CDA6530: Performance Models of Computers and Networks (Fall 2010)

Project 5: A Dog Chasing a Mailman (discrete-time simulation)

(Assigned 11/30; due: 12/09 midnight; Late due: 12/12 midnight with 10 points off)

This project is slightly modified from a project in a course taught by Dr. Mark Claypool:
http://web.cs.wpi.edu/~claypool/courses/533-S04/projects/proj1/index.html

Overview

This project should be done by each student individually. You are to simulate various scenarios involving a dog chasing a mailman. Basically, a mailman comes to the walkway of a house. The dog and the mailman see each other and begin actions at the same time. The dog tries to catch the mailman (either to bite him or to get the dog biscuits he's carrying) and the mailman tries to get away.

Because the simulation time step will affect the output, please simulate with each time tick representing 0.2 seconds.

Details

Let (x(*t*), y(*t*)) be the position of a dog at any time *t* (where distance is in feet and ***t* is in terms of seconds**). A mailman is located at the position (p(*t*), 0) and is moving straight line in the positive *x* direction at any time *t*, i.e., the mailman is running away following the X-axis to the right. The dog always runs directly towards the mailman with a speed of s(*t*) beginning at t=0. Assume that (x(0), y(0)) = (0, 20), and the dog was lying down so s(0) = 0. The initial position of the mailman is (10,0).

In the discrete-time simulation, the phrase "dog always runs towards mailman" means that at time tick k, the dog determines its running direction towards the mailman's position at time tick k, and runs in straight line in that direction until this time tick finishes.

There are two types of dogs to consider:

1. The speed of Type-1 dogs is:
   $s(t) = 2t$ for $0 < t < 5$
   $s(t) = 10$ for $5 <= t$
2. Type-2 dogs are a little bit faster than Type-1 one dogs, but they occasionally slip and fall. The speed of Type-2 dogs is:
   $s(t_{run}) = 3t_{run}$ for $0 < t_{run} < 4$
   $s(t_{run}) = 12$ for $4 <= t_{run}$
   where t_{run} is the time since the dog last slipped and fell. To determine if the dog slips and falls, call the function slip(t_{run}) (shown at the end of this document) at each time tick of your simulation. When slip happens, the dog will begin to run again at the next time step and gradually speed up according to the above formulas.

You are to write a simulation program to determine when each type of dog bites the mailman for two different types of mailmen (i.e. there are a total of four different cases to consider). Each mailman has an untied shoe at t=0.

a. Type-A mailmen stand still for 3 seconds to tie their shoe before running at a constant speed of 5.
b. Type-B mailmen leave their shoes untied and try to run with a loose shoe at half their normal speed (i.e. 2.5).

Determine which type of mailman runs the furthest before getting bitten by each type of dog. For the type-1 dog the scenario is deterministic so one simulation is enough; for the type-2 dog the simulation is statistical so generating average simulation results by simulating each situation 100 times.

Hints

For simplicity, at a time tick, if the dog runs cross-over the X-axis (i.e., $y(t)<0$), the dog will stop at the position when it crosses the X-axis and wait for the next time tick for continuing its run. In this way, the dog will not have a zig-zag running trace along the X-axis.

Your report should provide sufficient visual details for me to understand your results. That is to say, you should provide a 2-dimension figure showing the running traces of both the dog and the mailman on the X-Y position map (from time t=0 till the dog catches the mailman). For each simulation case, you should show two curves on one figure (for the two scenarios with type-2 dog, show the dog traces/curves for the first 3 simulation runs). In addition, show the dog running curves for four cases on the same figure (note to generate distinguishable curves in black-white printout; for a type-2 dog scenario, just show the dog trace for the first simulation run).

In addition, you should use a table to show for the four cases (for type-2 dog scenarios show the average results):

The final catch time; the final catch position;

The position of the dog and the mailman at the half catch time.

Submission:

a report containing:

1. A short description of your model.
2. The high-level algorithm used to perform the simulation.
3. Your termination and starting conditions.
4. The rule you use to update the simulation.
5. Your conclusion about whether or not the mailman should stop and tie their shoe before running from the dog.

Also, you should include

1. The source code of any scripts you used (if you use Matlab for simulation, you can change the following slip(t) function into matlab code).
2. The Matlab .m file analyzing and generating the simulation results and figures.

Winzip your files, including the report, the simulation source code, Matlab .m file.

```
#include <stdlib.h>      /* for srandom() */
#include <time.h>        /* for time() */
#include <math.h>        /* for floor() */
/* Return 1 if slip, 0 if not.  For type 2 dogs.*/
int slip(double t) {
  double x;
  if (floor(t)==t){   /* slip could only happen when the time is integer (in terms of seconds) */
    x = random() % 20;
    if (t > x)     return(1);
    else     return(0);
  }
  return(0);
}
```