Differential Diagnosis of Parasitic Diseases of the Gastrointestinal Tract Using Artificial Neural Networks

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Received Date: 25 September 2021 | **Accepted Date:** 21 October 2021 | **Published Date:** 26 October 2021

Citation: U N Musevi. (2021). Differential Diagnosis of Parasitic Diseases of the Gastrointestinal Tract Using Artificial Neural Networks. *Journal of Clinical and Laboratory Research*. 3(5); DOI:10.31579/2768-0487/053

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Abstract

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 illnesses 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 its training. For the created neural network, test results for the respective symptoms and disease prediction results for these symptoms were obtained.

Key Words: gastrointestinal tract; parasites; symptoms; neural network; structure; testing; prediction; error

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 ... Also, there are objective difficulties in identifying, isolating, and obtaining immunoreagent specific antigens of parasites.

Therefore, for example, the immune response in giardiasis is for the most part 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 pests, serological research methods are only of auxiliary value [1].

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). Still, there are also so-called extra intestinal forms of invasion - parasites can live in the lungs, heart and even the human brain [2].

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 loosen 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 challenging thing about this is that these symptoms of different infections 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 colitis*, *Ascaris lumbricoides*, *Enterobius vermicularis*, *Taenia solium (saginata)*, *Strongyloides stercoralis*, *Cryptosporidium parvum* [3].

Types of parasites	Habitat	Source
<i>Entamoeba</i>	large intestine	[4]
<i>Giardia lamblia</i>	small intestine	[5]
<i>Balantidium colitis</i>	large intestine	[6]
<i>Ascaris lumbricoides</i>	small intestine	[7]

<i>Enterobius vermicularis</i>	cecum or appendix, small intestine, colon	[8]
<i>Taenia solium (saginata)</i>	small intestine	[9]
<i>Strongyloides stercoralis</i>	duodenum, lean intestine	[10]
<i>Cryptosporidium parvum</i>	small intestine	[11]
<i>Echinostoma</i>	small intestine	[12]

Table 1: Location of parasites in the gastrointestinal tract

Colitis is an inflammation of the colon, observed in several 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 *Lamblia intestinalis* (*Giardia intestinalis*, *Giardia lamblia*). *Giardiasis* is an adequately widespread invasion throughout the world that affects all age groups, but children suffer from this disease more often than others [14].

Balantidium colitis 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. It causes a disease called balantidiasis or ciliated dysentery [6].

Ascariasis - intestinal invasion from the group of nematodes, the causative agents of which are roundworms (*Ascaris lumbricoides*).

Ascaris parasitizes in the small intestine [7].

Enterobiasis is an intestinal invasion by the pinworm *Enterobius vermicularis*, 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 *Taenia solium* occurs when eating food contaminated with helminth eggs [16].

Strongyloidiasis 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 nutritive route, often through contaminated water [17].

Echinostoma infects the gastrointestinal tract in humans and can cause a disease known as *echinostomes* [18].

No	Symptoms	Shortening	Gastrointestinal parasites								
			Entamoeba	lamblia	colitis	lumbricoides	Enterobius vermicularis	solium(saginata)	stercoralis	Cryptosporidium	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 Over growth in the wall of the large intestine Quality control department	TLI									
9	Amoebic intestinal structure	AIS	+								
10	Pain, bloating and rumbling in the stomach	PBRSt		+	+				+		+
11	Increased gassing	IG		+							
12	Vomiting, nausea	VN	+	+				+	+	+	
13	Magnification of the amount of undigested fat in feces	MFF		+						+	
14	Dysbacteriosis	DB		+							
15	Loss of appetite	LA		+		+	+	+	+		
16	Allergy	Aller		+			+		+		
17	Diarrhea	Diar			+			+	+		+
18	Spasm and soreness of the large intestine	SBLI			+	+	+				
19	Fever	Fev			+					+	
20	Slimming	Slim			+				+		+
21	Irritation peritoneum	IP			+			+			
22	Insomnia	Inso					+				
23	Stomach pains	StP								+	
24	Diarrhea	Diar								+	+

25	Disease associated with	Colitis	Giardi asis	Bala ntidia sis	Ascariasis	Enterobias is	Cysticerco sis	Strongyl oidosis	Crypospor itosdio	Echinosto mosis
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Table 2: Symptoms and diseases associated with major gastrointestinal parasites

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 diagnostic 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].

The experiment was carried out on a NeuroPro network emulator. NeuroPro0.25 beta version allows you to implement the following basic operations:

- the 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;
- train a neural network to solve forecasting and classification problems;
- testing of a neural network based on database files, calculating the significant 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. Twenty-four indications were selected (at the request of doctors, the number of symptoms can be increased, since these systems are open) and nine diseases (it should be noted that the number of illnesses 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 net system will be the solution of the neural network according to the training rules. Figure 1 shows a neural network corresponding to the first variant of the experiment.

Figure1: Neural network corresponding to the first variant of the experiment

No	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 3: Multiple network inputs with corresponding symptoms

No	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	Cryptosporitosdiosis	N32
9	Echinostomosis	N33

Table 4: Outputs of the neural network with corresponding diseases

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].

To test the created neural network, selected symptoms were chosen (Table 5).

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

Table 5: Input symptoms for testing

Table 6 shows the results of a neural network for predicting diseases by symptoms.

No	Symptoms	Relevant network outputs	Network forecast
1	Colitis	N25	-0.1516073
2	Giardiasis	N26	0.1060389
3	Balantidiasis	N27	0.3889541
4	Ascariasis	N28	-0.160576
5	Enterobiasis	N29	0.1938157
6	Cysticercosis	N30	-0.1561767
7	Strongyloidosis	N31	0.3709661
8	Cryptosporitosdiosis	N32	0.07566229
9	Echinostomosis	N33	0.4827752

Table 6: Neural network results

Conclusion

Thus, an efficient 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 illness 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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DOI: [10.31579/2768-0487/053](https://doi.org/10.31579/2768-0487/053)

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