

Predator-Prey Model

Izmailov Ruslan DS-02
r.izmailov@innopolis.university

April 2023

The code of the task, input data and plots available in the github perository:

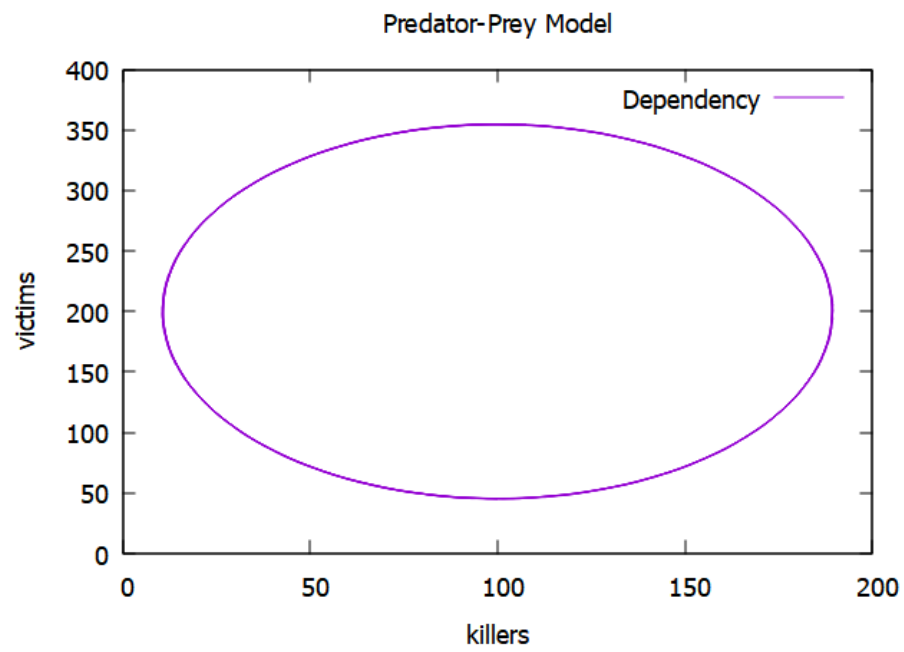
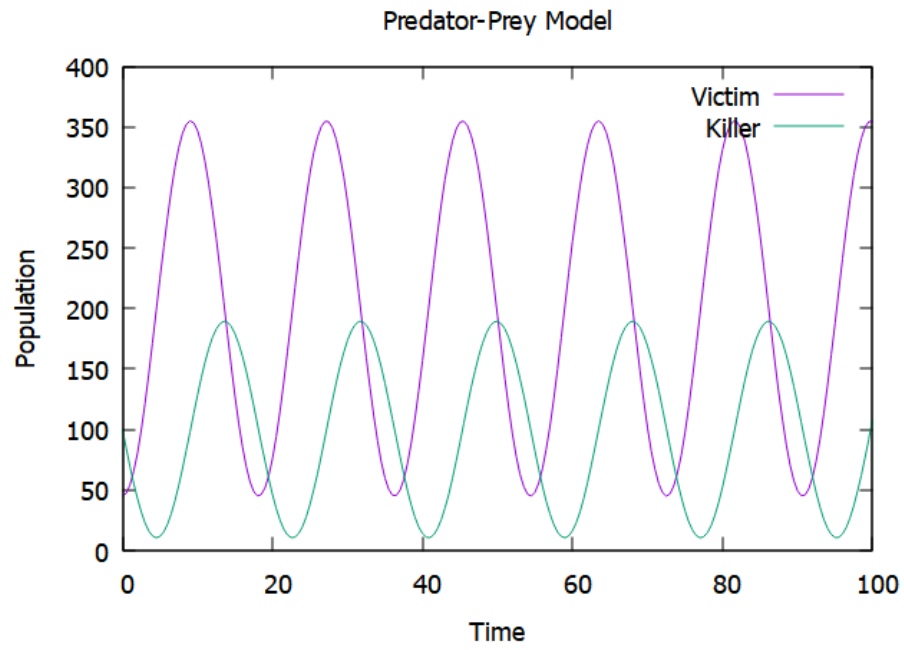
<https://github.com/Hexy00123/PredatorPreyModel/tree/main>

To test this model I used
45 victims and 100 killers at the beginning
 $\alpha_1 = 0.3$
 $\beta_1 = 0.003$
 $\alpha_2 = 0.4$
 $\beta_2 = 0.002$
Time of simulation = 100
Number of time points = 500

Therefore, input looks like this:

45
100
0.3
0.003
0.4
0.002
100
200

The resulting plots are follows:



Source code from yandex contest:

```
1 #include <iostream>
2 #include <vector>
3 #include <cmath>
4 #include <iomanip>
5
6 using namespace std;
7
8 void predatorPrey(int vs, int ks, double a1, double a2, double b1,
9 double b2, int timeLimit, int approximation) {
10     /*
11      *  $v'(t) = \alpha_1 * v(t) + \beta_1 * v(t) * k(t)$ ,
12      *  $k'(t) = -\alpha_2 * v(t) + \beta_2 * v(t) * k(t)$ 
13      */
14     auto time = vector<double>();
15     for (double i = 0; i <= timeLimit; i += (double) timeLimit / (
16 double) approximation) {
17         time.push_back(i);
18     }
19
20     double v0 = vs - a2 / b2;
21     double k0 = ks - a1 / b1;
22
23     auto v = vector<double>();
24     auto k = vector<double>();
25     for (auto t: time) {
26         v.push_back(
27             v0 * cos(sqrt(a1 * a2) * t) - k0 * sqrt(a2) * b1 *
28             sin(sqrt(a1 * a2) * t) / (b2 * sqrt(a1)) + a2 / b2);
29         k.push_back(
30             v0 * sqrt(a1) * b2 * sin(sqrt(a1 * a2) * t) / (b1 *
31             sqrt(a2)) + k0 * cos(sqrt(a1 * a2) * t) + a1 / b1);
32     }
33
34     cout << "t:\n";
35     for (auto value: time)
36         cout << value << " ";
37     cout << "\n";
38
39     cout << "v:\n";
40     for (auto value: v)
41         cout << value << " ";
42     cout << "\n";
43
44     cout << "k:\n";
45     for (auto value: k)
46         cout << value << " ";
47 }
48
49 int main() {
50     cout << fixed;
51     cout << setprecision(2);
```

```

52
53     int numberOfVictims, numberOfKillers;
54     cin >> numberOfVictims >> numberOfKillers;
55
56     double a1, a2, b1, b2;
57     cin >> a1 >> b1 >> a2 >> b2;
58
59     int timeLimit, approximationPoints;
60     cin >> timeLimit >> approximationPoints;
61
62     predatorPrey(numberOfVictims, numberOfKillers, a1, a2, b1, b2,
63                 timeLimit, approximationPoints);
64     return 0;
65 }

```

Source code for plotting:

```

1  #include <iostream>
2  #include <vector>
3  #include <cmath>
4  #include <iomanip>
5
6  using namespace std;
7
8  vector<vector<double>>>
9  predatorPrey(int vs, int ks, double a1, double a2, double b1,
10              double b2, int timeLimit, int approximation) {
11      /*
12       * v'(t) = alpha1 * v(t) + beta1 * v(t) * k(t),
13       * k'(t) = -alpha2 * v(t) + beta2 * v(t) * k(t)
14       */
15
16      auto time = vector<double>();
17      for (double i = 0; i <= timeLimit; i += (double) timeLimit / (
18          double) approximation) {
19          time.push_back(i);
20      }
21
22      double v0 = vs - a2 / b2;
23      double k0 = ks - a1 / b1;
24
25      auto v = vector<double>();
26      auto k = vector<double>();
27      for (auto t: time) {
28          v.push_back(
29              v0 * cos(sqrt(a1 * a2) * t) - k0 * sqrt(a2) * b1 *
30              sin(sqrt(a1 * a2) * t) / (b2 * sqrt(a1)) + a2 / b2);
31
32          k.push_back(
33              v0 * sqrt(a1) * b2 * sin(sqrt(a1 * a2) * t) / (b1 *
34              sqrt(a2)) + k0 * cos(sqrt(a1 * a2) * t) + a1 / b1);
35      }
36
37      auto res = vector<vector<double>>>();
38      res.push_back(time);
39      res.push_back(v);
40      res.push_back(k);
41  }

```

```

37     return res;
38 }
39
40 #ifdef WIN32
41 #define GNUPLOT_NAME "C:\\gnuplot\\bin\\gnuplot -persist"
42 #else
43 #define GNUPLOT_NAME "gnuplot -persist"
44 #endif
45
46 int main() {
47     #ifdef WIN32
48         FILE *victimsAndKillersOfTime = _popen(GNUPLOT_NAME, "w");
49         FILE *victimsOfKillers = _popen(GNUPLOT_NAME, "w");
50     #else
51         FILE* victimsAndKillersOfTime = popen(GNUPLOT_NAME, "w");
52         FILE *victimsOfKillers = _popen(GNUPLOT_NAME, "w");
53     #endif
54
55     cout << fixed;
56     cout << setprecision(2);
57
58     int numberOfVictims, numberOfKillers;
59     cin >> numberOfVictims >> numberOfKillers;
60
61     double a1, a2, b1, b2;
62     cin >> a1 >> b1 >> a2 >> b2;
63
64     int timeLimit, approximationPoints;
65     cin >> timeLimit >> approximationPoints;
66
67     auto res = predatorPrey(numberOfVictims, numberOfKillers, a1,
68                             a2, b1, b2, timeLimit, approximationPoints);
69     auto t = res[0], v = res[1], k = res[2];
70
71     fprintf(victimsAndKillersOfTime, "set title 'Predator-Prey
72     Model'\n");
73     fprintf(victimsAndKillersOfTime, "set xlabel 'Time'\n");
74     fprintf(victimsAndKillersOfTime, "set ylabel 'Population'\n");
75     fprintf(victimsAndKillersOfTime,
76             "plot '-' using 1:2 with lines title 'Victim', '-'
77             using 1:2 with lines title 'Killer'\n");
78
79     fprintf(victimsOfKillers, "set title 'Predator-Prey Model'\n");
80     fprintf(victimsOfKillers, "set xlabel 'killers'\n");
81     fprintf(victimsOfKillers, "set ylabel 'victims'\n");
82     fprintf(victimsOfKillers,
83             "plot '-' using 1:2 with lines title 'Dependency', '-'
84             using 1:2 with lines title 'Predator'\n");
85
86     // Plot the prey and predator populations
87     for (int i = 0; i < t.size(); ++i)
88         fprintf(victimsAndKillersOfTime, "%f\t%f\n", t[i], v[i]);
89     fprintf(victimsAndKillersOfTime, "e\n");
90
91     for (int i = 0; i < t.size(); ++i)
92         fprintf(victimsAndKillersOfTime, "%f\t%f\n", t[i], k[i]);
93     fprintf(victimsAndKillersOfTime, "e\n");

```

```

90
91     for (int i = 0; i < t.size(); ++i) {
92         fprintf(victimsOfKillers, "%f\t%f\n", k[i], v[i]);
93     }
94     fprintf(victimsOfKillers, "e\n");
95
96     fflush(victimsAndKillersOfTime);
97     fflush(victimsOfKillers);
98 #ifdef WIN32
99     _pclose(victimsAndKillersOfTime);
100    _pclose(victimsOfKillers);
101 #else
102     pclose(victimsAndKillersOfTime);
103     pclose(victimsOfKillers);
104 #endif
105
106     return 0;
107 }

```