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CHARACTERISTICS OF GDV-GRAMS OF PATIENTS WITH VARIOUS DISEASES

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1. Problem statement and methods of study

The GDV-grams of 85 patients were analyzed in the study. The patients were classified in the following groups according to their diseases:

- Hernia
- Cholelithiasis
- Stomach cancer
- Intestine cancer

In the last group, patients were grouped having cancer of rectum, cancer of sigmoid colon, cancer of blind gut, or cancer of large intestine. The filter GDV-grams of the patients were analyzed recorded on a day before the surgical operation.

The GDV parameters of the patients were calculated by means of *GDV Scientific Laboratory* program. The parameters comprised average values over all fingers, as well as values at each finger. The following normalization procedure was used to set values of all GDV parameters at a uniform scale: Each GDV parameter value at each finger of a patient was divided by the parameter average over all fingers.

The study aimed for finding possible correlations between parameters of the GDV-grams and the diagnostic information about the patients. The visual analysis of GDV-grams and the statistical analysis of normalized GDV parameters dispersion in groups of various diseases were used as the methods. For each disease, mean deviations of the normalized GDV parameters from their group average values in the disease group were compared to those in the group without the disease. An informative case for diagnostic aims would happen if the mean deviation of some GDV parameter in the group with a disease was smaller enough than that in the group without the disease.

2. Results

The visual analysis of the GDV-grams revealed that almost each patient had nontrivial patterns in the lower sector of some fingers. Fig. 1 presents examples of such patterns.

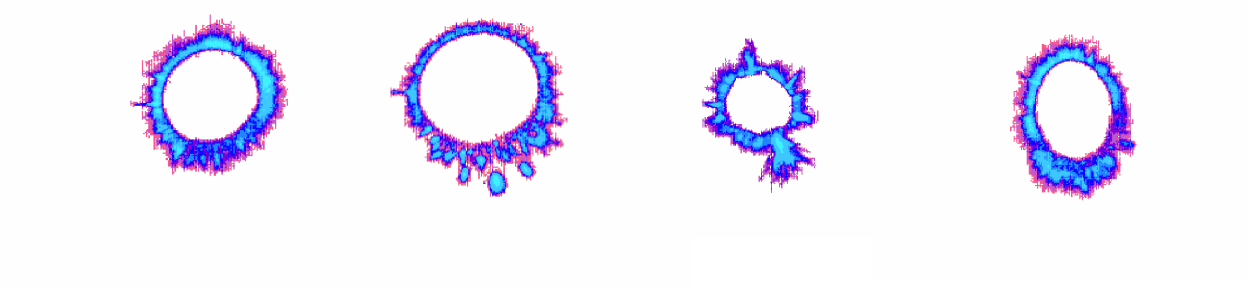

Fig. 1. Examples of nontrivial patterns in the lower sector of GDV-grams.

The distribution of these patterns over the fingers depends on a specific disease. Table 1 contains information about how many patients have the patterns at each finger and in each disease group.

Table 1. The number of patients in each disease group (in percent of the total number of patients in the group) having nontrivial patterns in the lower sector of the GDV-grams at various fingers. The color distinguishes the cases when this number is either less than 30% (almost no patients have the patterns) or more than 70% (almost all patients have the patterns).

	1R	2R	3R	4R	5R	1L	2L	3L	4L	5L
Hernia	71	57	57	14	43	43	86	14	14	71
Cholelithiasis	62	76	67	45	67	69	83	60	52	79
Stomach cancer	40	80	50	90	70	30	60	80	70	50
Intestine cancer	86	71	71	86	43	71	71	57	43	29

It is seen from the table that different diseases are characterized by different distributions of the lower sector patterns over the fingers.

The analysis of the normalized GDV parameters dispersion revealed that some parameters had much smaller dispersion in groups with certain diseases compared to the rest diseases. Fig. 2 shows values of mean deviations of those GDV parameters which discriminate the most between the groups with and without hernia.

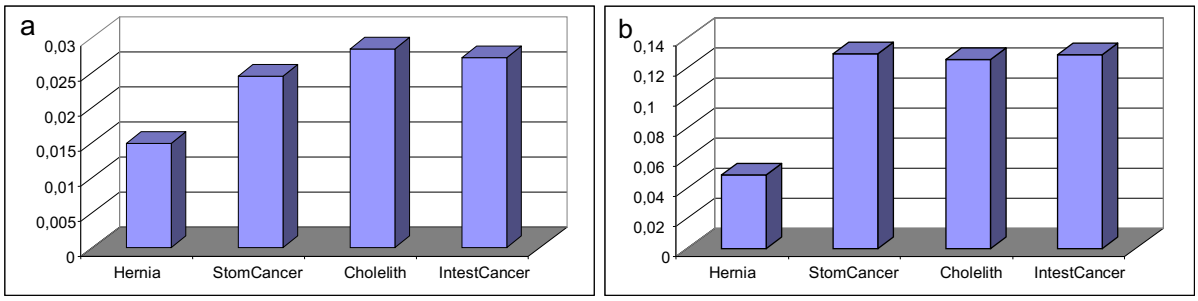

Fig. 2. Mean absolute deviations in all groups of normalized GDV parameters (a) Fractality at 5R and (b) RMS of Fractality at 3L.

Fig. 3 shows values of mean deviations of those GDV parameters which discriminate the most between the groups with and without stomach cancer.

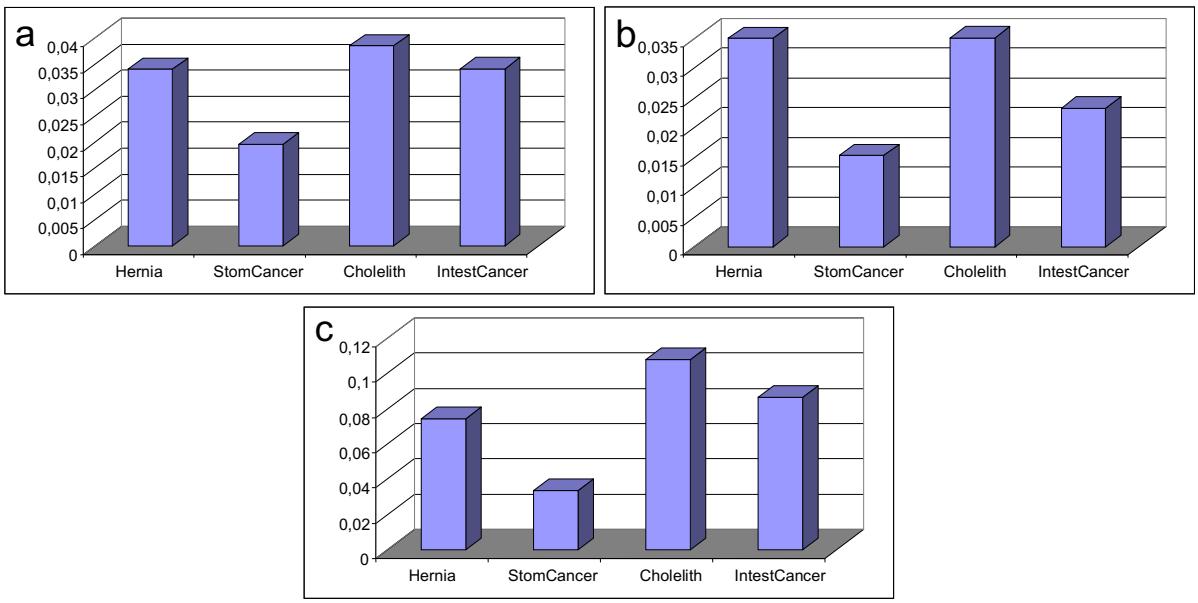

Fig. 3. Mean absolute deviations in all groups of normalized GDV parameters (a) Area at 5R, (b) Mean Intensity at 5R, and (c) Isoline Length at 4L.

Fig. 4 shows values of mean deviations of those GDV parameters which discriminate the most between the groups with and without intestine cancer.

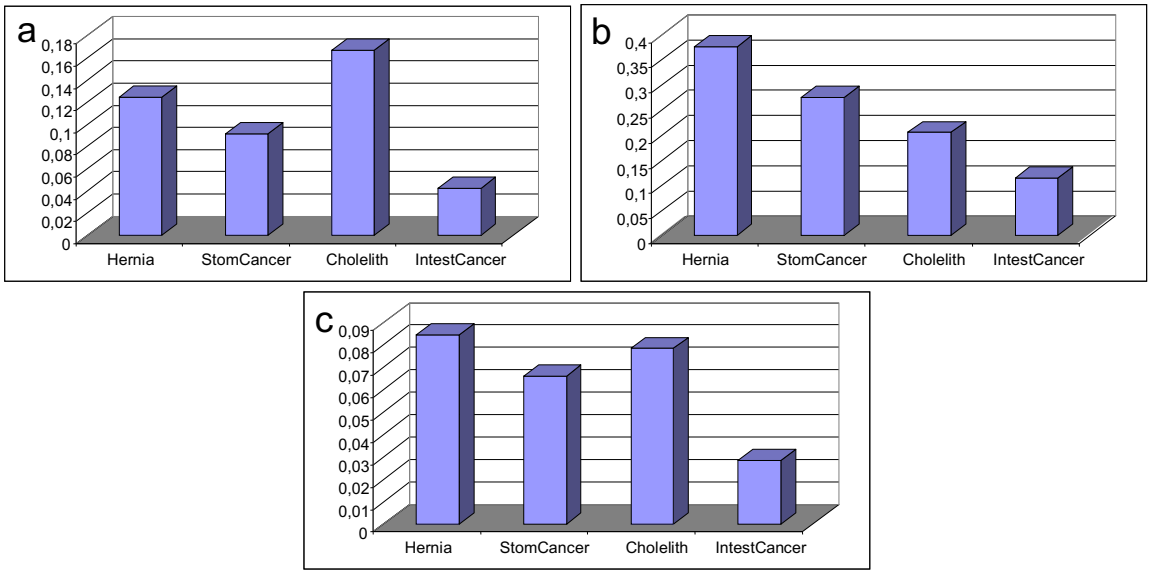

Fig. 4. Mean absolute deviations in all groups of normalized GDV parameters (a) Area at 1L, (b) Number of Fragments at 4L, and (c) Entropy at 4L.

3. Conclusions

The most of the patients with the described diseases possess nontrivial patterns in the lower sector of the fingers. It follows from Table 1 that each disease is characterized by its own combination of fingers at which it is very probable to find a nontrivial pattern, and a combination at which it is most likely that such patterns are absent. For example, almost all patients with hernia have the patterns at fingers 1R, 2L, and 5L, and almost no patients in this group have the patterns at fingers 4R, 3L, and 4L.

The analysis of mean absolute deviations of normalized GDV parameters in the disease groups revealed the following facts:

- The group with hernia is characterized by clustered values of GDV parameters Fractality at 5R and RMS of Fractality at 3L (Fig. 2).
- The group with the stomach cancer is characterized by clustered values of GDV parameters Area at 5R, Mean Intensity at 5R, and, especially, Isoline Length at 4L (Fig. 3).
- The group with the intestine cancer is characterized by clustered values of GDV parameters Area at 1L, Number of Fragments at 4L, and, especially, Entropy at 4L (Fig. 4).

These results can be helpful in the process of complex diagnostics of diseases considered.

GDV APPLICATION FOR DIAGNOSTICS OF PATIENT FUNCTIONAL STATES

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1. Problem statement and methods of study

The GDV-grams of 328 patients were analyzed in the study. The patients were classified in groups according to values of various parameters describing their functional states. The study aimed for finding possible correlations between parameters of the GDV-grams and the diagnostic information about the patients. In particular, possibilities were investigated for predicting disease diagnoses and other features of patients functional states based on the GDV parameters. We used the neural networks method and the method of analysis of normalized GDV parameters dispersion in groups of various diseases.

The GDV parameters of the patients were calculated by means of *GDV Scientific Laboratory* program. The parameters comprised average values over all fingers, as well as values at each finger. These GDV parameters were calculated for both filter and without-filter GDV-grams. We also considered parameters obtained by dividing and subtracting the filter and without-filter GDV parameters.

The following normalization procedure was used to set values of all GDV parameters at a uniform scale. Each GDV parameter value at each finger of a patient was divided by the parameter average over all fingers. In each disease group, mean deviations of the normalized GDV parameters from their group average values were analyzed. The idea was to compare these deviations (dispersion) with those in the group of conventionally healthy patients, who were the patients without the disease considered. For diagnostic aims, an informative case would be if the mean deviation of some GDV parameter in the group with a disease was smaller enough than that in the group without the disease. The following diseases were analyzed for the purpose:

- Diseases of gastrointestinal tract as the main syndrome (94 patients)
- Diseases of cardiovascular system (81 patients)
- Skin diseases (41 patients)

The method of neural networks was used to create models in which various sets of the GDV parameters served as the input parameters. The model output was the categorical parameters defining a class of functional states which a patient belongs to. The model was derived on the overall sample of patients, which was divided into three samples: training sample (about 80% of all patients), cross-validation sample (about 20%), and test sample (about 20%). The model training took place on the training sample, i.e. coefficients in the model were found to fit the model predictions to the actual division of the patients into diagnostic groups. This process was corrected in the on-line regime on the cross-validation sample. When the training was finished, the model predictions were tested on the test sample. The model was taken as satisfactory if its predictions were good enough on the all three samples.

2. Results

2.1. The model of patients distribution in groups of various values of parameter "Reserve"

The parameter "Reserve" quantifies states of increased and decreased internal functional reserve of organism. It is one of important characteristics used for the diagnosis process in Dr. Volkov's Clinic. A satisfactory neural net model was created based on the filter

GDV parameters at the left hand, which correctly predicts the distribution of patients in groups of different values of parameter "Reserve". Tables 1–2 present results of the model.

Table 1. The results of the neural net model based on the filter GDV parameters at the left hand, obtained on the training sample. The columns correspond to the actual distribution of the patients from the sample, and the rows correspond to the model predictions. The diagonal numbers in the table count the patients correctly classified by the model, while the off-diagonal terms are the numbers of incorrectly classified patients. For example, it follows from the table that 57 patients from the group "Decreased Reserve" were correctly put in this group by the model, while 17 patients from the same group were incorrectly put in the group "Increased Reserve" by the model. The last row contains the percent of correctly classified patients for each group.

Model / Fact	*Group "Decreased Reserve"*	*Group "Increased Reserve"*
Group "Decreased Reserve"	57	14
Group "Increased Reserve"	17	62
% of correctly classified patients	**77%**	**82%**

Table 2. The same as in Table 1, but for the test sample.

Model / Fact	*Group "Decreased Reserve"*	*Group "Increased Reserve"*
Group "Decreased Reserve"	19	6
Group "Increased Reserve"	7	16
% of correctly classified patients	**73%**	**73%**

2.2. Analysis of GDV parameters deviations from their average values in the groups of various diseases

Tables 3–8 present differences (in percent) between average deviation of normalized GDV parameters from the average value in a group with a disease and that in a group without the disease. The statistically significant difference was taken close or larger than 20%.

Table 3. The differences (in percent) between average deviations of normalized filter GDV parameters calculated in the group with the gastrointestinal tract disease and in the group of conventionally healthy patients. The first row contains brief names of the GDV parameters. The first column includes numbers of fingers at which these parameters are calculated. The statistically significant distinctions are marked with the color.

	Ar	KFo	ARI	NRMS_ARI	LI	En	AI	NFr	Fr	RMS_Fr
1L	22	12	17	1	8	4	10	8	1	7
2L	1	4	0	16	12	0	17	4	1	12
3L	14	11	8	5	12	5	10	5	9	0
4L	8	2	7	2	5	6	2	4	4	0
5L	2	9	2	6	4	2	7	2	1	8
1R	6	9	1	1	2	7	2	3	2	10
2R	1	7	17	11	2	3	4	18	0	7

3R	5	1	8	2	1	14	5	1	21	8
4R	12	6	10	2	3	11	6	9	2	9
5R	1	15	7	10	2	12	0	6	14	11

Table 4. The same as in Table 3, but for ratios of the filter and without-filter values of the GDV parameters.

	Ar	KFo	ARI	NRMS_ARI	LI	En	AI	NFr	Fr	RMS_Fr
1L	2	8	3	7	8	3	11	14	1	2
2L	18	6	11	2	22	7	18	10	5	14
3L	6	4	3	2	13	12	3	7	6	12
4L	7	13	10	10	3	13	7	17	3	3
5L	2	11	1	1	0	12	16	6	2	1
1R	0	1	7	7	5	11	19	11	1	8
2R	3	0	7	7	13	3	7	2	2	8
3R	5	6	3	1	18	16	0	**32**	18	18
4R	7	18	13	6	11	6	8	**28**	8	6
5R	12	12	13	7	6	9	10	24	8	8

Table 5. The differences (in percent) between average deviations of normalized filter GDV parameters calculated in the group with the cardiovascular system disease and in the group of conventionally healthy patients. The first row contains brief names of the GDV parameters. The first column includes numbers of fingers at which these parameters are calculated. The statistically significant distinctions are marked with the color.

	Ar	KFo	ARI	NRMS_ARI	LI	En	AI	NFr	Fr	RMS_Fr
1L	5	1	3	21	2	8	9	22	1	18
2L	5	8	7	14	6	15	17	3	1	4
3L	15	4	22	5	10	9	8	19	3	11
4L	18	13	21	20	1	0	12	4	0	8
5L	13	11	6	7	2	3	7	4	14	5
1R	0	15	2	6	7	13	3	26	15	13
2R	1	1	3	2	20	9	1	23	7	20
3R	6	0	3	8	6	9	16	17	6	11
4R	3	6	2	10	2	9	13	2	14	13
5R	14	2	17	1	12	2	9	1	14	6

Table 6. The same as in Table 5, but for ratios of the filter and without-filter values of the GDV parameters.

	Ar	KFo	ARI	NRMS_ARI	LI	En	AI	NFr	Fr	RMS_Fr
1L	17	24	1	1	3	8	12	1	2	13
2L	6	6	4	8	3	24	13	17	5	15
3L	4	2	0	6	17	10	10	4	10	2
4L	12	13	17	3	2	5	2	6	6	8
5L	3	3	17	10	0	2	**28**	4	13	3
1R	1	14	7	7	16	4	16	11	8	9
2R	4	7	9	13	3	8	3	25	4	15
3R	26	0	21	3	9	5	21	**38**	8	4
4R	11	9	11	5	3	8	10	13	11	19
5R	24	20	20	2	25	1	14	24	15	4

Table 7. The differences (in percent) between average deviations of normalized filter GDV parameters calculated in the group with the skin disease and in the group of conventionally healthy patients. The first row contains brief names of the GDV parameters. The first column includes numbers of fingers at which these parameters are calculated. The statistically significant distinctions are marked with the color.

	Ar	KFo	ARI	NRMS_ARI	LI	En	AI	NFr	Fr	RMS_Fr

1L	6	6	2	9	0	5	3	19	10	11
2L	21	16	11	15	24	7	6	10	15	17
3L	13	19	9	4	3	15	12	5	20	2
4L	12	8	11	19	4	6	25	11	5	**29**
5L	15	5	2	3	9	11	0	4	15	4
1R	1	11	15	4	14	16	13	26	1	2
2R	13	16	10	8	26	**29**	20	16	21	7
3R	18	22	16	3	1	6	2	1	8	19
4R	20	18	7	8	16	14	4	16	3	11
5R	15	19	10	13	2	**28**	8	11	9	4

Table 8. The same as in Table 7, but for ratios of the filter and without-filter values of the GDV parameters.

	Ar	KFo	ARI	NRMS ARI	LI	En	AI	NFr	Fr	RMS Fr
1L	6	22	10	4	14	9	12	**39**	2	0
2L	21	16	16	8	1	16	1	14	3	1
3L	**29**	2	16	11	1	2	4	16	19	2
4L	15	10	26	18	**30**	1	11	6	16	21
5L	3	10	1	16	4	3	20	24	22	2
1R	2	3	2	1	5	2	4	18	0	1
2R	**29**	8	23	3	22	10	4	2	14	9
3R	14	18	0	20	5	4	2	26	18	11
4R	2	13	15	28	17	14	16	**37**	4	14
5R	18	9	15	5	11	16	6	**31**	2	5

3. Conclusions

We can conclude from Tables 1–2 that there is a strong correlation between the GDV parameters and the diagnostic parameter measuring functional reserve capacity of a patient. This correlation has been revealed at its largest value at the filter values of the GDV parameters at the left hand. We have derived the neural net model that allows to classify a patient as having either increased or decreased reserve level with an average probability of 75%.

The analysis of the normalized GDV parameters dispersion in groups with diseases of gastrointestinal tract, cardiovascular system, and skin has shown that the maximal difference between parameters deviations in groups of conventionally ill and conventionally healthy is of 20–30% order (Tables 3–8). The maximal difference is particularly demonstrated by parameter “Number of fragments (NFr)” (up to 39%; see Table 8). Moreover, this parameter shows that large difference between ill and healthy patients at 6 of 10 fingers in the skin disease group (Table 8).

These results on GDV parameters average deviations can be helpful for the diagnostics in the presence of a representative diagnostic database. Such a database should be created by collecting values of the GDV parameters for each patient. Then, any new patient can be assigned to the risk group for a disease with a certain probability if his/her values of the GDV parameters lie in specific ranges, determined in Tables 3–8.