

150

Velocity (km/h)

0

Time (sec)



Composer / researcher:

Dimitri Voudouris

Composed:

[2016 - 2021]

Compositions:

1. cong(m)!:a (19z...,24y...,13.3i..)

Areas	Sub – areas	Sub – areas	Sub – areas
19z04/17	(19z7.5)04/17	(19z2)04/17	(19z0.9)04/17
24y09/15	(24y7.4)09/15	(24y3)09/15	
13.3i03/15	(13.3i7)03/15	(13.3i14)03/15	(13.3i23)03/15

Duration: 12 min 17 sec

Amplified grand piano and electronics
- matlab as an (assistant composer)-

2. cong(m)!:a (05g...,31v...,08p..)

Areas	Sub – areas	Sub – areas	Sub – areas
05g06/15	(05g2)06/15	(05g0.8)06/15	
31v08/15	(31v3)08/15	(31v17)08/15	
08p07/15	(08p7)07/15	(08p0.8)07/15	(08p55)07/15

Duration: 13 min 32 sec

Amplified grand piano
- matlab as an (assistant composer)-

3. cong(m)!:a(02p...,07d...,13k..)

Areas	Sub – areas	Sub – areas	Sub – areas
02p03/15			
07d04/15	(25.6u1.7)06/15		
13k03/15	(13k1)03/15	(13k0.4)03/15	

Duration – 9 min 34 sec

Music programming for MIDI piano realised by computer
-matlab as an (assistant composer)-

“...from chaos to discernible order...”

Index	Page
Abstract	4
Proposed Method A	4
Proposed Method B	5
Vehicles exhibiting elastic behaviour and structural changes	8
Composition	9
Assistant composer "suggestive selection process by Matlab" in composition <i>cong(m)!:a (19z.,24y.,13.3i.)</i>	10
Point set theory implemented in Matlab	10
Area 7 from the score	11

ABSTRACT:

“Chaotic modelling to structured order”. The dynamic properties of free flowing congestion.

- *The impact that lane-changing manoeuvres have by reducing the number of traffic congestion that are caused by spontaneous braking, these characteristics are described by using cellular automata model. - (Kohei Arai / Steven Ray Sentinuwo)*
- The simulation was implemented in Matlab programming language .
- *Vehicles exhibiting elastic behaviour and structural changes caused by (stop-and-go waves of synchronized congested traffic, braking, acceleration, deceleration).*

Location - *Sandton /Buccleuch interchange – Western Bypass, De Villiers Graaff Motorway and Eastern Bypass – Johannesburg, Gauteng, South Africa*

Date: *48 recordings of data were captured between February / 2015 – August / 2015.*

Time: *Peak hour recordings: 7h00 -9h00 and 16h00 -18h00*

Camera: *Four cameras installed*

PROPOSED METHOD - A:

Introduction of the (CA) model aided in the process of visualization forming a clearer understanding in the formation orderly structures in managing congestion.

The cellular automata model for traffic introduced by Nagel and Schreckenberg (NaSch) has been modified to present two additional elements.

The first additional element is spontaneous-braking parameter. This element is needed to illustrate the probability of spontaneous-braking behaviour of the vehicle that occur in the real traffic situation. The value of braking is a variable number and the spontaneous-braking represent the extreme value of a braking behaviour. Thus, the slow-down rule of vehicle $v(i) - 1$ cells/time-step cannot describe the characteristic of spontaneous-braking only by using a spontaneous-braking probability P_b : $v(i) \rightarrow v(i) - bx$. Here bx denotes the characteristic of driver whilst braking. The value of bx is equal or less than the current speed $v(i)$. This rule takes into account the dynamic characteristic of the driver whilst braking. To investigate the effect of spontaneous-braking behaviour the state of a road cell at the next time-step, from t to $t + 1$ is dependent on the states of the direct frontal neighbourhood cell of the vehicle and the core cell itself of the vehicle. The state of the road cells can be obtained by applying the following rules to all cells (vehicles) parallel updated:

$$\begin{aligned}
 \text{Acceleration: } & v(i) \rightarrow \min(v(i) + 1, v_{max}) \\
 \text{Deceleration: } & v(i) \rightarrow \min(v(i), gap(i)) \quad (5) \\
 \text{Spontaneous braking probability } & pb: v(i) \rightarrow v(i) - bx \\
 \text{Driving: } & x(i) \rightarrow x(i) + v(i)
 \end{aligned}$$

As this simulation model tries to investigate the effect of spontaneous-braking behaviour on traffic flow (*the model deliberately eliminates the randomization rule of original NaSch ($v(i) - 1$ cells/time-step)*) by avoiding the speed reduction of vehicles caused by this rule that could influence our simulation results. The variable $gap(i)$ indicates the distance between a vehicle $x(i)$ and its predecessor $x((i)+1)$. v_{max} represents the maximum speed of the vehicle.

The second additional element is lane-changing parameter. By applying multiple desired velocity types, to accommodates the lane-changing manoeuvres of vehicles. To evaluate the impact of lane-changing manoeuvres towards the traffic congestion that is caused by spontaneous-braking behaviour of the driver. The lane-changing manoeuvre is analogous as the movement of liquid. This lane-changing model will preserve the deceleration rule in our

model that is in equation (5). The lane-changing rule is applied to vehicles to change from right lane to left lane and conversely. Vehicles are only move sideways and they do not advance.

- $Cell_{next} > 0$
- $Cell_{target} = 0$
- $X(cells\ back) + V(cells\ back)_{t+1} \neq cell_{target}$ (10)

$Cell_{next}$, $Cell_{target}$, and $Cell_{back}$ are the parameters that inform the state of one cell ahead, state of next cell, and state of cells behind on the other lane, respectively. If one cell is unoccupied or free-cell then its state is 0. In the real traffic situation, a driver also has to look back on the other lane and estimate the velocity of another cars-behind to avoid a collision. Equation (10) accommodates the driver behaviour to estimate the velocity of vehicles before change the lane.

PROPOSED METHOD – B:

A site-specific project that investigates the elastic potential energies exhibited by [uni-directional] vehicular motion in lane changing and braking manoeuvres approaching various partial deadlocks of cluster formations. This was conducted by alterations in speed (acceleration, deceleration, driving) practises. Determining the linear momentum of the various groups of vehicles (a product of mass and velocity) which are frame dependant (a person driving a vehicle) and are subjected to various driving forces i.e. stop and start, acceleration and deceleration in speed - showed elastic property behaviours in cluster and outside cluster formations. Attention was placed in particular to the elastic mobility of vehicle Matlab allowed for the translation of the data collected from the micro-environment to be analysed into audio frequency parameter evaluation as well as time duration relationships for each occurring event.

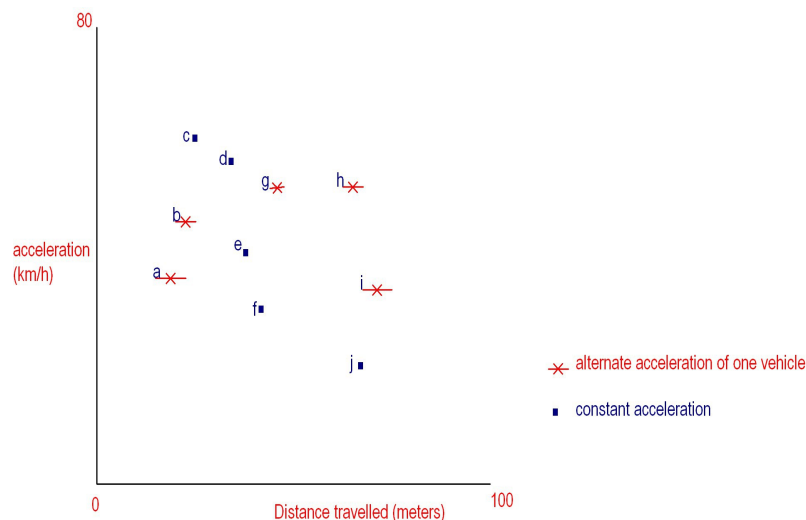


Diagram 1: shows vehicles at constant acceleration (c,d,e,f,j) and one vehicle with alternate accelerations (a,b,g,h,i), they are grouped into separate groups according to velocity range.

The mobility of vehicles are governed by the kinetic mobility theory, with exponents dominated solely by external characteristics of the intrinsic velocity distribution behaviours. The elastic behaviour generated resulted definitive structural changes of vehicle placements in pre-cluster, cluster and post cluster formations in a four lane unidirectionally system.

With the increase in the number of vehicles on the road, vehicle density increases. The smaller the spacing between vehicles, the higher interaction between vehicles is. When density maintains in a low level, the vehicles' movement are free. When the vehicle is moving forward, the relationship between position and time is linear and vehicle keeps constant speed. When

the density increase, the degree of free movement reduces and traffic blocking is generated in roadway. The relationship between position and time is non-linear. Traffic movement and congestion appear alternately, similar to the peaks and troughs of the wave propagation.

Cluster formation begins with 3 vehicles and increases accordingly. When a multiple of vehicles travel with a single velocity, positioning according to there pitch maybe presented together in a cluster minor key or major key (e.g. C3 , D3, E3 or C#3 , D#3, E#3) are used.

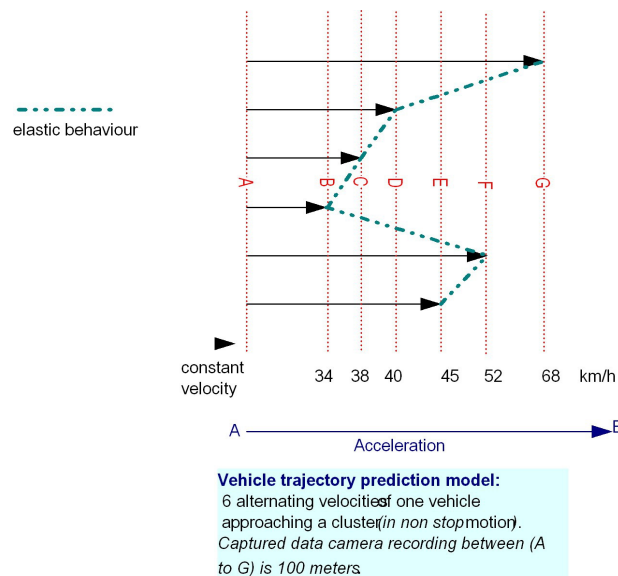


Diagram 2: shows 6 alternating velocities of a vehicle within a specific time frame to interpret this into sound the following key/notation was used 1 **major** and 1 **minor** keys (e.g. C3 and C#3) of isometric length (velocity) and specific positioning of data produce alternate frequency pattern this shows velocity variations occurring from a single vehicle. These configurations are only used to portray *elastic behaviour* when vehicles exhibit pitch / velocity variations in close proximity (*vehicles inserted at a constant or alternating acceleration as notation in musical composition could be recognised by the listener as one , two or a multiple of notes losing track of the number inserted. As sum of elements notes increase what is noted is not the sum of the notes but the escalating or de-escalating dynamic intensity.*)

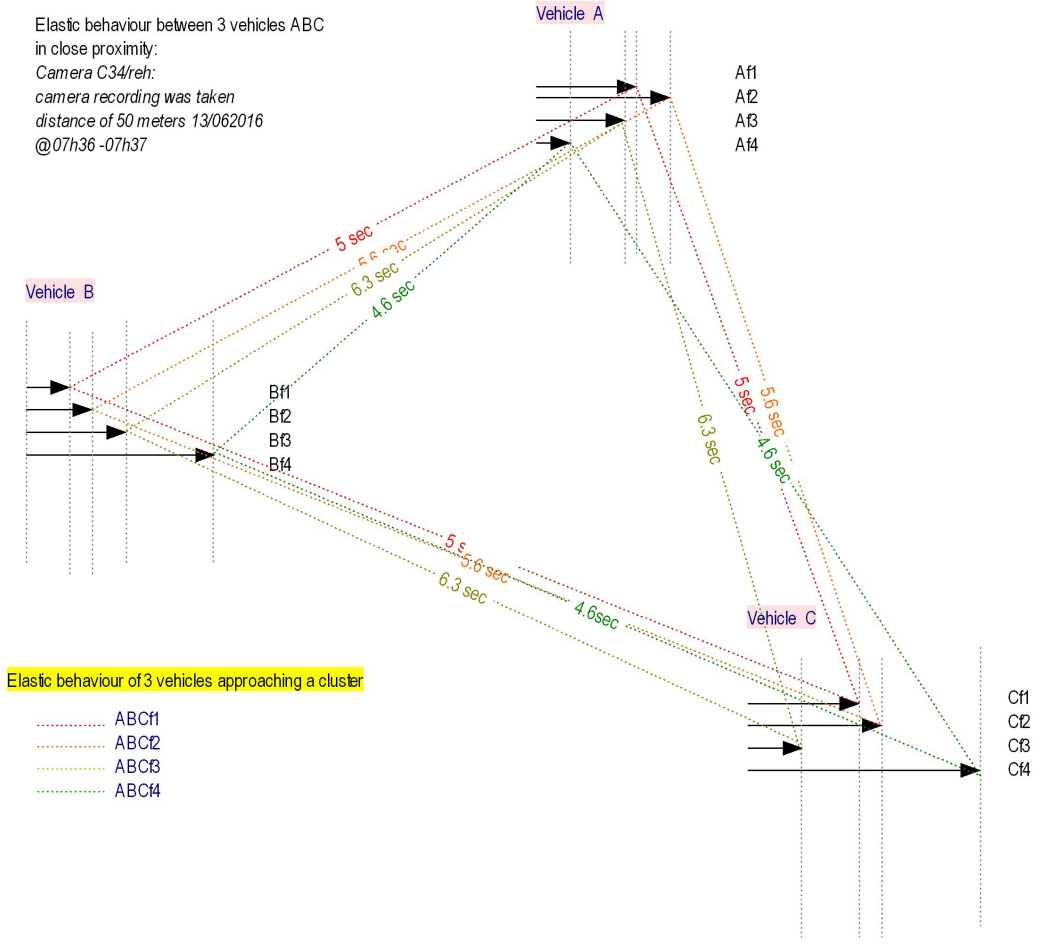
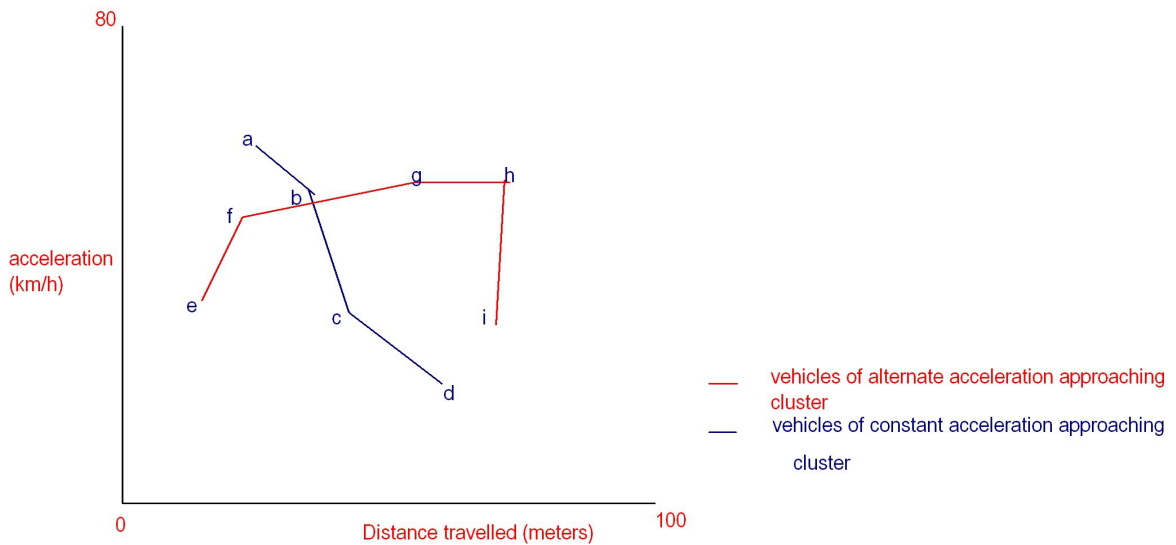
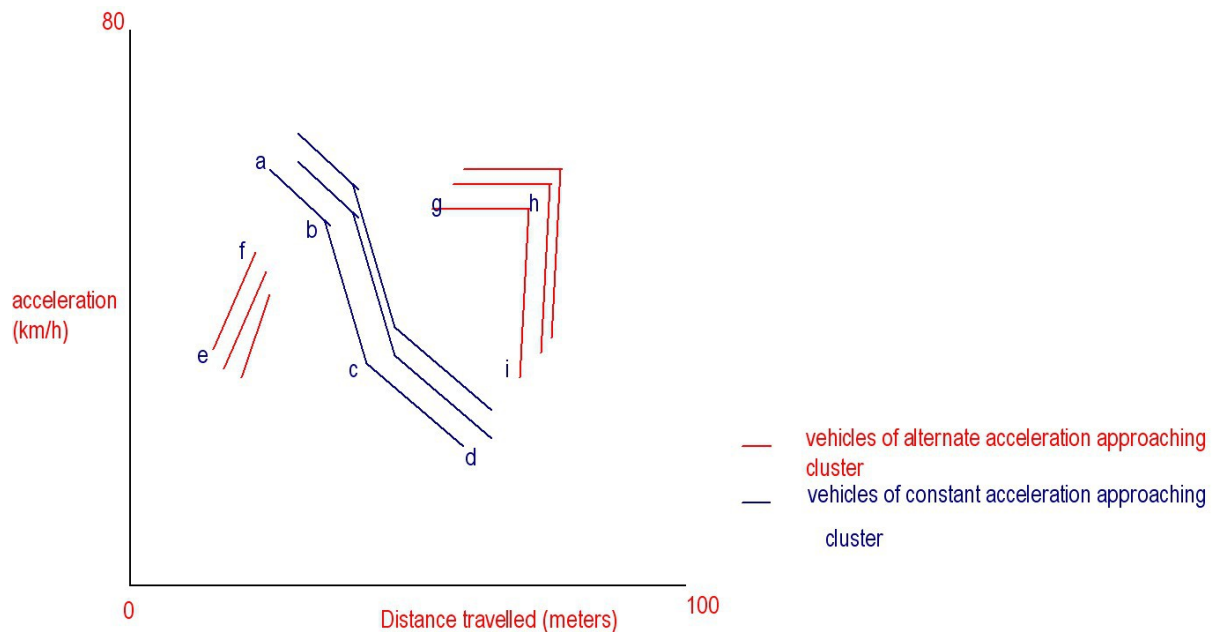


Diagram 3: shows elastic behaviour within 3 vehicles (ABC) travelling in close proximity to one another (elastic behaviour between 4 separate (velocity / time) variations between (Af1,Bf1,Cf1) , (Af2,Bf2,Cf2), (Af3,Bf3,Cf3) and (Af4,Bf4,Cf4)) are described in detail.





Vehicles exhibiting elastic behaviour and structural changes:

Expansion and contraction of clusters have these contributing factors:

- *(In)* flow and *(out)* flow densities must be continuous (free flowing).
- Speed (velocity) variations of individual vehicles travelling at a given distance and time (*showing elastic behaviour*).
- Constant speed acceleration of individual vehicles at a given distance and time do not exhibit elastic behaviour but structural changes.

This is the mechanical generator within the structural process where information creates the means by which building and dismantling of clusters occurs (*The dismantling or release cycle could exhibit implosive and explosive behaviour depending on an increase or decrease in localized density of vehicles present*).

Composition

In the above exercise we are able to simulate the data obtained from the real traffic situation by applying certain unclear areas of data to the new cellular automata model. Clarity was established in the logistics of motion of micro-environments such as a detailed explanation in areas of silence, deceleration, acceleration, macro-environments focusing on *mass* representation of vehicles undergoing dense structural changes. The elastic potential energies exhibited in lane changing and braking manoeuvres approaching various partial deadlocks of cluster formations. *Assisted composer* selection possibilities (in structure formations) influenced the dynamics of the composition.

cong(m)l:a(19z...,24y...,13.3i..) grand piano and electronics **/ (05g...,31v...,08p..)** for solo instrument the grand piano, **/ (02p...,07d...,13k..)** programming for MIDI piano realised by computer. The abbreviated wording of the title are as follows: congestion - **cong**, multi - **(m)**, lane - **l**, area/s - **a(..)**.

Matlab assisted in making statistical simulations to graphic analysis of meta-data extracted from 3 areas and 8 sub-areas of various free flowing vehicle congestions (possibilities of fragmentations relating to note dynamics, pitch positioning, densities, instants, intensity, constant / alternating velocities were created, a fraction of these fragments were used) created simplistic and complex rhythmical patterns which would otherwise be blurred by the chaotic mass of the polyphonic linear system in the macro-environment.

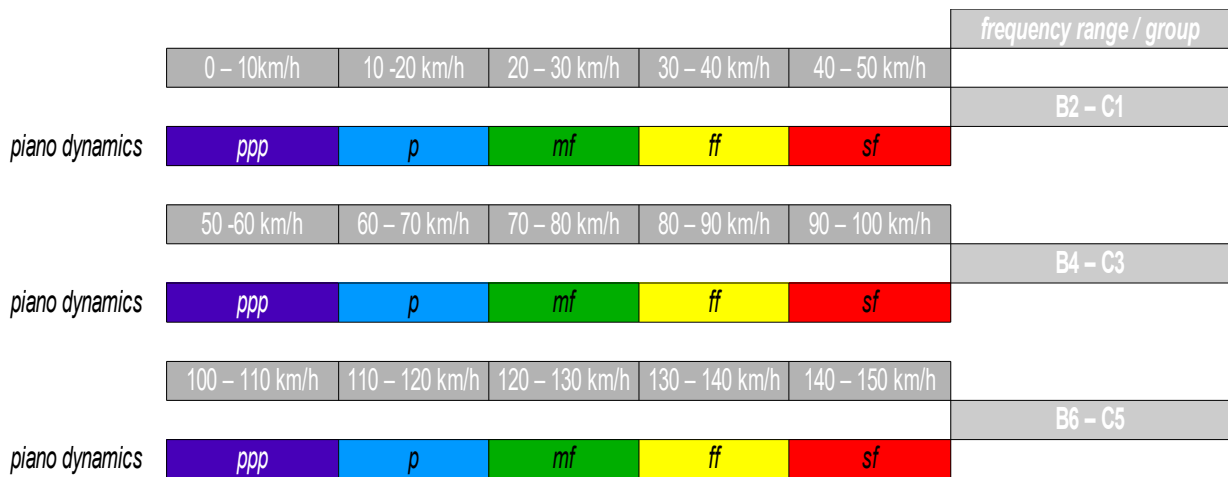


Diagram:6 - Piano note dynamics and note (pitch) frequency range in 15 groups of vehicles travelling between 0 - 150 km/h

An increase or decrease in - velocity, pitch and adjustment of dynamics play a central role in kinetic motion, behaviour of a vehicle in motion.

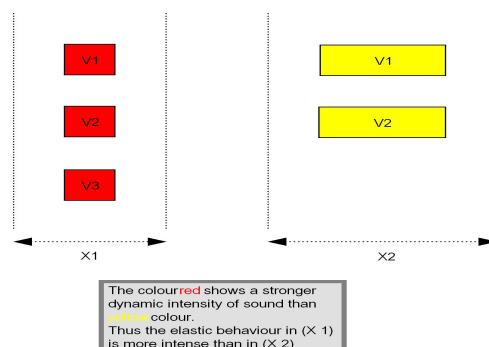


Diagram 7: shows elastic behaviour expansion between the densities of 3 vehicles travelling in a straight line at a constant acceleration (X1 column) with dynamic intensity (red) is greater than the elastic behaviour exercised by densities of 2 vehicles travelling in a straight line at a constant acceleration (X2 column) with dynamic intensity (yellow) i.e. cross comparison of dynamic intensity between columns X1 and X2 – 2 vehicles in column X2 would have the same dynamic intensity as one vehicle in X1 thus an alternate elastic behaviour is exercised between vehicles in X1 and X2.

Assistant composer "suggestive selection process by Matlab" in composition *cong(m)-l:a* (19z...,24y...,13.3i..) (05g...,31v...,08p..) / (02p...,07d...,13k.):

Data from the recording process was graphically arranged in (pitch / duration). 22 areas in the score were identified for the computer to act as an assistant composer. In these areas problems in selection and implementation arose which resulted in an in-decisive ability by the composer to take action (due to volume of data recordings and the similarities (sonically, graphically) in structure formation per area. The data provided 48 data recordings with graphic plottings ((*pitch* - divided into (*rows*) regions of piano notes between A7-G2) versus *duration* per area of (2 - 15 sec)). Matlab was used to analyse these fields and to execute non-deterministic computational tasks using probability as a process of selection.

Point set theory implemented in Matlab:

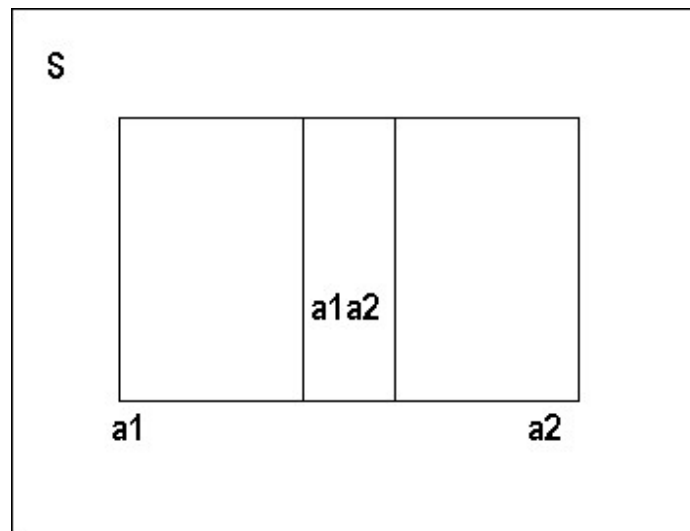


Diagram 8: indicates both graphic and sonic symbols explained below

- Data supplied as points in space (which can be of 1,2,3, etc. dimensions) called sample space S.
- If S contains only a finite number of points then with each point we can associate a non-negative number, called a probability, such that the sum of all numbers corresponding to all points in S add to one.
- An event is a set or collection of points in S such as indicated in the Venn diagram a1 or a2.
- The event $a1+a2$ is the set of points which are either in a1 or a2 or both while the event $a1a2$ is the set of points common to both a1 and a2. Then the probability of $a1+a2$ denoted by $\Pr\{a1+a2\}$, is the sum of probabilities associated with all points contained in the set $a1+a2$.
- If a1 and a2 have no points in common, i.e. the events are mutually exclusive, then $\Pr\{a1+a2\} = \Pr\{a1\} + \Pr\{a2\}$. If they have points in common then $\Pr\{a1+a2\} = \Pr\{a1\} + \Pr\{a2\} - \Pr\{a1a2\}$.
- The set $a1+a2$ is sometimes denoted by $a1 \cup a2$ and is called the union of the two sets. The set $a1a2$ is sometimes denoted by $a1 \cap a2$ and is called the intersection of the two sets. Extensions to more than two sets can be made.
- A special symbol φ is sometimes used to denote a set with no points in it, called the null set. The probability associated with an event corresponding to this set zero i.e. in the a1,a2 events if 1 - ∞ points correspond in pitch irrespective of time duration these sonic points will be nullified $\Pr\{\varphi\} = 0$.
- Other symbols used - intersection (.), union (+), negation (-) - ($a1^-$) sonic enumeration of the elements of S not included in a1, implication (\succ).

Area 7 from the score:
below - (5 min 07 sec – 5 min 10 sec).

From the 48 data cell recordings made, data was split into 4 rows or regions of piano keys (A,B,C,D ranging from A7-G2) 12 cells per row, the cells with no recorded data are labelled cells with no occurrences placed anywhere between rows A-D.

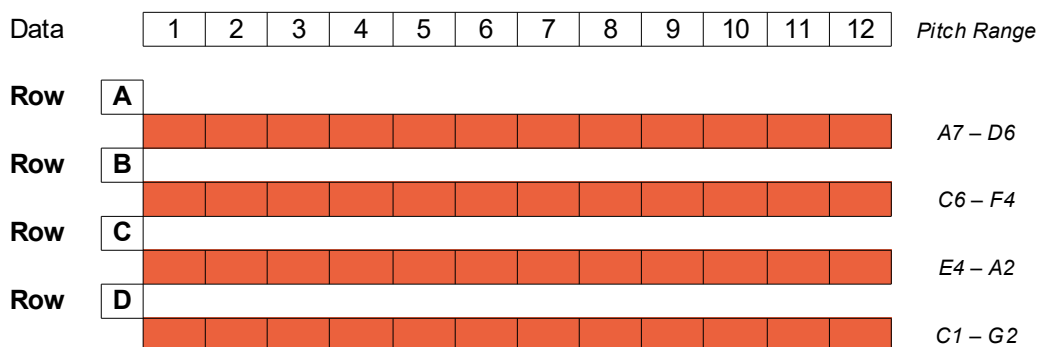


Diagram 9: 48 data captured are split into 4 Rows A – D of 12 data cells per row arranged as points in graphic form of pitch / duration.

First step:

Interactions are confined between data cells in each row, there are no interactions between rows e.g. a1 can interact with a8,a7,a3 etc, not with c7,b3,d12
 Data cells introduced to the **first step:** 48 data cells introduced, 27 have no occurrences, 13 $Pr\{\varphi\}=0$. $48 - 27 - 13 = 8$ occurrences.

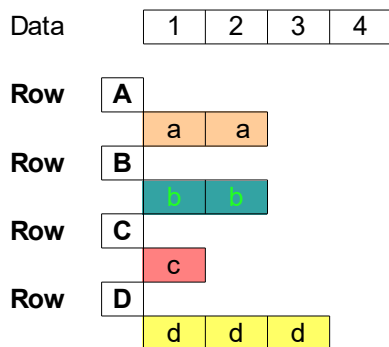


Diagram 10: 8 data occurrences arranged into Rows A (a1,a2), B (b1,b2), C (c1), D (d1,d2,d3).

Second step:

Interaction between rows A (a1,a2), B (b1,b2), C (c1), D (d1,d2,d3) in the formation of the final acceptable notated structure. **Area 7** = fusing of data from a1,a2,b1,b2,c1,d1,d2,d3 to produce structure.

Position	Status	Cha	Num	Val	Length/Info
154	4	4	125	Note	1 D#6 127 -- -- -- 1
155	1	1	59	Note	1 F6 127 -- -- -- 1
155	1	1	194	Note	1 D6 127 -- -- -- 212
155	1	1	194	Note	1 E6 127 -- -- -- 2 214
155	1	3	6	Note	1 D6 127 -- -- -- 1 137
155	1	4	143	Note	1 E5 112 -- -- -- 199
155	1	4	195	Note	1 D#6 127 -- -- -- 1
155	2	1	129	Note	1 F6 127 -- -- -- 1
155	2	1	207	Note	1 C#6 127 -- -- -- 1 79
155	2	1	240	Note	1 G#5 116 -- -- -- 1 24
155	2	1	240	Note	1 B5 127 -- -- -- 66
155	2	2	24	Note	1 A#4 127 -- -- -- 2 214
155	2	2	37	Note	1 F#5 104 -- -- -- 1
155	2	3	24	Note	1 D6 127 -- -- -- 212
155	2	3	24	Note	1 D6 121 -- -- -- 68
155	2	3	43	Note	1 D5 99 -- -- -- 197
155	2	4	37	Note	1 F#5 127 -- -- -- 2 203
155	2	4	76	Note	1 D6 127 -- -- -- 1 137
155	2	4	185	Note	1 E5 90 -- -- -- 2 60
155	3	1	37	Note	1 C6 127 -- -- -- 1 79
155	3	1	129	Note	1 A#5 127 -- 1 0 79
155	3	1	195	Note	1 F4 127 -- -- -- 1 7
155	3	2	47	Note	1 G4 127 -- -- -- 1 164
155	3	2	70	Note	1 D6 127 -- -- -- 66
155	3	2	189	Note	1 C#4 119 -- -- -- 2 29
155	3	3	37	Note	1 F3 127 -- -- -- 2 203
155	3	3	195	Note	1 D#6 127 -- -- -- 1
155	3	3	205	Note	1 D#4 108 -- -- -- 21
155	3	4	24	Note	1 C6 127 -- -- -- 212
155	3	4	30	Note	1 C5 127 -- -- -- 209
155	3	4	129	Note	1 A#3 127 -- 1 0 79
155	4	1	129	Note	1 G4 127 -- -- -- 1
155	4	1	166	Note	1 A#4 124 -- -- -- 2 56
155	4	3	24	Note	1 D#3 127 -- -- -- 2 214
155	4	3	76	Note	1 F#4 127 -- -- -- 1 137
156	3	4	129	Note	1 F#4 127 -- -- -- 1 137
156	4	1	129	Note	1 A4 127 -- -- -- 1 137
156	4	2	226	Note	1 C#5 116 -- -- -- 1 24
156	4	3	10	Note	1 D#4 127 -- -- -- 2 214
156	4	3	23	Note	1 B4 104 -- -- -- 1
156	4	4	29	Note	1 G4 99 -- -- -- 197

Diagram 11: cong(m)|:a(19z...,24y...,13.3i..) formation of notated structure in Area 7.

Reference:

- Richards, P.J., (1956), Shock waves on the highway, *Operations Research* 4, 42–51.
- Chandler, R., R. Herman, and E. Montroll (1958). Traffic dynamics; studies in car-following. *Operations Research* 6, 165+.
- Herman R, Montroll E W, Potts R B, et al (1959). Traffic dynamic: Analysis of Stability in car-following [J]. *Operations Research* 7, 86-106.
- Bank J (1991). Two-capacity phenomenon at freeway bottlenecks: a basis for ramp metering [J]. *Transportation Research Record*, 1320: 83-90.
- K. Nagel, M. Schreckenberg (1992). A cellular automaton model for freeway traffic, *Journal de Physique I* 2(12), 2221-2229.
- S. C. Benjamin, N.F. Johnson, P. M. Hui (1996). Cellular automata models of traffic flow along a highway containing a junction, *Journal of Physics A: Mathematical and General* 29(12) 3119-3127.
- R. Barlovic, L. Santen, A. Schadschneider and M. Schreckenberg (1998), Metastable states in cellular automata for traffic flow, *Eur. Phys. J. B* 5, 793.
- D. Chowdhury, L. Santen and A. Schadschneider (2000). Statistical physics of vehicular traffic and some related systems, *Physics Reports* 329, 199.
- Gary Lee Nelson. Real time transformation of musical material with fractal algorithms. URL: <http://www.timara.oberlin.edu/people/%7Egnelson/gnelson.htm>, 1993.
- Anthony R. Burton and Tanya Vladimirova. Generation of musical sequences with genetic techniques. *Computer Music Journal*, 23(4):59–73, 1999.
- Wentian Li. Protein and dna music. URL: http://linkage.rockefeller.edu/wli/dna_corr/music.html, 1998.
- K.Arai/ SR.Sentinuwo. Spontaneous-braking and lane-changing effect on traffic congestion using cellular automata model applied to the two-lane traffic. (IJACSA) *International Journal of Advanced Computer Science and Applications*, Vol. 3, No.8, 2012

© Copyright: D.Voudouris 2018 - 2021