MODELLING INTELLIGENT SPEED ADAPTATION

I. Spyropoulou[1], B. Heydecker[2], G. Yannis[1]

[1]National Technical University of Athens
[2]University College London

Objective

Initial attempt to model Intelligent Speed Adaptation (ISA) using a microscopic model

- System operation – driving behaviour
- Gipps' car-following model – model dynamics

Research (NTUA – UCL, Karatheodori) follow-up of post-doc (NTUA - TRL, HUMANIST)

Methodology

- Model selection – Simulation tool
  - Model Parameters

    ⇕
  - Experimental Design
- Simulator Study
- Model parameters – Study output – Software code
- Simulation Runs - Results

Simulator Experiment

TRL simulator

- Three ISA functionalities:
  - Informative
  - Warning
  - Intervening
    - Threshold < speed limit
- Driving Environment – rural road, 2-lane single carriageway, 20, 30 and 60mph, incidents (accident, slow vehicle), light traffic.
- Simulator Drives – familiarisation run & 4 drives
- Participant Characteristics – 23: 18m & 5f, 7(19-25) & 7(26-34) & 9(35-46), 6(<5y) & 3(5-9y) & 14(>9y)

Gipps' car-following model (1/2)

- Microscopic, discrete-time and continuous space
- Implemented in AIMSUN, DRACULA, SIGSIM and SITRAS

$$u_n(t+\tau) = \quad \textbf{minimum of}$$

$$u_n(t) + 2.5 a_n \tau (1 - u_n(t)/V_n)(0.025 + u_n(t)/V_n)^{1/2}$$

$$b_n \tau + \sqrt{(b_n{}^2 \tau^2 - b_n \left[2\left[x_{n-1}(t) - s_{n-1} - x_n(t) \right] - u_n(t)\tau - u_{n-1}(t)^2 / \hat{b} \right])}$$

$$x_n(t+\tau) = x_n(t) + 0.5\left[u_n(t) + u_n(t+\tau) \right]\tau$$

Gipps' car-following model (2/2)

where

$u_n(t)$ speed of vehicle *n* at time *t*,

a_n maximum acceleration which the driver of vehicle *n* wishes to undertake,

τ apparent reaction time, the same constant for all vehicles,

V_n speed at which the driver of vehicle *n* wishes to travel.

b_n most severe braking that the driver of vehicle *n* wishes to undertake (b_n <0),

$x_n(t)$ location of the front of vehicle *n* at time *t*,

s_n effective size of vehicle *n*, that is, the physical length plus a margin into which the following vehicle is not willing to intrude, even when at rest,

$\hat{b}$ value of b_{n-1} estimated by the driver of vehicle *n* who cannot know this value from direct observation.

Simulation Software

- SIGSIM – microscopic traffic simulation software
- Simulation of several groups/types of drivers
- Network at least one link connecting nodes (signalised or operated under priority rules)
- Data input (driver characteristics, network/signal characteristics, arrival rates)

Input parameters (1/5)

- V_n – speed at which the driver of vehicle *n* wishes to travel $N(20, 3.2^2)$

Maximum speed vs. Average speed

Mean speed (m/s)

	Base	Informative	Warning	Intervening
Mean	28.01	28.04	26.70	26.45
Variance	2.34^2	2.10^2	2.72^2	0.74^2

- a_n – maximum acceleration which the driver of vehicle *n* wishes to undertake $N(1.7, 0.3^2)$

Max recorded acceleration vs. Acceleration at 0.95Vn/3

Max modified acceleration (m/sec^2)

	Base	Informative	Warning	Intervening
Mean	2.06	2.23	2.24	1.97
Variance	1.06^2	1.07^2	0.96^2	0.54^2

- investigate model and driver movement dynamics further

- τ – apparent reaction time (2/3s)

Reaction to green dot

Driver reaction time (s)

	Base	Informative	Warning	Intervening
Mean	1.49	1.55	1.60	1.80
Variance	0.49^2	0.50^2	0.46^2	0.76^2

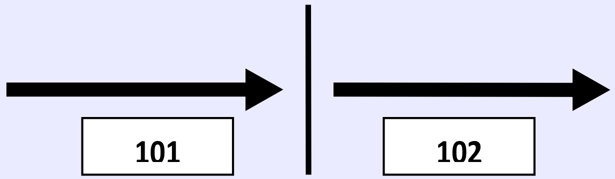
- 1.61s model behaves in a good manner & in agreement with literature findings

Input parameters (4/5)

- b_n – maximum deceleration which the driver of vehicle *n* wishes to undertake $-2a_n$
- $\hat{b}$ – value of b_{n-1} estimated by the driver of vehicle *n* $\min(-3, (b_n-3)/2)$
- s_n – effective size of vehicle *n* $N(6.5, 0.3^2)$

Input parameters (5/5)

- Simulated Network



No of Links	Link ide	Link length (m)	Entering flow	Saturation flow (PCU/h of green time)
2	101	750	Vehicle generation	1800
	102	750	101 outflow	1800

100% green, 4500s (900s), speed reduction factor, 10 runs

Light (0.33 - 600), medium (0.56 - 1000) and heavy flow (0.89 – 1600)

Similar vehicle types in each simulation

Results (1/3)

Light Flow

ISA functionality	Average delay (vehicles)	S.D.	Stop rates (number of stops/sec)	S.D.
Base				
101	26.81	31.049	0.00466	0.000201
102	34.19	22.952	0.01289	0.000707
Total	61.00	32.002	0.01756	0.000744
Informative				
101	20.87	14.595	0.00443	0.000274
102	28.58	20.387	0.01179	0.000401
Total	49.45	19.000	0.01622	0.000557
Warning				
101	19.67	20.172	0.00309	0.000374
102	25.91	19.306	0.01157	0.000348
Total	45.58	19.369	0.01466	0.000383
Intervening				
101	2.55	0.0156	0.00239	0.0000598
102	2.73	0.0147	0.00324	0.0000745
Total	5.28	0.0302	0.00563	0.0000922

Results (2/3)

❖ Medium Flow (observations at light flow)

ISA functionality	Average delay (vehicles)	S.D.	Stop rates (number of stops/sec)	S.D.
Base				
101	145.01	77.804	0.00639	0.000409
102	77.79	25.149	0.0143	0.000577
Total	222.79	64.073	0.02069	0.000775
Informative				
101	124.77	73.820	0.00526	0.000556
102	77.74	37.614	0.01358	0.000574
Total	202.51	57.502	0.01884	0.000913
Warning				
101	133.04	48.883	0.00486	0.000439
102	56.87	43.327	0.01177	0.000305
Total	189.91	38.734	0.01664	0.000619
Intervening				
101	4.49	0.0135	0.00224	6.18E-05
102	4.57	0.0122	0.00257	5.82E-05
Total	9.06	0.0245	0.00481	8.18E-05

Results (3/3)

❖ Heavy Flow (observation at light flow)

ISA functionality	Average delay (vehicles)	S.D.	Stop rates (number of stops/sec)	S.D.
Base				
101	310.95	93.202	0.00373	0.00023
102	134.7	63.655	0.01636	0.00063
Total	445.65	44.188	0.02009	0.000587
Informative				
101	287.43	79.241	0.004	0.000216
102	146.15	57.654	0.01586	0.000375
Total	433.58	45.100	0.01986	0.000467
Warning				
101	319.2	60.506	0.00286	0.000345
102	102.78	54.944	0.01393	0.000315
Total	421.98	22.088	0.01678	0.000562
Intervening				
101	122.85	0.6636	0.00223	1.81E-05
102	5.97	0.0154	0.00371	0.000176
Total	128.82	0.6659	0.00595	0.000182

Discussion

- Not a straightforward task
- Synchronisation of model parameters and observed behaviour
- Comprehension of model and driver behaviour dynamics
- Suitability of collected data

- Use of ISA influences network operational performance
- Effect is maximised under light & medium traffic conditions

- Different penetration rates, complex networks

MODELLING INTELLIGENT SPEED ADAPTATION

I. Spyropoulou[1], B. Heydecker[2], G. Yannis[1]

[1]National Technical University of Athens
[2]University College London