TRAFFIC FLOW MODEL

Sushmita Rose John

Under the Guidance of

Prof.S.Sundar

Department of Mathematics IIT Madras

Outline

Outline

1. Traffic Flow Model
2. Traffic Signal
3. Speed Breaker

Introduction

Some of the different traffic flow models are :

- LWR Model
- Greenshield's Model
- Greenberg Model
- PW Model
- Optimal Velocity Model
- Stochastic Traffic Cellular Automata

LWR Model

LWR Model

Traffic stream is treated as a 1-D compressible fluid.

LWR Model

Traffic stream is treated as a 1-D compressible fluid.

Conservation law

$$\rho_t + \phi_x = 0$$

where ϕ is the flux across the boundary.

LWR Model

Traffic stream is treated as a 1-D compressible fluid.

Conservation law

$$\rho_t + \phi_x = 0$$

where ϕ is the flux across the boundary.

In this model, $\phi = \rho v$ where ρ and v are the traffic density and velocity respectively.

Fundamental Diagram

Fundamental Diagram

Assumption

Velocity depends only on density.

Fundamental Diagram

Assumption

Velocity depends only on density.

- If $\rho = 0$ then $v = v_{max}$, the maximum velocity;

Fundamental Diagram

Assumption

Velocity depends only on density.

- If $\rho = 0$ then $v = v_{max}$, the maximum velocity;
- If $\rho = \rho_{max}$, the maximum density, then v=0;

Fundamental Diagram

Assumption

Velocity depends only on density.

- If $\rho = 0$ then $v = v_{max}$, the maximum velocity;
- If $\rho = \rho_{max}$, the maximum density, then v=0;
- $\dfrac{d\rho}{dv} \leqslant 0$.

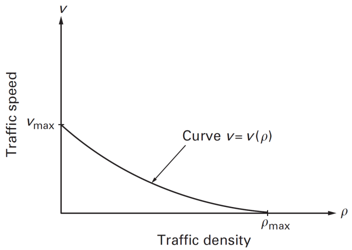


Figure: Fundamental Diagram showing density-velocity relation

Greenshields Model

Greenshields Model

- $v = v_{max}(1 - \frac{\rho}{\rho_{max}})$

Greenshields Model

- $v = v_{max}(1 - \frac{\rho}{\rho_{max}})$
- Modified Model : $\rho_t + (\rho v_{max}(1 - \frac{\rho}{\rho_{max}}))_x = 0$ where ρ_{max} is the maximum traffic density and v_{max} is the maximum velocity of traffic.

Greenshields Model

- $v = v_{max}(1 - \frac{\rho}{\rho_{max}})$
- Modified Model : $\rho_t + (\rho v_{max}(1 - \frac{\rho}{\rho_{max}}))_x = 0$ where ρ_{max} is the maximum traffic density and v_{max} is the maximum velocity of traffic.
- **Burgers Equation** : $u_t + (\frac{u^2}{2})_x = 0$ where $u = 1 - \frac{2\rho}{\rho_{max}}$.

Greenshields Model

- $v = v_{max}(1 - \frac{\rho}{\rho_{max}})$
- Modified Model : $\rho_t + (\rho v_{max}(1 - \frac{\rho}{\rho_{max}}))_x = 0$ where ρ_{max} is the maximum traffic density and v_{max} is the maximum velocity of traffic.
- **Burgers Equation** : $u_t + (\frac{u^2}{2})_x = 0$ where $u = 1 - \frac{2\rho}{\rho_{max}}$.
- These models are non-linear hyperbolic p.d.e.'s, and can be solved using the method of characteristics.

Conservative Numerical Schemes

Gudonov Method :For all i,n do :

- if $f'(u_i^n) \geqslant 0$ and $f'(u_{i+1}^n) \geqslant 0$ then $u_i^* = u_i^n$;
- if $f'(u_i^n) < 0$ and $f'(u_{i+1}^n) < 0$ then $u_i^* = u_{i+1}^n$;
- if $f'(u_i^n) \geqslant 0$ and $f'(u_{i+1}^n) < 0$ then $u_i^* = u_i^n$ if $(s \geqslant 0)$ or $u_i^* = u_{i+1}^n$ if $(s < 0)$ where $s = \dfrac{f(u_{i+1}^n) - f(u_i^n)}{u_{i+1}^n - u_i^n}$;
- if $f'(u_i^n) < 0$ and $f'(u_{i+1}^n) \geqslant 0$ then u_i^* is the unique solution of $f'(u_i^*) = 0$;
- Set $u_i^{n+1} = u_i^n - \dfrac{k}{h}(f(u_i^*) - f(u_{i-1}^*))$

This scheme has ben shown to be conervative, consistent and will converge to the entropy satisfying solution of the problem.

Assumptions

$u_{max} = 1$ and $v_{max} = 1$

Model

$\rho_t + (\rho(1-\rho))_x = 0.$

Burgers Equation

$u_t + (\frac{u^2}{2})_x = 0$ with $u = 1 - 2\rho$

Outline

1. Traffic Flow Model
2. Traffic Signal
3. Speed Breaker

Traffic Signal

PROBLEM

How does the traffic behave near a signal?

Aim

Suppose there is a traffic signal on the road.

Aim

Suppose there is a traffic signal on the road.

1. how the traffic moves when the signal is red.

Aim

Suppose there is a traffic signal on the road.

1. how the traffic moves when the signal is red.
2. how the traffic flow changes when signal turns from red to green.

Aim

Suppose there is a traffic signal on the road.

1. how the traffic moves when the signal is red.
2. how the traffic flow changes when signal turns from red to green.
3. how the traffic flow changes when signal turns from green to red.

Red Light

Suppose the signal light is red.

Red Light

Suppose the signal light is red.

Experience

Cars will pile up behind the signal as time passes.

Red Light

Let us model the road from $x = x_1$ to $x = x_{15}$.

Red Light

Let us model the road from $x = x_1$ to $x = x_{15}$.

Suppose that there is a signal at $x = \bar{x}$ between x_6 and x_7 which is red at t=0.

Red Light

Let us model the road from $x = x_1$ to $x = x_{15}$.

Suppose that there is a signal at $x = \bar{x}$ between x_6 and x_7 which is red at t=0.

We will use the Burgers equation to solve this problem.

Red Light

Let us model the road from $x = x_1$ to $x = x_{15}$.

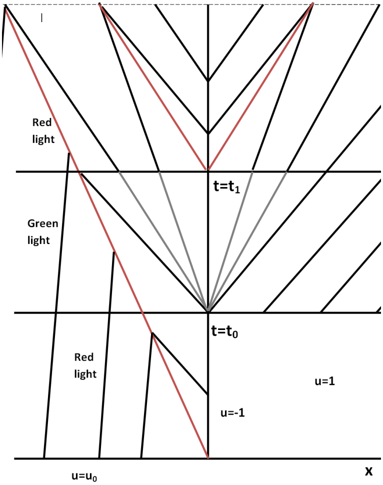
Suppose that there is a signal at $x = \bar{x}$ between x_6 and x_7 which is red at t=0.

We will use the Burgers equation to solve this problem.

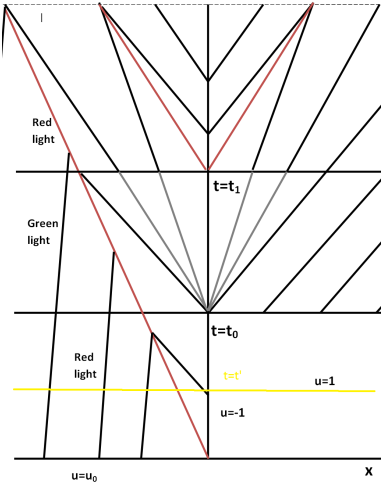
Assumption

$$u(\bar{x}, t) = -1 \text{ for all t.}$$

Characteristic Curves



Characteristic Curves



Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0
0.1	0.55	0.55001	0.550409	0.561946	0.677687	0.904947	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0
0.1	0.55	0.55001	0.550409	0.561946	0.677687	0.904947	0	0	0	0	0	0	0	0	0
0.2	0.550059	0.551451	0.576059	0.717113	0.908046	0.98727	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0
0.1	0.55	0.55001	0.550409	0.561946	0.677687	0.904947	0	0	0	0	0	0	0	0	0
0.2	0.550059	0.551451	0.576059	0.717113	0.908046	0.98727	0	0	0	0	0	0	0	0	0
0.3	0.552749	0.589143	0.744626	0.915865	0.984046	0.998433	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0
0.1	0.55	0.55001	0.550409	0.561946	0.677687	0.904947	0	0	0	0	0	0	0	0	0
0.2	0.550059	0.551451	0.576059	0.717113	0.908046	0.98727	0	0	0	0	0	0	0	0	0
0.3	0.552749	0.589143	0.744626	0.915865	0.984046	0.998433	0	0	0	0	0	0	0	0	0
0.4	0.602143	0.767777	0.924342	0.983805	0.997602	0.999809	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0
0.1	0.55	0.55001	0.550409	0.561946	0.677687	0.904947	0	0	0	0	0	0	0	0	0
0.2	0.550059	0.551451	0.576059	0.717113	0.908046	0.98727	0	0	0	0	0	0	0	0	0
0.3	0.552749	0.589143	0.744626	0.915865	0.984046	0.998433	0	0	0	0	0	0	0	0	0
0.4	0.602143	0.767777	0.924342	0.983805	0.997602	0.999809	0	0	0	0	0	0	0	0	0
0.5	0.788663	0.932553	0.984693	0.997289	0.999656	0.999977	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

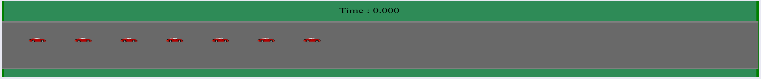
Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	0.55	0.55	0.55	0.55	0.55	0.55	0	0	0	0	0	0	0	0	0
0.1	0.55	0.55001	0.550409	0.561946	0.677687	0.904947	0	0	0	0	0	0	0	0	0
0.2	0.550059	0.551451	0.576059	0.717113	0.908046	0.98727	0	0	0	0	0	0	0	0	0
0.3	0.552749	0.589143	0.744626	0.915865	0.984046	0.998433	0	0	0	0	0	0	0	0	0
0.4	0.602143	0.767777	0.924342	0.983805	0.997602	0.999809	0	0	0	0	0	0	0	0	0
0.5	0.788663	0.932553	0.984693	0.997289	0.999656	0.999977	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the signal is red.

Visualization



Aim

1. how the traffic moves when the signal is red.
2. how the traffic flow changes when signal turns from red to green.
3. how the traffic flow changes when signal turns from green to red.

Green Light

At $t = t_1$, the signal turns green.

Green Light

At $t = t_1$, the signal turns green.

Experience

Traffic density starts spreading out to the right of the signal, with the car near the signal moving at maximum velocity at $t = t_1$ as the road is empty in front of it.

Green Light

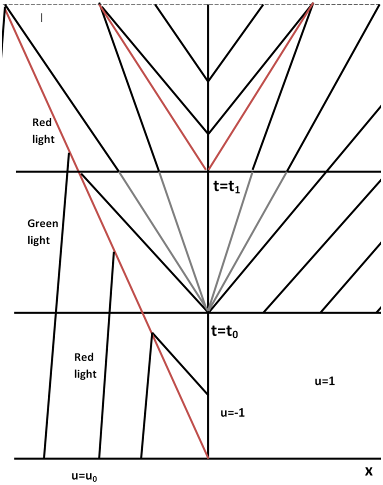
At $t = t_1$, the signal turns green.

Experience

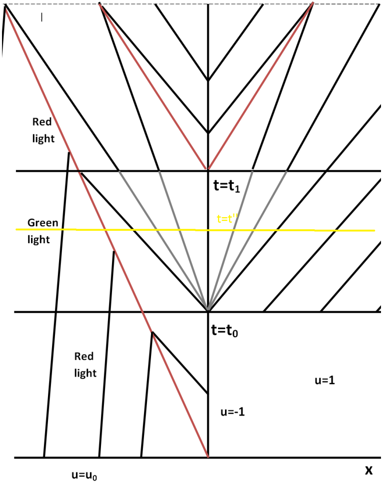
Traffic density starts spreading out to the right of the signal, with the car near the signal moving at maximum velocity at $t = t_1$ as the road is empty in front of it.

Take $u_0(x) = u(x, t_0)$

Characteristic Curves



Characteristic Curves



Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method when the traffic light is green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.93783	0.97706	0.97021	0.93252	0.86033	0.74554	0.25444	0.13960	0.067017	0.02700	0.0089124	0.0023857	0.00051888	$9.2e-5$	$1.3e-5$

Table: Data obtained using Gudonov Method when the traffic light is green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.93783	0.97706	0.97021	0.93252	0.86033	0.74554	0.25444	0.13960	0.067017	0.02700	0.0089124	0.0023857	0.00051888	$9.2e-5$	$1.3e-5$
0.7	0.94991	0.92946	0.88726	0.82856	0.75460	0.6635	0.33642	0.24537	0.17131	0.11213	0.067604	0.036933	0.018035	$7.7e-3$	$2.9e-3$

Table: Data obtained using Gudonov Method when the traffic light is green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.93783	0.97706	0.97021	0.93252	0.86033	0.74554	0.25444	0.13960	0.067017	0.02700	0.0089124	0.0023857	0.00051888	$9.2e-5$	$1.3e-5$
0.7	0.94991	0.92946	0.88726	0.82856	0.75460	0.6635	0.33642	0.24537	0.17131	0.11213	0.067604	0.036933	0.018035	$7.7e-3$	$2.9e-3$
0.8	0.89889	0.86061	0.81284	0.75745	0.69474	0.62281	0.37718	0.30524	0.24250	0.18696	0.13860	0.097884	0.06519	0.04054	0.02333

Table: Data obtained using Gudonov Method when the traffic light is green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.93783	0.97706	0.97021	0.93252	0.86033	0.74554	0.25444	0.13960	0.067017	0.02700	0.0089124	0.0023857	0.00051888	$9.2e-5$	$1.3e-5$
0.7	0.94991	0.92946	0.88726	0.82856	0.75460	0.6635	0.33642	0.24537	0.17131	0.11213	0.067604	0.036933	0.018035	$7.7e-3$	$2.9e-3$
0.8	0.89889	0.86061	0.81284	0.75745	0.69474	0.62281	0.37718	0.30524	0.24250	0.18696	0.13860	0.097884	0.06519	0.04054	0.02333
0.9	0.84302	0.80310	0.75858	0.71002	0.6572	0.59837	0.4016	0.34274	0.28995	0.24134	0.19663	0.15599	0.11982	0.08855	0.06254

Table: Data obtained using Gudonov Method when the traffic light is green.

Observations

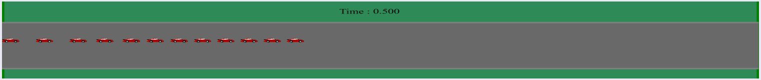
Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.93783	0.97706	0.97021	0.93252	0.86033	0.74554	0.25444	0.13960	0.067017	0.02700	0.0089124	0.0023857	0.00051888	$9.2e-5$	$1.3e-5$
0.7	0.94991	0.92946	0.88726	0.82856	0.75460	0.6635	0.33642	0.24537	0.17131	0.11213	0.067604	0.036933	0.018035	$7.7e-3$	$2.9e-3$
0.8	0.89889	0.86061	0.81284	0.75745	0.69474	0.62281	0.37718	0.30524	0.24250	0.18696	0.13860	0.097884	0.06519	0.04054	0.02333
0.9	0.84302	0.80310	0.75858	0.71002	0.6572	0.59837	0.4016	0.34274	0.28995	0.24134	0.19663	0.15599	0.11982	0.08855	0.06254
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722

Table: Data obtained using Gudonov Method when the traffic light is green.

Green Light

Visualization



Green Light

We can also model the traffic already present on the road when the signal turns green.

$$u_0(x) = \begin{cases} u(x, t_0), & x \geqslant x_1 \\ 1, & x < x_1 \end{cases}$$

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0

Table: Data obtained using Gudonov Method for the density changes in the existing traffic when the signal turned green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.71714	0.97706	0.97021	0.9325	0.8603	0.7455	0.25444	0.13960	0.067017	0.02706	0.00891	0.00238	0.00051	$9.2e-005$	$1.3e-005$

Table: Data obtained using Gudonov Method for the density changes in the existing traffic when the signal turned green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.71714	0.97706	0.97021	0.9325	0.8603	0.7455	0.25444	0.13960	0.067017	0.02706	0.00891	0.00238	0.00051	$9.2e-005$	$1.3e-005$
0.7	0.63935	0.92946	0.88726	0.82856	0.75460	0.66357	0.33642	0.24537	0.17131	0.11213	0.06760	0.03693	0.01803	0.00779	0.00297

Table: Data obtained using Gudonov Method for the density changes in the existing traffic when the signal turned green.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.71714	0.97706	0.97021	0.9325	0.8603	0.7455	0.25444	0.13960	0.067017	0.02706	0.00891	0.00238	0.00051	$9.2e-005$	$1.3e-005$
0.7	0.63935	0.92946	0.88726	0.82856	0.75460	0.66357	0.33642	0.24537	0.17131	0.11213	0.06760	0.03693	0.01803	0.00779	0.00297
0.75	0.56063	0.89441	0.84738	0.78927	0.72085	0.64027	0.35972	0.27913	0.21066	0.15229	0.10413	0.06649	0.03916	0.02103	0.01022

Table: Data obtained using Gudonov Method for the density changes in the existing traffic when the signal turned green.

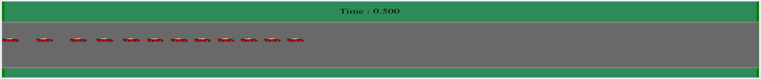
Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0.5	0.78866	0.93255	0.98469	0.99728	0.99965	0.99997	0	0	0	0	0	0	0	0	0
0.6	0.71714	0.97706	0.97021	0.9325	0.8603	0.7455	0.25444	0.13960	0.067017	0.02706	0.00891	0.00238	0.00051	$9.2e-005$	$1.3e-005$
0.7	0.63935	0.92946	0.88726	0.82856	0.75460	0.66357	0.33642	0.24537	0.17131	0.11213	0.06760	0.03693	0.01803	0.00779	0.00297
0.75	0.56063	0.89441	0.84738	0.78927	0.72085	0.64027	0.35972	0.27913	0.21066	0.15229	0.10413	0.06649	0.03916	0.02103	0.01022

Table: Data obtained using Gudonov Method for the density changes in the existing traffic when the signal turned green.

Visualization



Aim

1. how the traffic moves when the signal is red.
2. how the traffic flow changes when signal turns from red to green.
3. how the traffic flow changes when signal turns from green to red.

Red Light Again

At $t = t_1$, the signal changes back to red.

Red Light Again

At $t = t_1$, the signal changes back to red.

Experience

Cars before the signal will pile up near the signal and the cars beyond the signal will move ahead

Red Light Again

At $t = t_1$, the signal changes back to red.

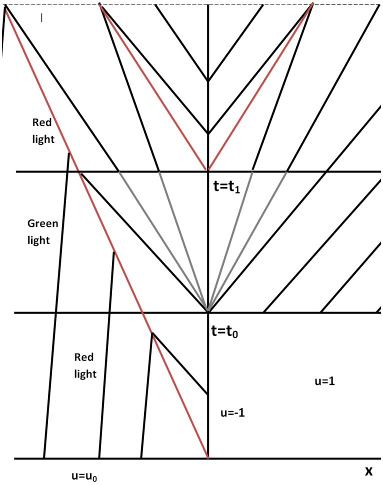
Experience

Cars before the signal will pile up near the signal and the cars beyond the signal will move ahead

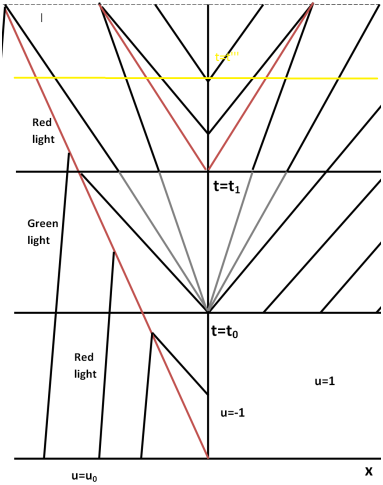
Assumptions

Divide the road into two sections at the signal. For the section before the signal we assume $u(\bar{x}, t) = -1$. For the section of the road after the signal we assume $u(\bar{x}, t) = 1$.

Characteristic Curves



Characteristic Curves



Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722

Table: Data obtained using Gudonov scheme when the traffic signal turned red at t=1.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722
1.1	0.75918	0.72552	0.69219	0.67403	0.74356	0.91597	0.084022	0.25643	0.32596	0.30778	0.27442	0.24065	0.20827	0.17758	0.14881

Table: Data obtained using Gudonov scheme when the traffic signal turned red at t=1.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722
1.1	0.75918	0.72552	0.69219	0.67403	0.74356	0.91597	0.084022	0.25643	0.32596	0.30778	0.27442	0.24065	0.20827	0.17758	0.14881
1.2	0.73178	0.71025	0.72062	0.80895	0.92967	0.98887	0.011122	0.070324	0.19103	0.27936	0.28971	0.26813	0.24024	0.21204	0.18478

Table: Data obtained using Gudonov scheme when the traffic signal turned red at t=1.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722
1.1	0.75918	0.72552	0.69219	0.67403	0.74356	0.91597	0.084022	0.25643	0.32596	0.30778	0.27442	0.24065	0.20827	0.17758	0.14881
1.2	0.73178	0.71025	0.72062	0.80895	0.92967	0.98887	0.011122	0.070324	0.19103	0.27936	0.28971	0.26813	0.24024	0.21204	0.18478
1.3	0.73233	0.76617	0.8561	0.94535	0.98765	0.99863	0.00136	0.01234	0.05464	0.14381	0.23380	0.26761	0.26014	0.23896	0.21476

Table: Data obtained using Gudonov scheme when the traffic signal turned red at t=1.

Observations

Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722
1.1	0.75918	0.72552	0.69219	0.67403	0.74356	0.91597	0.084022	0.25643	0.32596	0.30778	0.27442	0.24065	0.20827	0.17758	0.14881
1.2	0.73178	0.71025	0.72062	0.80895	0.92967	0.98887	0.011122	0.070324	0.19103	0.27936	0.28971	0.26813	0.24024	0.21204	0.18478
1.3	0.73233	0.76617	0.8561	0.94535	0.98765	0.99863	0.00136	0.01234	0.05464	0.14381	0.23380	0.26761	0.26014	0.23896	0.21476
1.4	0.80972	0.89272	0.95883	0.98911	0.99810	0.99983	0.000166	0.00189	0.01089	0.04116	0.10726	0.19024	0.24091	0.2491	0.23611

Table: Data obtained using Gudonov scheme when the traffic signal turned red at t=1.

Observations

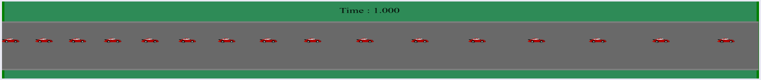
Gudonov Method

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1	0.79631	0.75903	0.71917	0.67687	0.63174	0.58208	0.41791	0.36825	0.32311	0.28078	0.24085	0.20331	0.16833	0.13619	0.10722
1.1	0.75918	0.72552	0.69219	0.67403	0.74356	0.91597	0.084022	0.25643	0.32596	0.30778	0.27442	0.24065	0.20827	0.17758	0.14881
1.2	0.73178	0.71025	0.72062	0.80895	0.92967	0.98887	0.011122	0.070324	0.19103	0.27936	0.28971	0.26813	0.24024	0.21204	0.18478
1.3	0.73233	0.76617	0.8561	0.94535	0.98765	0.99863	0.00136	0.01234	0.05464	0.14381	0.23380	0.26761	0.26014	0.23896	0.21476
1.4	0.80972	0.89272	0.95883	0.98911	0.99810	0.99983	0.000166	0.00189	0.01089	0.04116	0.10726	0.19024	0.24091	0.2491	0.23611
1.5	0.92101	0.9695	0.99116	0.99809	0.99972	0.99998	$2.0e-005$	0.000275	0.00190	0.00883	0.03042	0.07897	0.15032	0.21013	0.23389

Table: Data obtained using Gudonov scheme when the traffic signal turned red at t=1.

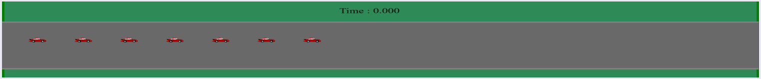
Red Light Again

Visualization

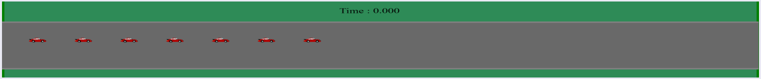


Visualizations

Incoming traffic present



No incoming traffic



Outline

1. Traffic Flow Model
2. Traffic Signal
3. Speed Breaker

Speed Breaker

PROBLEM

How does the traffic behave when there is a speed breaker on the road?

Aim

Suppose there is a speed breaker on the road.

Aim

Suppose there is a speed breaker on the road.

1. when the speed breaker is placed after a traffic signal.

Aim

Suppose there is a speed breaker on the road.

1. when the speed breaker is placed after a traffic signal.
2. when the speed breaker is placed before a traffic signal.

Speed breaker

Suppose there is a speed breaker on the road.

Speed breaker

Suppose there is a speed breaker on the road.

Experience

If there is a speed breaker on the road the cars will be forced to reduce their velocity.

Speed breaker

Suppose there is a speed breaker on the road.

Experience

If there is a speed breaker on the road the cars will be forced to reduce their velocity.

Assumption

In the slow down section, the maximum velocity attained is $v_s < v_{max}$

Speed breaker

Suppose there is a speed breaker on the road.

Experience

If there is a speed breaker on the road the cars will be forced to reduce their velocity.

Assumption

In the slow down section, the maximum velocity attained is $v_s < v_{max}$

Model

We will use $\rho_t + \rho(v_{max}(1 - \frac{\rho}{\rho_{max}}))_x = 0$ for this problem.

After Signal

Let us model the road from $x = x_1$ to $x = x_{15}$.

After Signal

Let us model the road from $x = x_1$ to $x = x_{15}$.

Suppose that there is a signal at $x = \bar{x}$ between x_6 and x_7, and a slow down section at x_7 and x_8. At t=0, signal becomes green.

After Signal

Let us model the road from $x = x_1$ to $x = x_{15}$.

Suppose that there is a signal at $x = \bar{x}$ between x_6 and x_7, and a slow down section at x_7 and x_8. At t=0, signal becomes green.

Assumption

Let $v_s = 0.1$.

Characteristic Curves

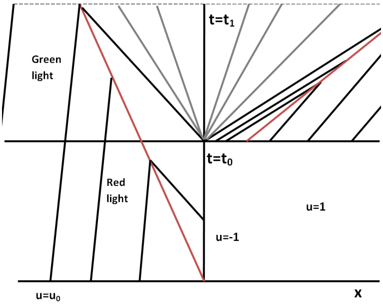


Figure: Speed Breaker after the signal

Characteristic Curves

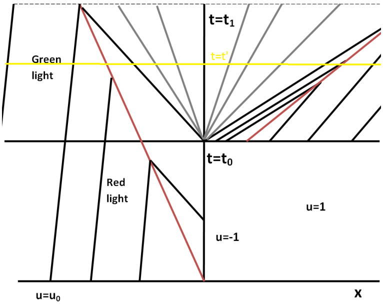


Figure: Speed Breaker after the signal

Observations

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
0.1	0.997614	0.991088	0.972994	0.932982	0.860396	0.745552	0.254448	0.139604	0.0670178	0.027006	0.00891243	0.00238574	0.000518881	$9.23026e-005$	$1.35184e-005$
0.2	0.963067	0.932396	0.887866	0.828682	0.754628	0.663573	0.336427	0.245372	0.171318	0.112134	0.0676043	0.0369332	0.0180353	0.00779943	0.00297482
0.5	0.796685	0.759141	0.719211	0.676881	0.631743	0.582083	0.417917	0.368257	0.323119	0.280789	0.240859	0.203315	0.168334	0.136193	0.107224

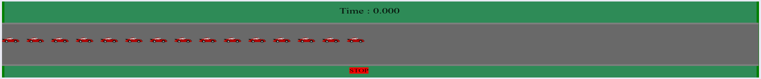
Table: Data obtained using Gudonov method when there is no speed breaker no the road.

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
0.1	0.99761	0.99108	0.97299	0.93298	0.86039	0.74555	0.04565	0.00409	0.00172	0.00060	0.00017	$4.1e-5$	$8.1e-6$	$1.3e-6$	$1.8e-7$
0.4	0.84400	0.80336	0.75865	0.71004	0.65725	0.59838	0.14328	0.04384	0.03555	0.02800	0.02132	0.01558	0.01088	0.007215	0.00452
0.5	0.79668	0.7591	0.71921	0.6768	0.63174	0.58208	0.16711	0.06023	0.05123	0.04278	0.03495	0.02783	0.02151	0.01606	0.01153

Table: Data obtained using Gudonov method when the speed breaker is placed after a signal

Visualization

Road Without Speed Breaker



Road With Speed Breaker

Aim

1. when the speed breaker is placed after a traffic signal.
2. when the speed breaker is placed before a traffic signal.

Before Signal

Let us model the road from $x = x_1$ to $x = x_{15}$.

Before Signal

Let us model the road from $x = x_1$ to $x = x_{15}$.

Suppose that there is a signal at $x = \bar{x}$ between x_8 and x_9, and a slow down section at x_6. At t=0, signal is red.

Before Signal

Let us model the road from $x = x_1$ to $x = x_{15}$.

Suppose that there is a signal at $x = \bar{x}$ between x_8 and x_9, and a slow down section at x_6. At t=0, signal is red.

Assumption

Let $v_s = 0.1$

Characteristic Curves

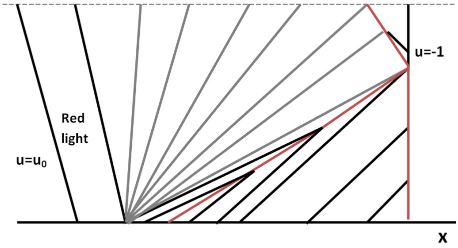


Figure: Speed Breaker before the signal

Characteristic Curves

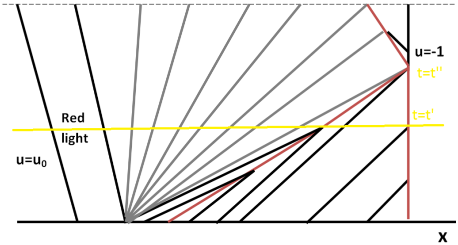


Figure: Speed Breaker before the signal

Observations

t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
0.1	0.997614	0.991088	0.972994	0.932982	0.860396	0.745552	0.254448	0.245552	0	0	0	0	0	0	0
0.2	0.963067	0.932396	0.887866	0.828682	0.754628	0.663573	0.336427	0.663573	0	0	0	0	0	0	0
0.5	0.797068	0.760879	0.727441	0.716018	0.77849	0.905034	0.981652	0.999048	0	0	0	0	0	0	0

Table: Data obtained using Gudonov method when there is no speed breaker on the road

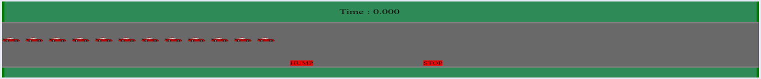
t	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
0.1	0.997614	0.991088	0.972994	0.932982	0.860396	0.745552	0.0456528	0.0434724	0	0	0	0	0	0	0
0.2	0.963067	0.932396	0.887866	0.828682	0.754628	0.663573	0.0836517	0.163483	0	0	0	0	0	0	0
0.5	0.796685	0.759141	0.719211	0.676881	0.631743	0.582083	0.167119	0.82881	0	0	0	0	0	0	0

Table: Data obtained using Gudonov method when the speed breaker is placed before a signal

Visualization

Road Without Speed Breaker

Road With Speed Breaker



Summary

Summary

- Traffic Flow Model

Summary

- Traffic Flow Model
- Traffic Signal

Summary

- Traffic Flow Model
- Traffic Signal
    - Red Light

Summary

- Traffic Flow Model
- Traffic Signal
    - Red Light
    - Green Light

Summary

- Traffic Flow Model
- Traffic Signal
    - Red Light
    - Green Light
    - Red Light again

Summary

- Traffic Flow Model
- Traffic Signal
    - Red Light
    - Green Light
    - Red Light again
- Speed Breaker

Summary

- Traffic Flow Model
- Traffic Signal
    - Red Light
    - Green Light
    - Red Light again
- Speed Breaker
    - After Signal

Summary

- Traffic Flow Model
- Traffic Signal
  - Red Light
  - Green Light
  - Red Light again
- Speed Breaker
  - After Signal
  - Before Signal

Summary

- Traffic Flow Model
- Traffic Signal
    - Red Light
    - Green Light
    - Red Light again
- Speed Breaker
    - After Signal
    - Before Signal
- Visualizations

THANK YOU