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Stat 133 BML Simulation Study

Simulation Study of the BML Traffic Model

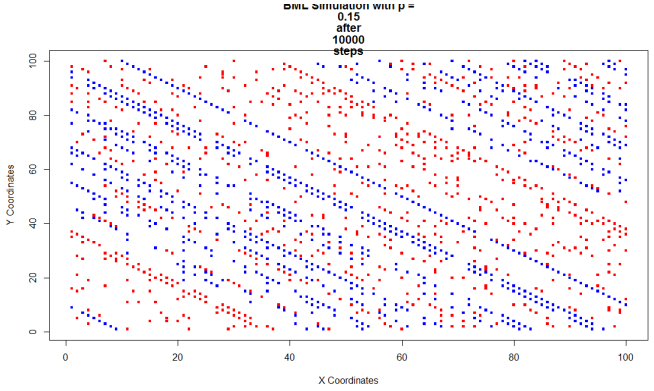
1. For what values of *p*, the density of the grid, did you find free flowing traffic and traffic jams? Did you find any cases of a mixture of jams and free flowing traffic?

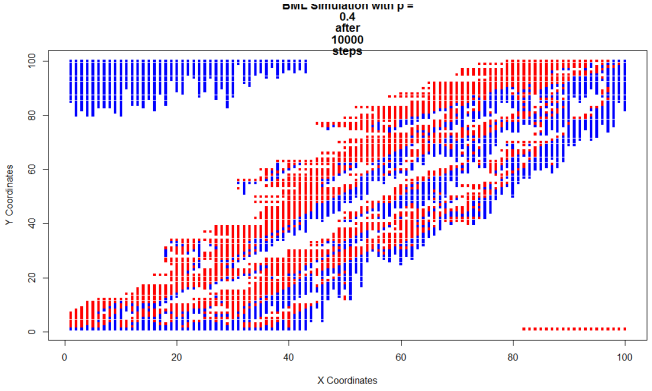
First, let us define the ratio of cars that are blocked as "block rate." Then, let us define "free flowing traffic" as a grid with a block rate of 0.02 or below, and "traffic jam" as a grid with a block rate greater than equal to 0.98.

The following table represents an average block rate of three simulations for each combination of steps and *p* on a 100 x 100 grid, to give a basic idea of how the BML works.

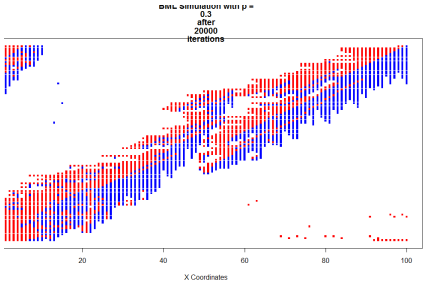
Steps / p	0.1	0.2	0.3	0.4	0.5
10	0.076	0.159	0.265	0.405	0.591
100	0.047	0.101	0.219	0.611	0.754
200	0.030	0.082	0.223	0.893	0.951
500	0.028	0.042	0.408	0.990	0.992
1000	0.025	0.034	0.482	0.994	0.985

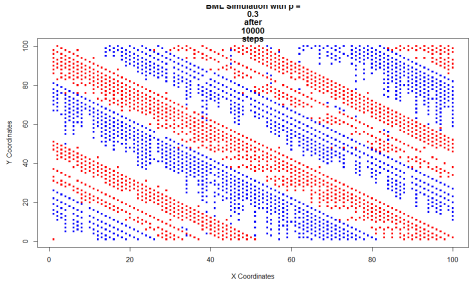
As the number of steps get larger, we can see for smaller p's (0.2 or below), the block rate gets smaller, whereas for larger p's (0.4 or above), the block rate gets larger. Therefore, very large number of steps with p = 0.2 (or smaller) should give us a free flowing traffic, whereas with p = 0.4 (or above) should give us a traffic jam. When p = 0.3, it is an exception, as will be explained below.





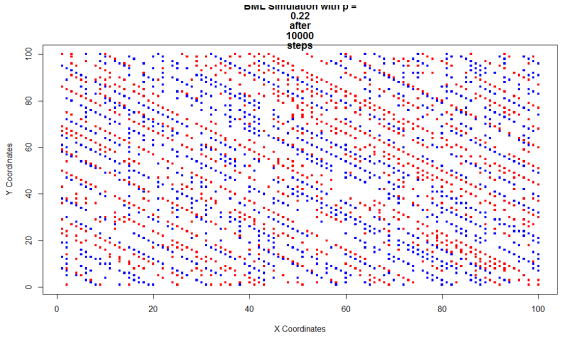
The graph on the left represents p = 0.15, after 10,000 steps. As expected, it shows a free flowing traffic, with a block rate of 0.018 (free flowing traffic). On the other hand, the graph on the right represents p = 0.4, after 10,000 steps, which had a block rate of exactly 1 (traffic jam).





As mentioned above, p = 0.3 is an exception. When p = 0.3 after 1000 steps (bolded and underlined numbers), the block rate varied very significantly, from 0.056 to 0.975. To observe more closely, I ran five more simulations with 10,000 steps, and came to a conclusion: the traffic can either freely flow or jam, depending on the initial positioning of cars. The diagrams on the left both represent p = 0.3 after 10,000 steps. One has a block rate of 0.990, whereas the other has a block rate of 0.0096.

Also after 10,000 steps, there were cases in which grid fit neither of the categories as I defined above. For example, the grid on the right represents p = 0.22 after 10,000 steps, which still had a block rate of over 5% (0.0513).



2. How many simulation steps did you need to run before observing this behavior?

With our exception (p = 0.3) as the base, the pattern in #1 can be observed from smaller number of steps as the p-value gets further away from the base.

For the block rate to reach 99%, it approximately took the number of steps on the right.

p-value	# of steps
0.4	510
0.5	400
0.6	330

3. Does the transition depend on the size or shape of the grid?

To observe the effect of changes in size and shape of the grid on the results, two more of the same simulations as the above chart were ran with grids 50 x 50 and 50 x 100, as given below.

50 x 50 Steps / p	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**
10	0.059	0.154	0.269	0.381	0.591
100	0.053	0.112	0.188	0.702	0.902
200	0.052	0.079	0.164	0.823	0.978
500	0.057	0.062	0.118	0.979	0.997
1000	0.037	0.082	0.243	0.987	0.998
50 x 100 Steps / p	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**
10	0.090	0.160	0.266	0.393	0.606
100	0.052	0.113	0.208	0.590	0.854
200	0.040	0.071	0.181	0.824	0.924
500	0.021	0.038	0.170	0.814	0.984
1000	0.029	0.071	0.340	0.942	0.963

Comparing the numbers, the trends are the same; lower end of the p-values will result in smaller block rate as the number of steps increase and vice-versa. However, the speed of the transition differs. Observing p = 0.5 for the 50x50 and 100x100 grids, we can see a much faster increase in block rate in 50x50 then 100x100 (In 50x50, the rate went from 0.591 to 0.902 as the number of steps went from 10 to 100, whereas in 100x100, it only increased to 0.754). Similarly, the 50x100 grid changed a bit more rapidly than the 100x100 grid, but not as quickly as the 50x50. As the BML model creates a “loop” for the cars, the shape of the grid does not change much, it still holds the same number of cars (assuming same size, for example, 100x100 and 50x200 grids), and it will send the car disappeared at the top to reappear at the bottom. However, the size of the grid creates a difference, as there is a smaller space for cars to move around, causing cars to run into each other more, making block rate rise at a more rapid pace.