhanced if a fraction of the people would follow the ant strategy?

- What is the optimal of this fraction to maximize the evacuation performance and minimize the blockage probability?

In order to answer these questions, the room evacuation problem was simulated using the social force model [4] considering different mixtures of both behaviors for the simulated pedestrians.

12:15

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ABSTRACT

Escape Velocity of the Leader in a Queue of Pedestrians

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14:00

Summary. The propagation speed of a starting wave, which is a wave of people's successive reactions in the relaxation process of a queue, has an essential role for pedestrians to achieve smooth movement. In the previous study [1], we have characterized the fundamental relation between propagation speed of a starting wave (a) and initial density of a queue (ρ) by the power law $a = \alpha\rho^{-\beta}$ ($\beta \neq 1$), where α and β are positive parameters. In addition, it is also significant that walking velocity of the leader of a queue is appropriately controlled to the escape velocity, where the flow in a queue becomes maximum and the queue is inseparate. For example, if the leader moves fast enough, it becomes difficult for the followings in the queue to keep up with the leader. On the other hand, if the leader moves very slowly, walking velocity of the followings is limited by the leader. In order to investigate how the behavior of the followings changes with the leader's velocity, we have performed the experimental measurements of real pedestrians. In our experiment, we set up two cameras mounted on the window of 5th floor to track the trajectory of pedestrians in a queue. Only the walking velocity of the leader was controlled by three kinds of tempos (slow, normal, and fast) on earphone, which are created by the electric metronome. The leader starts to walk after setting up the tempo, and then the followings move forward in order from the front of the queue. As a result, we have found that the difference between the walking velocity of the leader and the last, becomes large in the case of fast walking velocity, that is, the followings can not keep up with the leader. In this contribution, we will discuss the experimental data in detail by quantitative motion-image sequence analysis.

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Experimental study on the interaction mechanism of the cross-walking pedestrians

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Abstract
In the field of pedestrian dynamics, the interaction mechanism among pedestrians is significant for both system modelling and evacuation designing. In this study, a cross-walking experiment is conducted in two crossed passageways to investigate the microscopic interactions between individuals. Trajectories of fifty-one groups of pedestrians movements are extracted by means of image processing. Four main behaviours, i.e. accelerating, decelerating, detour and keep-walking, are identified when pedestrians walk crosswise. The pair velocities before and after the cross point are also calculated and classified to three modes: the first mode is one accelerating with the conflicting partner decelerating, the second mode is accelerating together or decelerating together, and the third mode is one keeping speed with the conflicting partner accelerating or decelerating. It is found that to avoid conflict, 90.2 percent of participants take accelerated behaviour or decelerated behaviour and only 5.9 percent of participants take detour behaviour, which implies pedestrians prefer to adjust their speeds rather than change their directions when facing potential conflict. Particularly, 64.7 percent of groups of pedestrian avoid the conflict through the coordination mode, i.e. one accelerating with the other decelerating, which indicates the major self-organized behaviour of pedestrian. Two kinds of detour behaviour are also observed from the experiment: detouring ahead the conflicting partner and detouring behind the conflicting partner. It is found the detour ahead the conflicting pedestrian would induce an approximate lateral movement of 0.65-0.75m, larger than that of 0.55m when detouring behind the conflicting pedestrian. It is hoped that this study would provide some useful experimental data or conclusions for the research field of pedestrian traffic.

Keywords: Pedestrian dynamics; Self-organized; Evacuation; Experiment; Cross-walking; Interaction.

ABSTRACT

Inflow process: a counterpart of evacuation

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14:50

We propose a new concept of 'inflow process' of pedestrians as a counterpart of evacuation process. In the inflow process, pedestrians enter a limited area without hurrying. This type of pedestrian motion can be observed in our daily life, e. g. getting in elevators, trains, etc. On the other hand, in the research field of pedestrian dynamics, evacuation process has been mainly focused on. The evacuation process deals with emergent situations, in which people may panic, rush to exits, and be injured.

Most attempts to describe pedestrian motion with a model assume that the motion is a result of attractive force for desired place, and physical or psychological repulsive force among pedestrians and walls. From this perspective, we can see clear contrast between the inflow process and the evacuation process. In the inflow process, pedestrians do not have a destination; but instead they are driven by psychological force to secure their personal space. In contrast, in the evacuation, pedestrians do not care about psychological uncomfortableness, but strong driving force toward the outside of the room or building acts on them to secure their life. Thus these two processes can be regarded as two different limits in pedestrian motion.

In this talk, we also introduce a CA model [1] and experimental results ([2]; see Fig. 1) on the inflow process, and their distinctive characteristics will be shown.

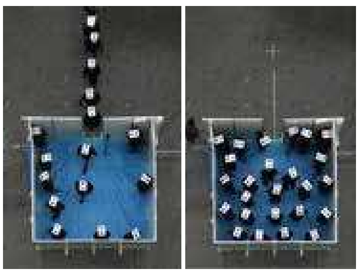

Fig. 1. Inflow process (experiment).

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Air Traffic, Boarding and Scaling Exponents

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Summary. The growing need for mobility through the world shows no sign of slowing down. The air traffic is a very important part of the global transportation network. In distinction from vehicular traffic, the boarding of an airplane is a significant part of the whole transportation process.

Here we study an airplane boarding model, introduced earlier by Frette and Hemmer [1], with the aim to determine precisely the asymptotic power–law scaling behavior of the mean boarding time $\langle t_b \rangle$ and other related quantities for large number of passengers N. The power–law scaling $\langle t_b \rangle \propto N^\alpha$ has been earlier stated in [1], with the exponent $\alpha = 0.69 \pm 0.01$ being evaluated from the data within $2 \leq N \leq 16$. Our analysis is based on Monte Carlo simulation data for very large system sizes up to $N = 2^{16} = 65\,536$. In analogy with critical phenomena, we have used appropriate scaling ansatz, which includes the leading term as some power of N, as well as power–law corrections to scaling. Our analysis clearly shows that the true (asymptotic) exponent α is $1/2$ ($\alpha = 0.5001 \pm 0.0001$). We have estimated also other exponents: $\nu = 1/2$ for the mean number of passengers taking seats simultaneously in one time step, $\beta = 1$ for the second moment of $\langle t_b \rangle$ and $\gamma \approx 1/3$ for its variance. The difference between the asymptotic exponents and the effective exponents, extracted from relatively small system sizes, is explained by corrections to scaling, which are described by the correction–to–scaling exponent $\theta \approx 1/3$. In relation to critical phenomena, this model can serve as a toy example, clearly demonstrating the importance of corrections to scaling and the necessity to consider very large systems to obtain correct values of the exponents.

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15:15

ABSTRACT

Microscopic Traffic-Like Characteristics of Zero-Range Processes, Comparison with Car-Following Models.

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The contribution focuses on microscopic characteristics of traffic flow represented by the time- and distance-headway distribution and their interpretation in particle hopping systems with accent to zero-range processes. Considering traffic models based on zero-range processes, mainly the fundamental diagram and jam ordering were analyzed and compared to real traffic ([1], [2]). We aim to analyze the headway distributions in such models similarly to [3].

The discrete nature of particle hopping processes does not allow to investigate the correspondence with real traffic by means of the continuous distribution approach useful for thermodynamical models [4]. Therefore, our goal is to extract hopping rates of considered ZRP by mapping the continuous traffic flow on the discrete lattice. As the reference system the Intelligent Driver Model is used. By means of the simulations, necessary conditions for hopping rates of ZRP are extracted with respect to microscopic characteristics of the discretized view on the IDM model.

Above mentioned results are discussed within the scope of considered models and their behaviour.

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A Review of Cellular Automata Model for Heterogeneous Traffic Conditions

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Summary. Over the years various microscopic models were developed to predict vehicular behaviour from mid-block section of road to the network level. In microscopic simulation model each vehicle is described by its own equation of motion, hence the computational time and memory required are greater for these models. In this context cellular automaton (CA) is found a promising approach to meet this challenge in recent past. A CA approach to traffic simulation is potentially useful in order to achieve a very high computational rate in microscopic simulation, and to facilitate distributed computing. Because of this CA models are becoming increasingly popular for their potential to simulate large scale road network using macroscopic traffic characteristics like flow and density. Previously due to coarser cell size these models were only good for homogeneous traffic conditions having no two wheelers or three wheelers and where drivers maintain lane discipline.

However due to the continuous improvements in computing power researchers have tried to reduce the cell size. This is done in order to incorporate more vehicle types even bicycles and capture microscopic interactions like acceleration/deceleration, platoon formation, work-zone and intersection modelling to better represent traffic at microscopic level. Further, it has enabled the application of CA models in heterogeneous conditions. Thus, there is a need to incorporate additional longitudinal and lateral movement rules to capture staggered movement behaviour of the follower to anticipate leaders speed and lane keeping behaviour as observed in heterogeneous traffic conditions. Also a conventional CA model does not consider speed of leader vehicle to determine the speed of follower vehicle unlike continuous car-following models. This leads to unrealistic deceleration of vehicles to avoid collision and raising doubts over its capability to model microscopic behaviour.

This paper provides a brief review of CA models developed for heterogeneous traffic conditions and provides insights for improvement. Model performance is evaluated using microscopic characteristics like speed, acceleration/deceleration, headway and lane keeping behaviour obtained from vehicle trajectories. The data collection was done on arterial roads in Ludhiana, India for this study.

ABSTRACT

A bounded acceleration interpretation of capacity drop and traffic hysteresis.

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Abstract. The object of this paper is to analyze the impact of merges, lane drops and incidents on capacity drops, a very important aspect for motorway operations. Traffic is assumed to be described by a LWR model [3] and [4], and the area subject to some capacity restriction is described by an internal state node model [1]. This model is modified in order to accomodate the impact of the boundedness of traffic acceleration as introduced in [2]. Some specific aspects of this model (phase transition) will be analyzed in depth. The dynamics of the node result from interaction of the node's supplies and demands with incoming demands and outgoing supplies. We thus generalize the approach initiated in [5].

It will be shown that the model accounts for capacity drop and hysteresis phenomena; the analysis extends to the case of merges. Comparisons will be carried out between the model and data collected within the Marius project (Marseille) for traffic management and driver information.

11:00

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A demonstration experiment of a theory of jam-absorption driving

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We have conducted an experiment to demonstrate a "jam-absorption driving", which is a method of driving with a car to avoid being entangled in a jam by changing its headway and velocity dynamically. This method was discussed without theoretical aspects [1], but recently, a simple theoretical framework was proposed with a kinematic-like traffic model [2]. As a next step, we experimentally verify this driving method with real cars on a circuit. In the experiment, based on the theory, the car doing jam-absorption driving takes a long headway in advance before a jam comes. It is found the jam is removed by this driving as the theory indicates. Besides that, comparing with the case of any car not taking the method, travel times and fuel consumption improve about 5% and 20%, respectively.

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ABSTRACT

Generic first-order car-following models with stop-and-go waves and exclusion

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Summary. Microscopic car-following traffic flow models are investigated. Many delayed first-order or second-order models with unstable homogeneous configurations are developed in the literature. The obtained non-homogeneous stationary states can be non-physical if the presence of collisions is not controlled. Yet, combining the exclusion between the vehicles and instability leads to multiple constraints, hardly exploitable. For that purpose, one develops and analyses two parsimonious models ensuring intrinsically the exclusion. The models are generic first-order ones, based on an optimal speed function and a reaction time parameter, and having the same stability conditions as classical delayed first-order or second-order models. After the analysis of the stability, the non-homogeneous stationary states of the models are described by simulation. If the speeds are homogeneous for low (free) density levels, bimodal speed distributions are observed for interactive density levels, with the stable propagation of kinematic stop-and-go waves. Experiments show how the modal speed values vary with the density level, by using piecewise linear, convex, concave or sigmoid optimal speed functions.

Keyword : Car-following model – Collision – Unstable homogeneous configuration – Stop-and-go wave – Bimodal velocity distribution

Influence of Velocity Variance of a Single Particle on Cellular Automaton Models

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Velocity of self-driven particles such as vehicles and pedestrians is not always exactly constant. Even if one particle moves straightly in vacant space without any interaction with other particles, its velocity fluctuates. Hopping probability in stochastic cellular automaton models well represents this phenomenon. However, the effect of velocity variance of a single particle (VVSP) has been seldom discussed, since the hopping probability does not only control the variance but also influences the mean velocity of a particle.

In order to analyze the effect of VVSP, we have newly developed a simple method that enables us to control VVSP without changing the mean velocity. By using this method, we have succeeded in investigating the effect of VVSP on cellular automaton models. Fig. 1 shows the normalized maximum flow in the totally asymmetric simple exclusion process with $V_{\max} \geq 2$ against the hopping probability p. When our method applies to the model, increase of p corresponds to decrease in VVSP and vice versa. Therefore, we see that the normalized maximum flow increases when VVSP decreases in Fig. 1. It is also observed that when $V_{\max}$ is small, the normalized maximum flow greatly changes against the change of p, whereas, when $V_{\max}$ is large, the change is small. This result implies that $V_{\max}$ weakens the effect of VVSP on the flow.

We have also analyzed the stochastic quick-start and slow-start model, and a simple evacuation model by our method. VVSP decreases the flow in the former two models but increases it in the simple evacuation model. Furthermore, it is investigated that the effect of VVSP is strengthened or weakened by the characteristic parameters of the models.

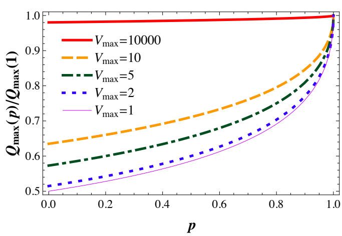

Fig. 1. Normalized maximum flow against hopping probability p.

GSOM traffic flow models with eulerian source terms.

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Abstract.
The GSOM (Generic second order modelling) family has been introduced in [3], with the idea of providing a generic framework to a large fraction of current macroscopic traffic flow models. Traffic dynamics in a GSOM model can be described by the combination of two distinct processes: i/ kinematic waves, such as described by the LWR model [4], [5], ii/ the dynamics of driver specific attributes (driver behaviour, vehicle class, destination, stochastic perturbations etc), which are described by ODEs (ordinary differential equations) and which are essentially lagrangian.

Some models such as [**?**] or [6], can be viewed as GSOM models perturbed by some eulerian source terms. The resulting dynamics are complex. We propose in the paper to analyse this problem by taking advantage of the existence of a variational formulation of the GSOM model [2] in order to estimate quantitatively the impact of the eulerian perturbations. Basic properties, numerical schemes will be derived and applied to examples.

14:00

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Critical density of experimental traffic jam

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In the previous experiment, we have demonstrated that a traffic jam emerges without any bottlenecks at a certain high density[1]. In the present work, we performed an indoor circuit experiment in Nagoya Dome and estimated the critical density. The circuit is large (312m in circumference). Positions of cars were observed in 0.16 m resolution. We performed 19 sessions by changing the number of cars from 10 to 40. We found that jammed flow was realized in high density while free flow was in low density. We also found the indication of metastability at an intermediate density.

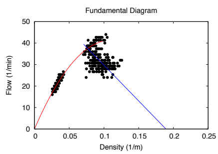

Fig. 1. The fundamental diagram for the selected sessions.

The critical density is estimated by analyzing the fluctuation in speed and the density-flow relation (Fig. 1). The value of the critical density locates between 0.08 m^{-1} and 0.09 m^{-1}. It is consistent with that observed in real expressways.

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14:25

ABSTRACT

Weather and Road Geometry Impact on Driver Behavior: Experimental Set-Up and Data Collection

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Transportation researchers tried for decades to investigate the dynamics of traffic flow in order to "optimize" the movement of goods and people under different surrounding conditions while reducing the negative environmental impacts and the economic losses due to congestion and traffic incidents. An important aspect missing from some previous studies relates to the activities through which drivers process the information representing a given surrounding. Such activities include: perception, evaluation, judgment and execution. Recognizing such limitation, the objective of this paper is utilize a 3-D driving simulator to advance the state of knowledge related to driving behavior while considering the surrounding environments impact (weather and road geometry) on drivers' decision-making logic.

Through a thorough literature review, the authors looked at the external factors that may impact longitudinal driving behavior [1, 2, 3, 4]. The major factors considered include visibility level, road friction, curvature, gradient, median existence, lane width and shoulder width. The literature review is then translated to an experimental set-up with variables that "parameterize" the external environment's characteristics. A total of 36 students and staff from the George Washington University, 26 male and 10 female, with varying driving experience participated in the experiments. The participants drove behind a yellow cab which speed patterns are dictated by real-word trajectories taken from the NGSIM data [5]. The collected performance measures include accelerations, speeds, longitudinal and lateral coordinates of the subject vehicle and the lead vehicle.

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Mobility Modelling in a Process Constrained Environment

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We present an empirical study of the movement of nurses working at a neonatal intensive care unit (NICU) within a UK hospital.

Aim: The aim of this study is to model the mobility of individuals within a process constrained built environment. Our objective is to create a model that recreates room occupancy distributions - this implies that we require a room transition model that predicts a person's next destination as well as a dwell model that predicts how long a person will stay in a room.

Significance: This class of situation is of theoretical and practical significance because nurses' movements are driven by sequences of purposeful activity that are logically and temporally constrained i.e. process constrained. Understanding the movement of people constrained by processes is of practical importance as it may enable process improvements and more accurate provision of space in buildings (such as hospitals and airports) and thus contribute to making safer and more efficient built environments.

Method: We used Ekahau Wi-Fi location tracking tags to collect room transitions of 10 day-shift nurses within a NICU for a period of 28 days from 08:00 Tuesday 14th June 2011 to 20:00 Monday 11th July 2011. We use this dataset to evaluate four proposed models of room transition: 1) random model; 2) an occupancy and distance model; 3) an attractiveness model; 4) a full transition matrix model.

Conclusion: We have identified the underlying statistical and probabilistic models that govern mobility in process constrained environments, which comprise a dwell model combined with a room transition model. To validate the results, analysis of the goodness-of-fit between empirical data and model predicted room occupancy distributions will be presented.

Further Work: There are many opportunities for further work in this area. There is a need for generic mobility models that take into account process constraints and make reliable predictions of room and corridor occupancy in built environments. There is also a need for mobility models where the process/processes are known and specifiable in advance.

LIST OF POSTER

LIST OF POSTER

From Drivers to Athletes – Modeling and Simulating Cross-Country Skiing Marathons

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Traffic flow of athletes in cross-country skiing marathons is an interesting example of a system of driven particles. The *Vasaloppet*, a 90-km race in Sweden with about 15 000 participants, is the most prominent example. Several other races attract up to 10 000 participants. Consequently, "traffic jams" among the athletes occur regularly. They are not only a hassle for the athletes but also pose organisational or even safety threats. While there are a few scientific investigations of the traffic around such events, we are not aware of any investigations on the dynamics of the crowd flow in the ski races *themselves*.

Unlike the athletes in running or skating events, the skiers in Marathons for the classic style (which is required in the Vasaloppet main race) move along fixed tracks, i.e., the traffic flow is *lane based*. This allows to generalize car-following and lane changing models to formulate a microscopic model for the motion of skiers. We propose a microscopic acceleration and track-changing model taking into account different fitness levels, gradients, and interactions between the athletes in all traffic situations. The model is calibrated on microscopic data of the *Vasaloppet 2012* (disaggregated with respect to the starting group representing the average fitness) at eight stationary locations. Using the multi-model open-source simulator `MovSim.org`, we simulate all 15 000 participants of the Vasaloppet during the first ten kilometers. We reproduce the observed stop-and-go waves on the starting field, and the congestion near the start. The congestion is caused by a steep uphill section and a simultaneous reduction of the number of tracks a few kilometers after the start and leads to a delay of up to 40 minutes for the last starting groups.

Simulating the model allows the event managers to improve the race organization by identifying bottlenecks, determining the optimum number of starting groups and the maximum size of each group, or optimizing the starting schedule. As an example, we simulate whether a staggered start instead of the traditionally applied simultaneous mass start (which is highly controversial) would help reduce or eliminate the congestions.

A discrete evacuation model considering crowd compressibility

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Abstract

In recent years, more and more crowd scenes appear with the increasing population. Thus pedestrians overlapping and compression become a common phenomenon. However most of discrete models have ignored these problems and can not express crowd compressibility towards evacuation. In the previous study, if a grid or cell is occupied by pedestrian, it is usually regarded that other pedestrian can not move toward the grid or cell. Actually, because of pedestrians compressibility, it is possible for the grid to hold several pedestrians. Thus in this study we put forward a parameter to reflect crowd compressibility, and meantime quantify the relationship between this parameter and the effect factors. If the compression parameter is high, it is more likely for one pedestrian move towards to the occupied grid, and vice versa. Here we mainly focus on three factors influencing pedestrians compressibility, i.e. panic factor, local pedestrian density and the distance to the desired destination. In the proposed model, When pedestrian is in the panic situation, it is easier for the pedestrian to endure the compression by others. And if the local pedestrian density is high, pedestrians overlapping and compression will more frequently happen. For the distance to the desire destination, when the distance becomes small, the pedestrians easily suffer from pushing and squeezing from other people, like pedestrians going on the bus or train. Furthermore we modify the transition probability of original floor field model by the compression parameter. Based on the modified model, we do the simulation experiment with a square room. The proposed model not only can reproduce the some typical phenomena, but also its simulation result is well consist with the output of the software. It is hoped that the improved model can reflect how crowd compressibility influences pedestrian evacuation in different situation.

Method to extract pedestrian movement parameters using RFID technology

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Abstract: Many researchers have conducted plenty of studies on the pedestrian dynamics, mainly including the modeling and experiments. The experiments could provide adequate data to verify the model and analyze pedestrian movement characteristics. Common methods of obtaining the pedestrian movement parameters include the video processing and the manual statistics. Nevertheless, these two ways both may be complicated and time consuming. In this paper, we propose a new method to calculate the velocity of pedestrian based on RFID technology. Single file channel experiments in daytime and dark scenario were conducted. There were five different groups of experiments and each one was repeated ten times. The velocity and the mean velocity of each people were extracted by both the common video processing method and the RFID method. The proposed method is validated by comparing with the velocities obtained from the two different methods. Compared with the velocities obtained by video processing, it is found that almost all the errors are less than 0.3m/s and more than 70% of the errors are less than 0.2m/s with the proposed method. The velocities calculated by our method obey the Gaussian distribution. We also compared with the velocities in daytime and dark environment obtained by the proposed method and found that nearly all the velocities in daytime are larger than or equal to the velocities in dark environment. The difference between the velocities derived from daytime and dark environment is significant through statistical analysis. It is also verified the new method is much easier than the traditional video processing and more time-saving than the manual process. It is hoped that through the method proposed in this study, more data about the parameters of pedestrian movement can be easily and quickly extracted.

New approach for simulation of pedestrian counter flow

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Abstract

A cellular automata model is proposed to simulate the pedestrian counter flow by incorporating some behavior rules of fish school. It is very interesting and meaningful to study pedestrian dynamics with a bionics approach. As an animal group, fish school performs many similar behaviors to humans. Prey, follow, swarm, and random move are some common behaviors of fish school, and collision preventation, velocity matching and centre focus are believed to be the three basic rules that dominate the group behaviors within fish school. Owing to its sensory abilities, fish has a sensing region, in which it can get the information of neighbors, and therefore, changes its own velocity and keeps the Nearest Neighbor Distance (NND) to others.

Inspired by these fish school behaviors, we apply a bionics approach to describe the pedestrian dynamics, and consider the sensing region, collision avoidance, follow, velocity matching, and other common pedestrian behaviors in this model. In this model, pedestrians have different velocities according to different situations. Different from the view filed or interaction area in previous studies, the sensing region here considers not only the number of pedestrians, but also their distances, velocities, and crowding degree, all of which affect pedestrians transition probabilities deeply. Then, we use this model to mimic the pedestrian counter flow under both open and periodic boundaries conditions. Compared with our pedestrian experiments, the model can well reproduce some typical phenomena, such as self-organized lane formation, phase transition, avoiding collision in advance, and velocity matching. The influence of the sensing regions size on the average velocity, critical density and average nearest neighbor distance are also studied. The results indicate that the modified cellular automata model with a bionics approach is very useful to simulate the pedestrian counter flow.

Observation and study of pedestrian flow on stairs with different dimensions

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Abstract: The movement of pedestrian on stairs influences the required safety evacuation time in case of fires. Much attention has been paid to evacuation study on stairs by experiments and modeling. In this study, the observational experiments are performed on four different stairs in a Chinese college campus. The pedestrian movements on stairs are recorded by video cameras and more than 2000 samples of pedestrian movements on the four stairs are collected. Based on the collected data, the speed distribution and the fundamental diagram for pedestrian flow on stairs are obtained and discussed. Moreover, the influencing factors on pedestrian speeds are analyzed using multifactor analysis of variance (ANOVA). The results indicate that the factors of stair dimensions, gender and grouping have significant influences on pedestrian speeds under normal condition. It is also found that the factors of gender and grouping have interactive effects on pedestrian speeds. Compared with no grouping, the factor of grouping decreases male's movement speeds by 10.48-27.83% for the four different stairs, while it decreases female's movement speeds by 3.42-11.85%, which indicate that the grouping has greater influences on male's movement speeds than female's. Besides, compared with female, the factor of male increases pedestrian movement speeds under no grouping by 11.86-22.98% for the four different stairs, while it increases pedestrian movement speeds under grouping by 4.01-8.48%, which indicate that gender has greater influences on pedestrian speeds under no grouping than grouping. The study concludes that the development of movement data down stairs and its application in evacuation research will promote the development of evacuation models and enhance the safety of evacuees in high-rise building.

First-order Macroscopic Pedestrian Flow Analysis: Non-Local Speed and Route Choice

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This paper concerns about the first-order macroscopic pedestrian flow in two-dimensional corridor which is continuum where pedestrians can freely move in any direction. The model uses the mass conservation law considering the non-local speed choice and non-local route choice which is interpreted with the force-based interaction of pedestrians with anisotropic characteristics. Numerical simulations of the initial-boundary value problems show the ability of the model in analyzing pedestrian movement with and without obstacles and some interesting phenomena can be found.

1 Summary

Firstly, some literature reviews about crowd motion are made. Secondly, a first-order conservation form is presented where the velocity is determined combining the speed and direction. The speed and direction is discussed not only in a local form, but also in a non-local form and the non-local form is the key point in this paper. Thirdly, force-based interaction of pedestrians with the anisotropic characteristics in our paper[1] is used to interpret the non-local effect and the former discrete one[1] is translated into a continuous one. Finally, numerical simulations of the initial-boundary value problems show the ability of the model in analyzing pedestrian movement with and without obstacles and some interesting phenomena can be found.

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A Measure for Estimating Self-organisation in Crossing Pedestrian Flows

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Self-organisation patterns in moving human crowds have been studied for more than a decade. Several patterns were found to appear in those crowds, such as bi-directional lane formation and stripe formation [1]. Depending on the angle at which pedestrian flows intersect either the first or the latter pattern arises. However, quantitative research of the self-organisation patterns arising during large-scale crowd movements has been limited. Measures able to identify the extent of self-organisation within these patterns are scarce. Biologists have studied the emergence of patterns within complex biological systems in a quantitative manner for some time by means of Polarization [2]). In the present study the effectiveness of Polarization and three other quantitative measures identifying the presence of self-organization within crowd movements are assessed.

Trajectories resulting from a laboratory experiment and several simulation data sets are used as a basis for the assessment. The laboratory experiment was performed by the Delft University of Technology [3]. The pedestrian flow situations were simulated using NOMAD ([4],[5]). In both the laboratory and simulation study two flow patterns were generated, being an crossing flow at a 90 degree angle and a bi-directional flow. In each of the experiments the existence of self-organisation is determined based on both visual examination, the cluster-method proposed by Moussaid et al. (2012), the measures proposed by Helbing et al. (2000) and the Polarization measure of Hemelrijk & Hildebrandt (2011). The differences with respect to manner in which self-organisation is portrayed by each of the methods is accordingly analysed.

It is found that not all measures capture the variation present within the self-organisation pattern over time. Especially the Cluster-method and Polarization give a good temporal indication of the presence of self-organisation. Furthermore, it is found that Polarization is a more effective measure for the identification of crossing flows, while the cluster-method is more effective for bi-directional flows. Both measures can henceforth be used as identification parameters in crowd management strategies.

Social Force Model Study Considering Evacuation Instructions

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Abstract A pedestrian is an individual with independent thinking ability in normal situation. Pedestrian traffic and evacuation dynamics is a kind of many-body system of strongly interacting persons. A great deal of factors should be taken into account in the study of pedestrian traffic and evacuation dynamics, such as human behavior, environment and architecture, especial in some typical emergency situation. In emergencies such as fire, evacuees will often tend to feel panic if they can't reach safety areas quickly, which is mainly due to not familiar with building environment or by the influence of fire and smoke. In such situation, evacuees will doubt the accuracy of current evacuation direction. Sometimes, they are likely to change the evacuation direction, even return along the original road, which will result in back run phenomenon and count-flow during evacuation. Obviously, back run phenomenon and count-flow will greatly reduce the evacuation efficiency, even will cause serious congestion in the evacuation route. In actual evacuation process, safety evacuation signs and the guidance of the staff for the evacuation process can cause certain effect, which can reduce the possibility of the count-flow. So, in evacuation simulation analysis, these factors, such as individual panic psychology and behavior, safety evacuation signs and the guidance of the staff, should also be considered, which will make evacuation model more in line with the actual situation, also increase the credibility of simulation results.

In this paper, we first build a physical function of panic psychology for the route choice of evacuee based on the traditional social force model, where the panic psychology can be affected by the visibility of evacuation path, evacuation time in the same direction, etc. With these modification, back run and count-flow phenomena are turned up during the simulation. Secondly, We introduce the safety evacuation signs and staff guidance into the social force model, which will change the evacuation direction for a certain evacuee to a certain degree. All these modification of social model seems to get more reasonable simulation results appropriate for the actual situation, especially for the emergency situation.

Keywords: Evacuation dynamics, Human behavior, Social force model

An expanded concept of the "borrowed time" as a mean of increasing isotropy in pedestrian dynamics simulations

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Discretization in numerical simulations holds big advantage of decreasing complexity of calculations, allowing for faster and larger-scale simulations. However, such a procedure leads to emergence of unwanted phenomena due to finite space and/or time resolution. For this reason when space is discretized usually regular lattices are used as they preserve highest rotational and translational symmetry.

In the presentation a method for measuring isotropy in multi-agent systems such as pedestrian dynamics will be proposed, namely the average speed isotropy. Usage of different grid types will be analyzed under this criteria with regard to different length scales. Concept of borrowed time will be introduced as a mean of decreasing anistropy without increasing complexity of calculations. It will be shown, that this concept can be expanded to further reduce anistropy at longer length scales. Finally, this approach will be compared with empirical data and its application for simulations will be discussed.

Deterministic vs. stochastic approach of Pedestrian Flow for Evacuation Modelling

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1 Abstract

Different works have considered the pedestrian flow from a deterministic point of view for modelling purpose as a relationship of density, speed and effective width [1]-[3]. However the flow value depends on several random factors, therefore it is a stochastic parameter. This paper explores the possibility to employ a deterministic versus a stochastic approach of pedestrian flow for evacuation modeling.

Firstly, we propose a methodology to empirically obtain the stochastic characteristics of pedestrian flow - per second and per meter - as a continuous random variable. This methodology is applied to real data from seven evacuation drills performed in different scenarios (Fig. 1) and the results are compared with data from scientific literature.

Secondly, we present a stochastic model that provides the total evacuation time by employing the random flow. Based on Monte Carlo methods, the model provides a sample of evacuation times and processes it.

Thirdly, a method is proposed in order to evaluate the error of using a deterministic versus a stochastic approach. This method is applied by using the stochastic model to different scenarios to establish the error in each case. A criteria for the acceptance level of errors are proposed.

Both, the method and the methodology are applied to a wide range of evacuation scenarios by varying the number of persons, the mean value and the variance of the flow. This is done to obtain the relationship between error and the related variables(Fig.2).

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Crowd modelling for a crisis

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1 Abstract

The project aims to develop upon the existing work on crowd simulation in the context of mass evacuation scenarios by utilising world-wide open spatial databases and computational mobility and behavioural models to achieve rapid simulation of large-scale evacuations as a response to major crises such as natural disasters or civil unrest. Another aim is to define an evacuation-friendly index for various administrative boundaries around the world and evaluate factors that give them such characteristics.

The recent Haiti relief effort benefited from web-based mapping efforts [1]. Analyses demonstrate that GIS tools were a key means though which individuals could make a tangible difference in the work of relief and aid agencies without being physically present in Haiti.

OpenStreetMaps [2] sets the initial stage for the project as it has consistently shown a better coverage for hard to reach places all over the world than other mapping platforms [3] due to crowd-sourced nature of information from the outset. Other means of crowd sourced social media indicators such as Twitter are considered as an early warning mechanism. Later on, crowd movement, urban centres, etc. will also need to be considered. The overall goal of the tool-kit is to help inform infrastructure planning and resource allocation in such a way that the least damage is felt during a crisis.

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Intelligent Image Analysis Methods for Crowd Safety During Mass Events

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The term socio-technical system was first used in the late 1950s early 1960s in different works of Tavistock Institute of Human Relations researchers, such as Eric Trist, Ken Bamforth, Fred Emery and others. In the paper Characteristics of socio-technical systems by F. Emery, the last revision of which was published in 1993, the following definitions are given:
A characteristic of open systems is that, while in constant commerce with the environment, they are also selective and, within limits, self-regulating.
The technological component, in converting inputs and outputs, plays a major role in determining the self-regulating properties of the enterprise. It functions as a major boundary condition of the social system in mediating between the ends of an enterprise and the external environment. Because of this, the materials, machines, and territory that make up the technological component is usually defined as "belonging" to an enterprise. They represent, as it were, an "internal environment."
Thus, it is not possible to define the conditions under which an open system achieves a steady state unless the "system constants" include mediating boundary conditions (cf. von Bertalanffy, 1950). The technological component has been found to play this mediating role. It follows that the open system concept, as applied to enterprises, ought to be referred to the socio-technical system, not simply to the social system.

Today, socio-technical systems are widely used in such fields of human activity, as:

1. Mining operations;
2. Transport and logistics;
3. Socio-ecological systems;

How idling pedestrians affect the overall dynamics. Real-life scenario examples at two major German railway stations

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Abstract Investigations in the area of pedestrian motion models are usually focused on various patterns of walking pedestrian dynamics, and the influence of idling persons has been largely neglected so far. However, the results of our field experiments at two major German railway stations demonstrate that idling pedestrians and their congestions are largely present at both railway stations and significantly influence pedestrian dynamics.

For example, hundreds of idling pedestrians are typically observed at the platforms several minutes before train arrival. The quantity and density of idling persons is usually low in the early afternoon till approx. 16 o'clock and increases significantly from 16 till 19 o'clock at a working day. During rush hours we observed densities of idling persons up to 1 person/m^2.

Whereas low-density congestions of idling pedestrians have no or very limited impact on pedestrian dynamics, density raise (given a sufficient occupied area) increases such impact: for example, heavily crowded platforms (with large and high-density idling pedestrian congestions up to 0.4p/m^2) typical for late Friday afternoons may extend the time that arriving passengers need to leave the platform by up to nearly 20%.

Apart from the field experiment, we evaluate the influence of idling pedestrian' congestions using a cellular automaton simulation model. We extend this model to consider idling pedestrians and validate it against scenarios observed in field experiments. We model various sequences of events with different railway station topologies and analyze the emergence of possible dangerous situations caused by awkward architectural planning. For example, our observations suggest that pedestrians are queuing next to the ticketing machines located at the platform entrances, and our simulation results show that such location of ticketing machines may be potentially dangerous in case of high densities.

We also simulate various densities of pedestrians idling at platforms and demonstrate that their large congestions with densities over 1,3 person/m^2 would increase the time needed for arrived persons to leave the platform by up to 100%.

To sum up, our study shows that the presence of idling person' congestions significantly influences pedestrian dynamics and therefore should not be neglected when modeling.

Heterogeneous Pedestrian Walking Speed in Discrete Simulation Models

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Discrete pedestrian simulation models are viable alternatives to particle based models, based on a continuous spatial representation (see, e.g., [2]) and they are able to reproduce realistic pedestrian dynamics from the point of view of a number of observable properties. The effects of discretisation, however, also imply some difficulties in modelling some phenomena that can be observed in reality. This paper focuses on the possibility of modelling heterogeneity in the walking speed of the simulated population of pedestrians by modifying an existing multi-agent model extending the floor field approach [3]. Whereas some discrete models allow pedestrians (or cars, when applied to traffic modelling) to move more than a single cell per time step (as discussed in [1]), in the present work we maintain a maximum speed of one cell per step, but we model lower speeds by having pedestrians yielding their movement in some turns. Different classes of pedestrians are associated to different desired walking speeds and we define a stochastic mechanism ensuring that they maintain an average speed close to this threshold. In the paper we will formally describe the model and we will show the results of its application in benchmark scenarios (single and counter flows in simple scenarios). Finally, we will also show how this approach can also support the definition of slopes and stairs as elements reducing the walking speed of pedestrians climbing them in a simulated scenario.

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A macroscopic model for bidirectional pedestrian flows in corridors

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Contrarily to car traffic, pedestrians may not all go in the same direction. In macroscopic models, this makes it more difficult to bound the density. Here we consider the case of a bi-directional pedestrian flow in a corridor. We show how the density can be bound even under congestion, by the use of a pressure term modeling the interactions between pedestrians and diverging when the density approaches the maximal density.

The model can be calibrated against real experimental data, and the density waves observed in the experiments can be reproduced in numerical simulations.

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Headway-dependent velocity model for 1d pedestrian dynamics at high densities

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Phase separation into a jammed phase and a free-flow phase is a well understood feature observed in vehicular traffic [1]. Experiments [2] have shown a similar behavior for pedestrians, though the situation in pedestrian dynamics is more complicated. The two separate phases in "single-file" pedestrian movement are a jammed high-density phase and a phase of medium to high density with slowly moving pedestrians.

We propose a one-dimensional stochastic *Headway-Dependent Velocity Model (HDV)* which is continuous in space but discrete in time. The velocity of each agent depends on its headway and on its velocity: standing agents have a probability p to not move in the next timestep. The HDV model can qualitatively reproduce the experimentally observed phase separation at high densities, see fig. 1. It also reproduces the observed velocity distribution [2].

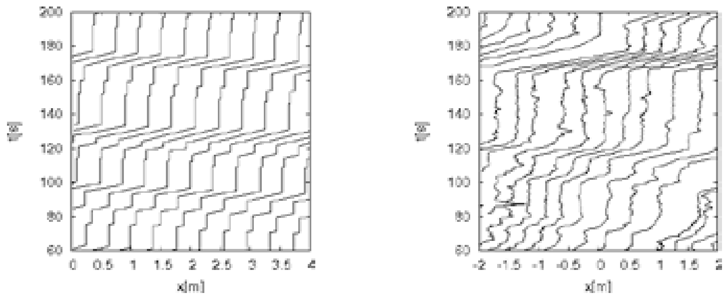

Fig. 1. Trajectories of the Hybrid model (left) and the experiment (right)

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A NaSch-like Cellular Automaton Model with Limited Braking Rule

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Summary. Nagel and Schreckenberg [1] analysed one of the first stochastic discrete automaton models for traffic simulation. Despite its simplicity, the model is able to reproduce empirically observed traffic phenomena such as spontaneous traffic jam formation. It has therefore attracted much attention and was extended in many ways since then. Most traffic cellular automata models achieve collision-free driving by explicitly allowing for unlimited braking capabilities. However, it is rather natural to view the collision-free traffic flow as a consequence of moderate driving instead of infinite braking capabilities. Barlovic et al. [2] introduced a traffic model focusing on limited acceleration and deceleration capabilities. The model is able to reproduce many empirically observed phenomena but it is very complicated at the same time. In this paper, we introduce and analyse a new non-deterministic traffic model with simple transition axioms and limited braking capabilities. We achieve collision-free driving with realistic decelaration rates by the introduction of a two-valued function $\mu(v_{t-1}^{\varphi(i)}, \delta_{t-1}^{i})$ which determines a vehicle's new velocity depending on the preceding vehicle's velocity $v_{t-1}^{\varphi(i)}$ and the headway δ_{t-1}^{i} between both vehicles.

The function $\mu(v_{t-1}^{\varphi(i)}, \delta_{t-1}^{i})$ can be written as

$$\mu(v_{t-1}^{\varphi(i)}, \delta_{t-1}^{i}) = \min\left\{ \left\lfloor \frac{1}{2}\sqrt{8\delta_{t-1}^{i} - 7 + 4v_{t-1}^{\varphi(i)}\left(v_{t-1}^{\varphi(i)} - 1\right)} - \frac{1}{2} \right\rfloor ;\ v_{\max} \right\}, \tag{1}$$

where $\lfloor\cdot\rfloor$ denotes the floor function, which returns the largest integer that is equal to or smaller than its argument. (The vehicles' maximum velocity is denoted as $v_{\max}$.)

After proving that this function limits the maximum deceleration rate to realistic values and guarantees the collision-freeness at the same time, we investigate the resulting traffic dynamics and show that there occurs a speed-synchronization between all vehicles on the road. From figure 1 one can several speed-synchronized states (different speeds v) depending on the road's vehicle density and the transition between such states.

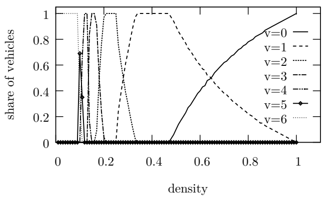

Fig. 1. Speed-synchronized flow and transition states in a closed system.

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POSTER

Flows at T-junctions as a special case of interacting pedestrian streams

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In many situations, e.g. evacuations, the prediction of the behaviour of interacting pedestrian streams is desirable. Computer simulations are a suitable approach. We use a cellular automata model, the floor field model [1], and examine its applicability to mixing pedestrian streams at T-junctions. For this situation large-scale experiments have been performed and analyzed [2-4].
In the floor field model pedestrians move on a lattice with Moore neighbourhoods. Temporal evolution is given by transitions probabilities for each occupied cell, which are based on the floor fields and friction parameters.
The floor field is divided into a static and a dynamic floor field. The static floor field consists mainly of information about the shortest path and geometric parameters as walls. Time-varying quantities, such as the trace of pedestrians, are considered in the dynamic floor field. Subsequent extensions which include additional interactions may be required in order to reproduce the empirical results [2-4].
Using the empirical from large-scale experiments with merging streams at T-junctions [2-4] the floor field model is calibrated and validated. By visualization of the temporal evolution, comparisons with video captures of the experiments are possible. Furthermore flows and densities under variation of external parameters (as input/output-rates) can be extracted and lead to fundamental diagrams and density profiles that can be compared with the experiments.

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Statistical analysis of high-flow traffic states

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Summary. The relation between the fundamental observables of traffic flow (i.e., vehicle density, flow rate, and average velocity) is of great importance for the study of traffic phenomena. Probably the most common source of such data are inductive loop detectors, which count the number of passing vehicles and measure their speed.

We will present an analysis of detector data collected by more than 4000 loop detectors during the past three years on the motorway network of the state of North Rhine-Westphalia (e.g., see [1, 2]). Besides presenting some general aspects of traffic flow, our analysis focuses on the characteristics of so-called high-flow states, i.e. traffic states where the flow rate exceeds 50 vehicles per minute and lane (3000 veh/h/lane). We investigate the duration, frequency and other statistics of such states and we study the conditions under which they occur.

The factors that influence the existence of high-flow states in traffic are, for instance, the fraction of slow vehicles (namely trucks), the motorway's general topology (e.g. number of lanes, slope, interchanges, ramps and exits), the flow rate on neighboring lanes, the hour of the day and day of the week, and weather conditions. Most of this information is directly accessible from the detector data.

For the analysis of weather conditions, however, we also included the evaluation of weather sensor data, which provide information on the (surface) temperature and the precipitation rate in a temporal and spatial resolution similar to the detector data.

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Exclusive queueing process: The dynamics of waiting in line

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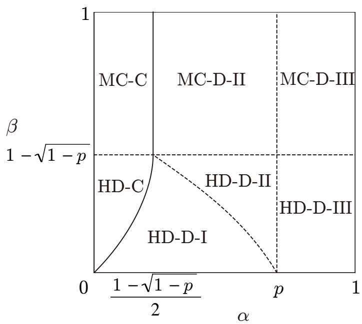
The dynamics of pedestrian crowds has been studied intensively in recent years, both theoretically and empirically. However, in many situations pedestrian movement is rather static, e.g. due to jamming near bottlenecks or queueing at ticket counters or the supermarket checkout. Classically such queues are described by a M/M/1 queue which neglects the internal structure (density profile) of the queue by focussing on the queue length as the only dynamical variable. This is different in the exclusive queueing process (EQP) [1] which considers the queue on a microscopic level. It is equivalent to a totally asymmetric exclusion process (TASEP) of varying length for which many exact results can be obtained. The EQP has a surprisingly rich phase diagram with respect to the arrival probability α and the service probability β. The behavior at the phase transition line is much more complex than for the TASEP. It is nonuniversal and depends strongly on the update procedure used.



Phase diagram of the EQP.

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Stability and homogenisation of the optimal velocity model

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Summary. Homogenisation properties of car-following traffic flow model are investigated. Stability analysis gives conditions to obtain homogeneous flow in stationary state. Homogenisation methods allow to obtain sufficient conditions ensuring physical convergence (*i.e.* with no collision) to the homogeneous stationary state. One proposes to calculate and compare the conditions for the optimal velocity second-order model. As expected, the homogenisation conditions obtained are more restrictive than the conditions for the linear stability. Simulation experiments show that collisions can appear in transient states even if the model is stable. On the other hand, no collision occur for any initial condition when the homogenisation condition holds. A new space parameter is hence suggested : Unstable (with potentially some collisions in transient and stationary states), stable (with potentially some collisions in transient state) and stable with no collision.

Keyword : Optimal velocity model – Stability – Homogenisation – Collision

1 Introduction

The paper is devoted to the "optimal velocity" car-following model for traffic developed by Bando *et al.* [1]. This model assumes a relaxation of vehicle speed towards an optimal speed that is a function of the distance gap.

The stability analysis of the model is investigated in the literature. See [6, 3] for such an analysis performed on a ring, or [1, 7] for the case of an infinite line.

In the same spirit but with more rigorous constraints, physical existence and homogenisation properties are developed with more general models, see [2, 5].

We propose to bring back the stability conditions of the optimal velocity model and to compare it to the (more restrictive) homogenisation conditions.

For that purpose, let us consider vehicles on an infinite line and denote $x_n(t) \in \mathbb{R}$ the position of the vehicle $n \in \mathbb{N}$ at time $t \geq 0$. The dynamics are the second-order system

$$\begin{cases} \dot{x}_n(t) = v_n(t) \\ \dot{v}_n(t) = \dfrac{1}{\tau}\big(V(x_{n+1}(t) - x_n(t)) - v_n(t)\big) \end{cases} \tag{1}$$

with

$$V(d) = \frac{1}{T}(d - \ell) \tag{2}$$

the affine optimal speed function with $\ell > 0$ the length of the vehicle and $T > 0$ the targeted time gap. Here $\tau > 0$ is the reaction (or relaxation) time parameter.

Network Fundamental Diagrams and their dependence on Network Topology

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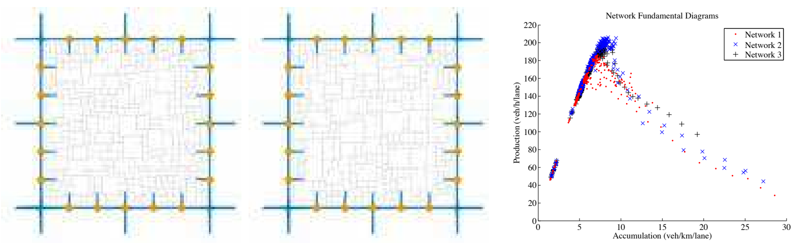
Traditionally, traffic is described at the level of individual vehicles (microscopic) or at the level of a link (macroscopic). Recent studies have shown that also aggregated over a whole network a rather crisp relation between average density (accumulation) and average flow (production) exists. This relationship is called the Macroscopic or Network Fundamental Diagram (NFD). This paper will show what the effect is of the exact network topology on the shape of the NFD. We developed a tool to automatically design networks. Using this tool, different networks are created for which the following general properties are the same: (1) the number of intersections, (2) length of signalised multi-lane arterial roads, (3) lengths of single-lane urban roads. Two examples are shown in the figure below. These networks are simulated in the microscopic simulation package VISSIM.

From the resulting traffic operations a NFD is created (fig c). The NFDs for different networks have different capacities and critical accumulations. The main contribution of the paper is that is shows that NFDs are not only dependent on the general network properties mentioned above, but also on the exact network layout (e.g., which link connects to which link) and/or origin-destination pattern. As a consequence, the NFD needs to be determined for each network separately and cannot be derived from these general properties.



(a) Network 1 (b) Network 2 (c) The NFD for all networks

Driver Heterogeneity in Rubbernecking Behaviour at an Incident Site

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Incident can reduce roadway capacity due to lanes blockages, and in some cases, also affect the flow in non-incident direction. This paper provides insights into change of driving behaviour while passing an incident site in attempt to assess rubbernecking activity. The empirical trajectory data on each lane of the opposite direction was obtained from a helicopter-mounted video camera. Traffic flow was recorded over a length of approximately 230 metres, starting approximately 125 metres upstream of the incident site. The speeds profiles over distance of individual vehicle passing an incident site of rolled-over van were used to describe behavioural changes. The point of where the deceleration and acceleration line meets was observed to determine rubbernecking activity.

There are two main findings from the study: 1) truck drivers react differently from passenger car drivers, and 2) vehicles in left lane demonstrate sharp deceleration compared to right lane vehicles. It is shown that the acceleration point of truck drivers occupying the right lane fell outside the study area. Most likely the truck drivers tend to decelerate earlier and farther upstream, at a distance more than 125 metres from the incident site, as truck approaching the study area at low speed. As for the left lane, the intersect point between deceleration and acceleration of passenger car can be seen at 50 - 100 metres before incident site. However, some drivers were not affected by the existence of incident and maintain a steady speed, vary less than 5 m/s throughout the incident location. This study emphasizes the difference between passenger car and truck driving behaviour while passing an incident location. The results provide a better understanding of rubbernecking behaviour and can be used to establish determinant factors to measure the rubbernecking effects.

Generalized Macroscopic Fundamental Diagram: Network Dynamics, Level of Service and Resilience Applications

Serge Hoogendoorn, Victor Knoop, Hans van Lint and Hai Le Vu

The generalised Macroscopic Fundamental Diagram (g-MFD) relates the network traffic density and the spatial variation of this density. Recent work of the authors show that by using both the average and the standard deviation in the density, a very crisp relation can be found.

This paper presents empirical results for the g-MFD using empirical data collected for the freeway network around Amsterdam. Next to presenting the g-MFD, we will show how the dynamics in the network relate to the path of the network state in relation to the network conditions. We will discuss regular dynamics, as well as the dynamics in case of incidents occurring in the network.

The presented results justify using the g-MFD for a number of applications that will be detailed in the rest of the paper. First of all, the g-MFD can be used to determine the network-wide service-level, both for recurrent and non-recurrent situations. The results for incident situations motivate the second application, namely the analysis of the resilience of the network by looking a the changes in the service level for specific network states. We will illustrate these applications using the aforementioned Amsterdam test case.

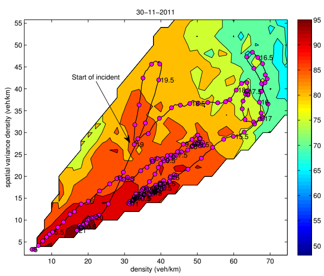

Fig. 1. Network state path $(k(t), \sigma(t))$ in relation to the g-MFD. The arrow indicates the starting time of the incident.

Traffic Flow States Classification: A comparative Study

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Transport investments are highly expensive investments which should be delicately planned. It is also important to measure and monitor the performance of such expensive investments to use them more efficiently. The relation between the capacity of the transport facility and the demand of the road users should be closely monitored so that efficient traffic control methods can be used. In order to increase the success of the traffic control methods, flow states should be estimated. Estimation process can be achieved successfully if the flow states are defined properly. This study aims to compare two well-known flow estimation methods which are Radial Basis Function Neural Networks (RBFNN) and Support Vector Machine (SVM). 3 different data sets are used to compare these two estimation methods. A data set which is obtained from Regiolab- Delft web site a data set which is obtained from RTMS units on Istanbul road network and an data set which is created with a micro simulation software VISSIM. Classification of traffic flow states and matching the corresponding real-time flow state is obtained dynamically inputting raw flow measures simultaneously to neural density mapping and traffic flow modelling processes. Both approaches are promising in capturing instantaneous changes on flow states and may be utilized within intelligent management strategies such as incident control. Although there are various methods which aim to classify or estimate flow state, it is shown that Support Vector Machine (SVM) method has some advantages over other methods. In this paper, first, traffic flow states and possible profits of traffic state estimation and classification are briefly defined. Then, popular methods of flow state classification and estimation are briefly explained. SVM and RBFNN methods are briefly introduced and their usage in traffic flow state classification are explained with simulated and real data. RBF neural network is trained with Levenberg-Marquardt back propagation method which updates weight and bias values according to Levenberg-Marquardt optimization. Two methods are tested with different flow characteristic both microscopically and macroscopically. For example driver behaviors are different in 3 different data set while two of them are collected from different countries (The Netherlands and Turkey) and the other data set is produced by using VISSIM micro-simulation software package. The main aim of this study is to test classification methods with different data sets and see how they react to change in flow characteristics and traffic regulations i.e. driver behavior, volume,
speed limits.

Relation between longitudinal and lateral action points

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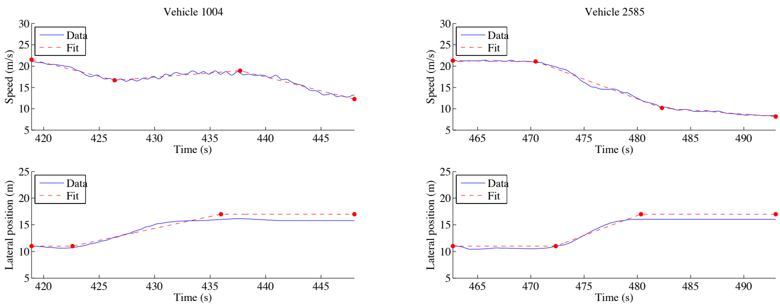
Delay on the motorways can be reduced by traffic management measures changing driving behaviour, which need to be tested before implementation. Microscopic traffic simulation is well suited for this, if sufficiently accurate. Recent studies show that drivers do not continuously change their acceleration, but rather at specific moments in time. These moments are called longitudinal action points. Also for lane changing, moments in time can be identified when drivers start and end changing lanes, so called lateral action points. Current models not incorporating this discontinuous behaviour correctly, might produce incorrect predictions.

We collected measurements of driving behaviour using a video camera mounted under a helicopter. We developed a methodology to fit piecewise linear functions in $(\dot{x},t)$ and (y,t), revealing the longitudinal and lateral action points (see figures). It can be hypothesised that drivers accelerate or decelerate in order to perform a lane change. The full paper will show the relationship between the longitudinal and lateral action points and show their correlation.

The approach using action points can be reproduced in a microscopic traffic flow simulation model. The final goal of this research is thus to help in developing more accurate simulation models in order to correctly assess the impact of traffic management measures.



A macroscopic traffic flow model for a binary mixture of vehicles

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Summary. One of the most important objectives in the development of traffic theories is to improve traffic conditions. To achieve this goal it is very important a good understanding of multistyle and/or multilane traffic. In this work we have directed our efforts to the construction of a model that considers different driving styles, different vehicle types or both. The point of view we will follow to study such a problem is based on the kinetic theory of traffic flow. In this approach we are interested in the evolution of the one vehicle distribution function, $f_i(x, v_i, t)$. We have constructed a kinetic equation describing the evolution of each specie of a binary mixture of vehicles in which a model for the average desired speed is introduced. We have considered the aggresive drivers model where the driving style is caracterized by an aggresivity parameter [1], [2], [3]. The kinetic model is solved for the steady and homogeneous state and also we have obtained a local distribution function from an information entropy maximization procedure. The macroscopic traffic model is constructed by means of a general transport equation obtained by the usual methods in kinetic theory. Then, a method akin with the maxwellian iterative procedure is achived in order to close the macroscopic model for the mixture where only the species densities are considered as relevant quantities. It is worth mentioning that the densities equations have a source in a way that only the total density is conserved. The linear stability analysis is presented and the numerical simulations for a closed circuit have also been performed. Such numerical procedures have considered a perturbed homogeneous steady state with a change in the vehicles densities, the time evolution has shown that there is a fast adaptation between different types of vehicles. Also, the long time behavior looks like a homogeneous steady state corresponding to the total density, no matter the initial perturbation.

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Vehicular traffic flow at a signalised urban intersection: A simulation study.

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We have simulated the vehicular traffic flow at a single intersection in which the possibility of turning when cars reach to the intersection is augmented to the problem. A set of traffic lights operating in a fixed time scheme controls the flow. Each street conducts a uni directional flow and has a single lane. We exclude the possibility of overtaking. The flow directions are taken south-north in street one and east-west in street two. Vehicles can turn when reaching to the intersection. A northward moving car can turn left and a westward moving car can turn right (towards north) when reaching to the intersection. We model each street by a chain of L sites. Nagel-Scheckenberg cellular automata is used to simulate the vehicular dynamics. The probability of turning a north-moving car to west is denoted by p_{sw}. Correspondingly the probability of turning a west-moving car to north is denoted by p_{en}. Three dimensional plot of total current for given input rates of vehicles in terms of signalisation parameters shows the existence of a 2D plateau region encompassed by almost flat planes of sharp decreasing currents. By extensive simulations we have examined the effect of turning on the output current. The dependence of J_t on the whole range of turning probabilities for fixed values of other parameters have been computed including the equal and nonequal input rates. Besides total current, total waiting time per cycle has been computed. Our investigations reveal that in the parameter space, the minimisation of total waiting time per cycle does not fully coincide with the maximisation of total current. This arises the natural question of *what quantity should be optimised in order to acquire the most efficiency for the intersection ?*

Why does traffic jam act universally?

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The theoretical reason of the existence of universal feature of traffic jam forming in various places and various number of cars on highways, is specified using exact solutions of a mathematical model for traffic flow, Optimal Velocity (OV) model [1].

OV model well reproduces the real traffic data of jam in several aspects, such as the critical density of forming a jam, the velocity of a jam cluster, e.t.c. where each value is almost universal. OV model using the Heaviside step function as a OV-function[2], which gives the optimal velocity determined by the headway-distance, has essentially the same properties as a realistic OV model.

Recently, we have obtained exact solutions of jam flow in the model for an arbitral number of cars $N > 3$ and density ρ. (In the special case with $N = 3$, the solution is obtained before [3].) In their solutions, the dependence of N and ρ are exponentially reduced to the identical solution, that is the solution for $N \to \infty$. This means that a jam formed by more than several tens of cars is the same as infinite number of cars. This result is caused by the fact that the model is built mathematically as dissipative equations of motions, originated in that traffic flow is one of non-equilibrium dissipative system of physics.

This explains the universality of jam flow.

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Simulations of TomTom vehicle data in urban traffic with the Kerner-Klenov model in the framework of the three-phase traffic theory

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Summary. In urban areas real-time information about vehicular traffic usually exists only as local detector data and only at a few positions within the city's street network. During the last years the situation has changed: With the increasing distribution of navigational devices in vehicles, more precise traffic data became available. This data allows for a better analysis of the spatio-temporal dynamics of traffic in urban areas.

In this presentation, we make simulations of TomTom probe vehicle data measured in city traffic through TomTom navigation devices in vehicles. An analysis of the vehicle trajectories in the TomTom data reveals the typical features of the traffic phases as defined in Kerner's three-phase traffic theory: free flow, synchronized flow and wide moving jam (moving queues). The existance of the synchronized flow phase has previously been found within traffic data from highways, but not within data from urban road networks.

Within the project "UR:BAN - Urban Space: User oriented assistance systems and network management", funded by the Federal Ministry of Economics and Technology, we simulate urban traffic within the street network of the city of Düsseldorf. We will show that the microscopic simulation of vehicular traffic with the stochastic Kerner-Klenov model on a multi-lane road stretch reproduces the spatio-temporal profiles of the vehicles' speed and acceleration found in the TomTom data. We will also compare the simulation results with local detector data.

The results of our simulations are used by our partners from Daimler AG to obtain energy consumption profiles which in turn will be used by TomTom and others to find energy optimized routes within the street network.

Bidirectional microtubule-based transport in axons

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Cellular automata have proven to be useful tools for the modelling of the collective behavior of molecular motors in in vitro experiments [1]. The modelling of in vivo axonal transport requires to describe bi-directional transport. It is still an open question to understand how it can be organized. In this talk we shall review several possible scenarios.

On the one-hand, it has been postulated that interactions between motors could lead to lane formation [2,4]. This phenomenon is highly dependent on the possibility to diffuse or not around the microtubules that serve as tracks for the motors - a possibility that is reduced in the crowded axonal environment.

On the other hand, the network of microtubules is itself highly dynamical. It has been shown on a simplified model that a transition from blocked to efficient bidirectional transport [3] could be induced by having a dynamical underlying lattice. Some real experiments also support the existence of a link between network dynamics and transport [5].

Actually these scenarios should not be considered as conflicting, but rather as complementary scenarios. We shall review the results already obtained and discuss the missing informations that should be obtained from experiments to be able to develop a new generation of more realistic models.

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Decentralized Control Scheme for Bodily Wave Generation in Earthworm Locomotion

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Earthworms can effectively move on the ground by appropriately propagating the wave of bodily contraction from the head to the tail. Inspired by this remarkable ability of earthworms, various earthworm-like robots have been developed [1,2]. However, they could not exhibit truly adaptive behavior because the phase relationship among the body parts were completely pre-determined.

To tackle this problem, we employed an unconventional approach: we theoretically derived an optimal force distribution on the basis of a continuum model, through which we developed a decentralized control scheme for an earthworm-like robot. As shown in Fig. 1, the simulated robot could move effectively by exploiting high frictional areas as "scaffolds." Our result could lead to various practical applications, *e.g.*, endoscopes, and could also provide a novel insight into the understanding of the mechanism underlying related phenomena such as traffic jams and crawling locomotion of other animals.

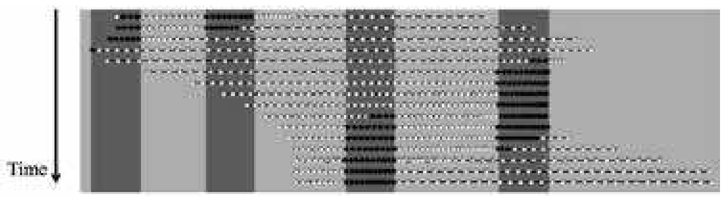

Fig. 1. Simulation result. Black particles are the particles that anchor the ground. Dark areas indicate high friction areas.

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Experimental and Numerical study on ants movement in a channel

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Abstract: Biological experiment research has revealed some common behaviours for both animal and human, such as herding behaviour, self-organized behaviour, etc. Some mechanism of human dynamic could also derive from the biological behavior. In this study, it is aimed at revealing the common and different character between ants and traffic in human society. A kind of large-size ant named "Camponotus japonicas" is chosen to study their following behaviour in the unidirectional channel. Low concentration citronella oil is used to drive them to move from one side of the channel to the other side in single-file way. The passing movements are recorded and then the velocity and headway are extracted by image processing. Experimental results show that the flow of ants will increase with increasing density of ants at ants density less than 10(1/cm). In addition, The maximum velocity of ants is acquired at ants density ranging from 3.5(1/cm) to 5(1/cm) and the maximum velocity is about 0.4 times more than the velocity of free moving mode. Subsequently, a one dimension cellular automaton model is built to describe the movement of ants. In our model, ants move forward depending on the pheromone occupation and ant occupation of the target cell. If pheromone is present and there is no ant occupation it moves with probability Q%, while in the absence of pheromone and ant occupation, it moves with q%, which is less than Q%. The parameter f% is utilized in our model, standing for pheromone volatile probability in unit interval, to simulate real ants movement more accurately. Through comparing simulated result with experimental data, it is found that they agree with each other approximately, especially, when ants density is less than 5(1/cm). Therefore, the result of our experimental and numerical study is rather different from vehicles traffic and pedestrian dynamics. Further more, this difference indicates some certain mechanism of cooperation may exist in the ants system.

Role of fine particles on the stability of a humid granular heap

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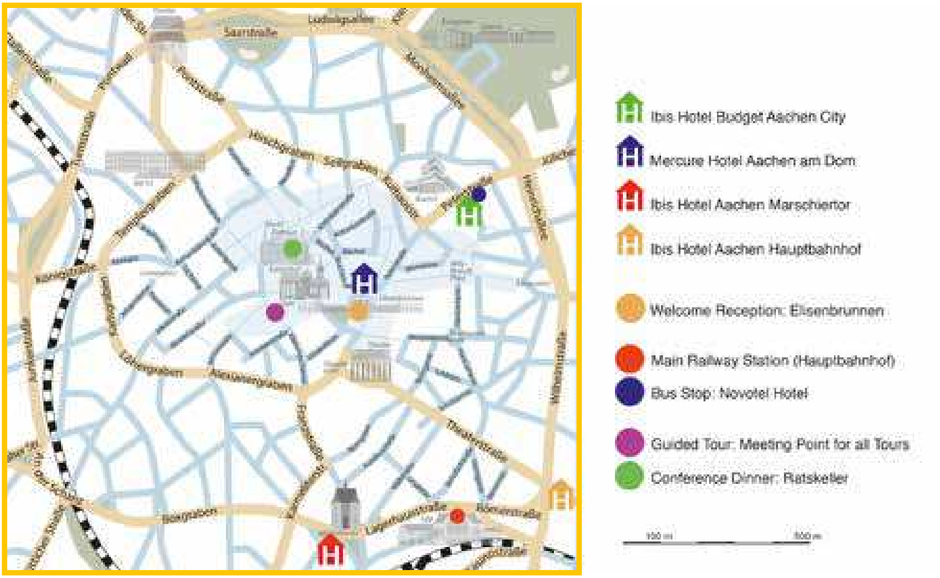
Re-agglomeration in the grinding industry has been studied for decades, this phenomenon contributing to the bad energy performance of the process. One aspect hardly studied is the effect of very fine particles, appearing at the beginning of the process, favoring the cohesion between particles. We present here the surprising influence of a small amount of fine particles on the stability of a granular pile in a rotating drum.

The experiments are carried out in a cylindrical rotating drum made of stainless steel with an inner diameter and length of 10 cm. The vertical walls are two glass disks with a hole of 2 cm at the center to assure air exchange. The cylinder is partial filled by glass bead of 200-300 μm. Fine glass beads of 0-20 μm are added with 0 to 1% volume fraction. The whole set-up is placed in a temperature and humidity-controlled box.

By varying the quantity of fine particles, we have established the stability diagram of the granular heap. When the concentration of fine particles is less than 0.15%, the heap destabilizes through avalanches when the drum rotates, and the fines tend to decrease its stability. Once the concentration is more than 0.15%, the destabilization of the heap proceeds through stick-slip, and the fines tend to increase its stability.

This apparent contradictory behavior has been understood in determining the plane where the destabilization sets up. In the small concentration regime, the avalanches start at the surface of the heap, and the filling of the interstitial space by the fine particles makes this surface smoother and smoother, thus destabilizing the heap. This destabilization is independent of humidity. Besides, the fines induce, through the nucleation of capillary bridges between grains, a increase of the bulk cohesion of the heap. So in the large concentration regime, the heap behaves as a solid body and the destabilization occurs at its bottom, where the fines particles induce a decrease of the real contact area between the pile and the inner wall of the drum.

GENERAL INFORMATION



24 September 2013:
A welcome reception will be held at Elisenbrunnen in Aachen from **6 pm** to 9 pm.

25-27 September 2013:
During the conference the transport to Forschungszentrum Jülich will be provided by complementary shuttle buses. The two marked points in the map above , near the recommended hotels will be the only stops where the bus shuttles will pick you up at **8 am** on each day to the venue at Forschungszentrum Jülich.

26 September 2013:
The social event starts with a guided tour in Aachen at **5:10 pm** at the meeting point for the treasury chamber tour and at **6:00 pm** at the meeting point for the old town tour. After the tour, we meet each other for the conference dinner at Ratskeller at **7:30 pm**.

27 September 2013:
For departure we provide shuttle buses on the last day from the venue leaving Jülich at **4 pm** to

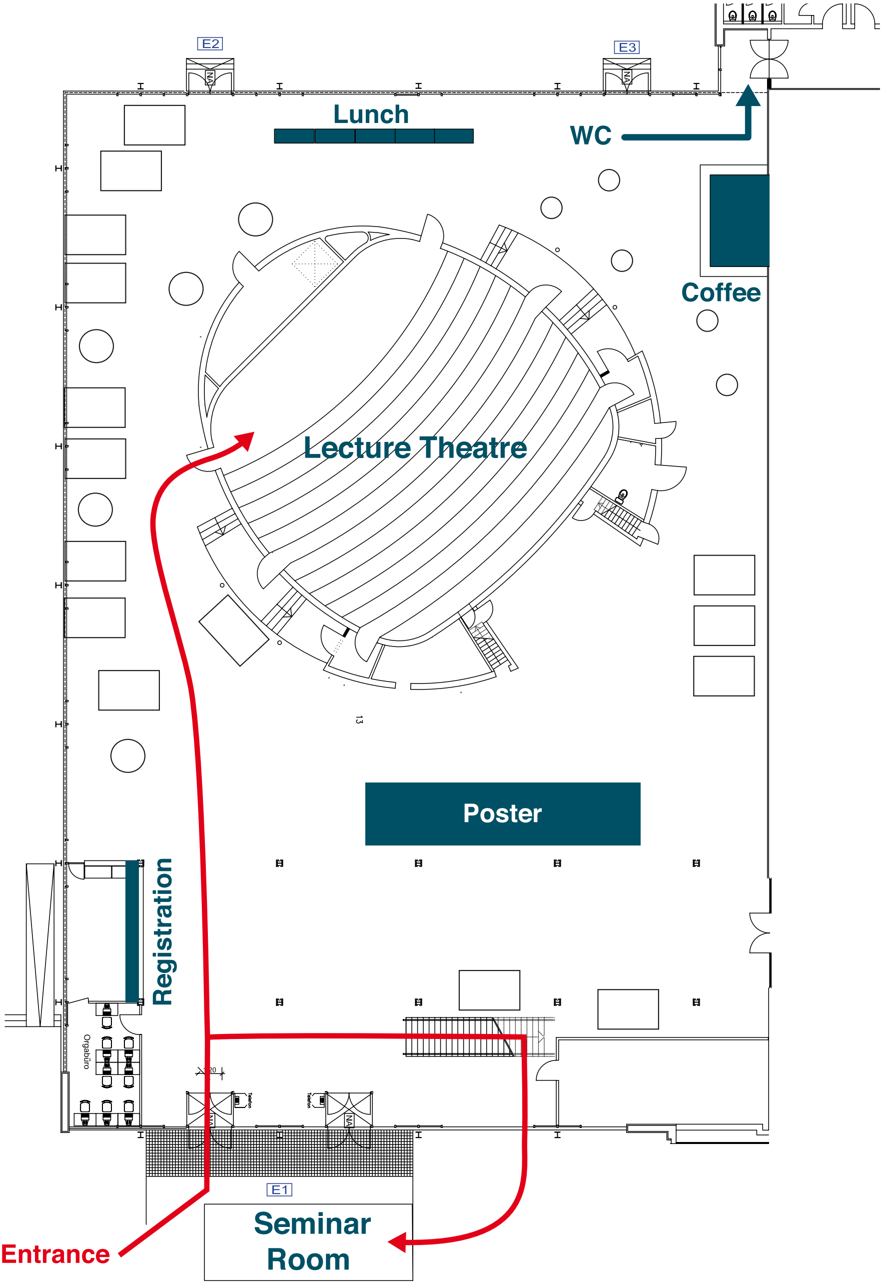
1. Düren Main Railway Station (~ 4:30 pm)
   ➔ Aachen Main Railway Station (~ 5:10 pm)
   ➔ Aachen Main Bus Station (~ 5:20 pm) (*)
2. Düsseldorf International Airport (~ 5 pm) (*)

(*) All times are only approximate times!


Düsseldorf
Linnich
Titz
Broich
Mersch
Bedburg
Bergheim
Koslar
Jülich
Stetternich
Aachen
Aldorf
Bourheim
Kirchberg
JÜLICH
Düren


Main entrance

GENERAL INFORMATION



NOTES

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Different approaches to the multilane traffic simulation.

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The paper deals with development of both macroscopic and microscopic approaches to the mathematical modeling of multilane vehicular traffic on city roads and highways.The macroscopic model considers synchronized traffic flow, uses the continuum approach and is based on the original quasi-gas-dynamic (QGD) system of equations [1]. The distinguishing feature of the model is the variable transverse velocity reflecting the speed of lane changing. The numerical implementation is explicit, the similarity with kinetically inconsistent finite differential schemes is used.The microscopic model is based on the cellular automata theory and presents generalization of Nagel-Schreckenberg model to the multilane case [2]. The computational domain is the 2D lattice where two directions correspond to the road length and width. The number of cells in the transverse direction corresponds to the number of lanes. Each cell of the lattice can be either empty or occupied by one vehicle. Such a model allows vehicles to change lanes and to overtake one another. The algorithm of cell state update is formed by two components: lane change (if it is necessary and possible), movement along the road by the rules of N-S model.The set of test problems was solved using both approaches to verify the results. The comparison with Aimsun TSS [3], widely used traffic simulation system, was carried out.Both models possess inner parallelism and can be easily adapted to multiprocessor computer systems of different architectures. Parallelization is based on the domain decomposition (data partitioning) technique and message passing between nodes of the cluster. Parallel implementation provides the description of vehicle behavior in details and the real time forecast of big city traffic states.

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Mathematical problems and theorems for saturated flows on chainmail

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- The study objects are complex socio-technical systems with functions of various kinds of communications: the transportation of mass, society, and information. In particular, one kind of such systems are saturated flows of road and rail transport.
- In this paper the substance transport model is presented in the form of homogeneous clusters, moving according to Newton's first law without interaction. Interaction scenario is postulated, for example, based on the classic studies of Lighthill-Whitham (Renkine-Hugoniot condition), [4], and modern physical concepts, [2]. In case of a single-lane movement, a homogeneous cluster is the limit state of following-the-leader chain, [1].
- Communications networks are considered as the unit cells construction, i.e. circuits allowing the decomposition of real complex networks. Chain-mail is a multi-dimensional network of engagement rings. In the early Russian history one of the options of the network used defenders Russia as an outer garment. Chailmail, as the shape of transportation network, allows to divide into local and global components, [3].
- We study some basic constructions based on the deterministic and stochastic approaches. For exactly posed problems the mathematical results as theorems with proofs were obtained.

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An expanded concept of the “borrowed time” as a mean of increasing isotropy in pedestrian dynamics simulations

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Discretization in numerical simulations holds big advantage of decreasing complexity of calculations, allowing for faster and larger-scale simulations. However, such a procedure leads to emergence of unwanted phenomena due to finite space and/or time resolution. For this reason when space is discretized usually regular lattices are used as they preserve highest rotational and translational symmetry.

In the presentation a method for measuring isotropy in multi-agent systems such as pedestrian dynamics will be proposed, namely the average speed isotropy. Usage of different grid types will be analyzed under this criteria with regard to different length scales. Concept of borrowed time will be introduced as a mean of decreasing anistropy without increasing complexity of calculations. It will be shown, that this concept can be expanded to further reduce anistropy at longer length scales. Finally, this approach will be compared with empirical data and its application for simulations will be discussed.