W99 Car Following Model
How It Works

Guanghui Liu @ HNTB

Overview

W99demo.com

Traffic simulation on a webpage

Adjust model parameter in real time

How I built it

How you can build it

Car Following Model & W99

What is W99, and why you should care

Car Following 101 - Internet Explorer

http://w99demo.com/

Car Following 101

W99 Car Following Model - How It Works

A demonstration of Wiedemann 99 Car Following Model, inspired by this video. Created by Guanghui Liu.

Simulation Control

Start | Step Forward | Pause | Reset

Vehicles and Drivers

Number of Cars

4 | 8 | 12 | 16

Spacing

Evenly Spaced | Closely Lined Up

Model Parameters

Reset Default

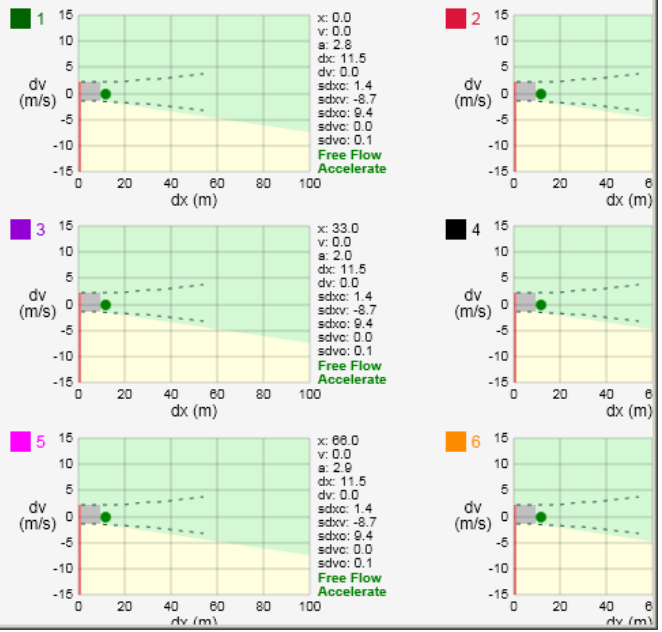
cc0: Standstill Distance - m

cc1: Spacing Time - sec

Simulation

System Status

Vehicle Status



Model Parameters

Reset Default

cc0: Standstill Distance - m

cc1: Spacing Time - sec

cc2: Following Variation - m

cc3: Threshold for Entering "Following" - sec

cc4: Negative "Following" Threshold - m/s

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cc6: Speed Dependency of Oscillation - 10^-4 rad/s

cc7: Oscillation Acceleration - m/s^2

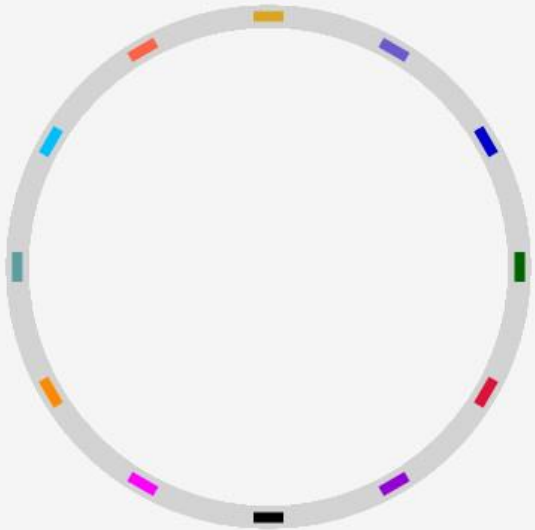
cc8: Standstill Acceleration - m/s^2

cc9: Acceleration at 80km/h - m/s^2

Simulation Control

Start | Step Forward | Pause | Reset

Simulation



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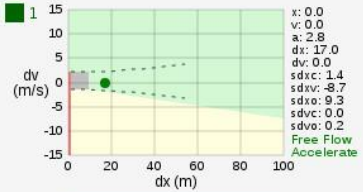
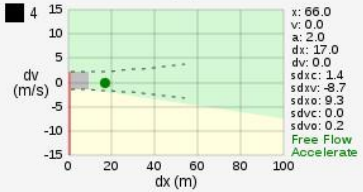
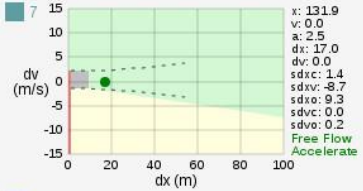
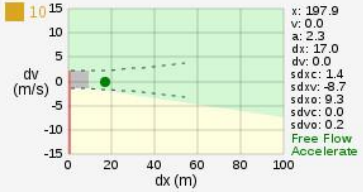








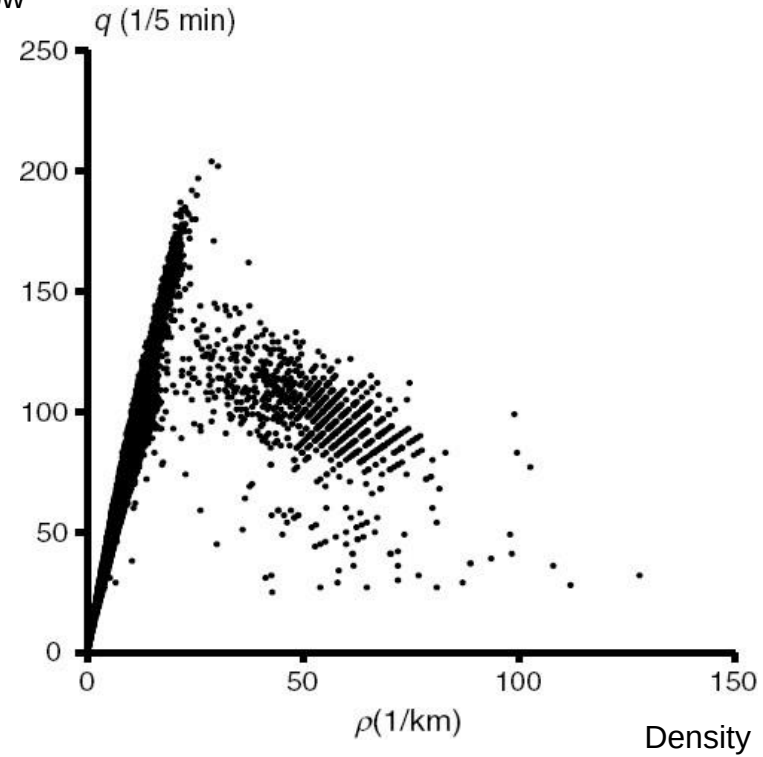
How it began

Watch this ~~Cat~~ Car Video on Youtube

https://youtu.be/7wm-pZp_mi0

What just happened?

Flow



Density

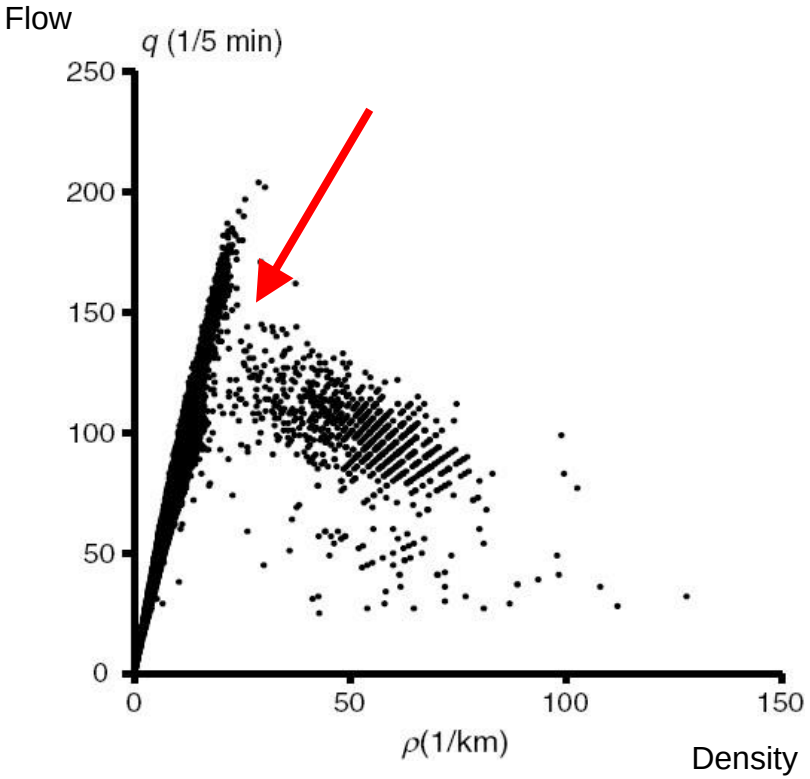
Sugiyama, Yuki, et al. "Traffic jams without bottlenecks—experimental evidence for the physical mechanism of the formation of a jam." New Journal of Physics 10.3 (2008): 033001.

“Flow Breakdown”

Critical Density

Uncongested ←→ Congested

Turbulence reaches critical level and breaks down traffic



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"Flow Breakdown"

Critical Density

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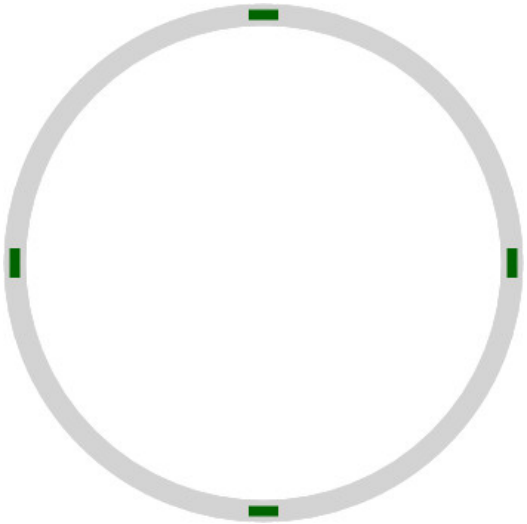
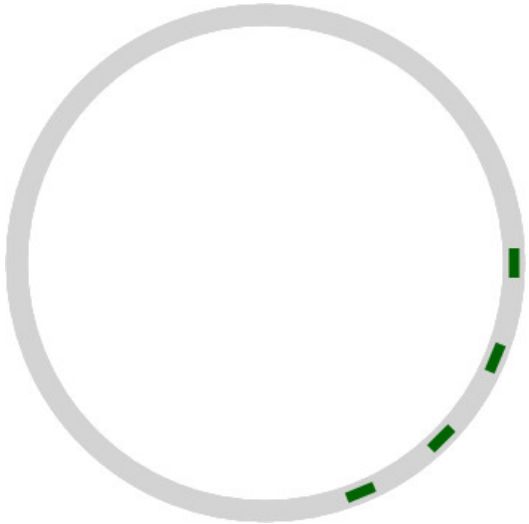
Turbulence reaches critical level and breaks down traffic

Can we do it on a webpage?

Let's draw a track...



... and some cars!



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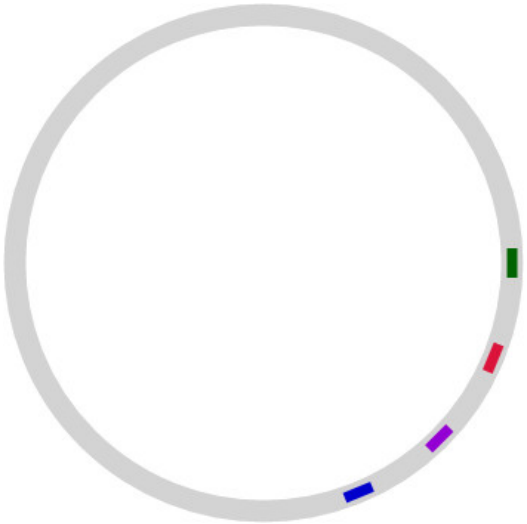

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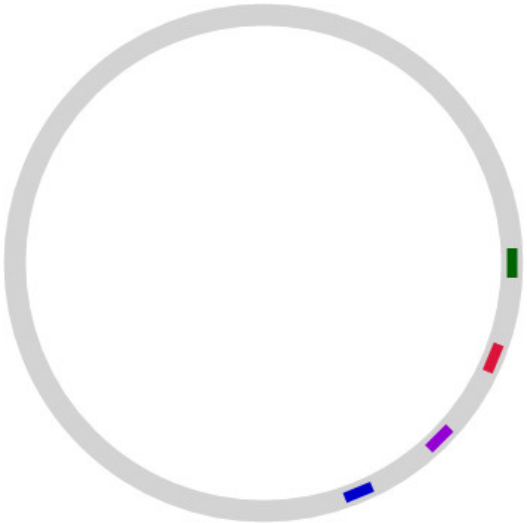
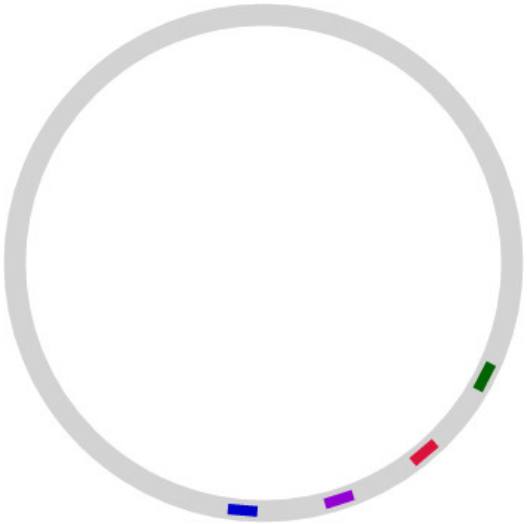


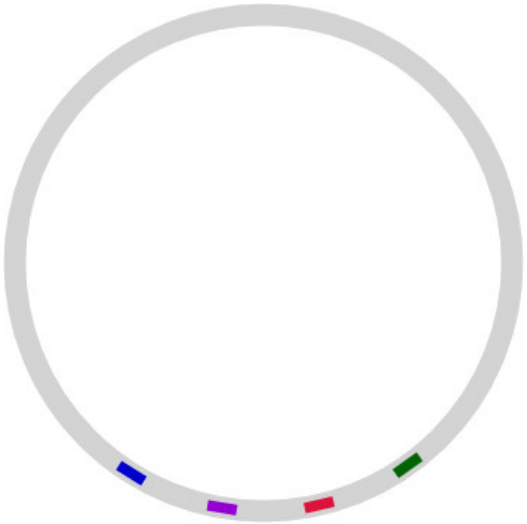
3, 2, 1, Go!!



High school physics

$x = x0 + v * t$

$v = v0 + a * t$



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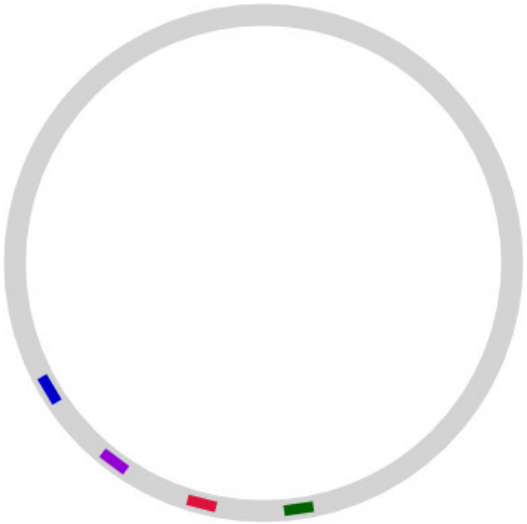

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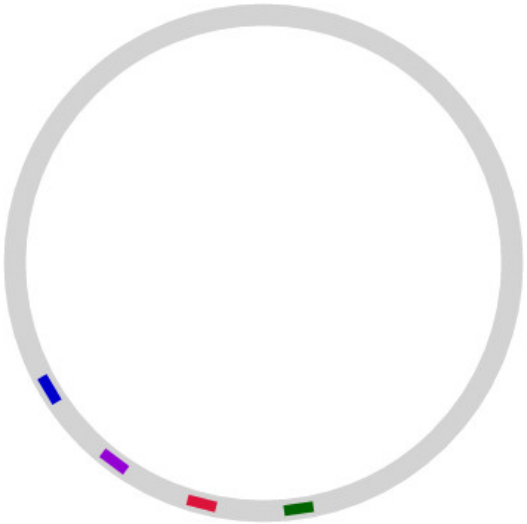


a - acceleration

How do we determine it?

a - acceleration

How do we determine it ?!

Car Following Model

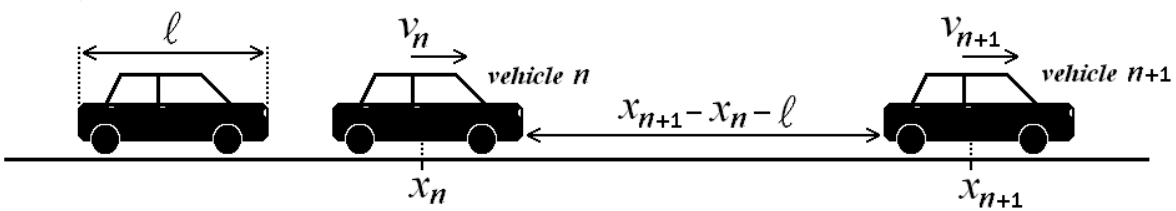
Define how vehicles interact with each other

How car “follows”

Goal: Avoid Collision

… and how car not follow

Goal: Drive at desired speed



...and then there is micro-simulation

W99 Car Following Model

Wiedemann's Car Following Models

Vissim's ~~favorite~~ car following model

“Psycho-Physical” Model

“Psycho-Physical” Model

Acceleration/Free Driving

Speed not constrained by other vehicles

Following

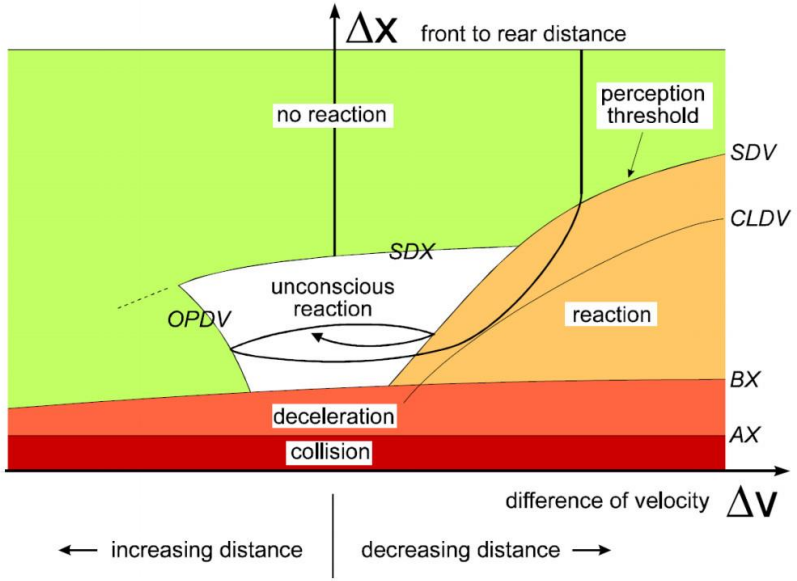
Maintain speed and distance with leader

Deceleration

Approaching slower vehicle

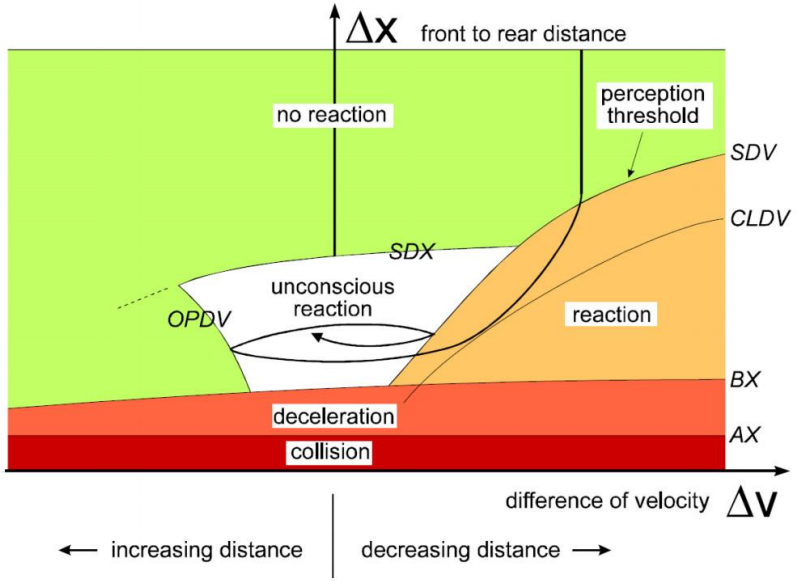
Emergency Deceleration

To avoid collision



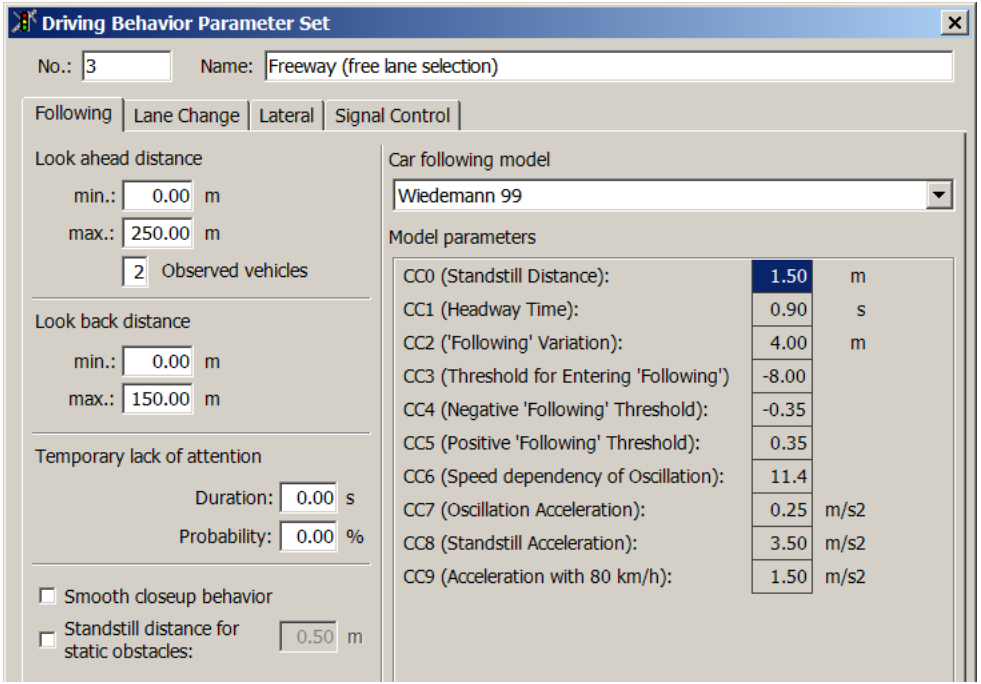
W99 Car Following Model - Parameters

AX – stationary distance
BX – min following distance
CLDV – perception threshold (near): speed higher than leader
SDV – perception threshold (far): speed higher than leader
OPDV – perception threshold: speed lower than leader
SDX – perception threshold: free acceleration



W99 Car Following Model - Parameters

cc0 – standstill distance
cc1 – headway time
cc2 – following variation
cc3 – threshold for entering “following”
cc4 – negative “following” threshold
cc5 – positive “following” threshold
cc6 – speed dependecy of oscillation
cc7 – oscilaltion acceleration
cc8 – standstill acceletation
cc9 – acceleration at 80 km/h

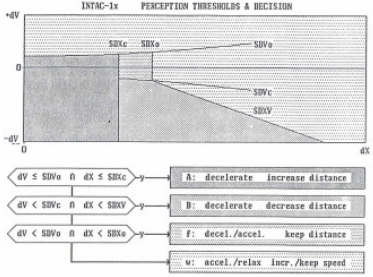


```
Interaction:  '=======================================================
              ' Traffic Flow Model INTAC-12    (SIMTOOL module)
              ' 04.02.96 ------------------------------------------
for I=M to N
 J =I-1
 DX=X(J)-X(I)-L(J)
 DV=V(J)-V(I)

  if V(J)<=0 then
     SDXc=CC(0)
  else
     if DV>=0 or B(J)<-1 then VIJ=V(I) else VIJ=V(J)-DV*(.5-Behav(I))
     SDXc=CC(0)+CC(1)*VIJ
  end if
  SDXo=CC(2)+SDXc
  SDV =CC(6)*DX^2
  if V(J)>0       then SDVc=CC(4) :SDV else SDVc=0
  if V(I)>CC(5) then SDVo=CC(5)+SDV else SDVo=SDV

  if DX<=SDXc and DV<=SDVo then
     OP$="A": Art(I)=3
     if V(I)>0 then
        if DV<0 then
           if DX>CC(0) then
              B(I)=min(B(J)+DV^2/(CC(0)-DX),B(I))
           else
              B(I)=min(B(J)+.5*(DV-SDVo),B(I))
           end if
           if B(I)>-CC(7) theh
              B(I)=-CC(7)
           else
              B(I)=max(B(I),-10+.5*sqr(V(I)))
           end if
        end if
     else
        B(I)=0
     end if

  elseif DV<SDVc and DX<SDXo+CC(3)*(DV-CC(4)) then
     OP$="B": Art(I)=2
     B(I)=.5*DV^2/(SDXc-DX-.01)
     B(I)=max(B(I),-10+sqr(V(I)))

  elseif DV<SDVo and DX<SDXo then
     OP$="f": Art(I)=1
     if B(I)<=0 then
        B(I)=min(B(I),-CC(7))
     else
        B(I)=max(B(I),CC(7))
        if L(I)>=6.5 then B(I)=.5*B(I)
        B(I)=min(B(I),W(I)-V(I))
     end if

  else
     OP$="w": Art(I)=0
     if DX>SDXc then
        if right$(OP12$(I),1)<>"w" then
           B(I)=CC(7)
        else
           Bmax=CC(8)+CC(9)*min(V(I),22.2)+Behav(I)
           if DX<SDXo then
              B(I)=min(DV^2/(SDXo-DX),Bmax)
           else
              B(I)=Bmax
           end if
        end if
        if L(I)>=6.5 then B(I)=.5*B(I)
        B(I)=min(B(I),W(I)-V(I))
     else
        B(I)=0
     end if

  end if
  OP12$(I)=right$(OP12$(I),11)+OP$
next
return '-----------------------------------------------------------------
```

Verwendung CC(6) und CC(9) siehe Seite 2

$$SDV = \frac{DX - SDXo}{CC3} + CC4$$

Modellierung des Lkw im Nahen grob!



SIMTOOL	INTAC-12-Constants	Calibration: 15.02.98 - 13:50			CC
THRESHOLDS for dX	SDXc	minimal distance	at V=0	[m] : 1.50	0
		additional time headway	at V>0	[s] : 1.30	1
	SDXo	maximal drift from SDXc	at dV=0	[m] : 4.00	2
	SDXV	SDXo + (-dX/dV)	at dV<0	[s] : -12.00	3
THRESHOLDS for dV	SDVc	minimal closing dV	at dV<0	[m/s] : -0.25	4
	SDVo	minimal opening dV	at dV>0	[m/s] : 0.35	5
		± dV/dX		[1/10^4 rad/s] : 6.00	6
DRIVING ACTIVITIES	car following activities ± b			[m/s²] : 0.25	7
	acceleration behaviour when starting			[m/s²] : 2.00	8
	acceleration behaviour at V=80 km/h			[m/s²] : 1.50	9

```
SystemStatus: '-------------------------------------------------------------
for I=M to N
  XV(I)=X(I)
  VV(I)=V(I)
    per=X(I-1)-L(I-1)
    B(I)<-V(I) then
    X(I)=XV(I)-.5*VV(I)^2/B(I)
    V(I)=0
    if Art(I)<2 then Art(I)=3: mid$(OP12$(I),12,1)=chr$(254)
  else
    X(I)=XV(I)+VV(I)+.5*B(I)
    V(I)=VV(I)+B(I)
  end if

  if X(I)>Bumper+.01 then
    X(I)=Bumper: V(I)=V(I-1)
    if X(I)>150 then mid$(OP12$(I),12,1)=chr$(219)
  end if
next
return '-------------------------------------------------------------------
```

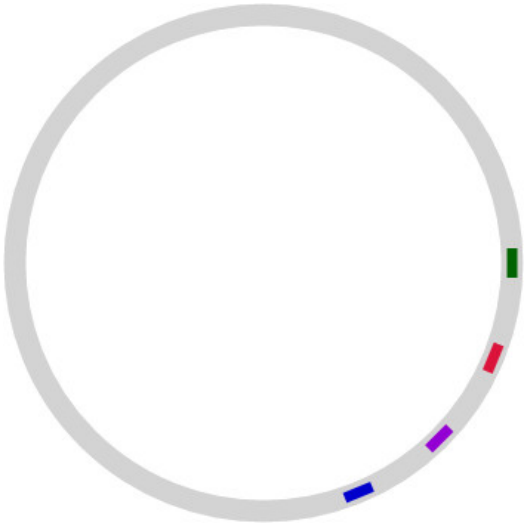
$$CC(6) = 0.0001 * CC(6) / 1.2$$

$$CC(9) = \left(CC(9) - CC(8)\right) * 3.6 / 5$$

Grob nach Anleitung von CALIBRATION bei 15.2 so umgewandelt, um Rechenzeit zu sparen!

Too many formulas
for a human being!

(Stay tuned)



$x = x0 + v * t$

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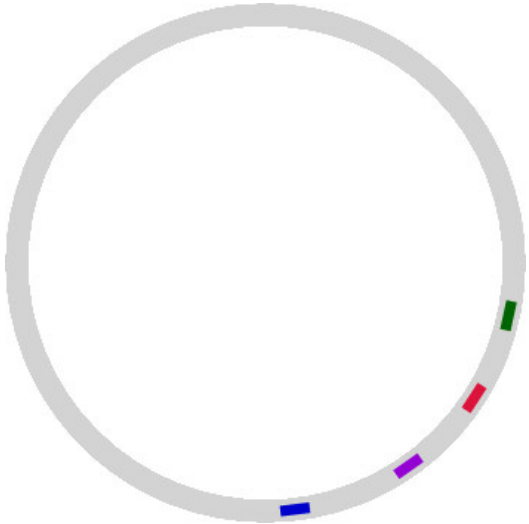
a from W99 model



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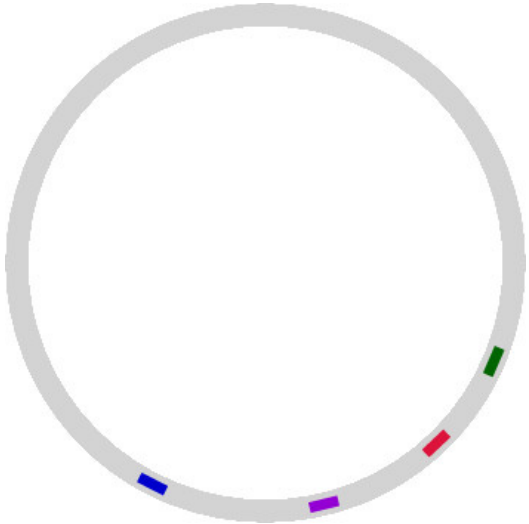

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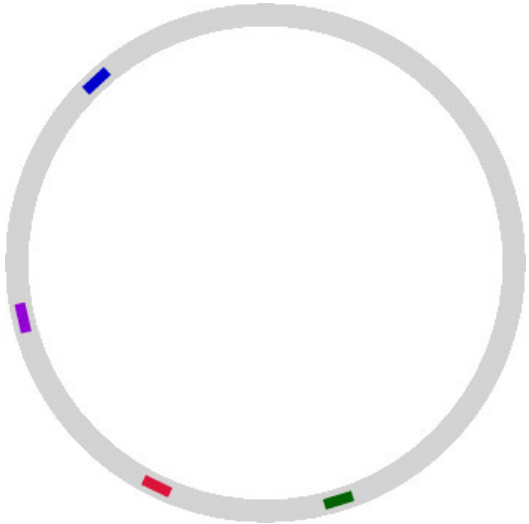

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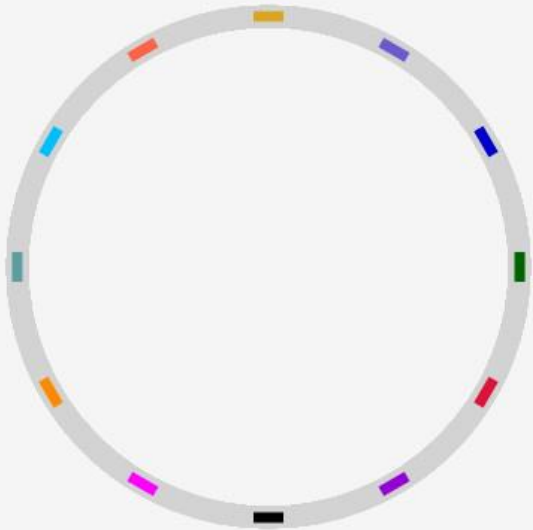
a from W99 model

Putting it Together

Simulation



Simulation Control

Start | Step Forward | Pause | Reset

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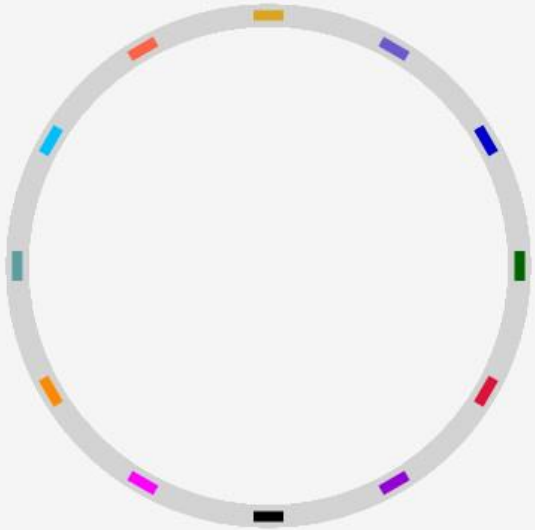

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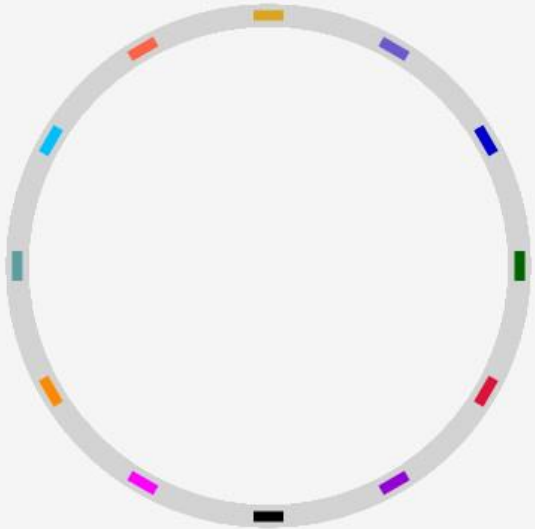

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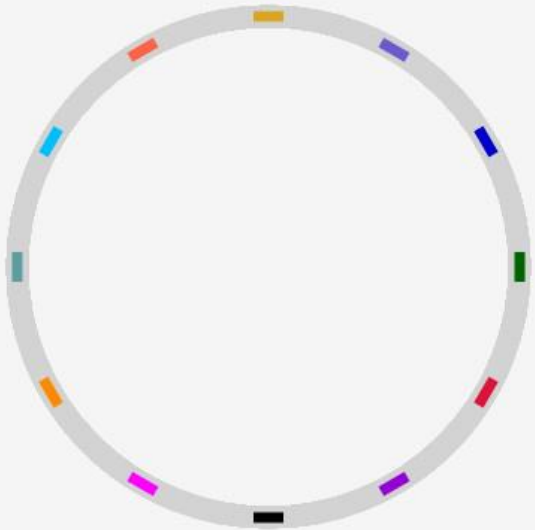
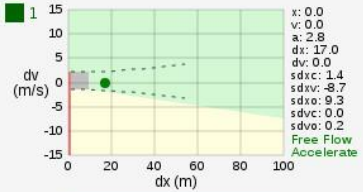
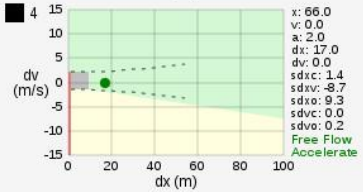
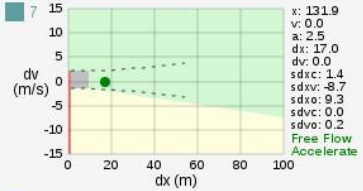
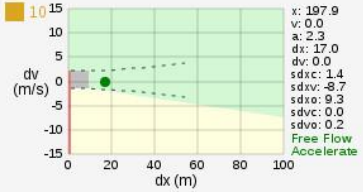


Vehicle Status









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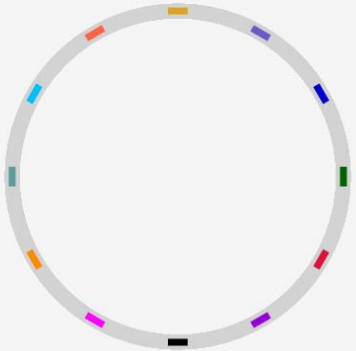


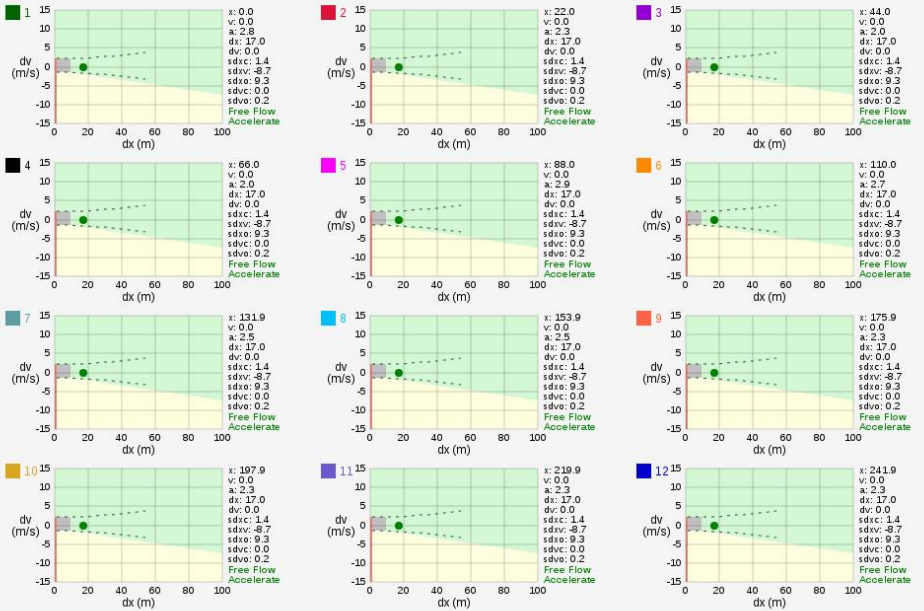
System Status

Normal

Speed - Average: 0.0 m/s

Speed - Standard Deviation: 0.0 m/s

Vehicle Status



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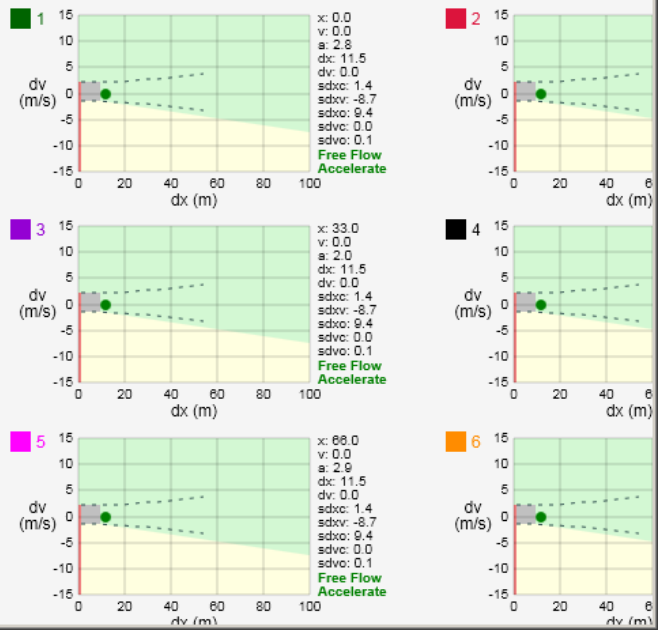
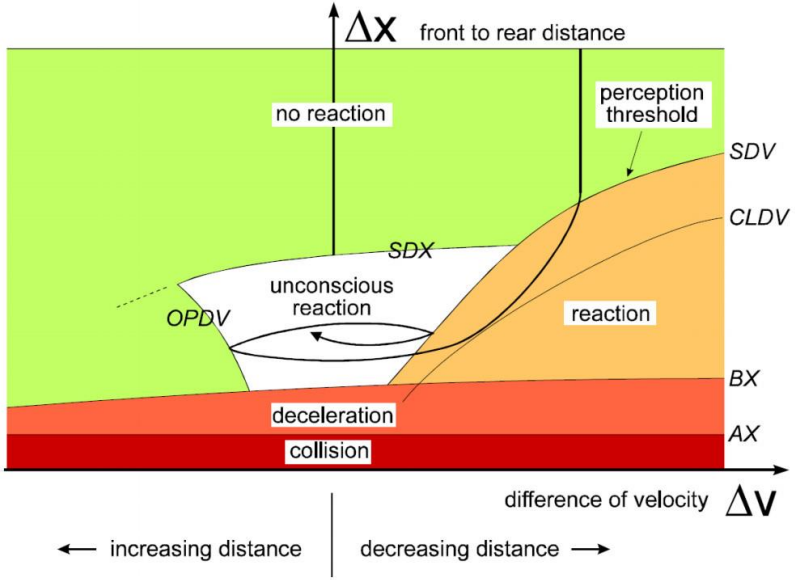
System Status

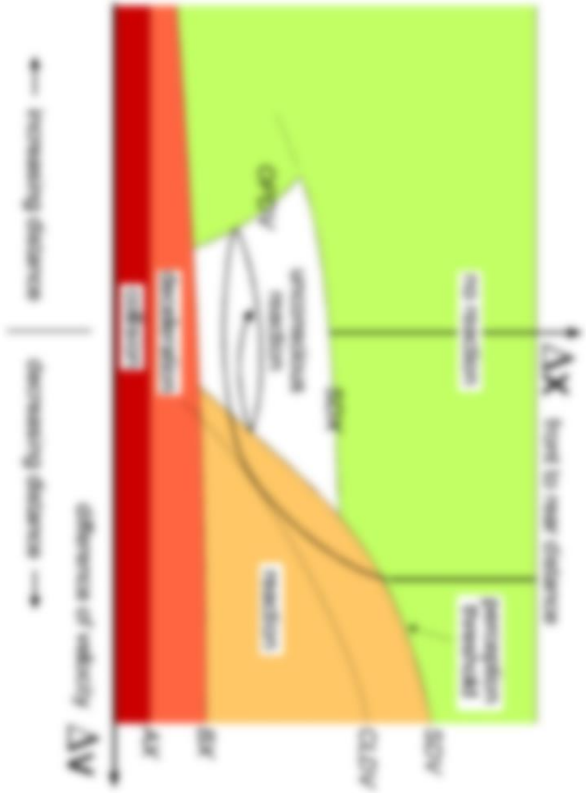
Vehicle Status



Demo Time!

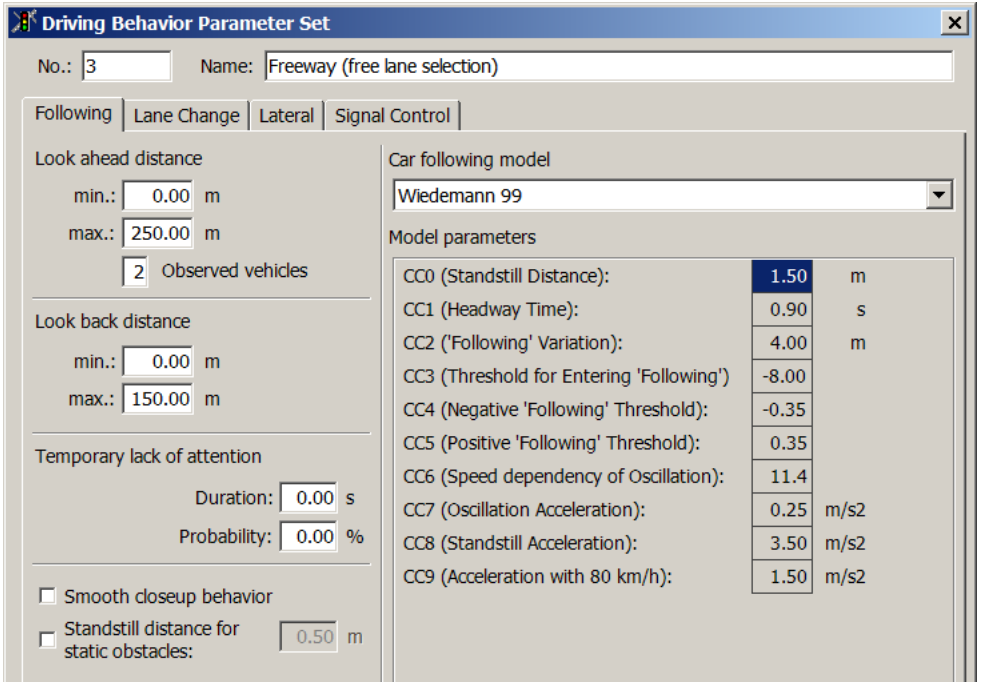
W99 Car Following Model - Parameters





W99 Car Following Model - Parameters

cc0 – standstill distance
cc1 – headway time
cc2 – following variation
cc3 – threshold for entering “following”
cc4 – negative “following” threshold
cc5 – positive “following” threshold
cc6 – speed dependecy of oscillation
cc7 – oscilaltion acceleration
cc8 – standstill acceletation
cc9 – acceleration at 80 km/h



Use it to learn, not to calibrate

Nerd Eyes Only

JavaScript + HTML5

~ 1000 lines of code

Source Control & Web Hosting: Github

MIT License

Thank you!
Visit W99demo.com