Agent modeling of vehicle traffic at a regulated intersection

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Abstract. The article contains information about the rules of agent-based modeling of the movement of a vehicle in a stream. The vehicle is considered as a homogeneous agent with reactive behavior. The reactive behavior of the agent allows you to control the distance with respect to the vehicle in front and react to the traffic light signal at an adjustable intersection. Testing the reactive behavior of the agents was performed in the NetLogo multi-agent programming environment. The article provides NetLogo code for a fragment of the agent model responsible for the movement of vehicles at the intersection. Obtained using the model, the graph of traffic intensity corresponds to the theoretical graph.

1. Introduction
The flow of vehicles can be considered as a combination of homogeneous or heterogeneous agents. When modeling the movement of vehicles, the most difficult option is modeling the behavior of heterogeneous agents. A simpler solution can be obtained if the flow of vehicles is considered as a collection of moving homogeneous agents. Such agents have a single scenario of behavior during changes in their environment. We list the main features of the behavior of a homogeneous vehicle agent.

The agent must control the distance to the front of the moving agent. The agent performs distance control by fixing the speed of the agent moving in front. If there is no agent at a safe distance, then the agent moves at a speed equal to the speed of the agent in front, which it increases by a constant value. If an agent is detected at a safe distance in front, it is necessary to reduce the speed by a constant value. In this case, the speed of the agent must vary within specified limits.

The agent must respond to a traffic signal. We will accept for the motion model that the traffic light can find in two states: supply of the enable signal, supply of the inhibitory signal of movement. Signals are green and red. When the red signal is fixed, the agent starts braking.

The model interface is shown in figure 1. NetLogo multi-agent modeling environment was used as a model development tool. Programming agent behavior is performed in an embedded language, which was created on the basis of programming languages such as Logo and StarLogo [1, 2].

The model works in discrete mode. The track consists of two segments. Agents move from left to right, after passing segments of the route the agent is destroyed. When the setup button is clicked, the numbers-of-cars agents are distributed on the main route. The number of agents numbers-of-cars = \{10,...,100\} change step 1. In the process of model work, new TPC agents appear on the left. The appearance of agents is a multiple of: f-input = \{0,...,100\} step 5.
Figure 1. Model interface; Q is the intensity of movement; AVG speed – average speed on a segment, n-cars – the number of cars on a segment

The green-n and red-n values specify the multiplicity when switching the green and red phase signals. These values vary from 1 to 300 in increments of 1.

TPC agents accelerate movement by an acceleration value equal to 0.0045 units, if there is no TPC ahead of you at a given distance equal to one; otherwise TPC slows down the movement by a deceleration value equal to 0.026 units.

At the fork, a TPC is selected with a probability of p-manevr for turning to the side segment. The value ranges from 0 to 100 percent. The step of change is 1.

In the process, a graph of the change in the intensity Q of movement on the segment of the route to the traffic light is displayed. The traffic intensity is calculated by formula 1:

\[ Q = K \cdot V \]  \( (1) \)

where K is the density of the traffic flow, V is the average speed of the TPC on the segment of the route, formula 2.

\[ K = \frac{N}{L} \]  \( (2) \)

N is the number of cars on the segment of the route, L is the length of the segment of the route.

A homogeneous agent has the following parameters:
speed – TPC speed. The initial speed value is set randomly from a range of 0.1 to 0.9 units;
speed-limit – speed limit;
speed-min – minimum speed;
manevr? – a sign of maneuver. Rotate to branch, true, otherwise false.

R is the radius of view of the environmental agent.

2. Agent Behavior

Programming discrete models in NetLogo requires a basic procedure, a code that defines the behavior of the entire model [3]:

to go
  ;Departure of vehicles
  if (f-input != 0) and (ticks >= 100) [ if ticks mod f-input = 0 [ put-car ] ]
; Traffic light control
set-lighter
; Driving a vehicle
ask turtles [  
  ; Traffic light tracking, red signal fixation
  let list-ag patches in-radius R
  let red? any? list-ag with [ pcolor = red]
  ; Red signal and stop line?
  ifelse red? and (pcolor = green )
  [ set speed 0 ] ; Yes
  [ go-rbase ] ; No traffic allowed
]
calc-q ; Calculate Q
tick ; Discrete step
end

The put-car command is used to put the agent on the track. Agents appear on the left and move along the segment of the route towards the traffic light. The agent in the process of moving inspect the environment in the radius of the viewing radius R. In the model, this value is assumed to be equal to 10 units. If a red signal is detected and the agent is on the stop line, then the agent speed is reset to zero. This behavior of the agent in combination with distance control forces agents to carry out a “tackle” in the flow of traffic to the agent traveling in front, when a red signal is given by the traffic light. The go-rbase command forces the agent to move along the track with distance control.

Set-lighter command is responsible for switching the traffic signal. Switching is performed multiple of the values red-n, green-n according to formula 3.

\[ t \mod phase = 0 \] (3)

where t is the values of the current discrete step, phase is the multiplicity of the signal switching phase.

Calculation of the current value of the load intensity of the stream Q is performed by calling the calc-q command. The calculation of the intensity occurs on the segment of the route, which begins from the point of start of movement to the stop-line. To determine the segment length, you need to calculate the difference between the stop line coordinate and the coordinate of the starting point of the trace segment along the x axis.

The agent movement code is specified in the go-rbase procedure.

; Distance control
; Search ahead of the traveling agent
let car-ahead one-of turtles-on patch-ahead 1
ifelse car-ahead != nobody [  
  set speed [speed] of car-ahead
  slow-down-car ] ; Ahead there is an agent, braking
  [ speed-up-car; ] ; No agent, increase speed
  ; Speed control
  if speed < speed-min [ set speed speed-min]
  if speed > speed-max [ set speed speed-max]
  ; Deciding to turn to the side segment
  if random 100 < p-manevr [  
    if (pxcor >= 10 ) and (pxcor <= 11) [  
      set manevr? true ; Decision is made
      set heading 360
      set xcor 10 ]  
  ]
  ; Removing Agents completed movement
ifelse not manevr?
[ if xcor + 1 > max-pxcor [ die ]
[ if ycor + 1 > max-pycor [ die ]
fd speed ;Driving on the highway
The slow-down-car and speed-up-car commands decrease or increase the speed of the agent. The speed-max agent speed limit is set to 1, and the minimum speed-min agent speed is zero.

3. Model testing
The model in action is shown in figure 2. The traffic light gives a green signal that permits movement. After passing the stop line, two agents decided to make a maneuver, one continues to move along the main highway.

Figure 2. f-input =5, numbers-of-cars=20, p-manevr=26;green-n=90,red-n=190

Figure 3 shows a graph of the movement intensity, it can be seen that on the controlled segment in front of the traffic light there are fluctuations in traffic intensity. The nature of the graph changes is close to a parabola, which corresponds to the mode of motion in the stream [4].

Figure 3. Traffic intensity on the segment

4. Conclusion
The considered algorithm of the behavior of vehicles in the stream allows you to get a traffic model close to the real situation on the tracks. It can be concluded that it is advisable to use a model based on the concept of reactive homogeneous agents as a model of the behavior of a vehicle driver. This model of behavior is advisable to use when modeling the movement of unmanned vehicles.

References
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