Traffic Flow Model Using Cellular Automaton

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Why Traffic Flow?

Traffic Jams *ARE* A Problem

- Opportunity cost of wasted time
- Environmental impact of stagnant traffic
- Road rage and stress on drivers

Interesting Properties

- Driver behavior adds interesting properties
- Instability at critical density
- Traffic waves
- Multiple phases (ex. free flow, congestion)

Organizations Interested In Traffic Flow Models

- U.S. Department of Transportation
- General Motors

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Methods of Approach

Macroscopic Description

- Solely concerned with mean properties of traffic
- Use fluid dynamics to describe traffic flow
- Good for determining the flow rate supremum
- Fails to take into account variance of individual vehicles

Microscopic Description

- Each car is treated separately
- More computation needed
- Allows us to view phase changes (ex. traffic jams)

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Cellular Automaton Intro

How It Works

- Divide road into sections of fixed length
- Divide time into discrete quantities
- Each box can contain one car at max
- Iterate the car forward probabilistically according to rules

A Simple Example: Rule 184

Current	111	110	101	100	011	010	001	000
Next	1	0	1	1	1	0	0	0

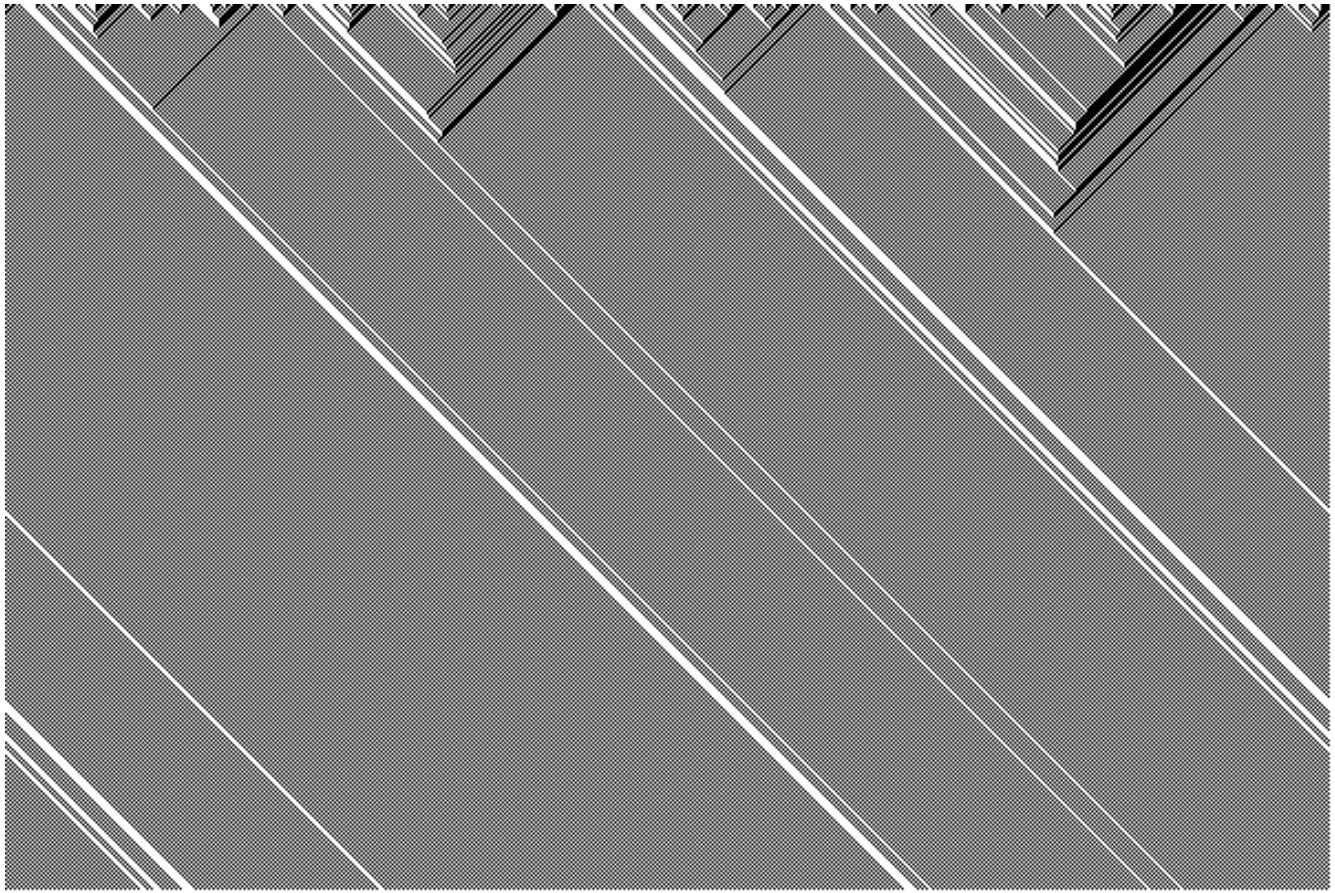

image from wolfram.com

Basic Highway Example

Single Lane Model

- If a car is not blocked then it advanced to next cell with probability p
- If a car is blocked then it does not move
- Note that the decision of each driver is calculated
- Boundary conditions can either be cyclical or a source

Two Lane Model

- Same as single lane but now cars can make a lane change
- If car is blocked and the cell beside and diagonally forward are unoccupied then change lanes

What Can I Test For?

- How fast can a metro area be evacuated?

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Basic City Traffic Model

Traffic Light Model

- Same as highway model but now cars have to stop at traffic lights
- If light is red then cars must stop at intersection
- If light is green then cars can go through intersection

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- Are green waves beneficial?

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Single Lane Sample Code

```
#define _GNU_SOURCE
#include <stdio.h>
#include <stdlib.h>
#include <gsl/gsl_matrix.h>
#include <gsl/gsl_randist.h>

int main (int argc, char *argv[])
{
   /* Declarations */
   gsl_matrix_uint *m = gsl_matrix_uint_calloc (100,100);
   gsl_rng * r = gsl_rng_alloc (gsl_rng_taus);
   double a=0, b=1,c;
   unsigned int i,t,d,e;
   gsl_rng_env_setup();
```

Single Lane Sample Code

```
/* Initialize Cells*/
for (i=0; i<100; i++) {
   c =  gsl_ran_flat (r, a, b);
   if ( c < 0.4 )
      gsl_matrix_uint_set (m, i, 0, 1);
}

/* time iteration */
for (t=1; t<10; t++) {
   /* cyclic boundary */
   for (i=0; i<100; i++) {
      c = gsl_rng_uniform (r);
      d = gsl_matrix_uint_get (m, i, t-1);
```

Single Lane Sample Code

```
            if (i==99) {
               e = gsl_matrix_uint_get (m, 0, t-1);
               if (d == 1)
                  if ( (e == 0) && (c < 0.8) )
                     gsl_matrix_uint_set (m,0,t,1);
                  else
                     gsl_matrix_uint_set (m,i,t,1);
            } else {
               e = gsl_matrix_uint_get (m, i+1, t-1);
               if ( d == 1)
                  if ( (e == 0) && (c < 0.8) )
                     gsl_matrix_uint_set (m,i+1,t,1);
                  else
                     gsl_matrix_uint_set (m,i,t,1);
            }
         }
      void gsl_rng_free (gsl_rng * r);
}
```

The End