



RESEARCH ARTICLE

Studying the Effect of Physical Plasma on the Blood using Digital Image Processing

Alyaa Hussein Ali¹, Hamid H.Murbet², Iman Abdulsttar ALhmeedi³,
Alaa Nazar⁴, Nisreen Kaleel A.ALameerr⁵

¹Department of Physics Baghdad University, Iraq

²Department of Physics Baghdad University, Iraq

³Department of Physics Baghdad University, Iraq

⁴Department of Physics Baghdad University, Iraq

⁵Department of Physics Baghdad University, Iraq

aliahusain@ymail.com; dralaanazar@yahoo.com

Abstract— The present work deals with physical plasma and digital image processing, it is a new way to finding the changes which occur in the blood texture as a result from exposure the blood samples to the plasma for different time; this effect can be study using the texture analysis method which is the co-occurrence matrix. It is important to mentioned that the search include four type of blood Healthy (N), Smoker (s), Diabetes (D) and High blood pressure (P), the healthy and high blood pressure shows a good response to the plasma while the Smoker and Diabetes shows a very small response since their blood has high viscosity.

Keywords— cold Plasma, gray level co-occurrence matrix, Statistical Feature, Image segmentation

1. INTRODUCTION

Plasma is the fourth state in addition to the three States of matter (solid, liquid and gas),Plasma is an ionized gas and could be divided into two categories: thermal and non-thermal. In the thermal Plasma all the particles (Electrons ,Positive ions, Neutral atoms) are in thermodynamic equilibrium, whereas in Non-thermal Plasma, there is a significant difference in kinetic Energy i.e. temperature of Electrons and ambient gas particles.Namely the corona discharge and the Dielectric Barrier Discharge (DBD) , the (DBD) discharges are predestined for applications of large volume plasma. Barrier discharges, also referred as silent discharges are Characterized by the presence of at least one insulating layer between two planar or cylindrical electrodes connected to an (AC) power supply [1] . The feature of the task and the great interest of the Dielectric Barrier Discharge method , method is the possibility of producing plasma economical and reliable . This feature has led to you use them in many industrial applications including Environmental task [2,3] , Medical [4,5] Sterilization and Disinfection Bacteria [6,7],[Surface Treatment[8] and Ozone generating [9]. The aim of our research is design and fabrication of the dielectric barrier discharge system and using Digital Image Processing to study the effect of Plasma on the Blood.

2. SECOND ORDER STATISTICAL FEATURES

Using the Statistical Textural analysis method which is the second order method depend on the gray level scale.

- **Gray-Level Co-occurrence Matrix:** Two-dimensional Co-occurrence (gray-level dependence) Matrices, proposed by Haralick in 1973, are generally used in texture analysis because they are able to capture the spatial dependence of gray-level values within an image. A 2D Co-occurrence Matrix, P , is an $(n \times n)$ Matrix, where n is the number of gray-levels within an image. For reasons of computational efficiency, the number of gray levels can be reduced if one chooses to bin them, thus reducing the size of the Co-occurrence Matrix. The Matrix acts as an accumulator so that $P[i, j]$ counts the number of pixel pairs having the intensities i and j . Pixel pairs are defined by a distance and direction which can be represented by a displacement vector $d = (dx, dy)$, where dx represents the number of Pixels moved along the x-axis, and dy represents the number of pixels moved along the y-axis of an image slice. In order to quantify this spatial dependence of gray-level values, we calculate various textural features proposed by Haralick, including Entropy, Energy, Contrast, Homogeneity and Correlation [10].

- **Contrast:** Contrast is a measure of intensity Contrast between a pixel and its neighbour over the entire image. If the image Contrast equal 0 while the biggest value can be obtained when the image is a random intensity image and that pixel intensity and neighbour intensity are very different. The equation of the contrast is as follows [11].

$$\text{Contrast} = \sum_{i=0}^{255} \sum_{j=0}^{255} P(i, j) (i - j)^2$$

- **Energy:** Energy is a measure of uniformity the value is maximum when the image is constant. The equation of the contrast is as follows [11].

$$\text{Energy} = \sum_{i=0}^{255} P(i, j)^2$$

- **Homogeneity:** Homogeneity measures the spatial closeness of the distribution of the co-occurrence matrix. Homogeneity equal 0 when the distribution of the co-occurrence matrix is uniform and 1 when the distribution is only on the diagonal of the matrix. The equation of the contrast is as follows[11]:

$$\text{Homogeneity} = \sum_{i=0}^{255} \sum_{j=0}^{255} \frac{P(i, j)}{(1 + (i - j)^2)}$$

- **Entropy:** Entropy measures the randomness of the elements of the co-occurrence matrix. Entropy is maximum when elements in the matrix are equal to 1, while is equal to 0 if all elements are different. The equation of the contrast is as follows [11]:

$$\text{Entropy} = - \sum_{i=0}^{255} \sum_{j=0}^{255} P(i, j) \log (P(i, j))$$

- **Correlation:** is expressed by the correlation coefficient between two random variables i and j , where i represents the possible outcomes in gray tone measurement for the first element of the displacement vector, while similarly j is associated with gray tones of the second element of the displacement vector. [12]:

$$\text{Correlation} = \frac{\sum_{i=0}^{255} \sum_{j=0}^{255} P(i, j) (i - \mu_x) (j - \mu_y)}{\sigma_x \sigma_y}$$

Where $\sigma_x \sigma_y$ are standard deviation in the x and y directions, and $(\mu_x)(\mu_y)$ are means.

Correlation is a measure of gray tone linear-dependencies in the image; in particular, the direction under investigation is the same as vector displacement. High correlation values (close to 1) imply a linear relationship between the gray levels of pixel pairs. Thus, GLCM correlation is uncorrelated with GLCM energy and entropy, i.e., to pixel pairs repetitions. Correlation reaches it maximum regardless of pixel pair occurrence, as high correlation can be measured either in low or in high energy situations. GLCM correlation is also uncorrelated to GLCM contrast, as high predictability of the gray level of one pixel from the second one in a pixel pair is completely independent 32 from contrast. As a limiting case of linear-dependency a completely homogeneous area may be considered, for which correlation is equal to 1[12].

3. Method and Material

A. Blood Sample

The samples are taken for man with age between (30 – 40) years, blood samples are for four cases -Healthy case (N), Diabetes case (D), Hypertension case (P) and Smoky case (S).

B. Preparation of Blood samples

The preparation can be done by exposure each sample to the Cold Plasma starting from two second up to 50 second. Taking Image for each step, since the exposures are two step.

4. Results and discussion

Figure (1)(a,b), Figure (2)(a,b), Figure(3)(a,b),and Figure (4)(a,b), showing Digital Image and Gray Image for Blood samples person (Healthy (N) ,smoker (S) , Patients with diabetes (D) , Patients with high blood pressure (P)) cases.

| Gray Image | Sample(N) | Time (sec) | Gray Image | Sample (N) | Time (sec) |
|------------|-----------|------------|------------|------------|------------|
| | | 14 | | | 2 |
| | | 16 | | | 4 |
| | | 18 | | | 6 |
| | | 20 | | | 8 |
| | | 22 | | | 10 |
| | | 24 | | | 12 |

Fig. (1)(a) Shows Image of Blood samples, and Gray Image of Healthy (N) Sample at a Threshold of (100).

| | | | | | |
|--|--|----|--|--|----|
| | | 40 | | | 26 |
| | | 42 | | | 28 |
| | | 44 | | | 30 |
| | | 46 | | | 32 |
| | | 48 | | | 34 |
| | | 50 | | | 36 |
| | | | | | 38 |

Fig.(1)(b) Shows complement Image of Blood samples, and Gray Image of Healthy (N) Sample at a Threshold of (100).

| Gray Image | Sample(S) | Time (sec) | Gray Image | Sample(S) | Time (sec) |
|------------|-----------|------------|------------|-----------|------------|
| | | 14 | | | 2 |
| | | 16 | | | 4 |
| | | 18 | | | 6 |
| | | 20 | | | 8 |
| | | 22 | | | 10 |
| | | 24 | | | 12 |

Fig(2)(a). shows Image of Blood samples, and Gray Image of Smoker (S) sample at a Threshold of (100).

| Gray Image | Sample(S) | Time(sec) | Gray Image | Sample(S) | Time (sec) |
|------------|-----------|-----------|------------|-----------|------------|
| | | 40 | | | 26 |
| | | 42 | | | 28 |
| | | 44 | | | 30 |
| | | 46 | | | 32 |
| | | 48 | | | 34 |
| | | 50 | | | 36 |
| | | | | | 38 |

Fig. (2)(b) Shows complement Image of Blood samples, and Gray Image of Smoker (S) Sample at a Threshold of 100.

| Gray Image | Sample(D) | Time (sec) | Gray Image | Sample (D) | Time(sec) |
|------------|-----------|------------|------------|------------|-----------|
| | | 14 | | | 2 |
| | | 16 | | | 4 |
| | | 18 | | | 6 |
| | | 20 | | | 8 |
| | | 22 | | | 10 |
| | | 24 | | | 12 |

Fig(3)(a). shows Image of Blood samples, and Gray Image of a Diabetes (D) sample at a Threshold of (100).

| Gray Image | Sample(p) | Time(sec) | Gray Image | Sample (p) | Time (sec) |
|------------|-----------|-----------|------------|------------|------------|
| | | 40 | | | 26 |
| | | 42 | | | 28 |
| | | 44 | | | 30 |
| | | 46 | | | 32 |
| | | 48 | | | 34 |
| | | 50 | | | 36 |
| | | | | | 38 |

Fig. (3)(b) shows complement Image of Blood samples, and Gray Image of with Diabetes (D) sample at a Threshold of (100).

| Gray Image | Sample(p) | Time (sec) | Gray Image | Sample (p) | Time (sec) |
|------------|-----------|------------|------------|------------|------------|
| | | 14 | | | 2 |
| | | 16 | | | 4 |
| | | 18 | | | 6 |
| | | 20 | | | 8 |
| | | 22 | | | 10 |
| | | 24 | | | 12 |

Fig(4)(a). Shows Image of Blood samples, and Gray Image of High Blood Pressure (P) Sample at a threshold of (100).

| Gray Image | Sample(p) | Time(sec) | Gray Image | Sample (p) | Time (sec) |
|------------|-----------|-----------|------------|------------|------------|
| | | 40 | | | 26 |
| | | 42 | | | 28 |
| | | 44 | | | 30 |
| | | 46 | | | 32 |
| | | 48 | | | 34 |
| | | 50 | | | 36 |
| | | | | | 38 |

Fig. (4)(b) shows complement Image of Blood samples, and Gray Image of High Blood Pressure (P) at a Threshold of(100).

Table (1) shows Contrast values of Gray Image for Blood samples person (Healthy (N), smoker (S) , Patients with diabetes (D) , Patients with high blood pressure (p).

TABLE (1)
SHOWS CONTRAST VALUES OF GRAY MATRIX FOR BLOOD SAMPLES PERSON (N,S,D,P).

| Time(s) | Normal (N) | Smoker (S) | Diabetes (D) | Pressure (P) |
|---------|------------|------------|--------------|--------------|
| 2 | 0.5729 | 0.7004 | 0.2360 | 0.3060 |
| 4 | 0.3120 | 0.4874 | 0.5207 | 0.4186 |
| 6 | 0.6353 | 0.6120 | 0.8549 | 0.7431 |
| 8 | 0.2356 | 0.9914 | 0.1786 | 0.6538 |
| 10 | 0.2993 | 0.6529 | 1.1956 | 0.4854 |
| 12 | 0.7560 | 0.9894 | 0.3547 | 0.8721 |
| 14 | 0.2166 | 0.5126 | 0.6717 | 0.5557 |
| 16 | 0.8800 | 0.8529 | 0.8147 | 0.6161 |
| 18 | 0.7268 | 0.5143 | 0.7470 | 0.5612 |
| 20 | 0.8051 | 0.4514 | 0.5188 | 0.6069 |
| 22 | 0.8723 | 0.8368 | 0.3820 | 0.9232 |
| 24 | 0.6860 | 0.5650 | 1.3304 | 0.7708 |
| 26 | 0.7432 | 0.5903 | 0.3992 | 0.7435 |
| 28 | 0.6870 | 0.4227 | 1.4180 | 0.6924 |
| 30 | 1.1880 | 0.3780 | 0.2924 | 0.4716 |
| 32 | 0.4434 | 0.6851 | 0.2547 | 0.6826 |
| 34 | 0.8997 | 0.5163 | 0.2084 | 0.6524 |
| 36 | 0.6559 | 0.4007 | 0.3095 | 0.6230 |
| 38 | 0.1407 | 0.6351 | 0.3939 | 0.5699 |
| 40 | 1.0450 | 0.5735 | 0.4866 | 0.6485 |
| 42 | 0.3640 | 0.6346 | 0.4182 | 0.3800 |
| 44 | 0.2952 | 0.2395 | 0.5163 | 0.4886 |
| 46 | 0.5606 | 0.5986 | 0.2956 | 0.3869 |
| 48 | 1.2125 | 0.6153 | 0.9406 | 0.8414 |
| 50 | 0.6712 | 0.5254 | 1.1855 | 0.2976 |

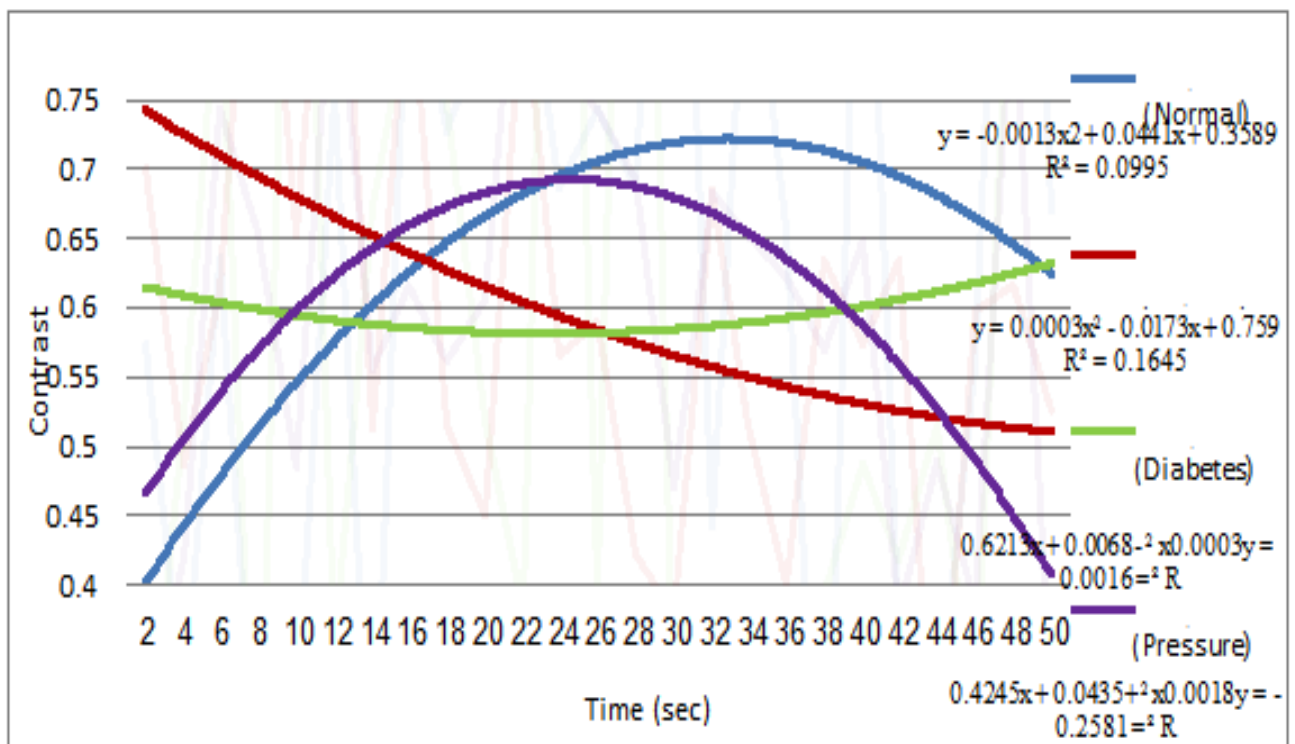


Fig. (5) shows contrast values as a function of time for (N,S,D,P).

Table (2) shows Homogeneity values of Gray Image for Blood samples person (Healthy (N), smoker (S) , Patients with diabetes (D) , Patients with high blood pressure (p).

TABLE (2)
SHOWS HOMOGENEITY VALUES OF GRAY MATRIX FOR BLOOD SAMPLES PERSON (N,S,D,P).

| Time (S) | Normal (N) | Smoker (S) | Diabetes (D) | Pressure (P) |
|----------|------------|------------|--------------|--------------|
| 2 | 0.8442 | 0.8408 | 0.9220 | 0.9071 |
| 4 | 0.8945 | 0.8821 | 0.8836 | 0.8934 |
| 6 | 0.8414 | 0.8450 | 0.8541 | 0.8399 |
| 8 | 0.9391 | 0.8216 | 0.9592 | 0.8740 |
| 10 | 0.8806 | 0.8580 | 0.7607 | 0.8874 |
| 12 | 0.8532 | 0.7889 | 0.9090 | 0.8273 |
| 14 | 0.9324 | 0.8745 | 0.8652 | 0.8597 |
| 16 | 0.7932 | 0.8342 | 0.8652 | 0.8539 |
| 18 | 0.8179 | 0.9041 | 0.8436 | 0.8608 |
| 20 | 0.8034 | 0.9098 | 0.8678 | 0.8789 |
| 22 | 0.7759 | 0.8634 | 0.8947 | 0.8030 |
| 24 | 0.8312 | 0.8959 | 0.7695 | 0.8693 |
| 26 | 0.8512 | 0.8405 | 0.8953 | 0.8637 |
| 28 | 0.8435 | 0.8821 | 0.7618 | 0.8311 |
| 30 | 0.7707 | 0.9063 | 0.9297 | 0.9018 |
| 32 | 0.8793 | 0.8498 | 0.9257 | 0.8663 |
| 34 | 0.8439 | 0.8749 | 0.9227 | 0.9003 |
| 36 | 0.8518 | 0.9195 | 0.9381 | 0.8685 |
| 38 | 0.9296 | 0.8929 | 0.8996 | 0.8562 |
| 40 | 0.8123 | 0.9124 | 0.8850 | 0.8239 |
| 42 | 0.8842 | 0.8973 | 0.9141 | 0.9144 |
| 44 | 0.8911 | 0.8862 | 0.9064 | 0.8736 |
| 46 | 0.8649 | 0.9025 | 0.9232 | 0.8893 |
| 48 | 0.7749 | 0.9004 | 0.8243 | 0.8584 |
| 50 | 0.7749 | 0.9004 | 0.8243 | 0.8584 |

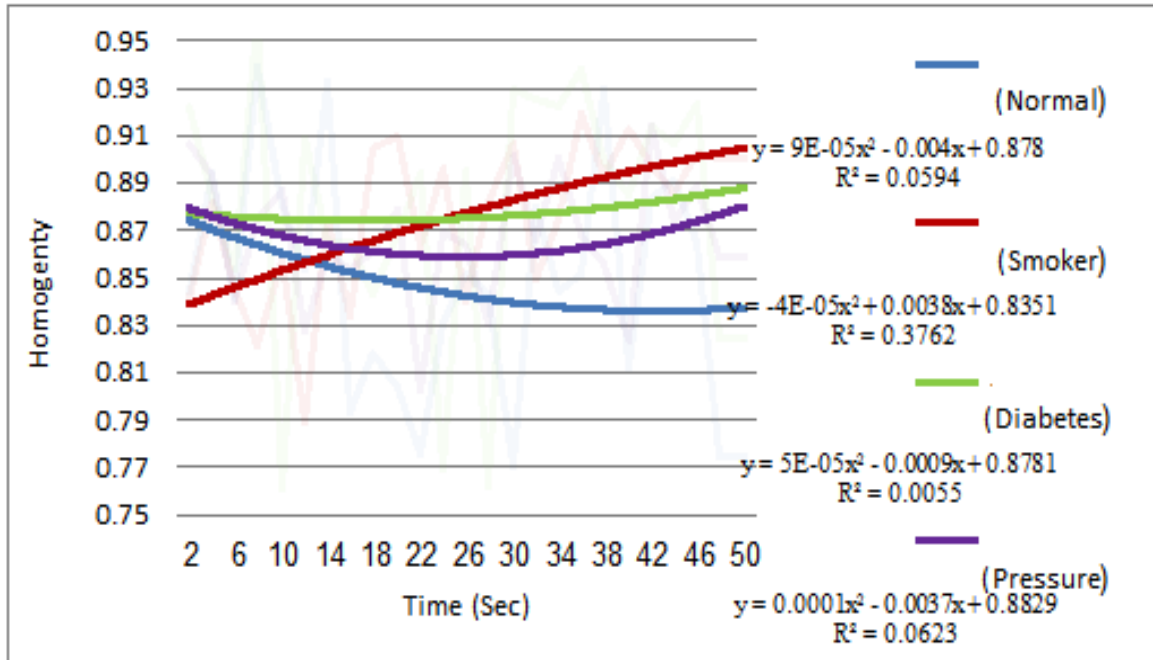


Fig.(6) Shows Homogeneity values as a function of time for(N,S,D,P).

Table (3) shows Correlation values of Gray Image for Blood samples person (Healthy (N), smoker (S) , Patients with diabetes (D) , Patients with high blood pressure (p).

TABLE (3)
SHOWS CORRELATION VALUES OF GRAY MATRIX FOR BLOOD SAMPLES PERSON (N,S,D,P).

| Time(s) | Normal(N) | Smoker(S) | Diabetes(D) | Pressure(P) |
|---------|-----------|-----------|-------------|-------------|
| 2 | 0.5135 | 0.5048 | 0.5493 | 0.65970 |
| 4 | 0.6135 | 0.5214 | 0.4651 | 0.58800 |
| 6 | 0.6353 | 0.5031 | 0.4387 | 0.48200 |
| 8 | 0.4770 | 0.5144 | 0.6965 | 0.46790 |
| 10 | 0.6115 | 0.4952 | 0.2823 | 0.41600 |
| 12 | 0.4182 | 0.2798 | 0.4761 | 0.46070 |
| 14 | 0.4972 | 0.5333 | 0.2147 | 0.56620 |
| 16 | 0.3440 | 0.4413 | 0.3549 | 0.58260 |
| 18 | 0.3678 | 0.5908 | 0.3460 | 0.56220 |
| 20 | 0.3089 | 0.5746 | 0.5280 | 0.63960 |
| 22 | 0.2382 | 0.5386 | 0.6007 | 0.42680 |
| 24 | 0.4045 | 0.4887 | 0.3894 | 0.52818 |
| 26 | 0.5371 | 0.5037 | 0.5104 | 0.53210 |
| 28 | 0.3809 | 0.4227 | 0.3602 | 0.50400 |
| 30 | 0.2927 | 0.7053 | 0.2366 | 0.58010 |
| 32 | 0.4134 | 0.5173 | 0.4167 | 0.52260 |
| 34 | 0.5261 | 0.5625 | 0.6030 | 0.60540 |
| 36 | 0.5670 | 0.4451 | 0.4040 | 0.57560 |
| 38 | 0.3187 | 0.5795 | 0.4603 | 0.53980 |
| 40 | 0.4491 | 0.5331 | 0.4172 | 0.40750 |
| 42 | 0.5034 | 0.4179 | 0.4642 | 0.57620 |
| 44 | 0.6276 | 0.6257 | 0.3582 | 0.53770 |
| 46 | 0.4318 | 0.6681 | 0.3237 | 0.59600 |
| 48 | 0.3511 | 0.5189 | 0.4035 | 0.48540 |
| 50 | 0.5769 | 0.4528 | 0.4258 | 0.69260 |

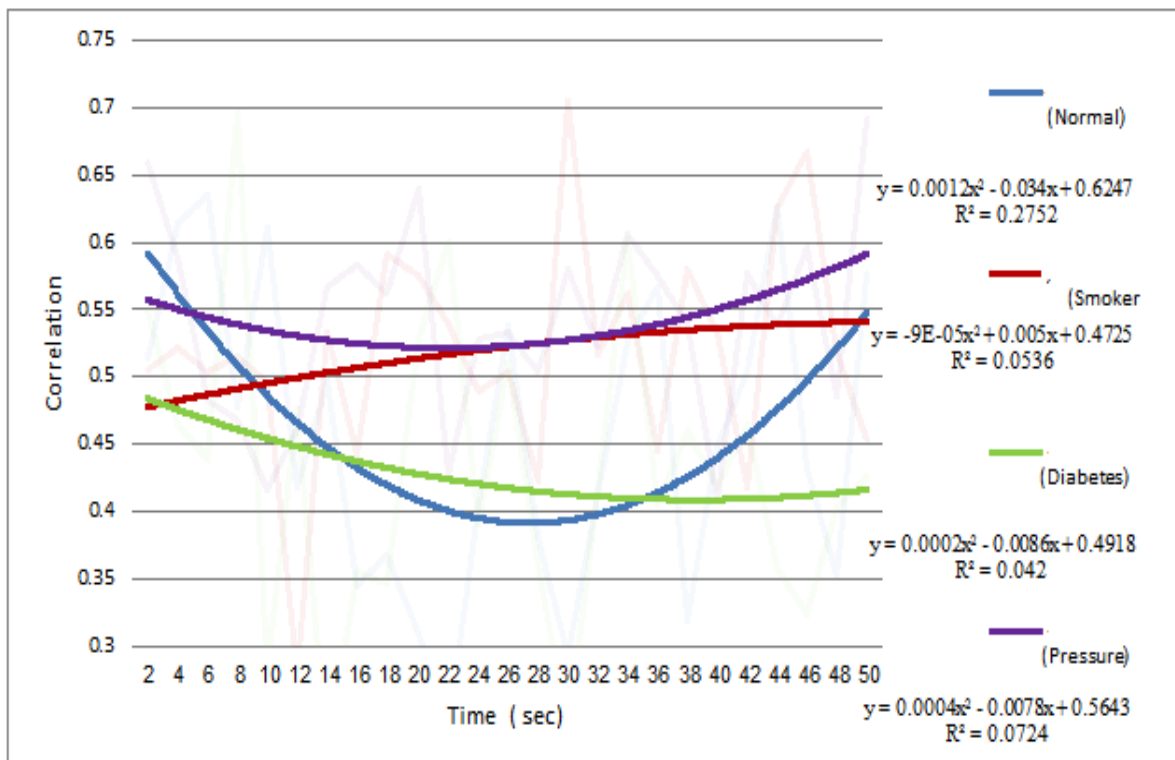


Fig.(7) shows correlation values as a function of time for (N,S,D,P).

Table (4) shows Energy values of Gray Image for Blood samples person (Healthy (N), smoker (S) , Patients with diabetes (D) , Patients with high blood pressure (p).

TABLE (4)
SHOWS ENERGY VALUES OF GRAY MATRIX FOR BLOOD SAMPLES PERSON (N,S,D,P).

| Time(S) | Normal (N) | Smoker(S) | Diabetes(D) | Pressure(P) |
|---------|------------|-----------|-------------|-------------|
| 2 | 0.2423 | 0.2369 | 0.56610 | 0.3033 |
| 4 | 0.3121 | 0.2827 | 0.45790 | 0.2873 |
| 6 | 0.2109 | 0.2096 | 0.37960 | 0.2904 |
| 8 | 0.6977 | 0.2248 | 0.72480 | 0.4390 |
| 10 | 0.2972 | 0.3548 | 0.15340 | 0.3706 |
| 12 | 0.3437 | 0.1767 | 0.57500 | 0.2047 |
| 14 | 0.5695 | 0.2450 | 0.49970 | 0.2147 |
| 16 | 0.1841 | 0.3212 | 0.44020 | 0.2129 |
| 18 | 0.2087 | 0.5026 | 0.40330 | 0.2071 |
| 20 | 0.1914 | 0.5418 | 0.36330 | 0.2857 |
| 22 | 0.1719 | 0.3730 | 0.46320 | 0.1615 |
| 24 | 0.2209 | 0.5307 | 0.18450 | 0.5810 |
| 26 | 0.2269 | 0.2340 | 0.51790 | 0.5321 |
| 28 | 0.3047 | 0.2757 | 0.19370 | 0.2126 |
| 30 | 0.1514 | 0.4079 | 0.66650 | 0.5801 |
| 32 | 0.3520 | 0.3169 | 0.63650 | 0.3655 |
| 34 | 0.3088 | 0.2288 | 0.55050 | 0.4261 |
| 36 | 0.3273 | 0.4451 | 0.70170 | 0.2158 |
| 38 | 0.6799 | 0.3959 | 0.53650 | 0.2080 |
| 40 | 0.2622 | 0.5462 | 0.51250 | 0.2066 |
| 42 | 0.3557 | 0.5312 | 0.55505 | 0.5572 |
| 44 | 0.3009 | 0.3124 | 0.53620 | 0.3355 |
| 46 | 0.3740 | 0.3753 | 0.65940 | 0.3248 |
| 48 | 0.1536 | 0.5217 | 0.27990 | 0.3736 |
| 50 | 0.2296 | 0.5623 | 0.23960 | 0.6024 |

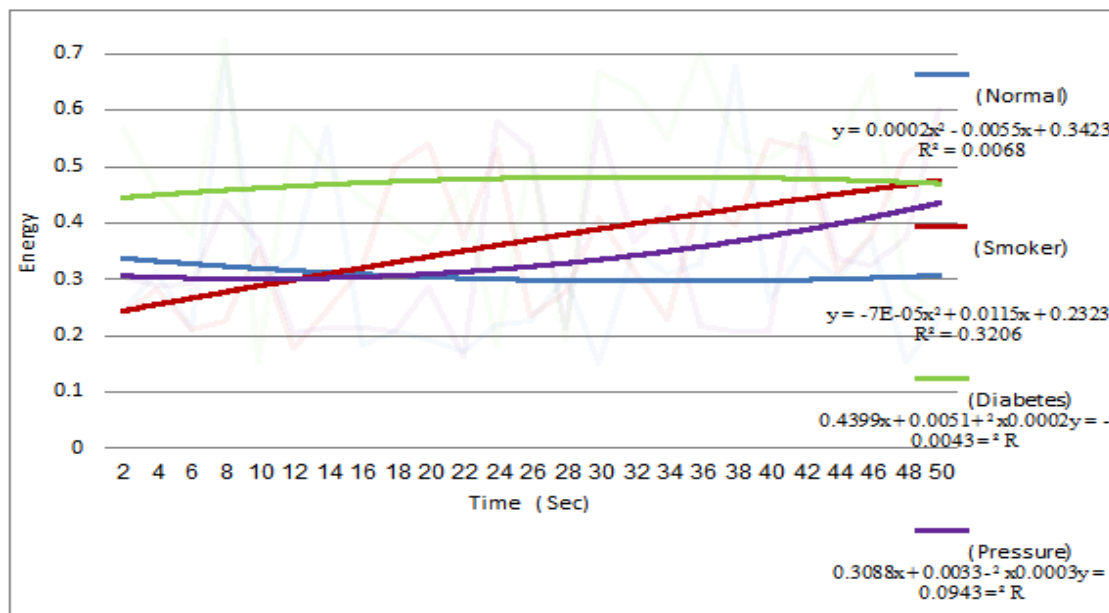


Fig. (8) shows Energy values as a function of time for (N,S,D,P).

Fig(5,6,7,8) show the statistical features with time .Fig (5) which is the contrast with time shows that for the Normal and the Pressure case the Contrast curve increase with time which is between (24 and 30 second),while for the Smoker and Diabetes case the curve behaviour inverses .It's value decrease with time to accretion second then the curve increased roughly.

Fig.(6) represented the Homogeneity with time curve ,the Diabetes shows very small response to the Plasma effect while the Smoker shows small increase with time .The Pressure and Normal case decrease with time , since the Homogeneity gives indication about the purity of the tissue .

Fig.(7) which the Correlation with time it's behaviour in opposite to the Contrast and this can observed from the graph the normal and pressure case decrease with time for a certain time .while the Smoker curve shows small increasing with time .

Fig.(8) which the Energy time curve the Diabetes and the Normal case shows no response to the effect of Plasma while the Smoker curve increase with time, and the Pressure case shows very small response to the Plasma effect .

5. Conclusions

The concluding can be expressed as follows:

1. The *Contrast* values changes significantly in the samples (N,P) , and changes little in the samples (S,D).
2. The values of both the *Homogeneity* and the *Correlation* changes significantly in the samples of (N,P), and changes very little almost unnoticed in (S,D) samples .
3. The Energy values changes little in (S,P) samples , and does not change in (N,D) samples .

From the above it can be concluded that the effect of the Cold Plasma in the Blood samples of both the smokers and people with Diabetes mellitus was very limited and does not show a clear change in the properties of Image Texture , but its effect on the Blood samples of the healthy person , and the person with High Blood Pressure (hypertension) can be observed from the change occurred in the Image Texture .

REFERENCES

- [1] Vijay Nehra ,Ashok Kumar and H K Dwivedi",Atmospheric Non-Thermal Plasma Sources ."International Journal of Engineering ,Vol : (2) Issue (1), 2007.
- [2] Arben Kojtari¹, Utku K Ercan², Josh Smith¹, Gary Friedman³, Richard B Sensenig², Somdev Tyagi, Suresh G Joshi, Hai-Feng Ji and Ari D Brooks , Nanomedine Biotherapeutic Discov 2013, 4:1.
- [3] Janga D. I., Leea S. B., Moka,c Y. S., Jangb D. L., International Journal of Chemical and Environmental Engineering . June 2013, Volume 4, No.3.
- [4] Garcia-Alcantara E, Lopez-Callejas R, Morales-Ramirez PR, Pena-Eguiluz R,Fajardo-Munoz R, Mercado-Cabrera A, Barocio SR, Valencia-Alvarado R, Rodriguez-Méndez BG, Munoz-Castro AE, de la Piedad-Beneitez A, Rojas-Olmedo IA, Arch Med Res, 2013, 44(3):169–177.
- [5] Fridman G, Friedman G, Gutsol A, Shekhter AB, Vasilets VN, Fridman A, Plasma Processes Polym 2008, 5:503–533..
- [6] Chipper AS, Chen W, Mejlholm O, Dalgaard P, Stamate E, Plasma Sources Sci Technol 2011, 20:10.
- [7] Chiang MH, Wu JY, Li YH, Wu S, Chen SH, Chang CL, Surf Coat Technol 2010, 204:3729–3737.
- [8] Wagner HE, Brandenburg R, Kozlov KV, Sonnenfeld A, Michel P, Behnke JF, Vacuum 2003, 71:417– 436.
- [9] Kogelschatz U, Hirth M, Eliasson B, J Phys D: Appl Phy 1987, 20:1421–1437.
- [10] David A. Clausi . "An analysis of co-occurrence texture statistics as a function of gray level quantization" .Can. J. Remote Sensing, Vol. 28, No.1, pp. 45-62., 2002
- [11] Laws K., " Textured image segmentation". Ph.D. dissertation, University of Southern California.1980
- [12] Guneet Saini ." Texture Analysis Of CT Scan Images".Thesis submitted in partial fulfillment of the requirement for the award of degree of Master of Engineering in Electronic Instrumentation and Control. By Electrical and Instrumentation Department Thapar University, Patiala, June 2008.