Genetic Flappy Bird

Annual project on the subject **NPRX035 / NPRG035**

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The idea of the project

Background

It's 2014, when I am still a high school student, among my classmates, I learn about a new explosive platform game called **Flappy Bird**.

All my surroundings and classmates played it during breaks and even in class, because due to its graphic simplicity and seeming ease in the control mechanics, it attracted everyone!

Everyone wanted to set the very same record that the whole school then tried to beat!

If you suddenly forgot or did not know about this game, then let's conduct a short educational program, what kind of game it is and what mechanics it uses.

What is Flappy Bird?

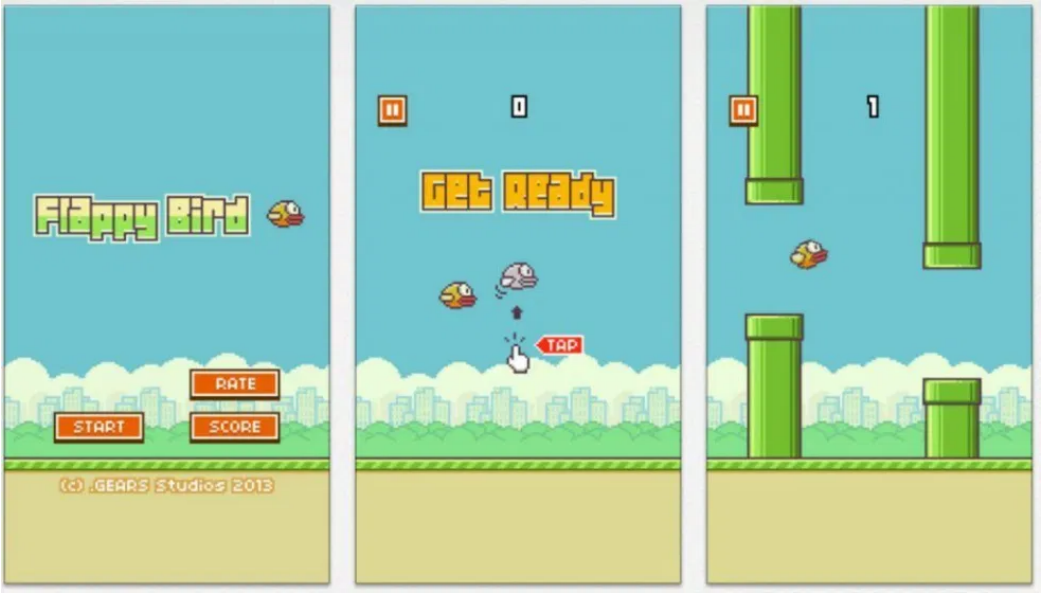
Flappy Bird is a **platform game** for mobile devices developed by Vietnamese developer **Dong Nguyen**, in which the player uses screen taps to control the bird's flight between rows of green pipes without touching them. It was implemented on iOS and Android platforms.

At the end of January 2014 it became the most downloaded free game in the App Store. During this time, the developer was earning $ 50,000 per day for in-app ads.

On February 10, 2014, Flappy Bird **was removed** from the App Store and Google Play by the developer.

Flappy Bird gameplay

Flappy Bird has gameplay involving 2D graphics. The object of the game is to control the flight of the bird, which moves continuously between the rows of green pipes. Upon collision with them, the game ends. Control is performed by touching the screen, in which the bird makes a small jerk upward. If there is no jerk, the bird falls due to gravity, and the game also ends. Points are earned for each successful flight between two tubes. The gameplay does not change throughout the entire game.



What is Genetic Flappy Bird?

Now it's 2021. It's been 8 years since the game was released. Machine learning and neural networks are starting to develop all over the world.

I thought, why not make the game play itself?

A computer in most aspects surpasses a person when performing the same type of actions (namely, this is how you can call a cyclic press on the phone display). A person can accidentally be distracted by something happening around him. The machine is not affected by such factors. Therefore, I came to the conclusion that I need to make Flappy Bird, which will pass itself!

I took a **genetic algorithm** as the basis of my program.

What is a genetic algorithm?

The genetic algorithm is primarily an evolutionary algorithm, in other words, the main feature of the algorithm is crossing (combining). As you might guess, the idea of the algorithm is impudently taken from nature, since it will not sue for it. So, by enumeration and, most importantly, selection, the correct "combination" is obtained.

The algorithm is divided into three stages:

- Crossbreeding
- Selection
- Formation of a new generation

If the result does not suit us, these steps are repeated until the result begins to satisfy us or one of the following conditions occurs:

- The number of generations (cycles) will reach a preselected maximum
- Time for mutation has run out

Learn more about the steps

Creation of a new population. This step creates an initial population, which may well be non-kosher, but it is highly likely that the algorithm will fix this problem. The main thing is that they correspond to the “format” and be “adapted to reproduction”.

Reproduction. Well, everything is like with people, it takes two parents to get a descendant. The main thing is that the descendant (child) can inherit their traits from their parents. At the same time, everyone reproduces, and not only the survivors (this phrase is especially absurd, but since we have everything in a spherical vacuum, everything is possible), otherwise one alpha male will stand out, whose genes will block all the others, and this is fundamentally unacceptable to us.

Mutations. Mutations are similar to reproduction, a certain number of individuals are selected from mutants and changed in accordance with predetermined operations.

Selection. Here the sweetest begins, we begin to select from the population the proportion of those who will "go further." In this case, the proportion of “survivors” after our selection, we determine in advance by hands, indicating in the form of a parameter. Sadly, the rest of the individuals must die.

More information can be found here

Detailed description of the used algorithm

Neural network

By and large, only direct signal propagation is used from the neural network. There are layers in the network, in each layer there is a matrix of weight coefficients that are randomly set at the initial moment of time. Also, in each layer, a non-linear activation function is specified, which introduces non-linearity into the calculations. How this works is easiest to consider using the example of the formula for a two-layer network (which is exactly what is used):

y = f2(W2*(f1(W1*x + b1)) + b2)

y1 = f1(W1*x + b1) - *first layer*

y2 = f2(W2*y1 + b2) - *second layer*

Genetic Algorithm

A population of a given number of birds is created. As long as at least one bird is alive, a simulation of the game takes place - the movement of obstacles is started and each bird, depending on the value at the output of its neural network, performs a hovering. As soon as one of the birds crashes into an obstacle, it is marked dead and does not participate further. It also remembers the distance that it flew. As soon as all birds die, selection starts - the population is sorted in descending order of fitness function - memorized distance traveled. The top N birds are referred to as parents, and the rest of the birds are replaced by the parent crossing process. After that, each of the individuals mutates with a given probability (the weight coefficients of their neural networks change randomly)

Bird

Each bird has its vertical and horizontal position. Horizontally, it is only needed for drawing, but vertically, it also determines if the bird has fallen. There is also speed and acceleration (vertical only). Each update of the rendering is an update of these parameters (the application of gravity is performed, which affects the speed of the bird and its position). When flapping, the bird is given a predetermined speed, so that it rises up.

Main program

At startup, the input parameters for the genetic algorithm are read and the genetic algorithm itself is launched.

Was there an alternative version of the algorithms?

Yes of course. This is especially evident in genetic operators. Instead of selection by cutting off the TOP-N of the best, it would be possible to use roulette selection or tournament selection. One-point, multi-point, or uniform selection could be used as the crossing operator. As mutations, many values could be replaced, or only one, or even replaced with a completely new individual Likewise with the "neural network". Starting from the choice of the activation function (ReLU was chosen, although it can be replaced with an infinite number of other non-linear functions), and ending with the number of layers, their sizes, etc.

The main data structure

Several "basic" data structures are used:

- **Bird** - has the ability to draw, as well as perform unzipping and change flight parameters.
- **Neural network** - needed for the "brain" of birds and, depending on the input parameters, indicates to the bird when to flutter.
- **Operators of the genetic algorithm** - selection by truncation, uniform crossing and random mutation.
- Actually the **form** on which everything happens.

Was there an alternative implementation of this program?

As with any program, there can be an infinite number of such options. Starting from changing the look of the graphical interface to the architecture of the neural network / genetic operators.

Description of the correct preparation and writing of input data

No preliminary data preparation is required. The following parameters are used as input data:

- population size
- the number of the best individuals who become parents to the rest
- the probability of mutation of an individual

Each of these parameters is set via **NumericUpdown**, in which restrictions on the minimum (and / or maximum) value are set, which prevents the possibility of incorrect data entry.

Description of the correct interpretation of the output

The output is an application, which allows you to observe a gradual improvement in the fitness function (namely, flight range) of both one bird and all birds of the population. Initially, almost all birds do not even reach the first obstacle, but through the use of genetic operations - selection, crossing and mutations, more and more "smart" birds remain in the population, which fly farther and more accurately.

How did you write the program?

Since the program is an application with a graphical interface, namely a Windows Forms application, the layout of the form was originally developed through a visual editor (components were sketched, some properties were set up, such as size, position, handlers for main events, etc.), images for birds were also added to the form of resources that are automatically built into the application during assembly. Then the classes-entities necessary for the program to work were described. After describing the entities, methods were described for the genetic algorithm and its combination with the rendering of what is happening on the image.

Information resources used:

1. Information about Flappy Bird
2. Information about the genetic algorithm
3. Flappy Bird Pictures