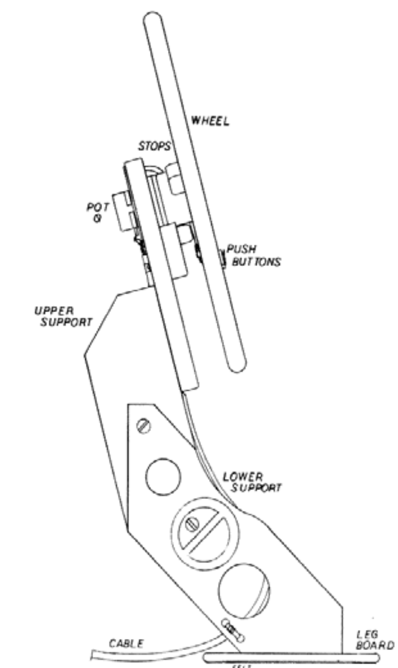
# UVMI


WHEEL
STOPS
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CABLE
LEG
BOARD
FELT

**Composition:**

**Computer Music for Contemporary Dance Theatre**

**Composer:**

**Dimiti Voudouris**

**[1961-]**

**Composed:**

**2008**

**Duration:**

**7 min 45 sec**

| INDEX | PAGE |
|---|---|

## Traffic Observations

Experimental data from traffic observations revealed that, depending on the car density, there are several separated phases of flow: free flow, stop and go traffic, and synchronous flow. It is believed that for sufficiently high densities a hydrodynamic, coarse–grained description of traffic flow adequately describes many of the experimentally observed phenomena. For low densities, however, this continuous approximation fails, and one has to refer to computer simulations and/or different phenomenological approaches.

One of the interesting phenomena in traffic flow is formation of clusters, or platoons, which happens even at low densities. In vehicle control, such as speed and headway distance maintenance, is fully automatic. Cars are allowed to travel in closely packed clusters, where the intra–cluster distance can be as small as 1 meter, and the headway between clusters 6 meters. Such "structured" flow increases the freeway capacity, and is considered to be much safer thanks to the small variance in car velocities.

Each car (agent) has its own characteristics (speed, acceleration, etc.) and goals (reaching final destination in a given time, maintaining safety, etc.). Autonomous multi–agent systems that are characterized by distributed control mechanisms are much more robust compared to systems with centralized control. The absence of a centralized control requires interaction among agents to form and maintain platoons. As we mentioned above, platoons form spontaneously due to the differences in inherent velocities. If no passing is allowed, then platoons form behind the slowest cars so that the performance of the system is solely determined by the fraction of the slow cars. If passing is allowed for all agents, however, platoons might not form at all since each agent will tend to maintain its inherent velocity to minimize its travel time.

I propose a model with "restricted" passing, where agents are allowed to pass with probability depending on the "slowdown" they will experience by joining the platoon. The higher the slowdown, the higher the probability of passing.

## Raw data collected from field studies

- Between December 2005 – February 2006.
- Urbanised environment central Maputo - Mao Tse Tung avenue, left hand side of road.
- Time 7H00 - 9H00.
- Weather conditions - 9 days sunny, 5 days overcast.
- Weather – Summer, at 34°c.
- Condition of the road – Visibility of potholes.
- Road – Poor signage.
- Average speed travelled by vehicles – 10 – 60 km/h.
- Traffic lights not synchronized.

**Factors governing end performance:-**

- Submicroscopic simulation models (high-detail description of the functioning of vehicles' subunits and the interaction with their surroundings).
- Microscopic simulation models (high-detail description where individual entities are distinguished and traced).
- Mesoscopic models (medium detail).
- Macroscopic models (low detail).

Traffic models may be classified according to the *level of detail* with which they represent the traffic systems. This categorisation can be operationalised by considering the *distinguished traffic entities* and the *description level* of these entities in the respective flow models.

**Proposing the following classification models:-**

A *microscopic simulation model* describes both the space-time behaviour of the systems' entities (i.e. vehicles and drivers) as well as their interactions at a high level of detail (individually). For instance, for each vehicle in the stream a lane-change is described as a detailed chain of drivers' decisions.

Similar to microscopic simulation models, the *submicroscopic simulation models* describe the characteristics of individual vehicles in the traffic stream. However, apart from a detailed description of driving behaviour, also *vehicle control behaviour* (e.g. changing gears, etc.) in correspondence to prevailing surrounding conditions is modelled in detail.

A *mesoscopic model* does not distinguish nor trace individual vehicles, but specifies the *behaviour* of individuals, for instance in probabilistic terms. To this end, traffic is represented by (small) groups of traffic entities, the activities and interactions of which are described at a low detail level. For instance, a lane-change manoeuvre might be represented for an individual vehicle as an instantaneous event, where the decision to perform a lane-change is based on e.g. relative lane densities, and speed differentials. Some mesoscopic models are derived in analogy to gas-kinetic theory. These so-called gas-kinetic models describe the dynamics of velocity distributions.

*Macroscopic flow* **models** describe traffic at a high level of aggregation as a flow without distinguishing its constituent parts. For instance, the traffic stream is represented in an aggregate manner using characteristics as flow-rate, density, and velocity. Individual vehicle manoeuvres, such as a lanechange, are usually not explicitly represented. A macroscopic model may assume that the traffic stream is properly allocated to the roadway lanes, and employ an approximation to this end. Macroscopic flow models can be classified according to the *number* of partial differential equations that frequently underlie the model on the one hand, and their *order* on the other hand.

### Scale of the independent variables:-

Since almost all traffic models describe dynamical systems, a natural classification is the time-scale. I will distinguish two time scales, namely continuous and discrete. A *continuous* model describes how the traffic system's state changes continuously over time in response to continuous stimuli. *Discrete models* assume that state changes occur discontinuously over time at discrete time instants. Besides time, also other independent variables can be described by either continuous or discrete variables (e.g. position, velocity, desired velocity).

### Representation of the processes:-

Distinguishing *deterministic* and *stochastic* models. The former models have no random variables implying that all actors in the model are defined by exact relationships. Stochastic models incorporate processes that include random varieties. For instance, a car-following model can be formulated as either a deterministic or a stochastic relationship by defining the driver's reaction time as a constant or as a random variable respectively.

### Operationalisation:-

With respect to the operationalisation criterion, models can be operationalised either as analytical solutions of sets of equations, or as a simulation model.

### Scale of application:-

The application scale indicates the area of application of the model. For instance, the model may describe the dynamics of its entities for a single roadway stretch, an entire traffic network, a corridor, a city, etc.

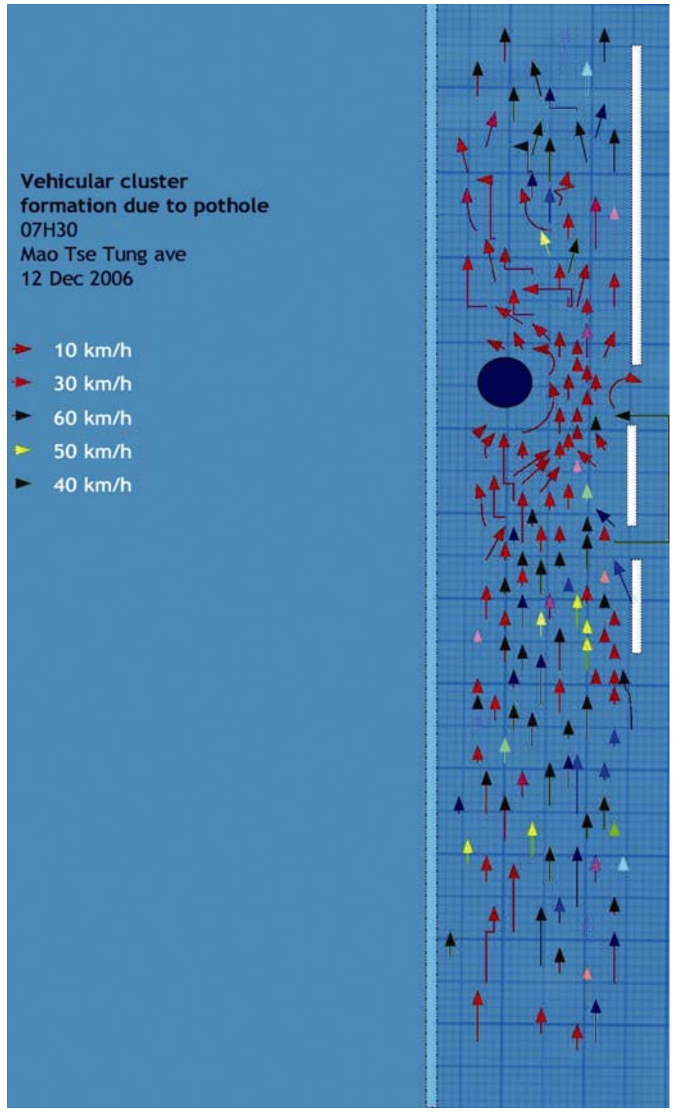



*Diagram 1*

## Microscopic simulation models

These models distinguish and trace single cars and their drivers. Driver's behaviour is generally described by a large set of if-then rules (production-rule systems). From driver behaviour and vehicle characteristics, position, speed and acceleration of each car are calculated for each time step.

## Submicroscopic simulation models

In addition to describing the time-space behaviour of the individual entities in the traffic system, submicroscopic simulation models describe the functioning of specific parts and processes of vehicles and driving tasks. For instance, a submicroscopic simulation model describes the way in which a driver applies the brakes, considering among other things the driver's reaction time, the time needed to apply the brake, etc. These submicroscopic simulation models are very suited to model the impacts of driver support system on the vehicle dynamics and driving behaviour.

## Mesoscopic traffic flow models

Mesoscopic flow models describe traffic flow at a medium detail level. Vehicles and driver behaviour are not distinguished nor described individually, but rather in more aggregate-terms (e.g. using probability distribution functions). However, the behaviour rules are described at an individual level. For instance, a gas-kinetic model describes velocity distributions at specific locations and time instants. The dynamics of these distributions are generally governed by various processes (e.g. acceleration, interaction between vehicles, lane-changing), describing the individual driver's behaviour.

### Cluster models:-

Cluster models are characterised by the central role of *clusters* of vehicles. A cluster is a group of vehicles that share a specific property. Different aspects of clusters can be considered. Usually, the *size* of a cluster (the number of vehicles in a cluster) and the *velocity* of a cluster are of dominant

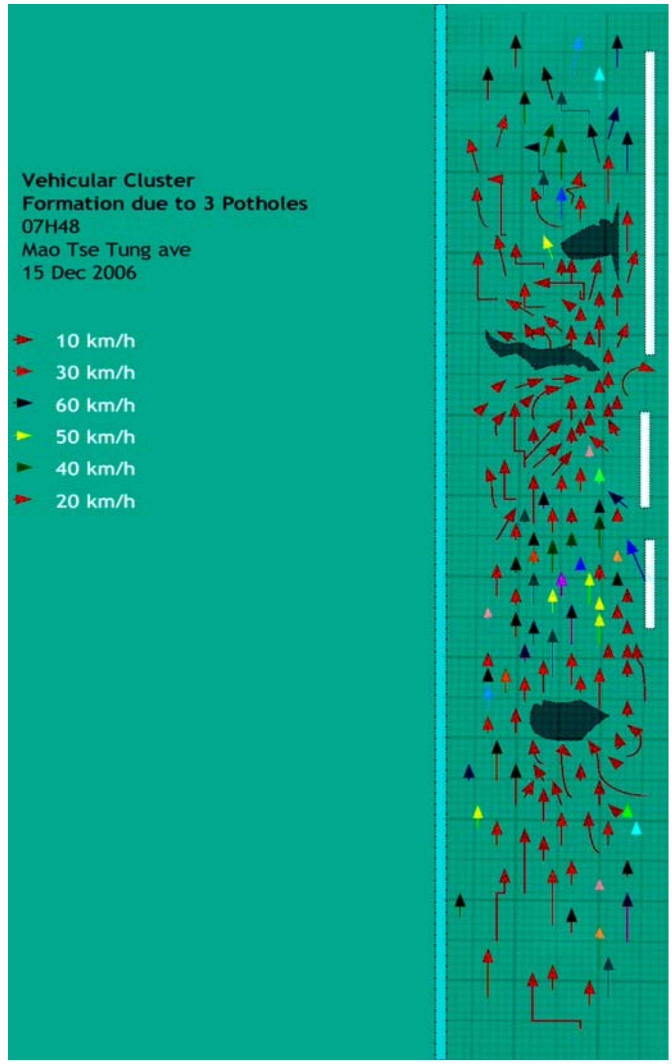
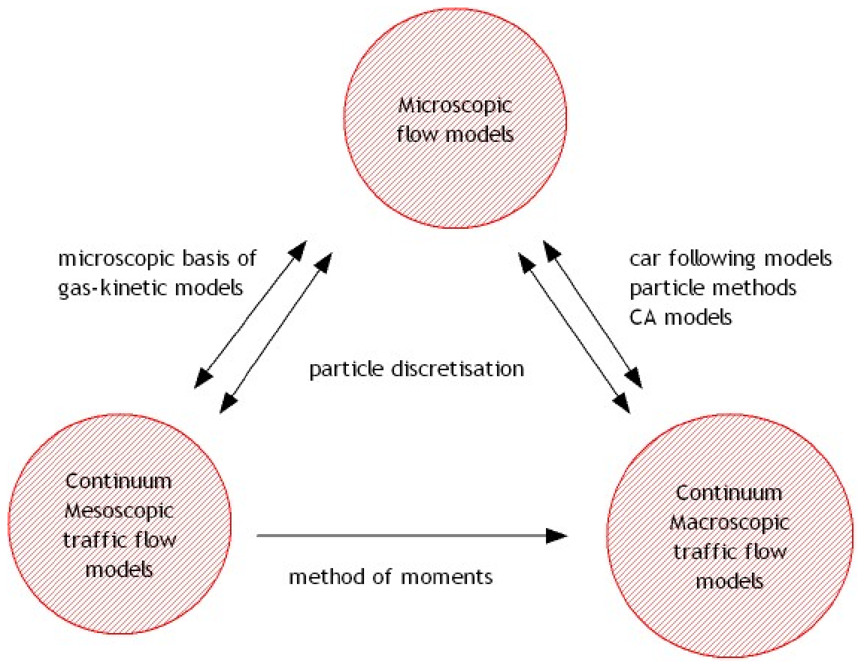



*Diagram 2*

importance. Generally, the size of a cluster is dynamic: clusters can grow and decay. The within cluster traffic conditions, e.g. the headways, velocity differences, etc., are usually *not* considered explicitly: clusters are *homogeneous* in this sense. Usually, clusters emerge because of restricted overtaking possibilities due to e.g. overtaking prohibitions, or interactions with other vehicles making overtaking impossible, or due to prevailing weather or ambient conditions.
In Maputo restricted overtaking occurred because of on coming traffic from the opposite lane during peak hour traffic.




Relations between microscopic, mesoscopic, and macroscopic flow models.
*Diagram 3*

## Continuum macroscopic traffic flow models

Macroscopic traffic flow models assume that the *aggregate* behaviour of drivers depends on the traffic conditions in the drivers' direct environments. That is, they deal with traffic flow in terms of aggregate variables. Usually, the models are derived from the analogy between vehicular flow and flow of continuous media (e.g. fluids or gasses).

The independent variables of a continuous macroscopic flow model are location *x* and time instant *t*. To introduce the dependent traffic flow variables, consider a small segment **[***x***,***x***+d***x***)** of a roadway referred to as 'cell *x***'**. Most macroscopic traffic flow models describe the dynamics of the density *r* **=** *r***(***x***,***t***)**, the velocity *V* **=** *V***(***x***,***t***)**, and the flow *m* **=** *m***(***x***,***t***)**. The density *r***(***x***,***t***)** describes the *expected number of vehicles* on the roadway segment **[***x***,***x***+d***x***)** *per unit length* at instant *t*. The flow *m***(***x***,***t***)** equals the *expected number of vehicles* flowing past *x* during **[***t***,***t***+d***t***)** per time unit. The velocity ***V*(*x*,*t*)** equals the *expected velocity of vehicle* defined by ***m*(*x*,*t*)/*r*(*x*,*t*).**

Helbing (1998) shows how this non-locality yields the occurrence of *different traffic states* (types of congestion), depending on the combined values of the flow-rate on the main road .Self-formation of spatial clusters and the congestion due to active bottlenecks are correlated, that is, caused by similar mechanisms. Similar occurrence caused by potholes can cause active bottlenecks. Due to the potholes and bottleneck situations, traffic breakdown under metastable or linearly unstable conditions will occur frequently (that is, with a very high probability).

**Dirk Helbing-type models:-**

Helbing (1996) has extended the Payne-type models by introducing an additional partial differential equation for the velocity variance $\Theta$**.** His macroscopic model is derived from gas-kinetic equations and consists of the conservation of vehicles equation, the velocity dynamics, and the following equation describing the dynamics of the variance $\Theta$:

$$\partial^{t}\Theta + V\partial^{x}\Theta = -2(P/x)\partial^{x}V + 2(\Theta^{e}-\Theta)/T-(1/r)\partial^{x}J$$

where the *flux of velocity variance* $J = J(x,t) = r(x,t)\Gamma(x,t)$ is defined by the product of the density and the skewness of the velocity distribution. Rather than being experimentally determined, the equilibrium velocity $V^{e}$ and variance $\Theta^{e}$ are determined by considering the interaction process between vehicles in the stream. The resulting expressions are functions of the density $r$, the velocity $V$ and the velocity variance $\Theta$, namely:

$$V^{e}(r,V,\Theta) = V^{0}-T(1-p(r))P \text{ and } \Theta^{e}(r,V,\Theta) = C-T(1-p(r))J$$

where $p(r)$ denotes the immediate overtaking probability while $C$ is the *covariance* between the velocity and the desired velocity. The model equations are ‘closed’ by specifying expressions for $p$, $C$ and $J$. Helbing (1996) also proposes techniques to incorporate the fact that vehicles occupy a nonvanishing amount of roadway space.
The way in which disturbances in the flow are transported can again be analysed by considering the characteristic curves. Helbing-type models have *three characteristic curves* (one path-line and two Mach-lines), along which small perturbations propagate. This implies that small disturbances are transported both along with the (mean) traffic flow as well as in the upstream and downstream directions with respect to this mean flow.

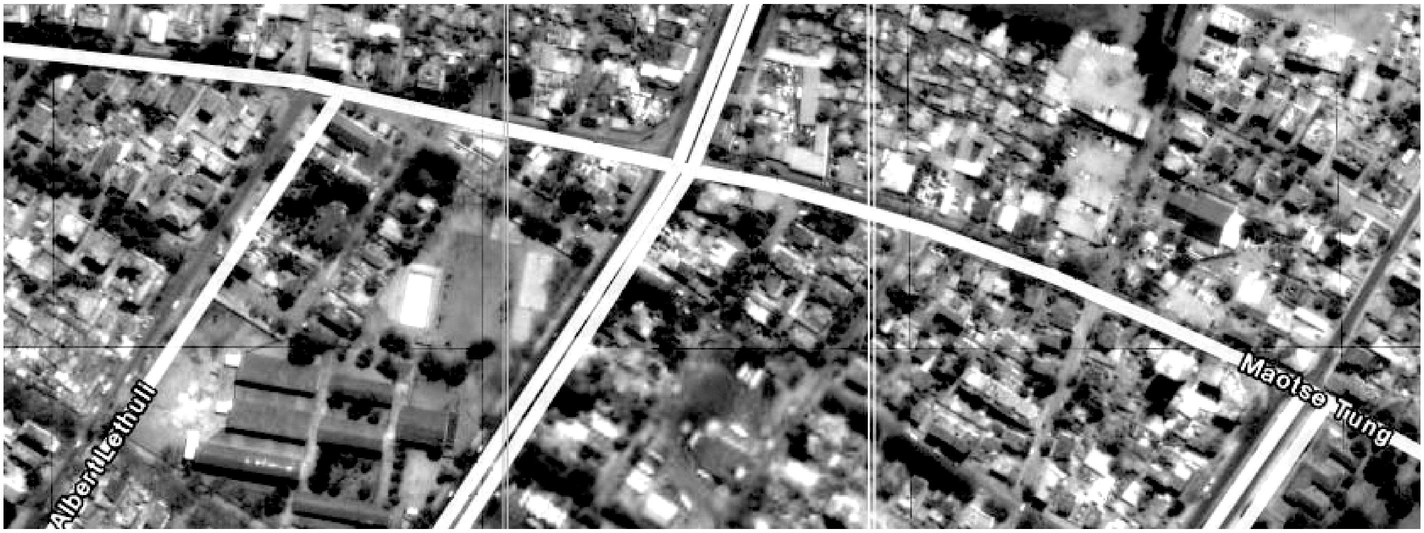


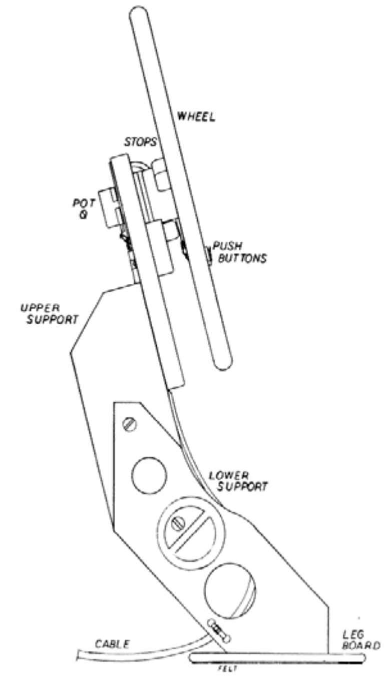

*Diagram 4*

## Composing UVIVI [*Zulu for daybreak*]

This computer music composition was constructed with the aid of the Helbing equation  which focuses on linearity and infinite memory in the kinetic flow of vehicular traffic. Each sound component is of equal strategical importance and is governed by the kinetic motion theory that is simplified by the Helbing equation were the equated results allowed for the study in cluster creations [*platoon formations*] that exhibit scaling behaviours, with exponents dominated solely by external characteristics of the intrinsic velocity distribution behaviours. Direct relationships between the flow of clusters that are directly related to density formations were associated to audio frequency variations and velocity variations to time duration relationships. Matlab allowed for the translation of the data collected from the analysis of the kinetic theory of vehicular traffic further formulations allowed for audio frequency parameter evaluation as well as time duration relationships for each occuring event.
The sounds created were specifically chosen and their dynamic modulation was changed to suit the dynamics of the composition. Particular attention was payed in formations of clusters and scaling behaviours by focusing on velocity, time and density formations.

## References:-

1] Helbring D. (1995) High Fidelity Macroscopic Traffic Equations. Physica A,Volume 219, pp.319-407
2] Payne.H (1971). Models of freeway Traffic and Contol.Simulation Council Procs,Simulation Council, La Jolla,CA,Vol.1,pp.51-61
3] Phillips,W.F.(1977) A Kinetic Model for Traffic Flow with Continuum Implications. Transportation Planning and Technology,Volume5, pp. 131-138
4] Prigogine I. And F.C.Adrews (1960). A Boltzmann-like Approach for Traffic Flow.Operations research,Volume 8, pp.789-797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# The End