The use of the Neural Network in Predicting a Number of Diseases of the Gastrointestinal Tract Caused by Parasites

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Annotation- Disorders of the functional state of the gastrointestinal tract associated with the influence of various parasites are considered. The symptoms of diseases caused by parasites and their location in the gastrointestinal tract are given. The possibility of using neural network technology in diagnosing diseases as a result of the influence of various parasites is estimated. The structure of the neural network is given, indicating the set of inputs and outputs, as well as the result of training the network. For the created neural network, test results for the corresponding symptoms and disease prediction results for these symptoms were obtained.

Keywords: gastrointestinal tract, parasites, symptoms, neural network, structure, testing, prediction, error.

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I. INTRODUCTION

Often, a violation of the functional state of the gastrointestinal tract (GIT) is associated with the influence of various parasites. Parasites have a more complex structure and have well-oiled defense mechanisms directed against the human immune system (encapsulation, antigenic mimicry, antigenic "drift", inactivation of enzymes and biologically active substances, etc.), which allows them to exist for a long time in various human organs and tissues. In addition, there are objective difficulties in identifying, isolating and obtaining immunoreagent specific antigens of parasites. So, for example, the immune response in giardiasis is largely due not to the surface proteins of the parasite, but to antigens that enter the human body along with the products of their vital activity. Thus, in the laboratory diagnosis of many parasites, serological research methods are only of auxiliary value [1].

II. IMMUNE DISORDERS AND DISEASE SYMPTOMS

Parasites weaken the immune system, lowering the release of immunoglobulin, and their presence constantly stimulates the system's response and, over time, can weaken this vital immune mechanism, opening the way for bacterial and viral infections to enter the body.

These symptoms are just a few of them. In reality, the symptoms of diseases caused by parasites in the digestive tract are more extensive. The most difficult thing about this is that these symptoms of different diseases are very close and require additional techniques to clarify the diagnosis.

Probable etiological factors of gastrointestinal tract dysfunction are mainly parasites: *Entamoeba*, *Giardia lamblia*, *Balantidium coli*, *Ascaris lumbricoides*, *Enterobius vermicularis*, *Taeniasolium* (saginata), *Strongyloides stercoralis*, *Cryptosporidium parvum* [3].

| Types of parasites         | Habitat                               | Source |
|---------------------------|---------------------------------------|--------|
| *Entamoeba*               | large intestine                       | [4]    |
| *Giardialamblia*          | small intestine                       | [5]    |
| *Balantidiumcoli*         | large intestine                       | [6]    |
| *Ascaris lumbricoides*    | small intestine                       | [7]    |
| *Enterobius vermicularis* | cecum or appendix, small intestine, colon | [8]    |
| *Taenia solium* (saginata)| small intestine                       | [9]    |

Table 1: Location of parasites in the gastrointestinal tract

The World Health Organization has proven that 95% of humanity has a variety of parasites in the body. These living organisms are not as harmless and safe as it might seem in the first place. Most of them are localized in the organs of the gastrointestinal tract (the eggs of the worms get here along with contaminated water and food), but there are also so-called extra intestinal forms of invasion - parasites can live in the lungs, heart and even the human brain [2].

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**Colitis** is an inflammation of the colon, observed in a number of diseases, namely, in chronic inflammatory bowel diseases, pseudomembranous colitis and infections caused by bacteria, parasitic protozoa (amoeba) and viruses. Irritable bowel syndrome, otherwise called mucosal or spastic colitis, is not associated with inflammation of the colon, although it has similar symptoms [13].

The causative agent of giardiasis in humans is *Lambli intestinialis* (*Giardia intestinalis, Giardia lumbria*). *Giardiasis* is a fairly widespread invasion throughout the world that affects all age groups, but children suffer from this disease more often than others. [14]

*Balanidium coli* is a type of ciliates parasitizing in the large intestine of some mammals: as a rule, in pigs, less often in rats, dogs, and also in humans. Causes a disease called balantidiasis, or ciliated dysentery. [6]

*Ascarias*- intestinal invasion from the group of nematodes, the causative agents of which are roundworms (*Ascarislumbricoides*). *Ascaris* parasitizes in small intestine. [7]

*Enterobiasis* is an intestinal invasion by the pinworm Enterobiusvermicularis, usually found in children. [15]

*Cysticercosis* is the most common parasitic disease of the central nervous system. The invasion of the central nervous system by the larvae of the pork tapeworm *Taeniasalium* occurs when eating food contaminated with helminth eggs. [16]

Strongyloidosis is an invasion caused by *Strongyloides stercoralis*. [15]

*Cryptosporidiosis* is a parasitic disease caused by protists of the genus *Cryptosporidium* from the Apicomplex type. *Cryptosporidiosis*, as a rule, manifests itself as an acute and short-term infection and is spread by the alimentary route, often through contaminated water. [17].

*Echinostoma* infect the gastrointestinal tract in humans, and can cause a disease known as echinostomosis [18].

| №  | Symptoms                                      | Shortening | Entamoeba | Lamblia | Coli | Lumbriocoides | Enterobius vermicularis | solium (seg) | stercoralis | Cryptosporidium lumbanum | Echinostoma |
|----|-----------------------------------------------|------------|-----------|---------|------|---------------|-------------------------|--------------|-------------|--------------------------|------------|
| 1  | Intensity invasions                           | II         | +         | +       | +    | +             |                         |              |             |                          |            |
| 2  | Violations intestinal peristalsis             | VIP        | +         |         | +    |               |                         |              |             |                          |            |
| 3  | Immunodeficiency                              | ID         | +         |         | +    | +             |                         |              |             |                          |            |
| 4  | Fasting                                      | Fast       | +         |         | +    |               |                         |              |             |                          |            |
| 5  | Stress                                       | ST         | +         |         | +    |               |                         |              |             |                          |            |
| 6  | Perforation intestines                        | PI         | +         |         | +    |               |                         |              |             |                          |            |
| 7  | Intestinal bleeding                           | IB         | +         | +       | +    | +             |                         |              |             |                          |            |
| 8  | Tumor overgrowth in the wall of the large intestine | TLI       | +         |         | +    | +             |                         |              |             |                          |            |
| 9  | Amoebic intestinal structure                  | AIS        | +         |         | +    |               |                         |              |             |                          |            |
| 10 | Pain, bloating and rumbling in the stomach   | PBRSt      | +         | +       | +    | +             |                         |              |             |                          |            |
| 11 | Increased gasping                             | IG         | +         |         | +    |               |                         |              |             |                          |            |
| 12 | Vomiting, nausea                             | VN         | +         | +       | +    | +             |                         |              |             |                          |            |
III. A Neural Network Model for Predicting Gastrointestinal Diseases Caused by Parasites

Artificial neural networks are effectively used in the diagnosis of various diseases [19, 20]. Neural network technologies are also used for the diagnosis of diseases of the gastrointestinal tract, for example, for the differential diagnosis of liver diseases [21] and in predicting the development of abdominal sepsis in patients with severe acute pancreatitis [22,23].

Let us consider the possibilities of using the processing and analysis method in medical research using a neural network to improve the accuracy in diagnosing gastrointestinal diseases as a result of the influence of various parasites.

The experiment was carried out on a NeuroPro network emulator. NeuroPro0.25 beta version allows you to implement the following basic operations:
- creation of neuroprojects;
- connect data files with a neuroproject;
- adding layer architectures to neural projects from 1 to 10 layers, with up to 100 neurons in each layer;
- train a neural network to solve forecasting and classification problems;
- testing of a neural network based on database files, calculating the significance indicators of input signals;
- simplify the neural network;
- selection of learning algorithms, determination of forecasting for a given accuracy, etc.

Setting up an experiment

A neural network that determines the prognosis of diseases using the symptoms of diseases.

For the experiment, we select the symptoms of various gastrointestinal forgetfulness, progressing with parasites. 24 symptoms were selected (at the request of doctors, the number of symptoms can be increased, since these systems are open) and 9 diseases (it should be noted that the number of diseases created by parasites is quite large, the most common of them were selected) (table 2). For the experiment, a neural network simulator NeuroPro 0.25 was used.

The input parameters of the neural network are the symptoms shown in Table 2, the set of inflows includes 9 varieties, and the output of the network will be the solution of the neural network according to the training rules. Fig. 1 shows a neural network corresponding to the first variant of the experiment.

Input parameter.
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Fig. 1: Neural network corresponding to the first variant of the experiment

The preprocessing of the input database fields for feeding into the network are calculated with the following formula:

$$I = (I - a_i)/b_i,$$

where $I$ is an input number, $a_i$, $b_i$ are coefficients calculated for each input. Thus, preprocessing of input database fields, functional transformers and post-processing of final syndromes is carried out according to the formulas:

Database fields (initial symptoms):

N1, N2, N3, N4, N5, N6, N7, N8, N9, N10, N11, N12, N13, N14, N15, N16, N17, N18, N19, N20, N21, N22, N23, N24

Database fields (end symptoms):

N25, N26, N27, N28, N29, N30, N31, N32, N33

Preprocessing of DB input fields for network feed:

N1=(N1-0,5)/0,5
N2=(N2-0,5)/0,5
N3=(N3-0,5)/0,5
N4=(N4-0,5)/0,5
N5=(N5-0,5)/0,5
N6=(N6-0,5)/0,5
N7=(N7-0,5)/0,5
N8=(N8-0,5)/0,5
N9=(N9-0,5)/0,5
N10 = (N10 - 0.5) / 0.5
N11 = (N11 - 0.5) / 0.5
N12 = (N12 - 0.5) / 0.5
N13 = (N13 - 0.5) / 0.5
N14 = (N14 - 0.5) / 0.5
N15 = (N15 - 0.5) / 0.5
N16 = (N16 - 0.5) / 0.5
N17 = (N17 - 0.5) / 0.5
N18 = (N18 - 0.5) / 0.5
N19 = (N19 - 0.5) / 0.5
N20 = (N20 - 0.5) / 0.5
N21 = (N21 - 0.5) / 0.5
N22 = (N22 - 0.5) / 0.5
N23 = (N23 - 0.5) / 0.5
N24 = (N24 - 0.5) / 0.5

The sigmoid function was chosen as the activation function.

Functional converters:
Sigmoid 1 (A) = A / (0.1 + | A |)
Sigmoid 2 (A) = A / (0.1 + | A |)
Sigmoid 3 (A) = A / (0.1 + | A |)

Post-processing of end-point syndromes:
N25 = ((N25*1) + 1) / 2
N26 = ((N26*1) + 1) / 2
N27 = ((N27*1) + 1) / 2
N28 = ((N28*1) + 1) / 2
N29 = ((N29*1) + 1) / 2
N30 = ((N30*1) + 1) / 2
N31 = ((N31*1) + 1) / 2
N32 = ((N32*1) + 1) / 2
N33 = ((N33*1) + 1) / 2

Table 3 gives a set of network inputs with corresponding symptoms.
### Table 3: Multiple network inputs with corresponding symptoms

| №  | Symptoms                              | Relevant network inputs |
|----|---------------------------------------|-------------------------|
| 1  | Intensity invasions                    | N1                      |
| 2  | Violations intestinal peristalsis      | N2                      |
| 3  | Immunodeficiency                       | N3                      |
| 4  | Fasting                               | N4                      |
| 5  | Stress                                | N5                      |
| 6  | Perforation intestines                | N6                      |
| 7  | Intestinal bleeding                   | N7                      |
| 8  | Tumor overgrowth in the wall of the large intestine | N8 |
| 9  | Amoebic intestinal structure          | N9                      |
| 10 | Pain, bloating and rumbling in the stomach of BWU | N10 |
| 11 | Increased gassing                     | N11                     |
| 12 | Vomiting, nausea                      | N12                     |
| 13 | Magnification of the amount of undigested fat in feces | N13 |
| 14 | Dysbacteriosis                        | N14                     |
| 15 | Loss of appetite                      | N15                     |
| 16 | Allergy                               | N16                     |
| 17 | Diarrhea                              | N17                     |
| 18 | Spasm and soreness of the large intestine | N18 |
| 19 | Fever                                 | N19                     |
| 20 | Slimming                              | N20                     |
| 21 | Irritation peritoneum                 | N21                     |
| 22 | Insomnia                              | N22                     |
| 23 | Stomach pains                         | N23                     |
| 24 | Diarrhea                              | N24                     |

Table 4 shows the outputs of the neural network with the corresponding diseases.

### Table 4: Outputs of the neural network with corresponding diseases

| №  | Symptoms                              | Relevant network outputs |
|----|---------------------------------------|-------------------------|
| 1  | Colitis                               | N25                     |
| 2  | Giardiasis                            | N26                     |
| 3  | Balantidiasis                         | N27                     |
| 4  | Ascariasis                            | N28                     |
| 5  | Enterobiasis                          | N29                     |
| 6  | Cysticercosis                         | N30                     |
| 7  | Strongyloidosis                       | N31                     |
| 8  | Crypto sporotidosiosis                | N32                     |
| 9  | Echinostomosis                        | N33                     |

After displaying the input and output parameters of the network, the network is trained.

The analysis shows that the most optimal algorithm for learning a multilayer perceptron is the back propagation algorithm [24]. The corresponding learning outcomes, inputs and outputs, parameters are given in Fig. 2-6.
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**Fig. 2:** The structure of the neural network

**Fig. 3:** Network inputs
To test the created neural network, selected symptoms were selected (Table 5).
### Table 5: Input symptoms for testing

| Corresponding network inputs | Symptoms                          |
|------------------------------|-----------------------------------|
| N1                           | Intensity invasions               |
| N5                           | Stress                            |
| N6                           | Bowel perforation                 |
| N7                           | Intestinal bleeding               |
| N10                          | Pain, bloating and rumbling in the stomach |
| N11                          | Increased gassing                 |
| N14                          | Dysbacteriosis                    |
| N17                          | Diarrhea                          |
| N20                          | Slimming                          |
| N21                          | Peritoneal irritation             |

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![Network forecast for outputs N25-N27](image)

**Fig. 7-9:** Shows the network prediction results for the corresponding symptoms

| №  | N28 Прогноз сети | Ошибка | N29 Прогноз сети | Ошибка | N30 Прогноз сети | Ошибка |
|----|-----------------|--------|-----------------|--------|-----------------|--------|
| 1  | 0               | 0,09344602 |-0,00344602 | 0      | 0,0925135      | -0,0095135 |
| 2  | 0               | 0,03447102 |-0,00347102 | 0      | 0,0564446      | -0,0564446 |
| 3  | 0               | -0,00905226 | 0,00905226 | 0      | 0,08263764     | -0,08263764 |
| 4  | 1               | 0,11930565 | 0,00336351 | 0      | 0,0572728      | -0,0532728 |
| 5  | 0               | 0,0143329  | -0,014329  | 1      | 0,0450059      | 0,05499509 |
| 6  | 0               | 0,0143329  | -0,014329  | 1      | 0,0450059      | 0,05499509 |
| 7  | 0               | 0,1971248  | -0,1971248 | 0      | 0,0807557      | 0,0807557 |
| 8  | 0               | 0,0095022  | -0,0095022 | 0      | 0,0305676      | 0,0305676 |
| 9  | 0               | 0,08467203 | -0,08467203 | 0      | 0,05847192     | 0,05847192 |
| 10 | -0,1610576      | 0,1930157 | -0,1930157 | 0      | 0,0807557      | 0,0807557 |

**Fig. 7:** Network forecast for outputs N25-N27
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**Fig. 8:** Network forecast for outputs N28-N30

| №  | N28 | Ошибка | N29 | Ошибка | N30 | Ошибка |
|----|-----|---------|-----|---------|-----|---------|
| 1  | 0   | 0.03344602 | 0   | 0.0925135 | 0   | 0.00480025 |
| 2  | 0   | 0.03497162 | 0   | 0.0564846 | 0   | -0.0564846 |
| 3  | 0   | -0.0095228 | 0   | 0.0253764 | 0   | -0.0253764 |
| 4  | 0   | 0.1919365  | 0   | 0.0532728 | 0   | -0.0532728 |
| 5  | 0   | 0.0143323  | 1   | 0.0450069 | 0   | 0.0783689  |
| 6  | 0   | 0.0602056  | 0   | 0.0422267 | 1   | 0.9999515  |
| 7  | 0   | 0.01971248 | 0   | -0.0940757 | 0   | -0.0940757 |
| 8  | 0   | 0.00959022 | 0   | 0.0364676 | 0   | 0.02319735 |
| 9  | 0   | 0.08467203 | 0   | -0.0547192 | 0   | -0.0547192 |
| 10 | 0   | -0.1610576 | 0   | 0.1938157 | 0   | 0.1561767  |

Правильно: 9 (100%)

Неправильно: 0 (0%)

Всего: 9

Ср. ошибка: 0.0601243

Макс. ошибка: 0.0940757

**Fig. 9:** Network forecast for outputs N31-N33

| №  | N31 | Ошибка | N32 | Ошибка | N33 | Ошибка |
|----|-----|---------|-----|---------|-----|---------|
| 1  | 0   | -0.08795309 | 0   | -0.09518129 | 0   | 0.09196231 |
| 2  | 0   | 0.03950256 | 0   | -0.0976416 | 0   | 0.04720494 |
| 3  | 0   | -0.08714955 | 0   | 0.09131168 | 0   | -0.0622557 |
| 4  | 0   | -0.09295678 | 0   | 0.05958516 | 0   | 0.0153062 |
| 5  | 0   | -0.07158798 | 0   | 0.0947861 | 0   | -0.0907051 |
| 6  | 0   | 0.09958288 | 0   | 0.08756733 | 0   | 0.0726791 |
| 7  | 0   | -0.00879321 | 0   | 0.0941673 | 0   | -0.0331657 |
| 8  | 0   | 0.07139317 | 1   | 0.0965436 | 0   | 0.0501843 |
| 9  | 0   | 0.0772183  | 0   | 0.09204635 | 1   | 0.0151728 |
| 10 | 0   | 0.3709661  | 0   | 0.07566229 | 0   | 0.4627752  |

Правильно: 9 (100%)

Неправильно: 0 (0%)

Всего: 9

Ср. ошибка: 0.0879321

Макс. ошибка: 0.09958288
Table 6 shows the results of a neural network for predicting diseases by symptoms.

| № | Symptoms          | Relevant network outputs | Network forecast |
|---|-------------------|--------------------------|------------------|
| 1 | Colitis          | N25                      | -0.1516073       |
| 2 | Giardiasis       | N26                      | 0.1060389        |
| 3 | Balantidiasis    | N27                      | 0.3889541        |
| 4 | Ascarasis        | N28                      | -0.160576        |
| 5 | Enterobiasis     | N29                      | 0.1938157        |
| 6 | Cysticercosis    | N30                      | -0.1561767       |
| 7 | Strongyloidiosis | N31                      | 0.3709661        |
| 8 | Cryptosporidiosis| N32                      | 0.0756629        |
| 9 | Echinostomosis   | N33                      | 0.4827752        |

IV. Conclusion

Thus, an effective type of structure of an artificial neural network designed to solve problems of medical diagnostics and prognosis is a perceptron with sigmoid activation functions, the input of which is information about the symptoms of a patient's diseases, and the output is a diagnosis of the disease. According to the results obtained by the neural network, it is possible to confidently clarify the disease that corresponds to the "Echinostomosis" output, created by parasites of the small intestine, which as a result leads to a violation of the functional state of the gastrointestinal tract.

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