

The communication between the gateways and the terminal devices is two-way. Still, it is assumed that the bulk of the data is transmitted from the terminal devices to the gateways. LoRa technology provides wireless transfer rates from 0.3 to 50 kbps.

LoRa provides a large radius of action in an open area (up to 15 km), as well as high penetrating power so that it can receive information from devices used in basements, sewers and other inaccessible places. Under urban conditions, the radius of action decreases markedly and is about 1-6 km, depending on the density of buildings [2].

As of 2019, LoRaWan technology is not widespread in the Republic of Belarus, but it is actively developing in the Russian Federation and the European Union. Several companies produce equipment for creating networks based on the LoRaWan protocol, the most famous of which are Kerlink BS (France), Vega BS (Russia), Cisco BS (USA) [2].

Acsip S76G modules are an integrated solution based on the SX1276 RF module and the STM32F0 protocol. The module is capable of operating in the range from 137 MHz to 1020 MHz. For the module, the manufacturer provides a ready-made library, and programming is carried out similarly to STM32 microcontrollers. It is recommended to use STLinkV2 or similar to software. The module can support LoRa and LoRa-WAN technologies.

When testing the Acsip S76G radio communication modules, the point-to-point mode at a frequency of 868 MHz was used. It was possible to obtain a communication range of ~ 12 km in a direct line of sight. The main problem during testing was the lack of open areas of sufficient length.

Conclusion. When checking communications in conditions of indirect visibility, it was possible to get a reliable connection range of ~5km. The data transfer rate was 1200 bytes / s. This speed is sufficient for polling most devices.

1. The Internet of Things is the basis of the new economy - 2016 - Access mode: <https://www.itweek.ru/iot/article/detail.php?ID=182807> - Access date: 02/03/2019.
2. Basics of LoRa and LoRaWAN - 2018 - Access mode: <http://lorawan.lace.io/faq/> - Access date: 02/03/2019.

CHESS GAME IN UNITY 3D WITH MACHINE LEARNING

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We often hear such verbal constructions as “machine learning”, “neural networks”. These words have already entered into the public consciousness and often associated with pattern and speech recognition, with the generation of a human-like text. In fact, machine learning algorithms can solve many different types of problems.

Chess is a game with a final number of states. This means that, with endless computing resources, we could find a solution to this game. The history of chess machines is older than the history of computers. The idea of creating a machine that plays chess dates back to the XVIII century. The developed machine learning algorithm on the example of chess will allow us to better understand the structure of the learning process.

The purpose of this work is to analyze machine learning algorithms and develop our own 3D chess game.

Material and methods. Let's look at some technical terms. A neural network is a sequence of neurons interconnected by synapses. The structure of the neural network came into the world of programming directly from biology. Thanks to this structure, the machine gains the ability to analyze and even remember various information. Machine learning is a class of artificial intelligence methods, the characteristic feature of which is not a direct solution to a problem, but training in the process of applying solutions to many similar problems. To construct such methods are used mathematical statistics, numerical methods, optimization methods, probability theory, graph theory, various techniques for working with data in digital form.

In the game we will use the following machine learning algorithms:

1. Minimax. This is a decision-making rule used in game theory, decision theory, operations research, statistics, and philosophy to minimize possible losses. In mathematics, the minimax principle is used in problems of approximating functions by algebraic polynomials, in nonlinear programming problems [1].

2. Alpha-Beta pruning. The main idea is that a number of positions can not be considered [2].

3. Heuristics. This is an algorithm for solving the problem, the correctness of which for all possible cases has not been proven, but about which it is known that it gives a fairly good solution in most cases [3].

Findings and their discussion. Let's start by developing the algorithm. The first step is to evaluate the board. It was necessary to understand which of the playing sides is stronger in a certain position.

Using the minimax algorithm, we will create a search tree. The algorithm will use it to select the appropriate move. In this case, the recursive tree of all possible moves is examined to a given depth.

To improve the minimax algorithm we will apply alpha-beta pruning. Initially, the program takes the pieces on the board and calculates their weights. This is a rather naive approach, so it's worth improving it. We will begin to consider not only the weight, but also the position of the figures. For example, the figure of the horse on the edge of the board is less "expensive" than the same figure in the middle of the board, because it has much more places available for movement.

After we apply the described improvement, we will get a good algorithm. He plays chess much better than the average person.

The next step will be to implement the chess game on Unity3D. The main scene of the game consists of terrain, a chessboard, a GameManager object for the main script, lighting and a camera. In the project folders we can see the following:

1. Prefabs: it contains a board, individual pieces and squares indicators to highlight cells that will be used in the process of choosing a move.
2. Materials: here are materials for a chessboard, pieces and cells.
3. Scripts: contains scripts that control the game, its components and behavior.

The script responsible for the main aspects of the game will be BoardManager - it is responsible for the initial initialization of chess on the board; handling events of choice and moving a chess piece; designations of available movements; destruction of chess pieces; playback of the background melody and relevant sounds; drawing a chessboard; game behavior after end of game.

The BoardHighlights script is responsible for highlighting the selected chess piece and the moves available for it.

The Chessman script is a generalizing class for the scripts of each chess piece and includes positioning and processing of possible movements.

Scripts King, Bishop, Knight, Pawn, Queen and Rook are responsible for the actions of each of the chess pieces. They are inherited from the Chessman class and in each of them the possible cells for their movement are uniquely calculated. Their current position, the location of other chess pieces on the board and the sequence of moves are taken into account.

Conclusion. As a result of the work done, an initial version of the machine learning algorithm for chess was developed using minimax, alpha-beta pruning and some heuristics. Using Unity3D, a visual component of the game was developed with fully functional behavior of objects. A screenshot of the running game can be seen in Fig. 1.



Fig. 1. Screenshot of the running game.

Further it is planned to implement the written machine learning algorithm into the game and improve it, then hold competitive matches between the machine and the person, as well as the machine and the machine.

1. Maschler, M., Solan, E., Shmuel, Z. Game Theory – Cambridge University Press, 2013. – 176–180 pp.
2. Abramson, B. Control Strategies for Two-Player Games – ACM Computing Surveys (CSUR), Volume 21 Issue 2, 1989. – 137 p.
3. David-Habibi O., Netanyahu N. S. Verified null-move pruning – ICGA Journal, 2002. – 154–156 pp.

MULTI-LINGUAL DICTIONARY AS A DIDACTIC TOOL FOR LEARNING A FOREIGN LANGUAGE

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In the process of learning a foreign language, the work with the dictionary is essential. Such work can be different. At first, it is usually limited to translation: we use translation dictionaries in which semantic material is presented both in the language being studied and in a known language. Afterwards there is a progressive change of teaching methods and, accordingly, the transition to explanatory, monolingual dictionaries of the language under study. Lexicographic publications and materials of various types accompany the process of studying a foreign language communication at all levels and stages.

Coined in English 1680, the word "lexicography" derives from the Greek λεξικόν lexicon and γράφω grapho, "to scratch, to inscribe, to write". Lexicography can be divided into two separate but equally important groups: theoretical and practical ones [1]. The theoretical lexicography studies the semantic structure of words, their peculiarities, interpretation and so on. The practical study is dealing with issues of compiling, writing and editing dictionaries. The practical applied orientation is particularly important in today's realities. Today, the term "computer (or electronic) lexicography" appears more and more frequently in scientific publications and studies because of the Informatization of all spheres of the human life, which entails the informatization of science and its individual branches.

One of the leading specialists in computer linguistics Vladimir Selegey notes, that computer lexicography is a special area of practical lexicography with its own approaches not only to the type of displaying a dictionary but also to the content of it [2].

The form and content of dictionaries should not be overlooked, a function that is undoubtedly subject to change within the context of automation and informatization of educational process.