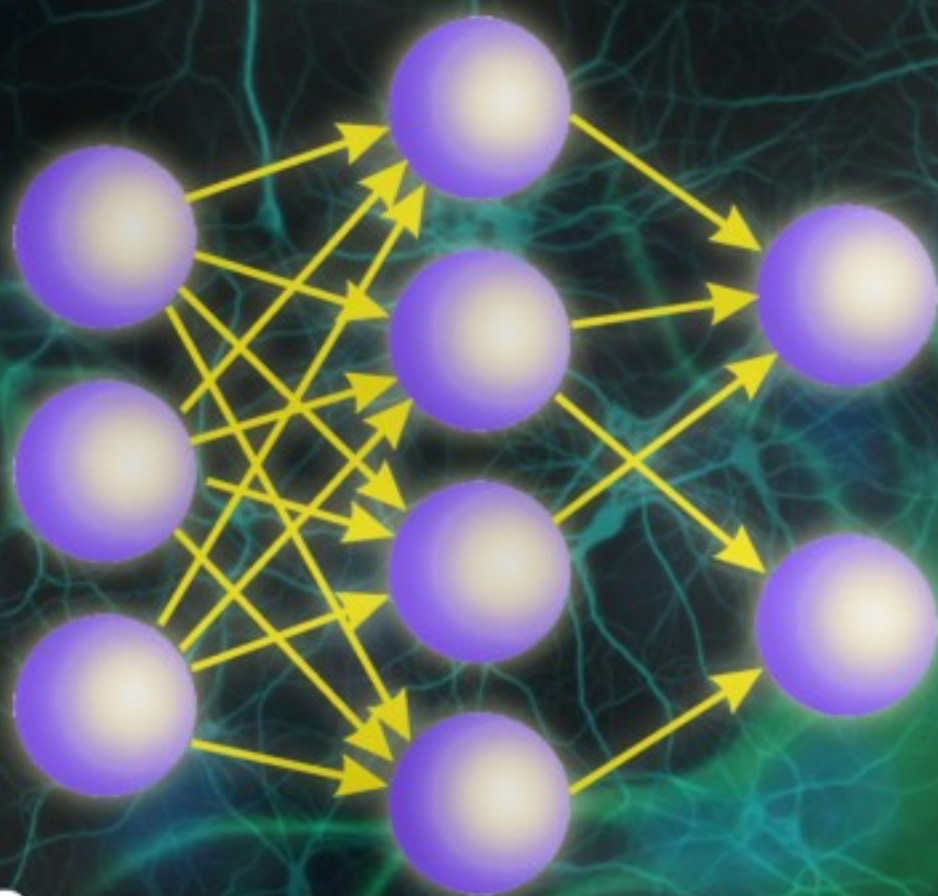


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International Frequency Sensor Association (IFSA).

## **pH Homeostasis Linked with Capacitance Relaxation Phenomena and Electrostrictive Energy in Cancer Cells**

**\*T. K. Basak, T. Ramanujam, J. C. Kavitha, Poonam Goyal, Deepali Garg, Arpita Gupta, Suman Halder**  
Krishna Engineering College, Ghaziabad, India

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**Abstract:** The present paper describes the capacitance relaxation phenomenon linked with the metastasis of cancer cells (US Patent No. TK Basak 5691178, 1997). The capacitance relaxation phenomenon is so significant that it can be correlated with the pH homeostasis and the electrostrictive energy of the cancer cells. The electrostrictive phenomenon is due to the composite dielectric property of the cancer cell concomitant with the capacitance relaxation phenomena. It is to be noted that pH homeostats in cancer cells are directly linked with the gene homeostat in a novel way so far as dephosphorylation of the oncogenes is concerned. This phenomenon in respect of pH homeostasis has been correlated with capacitance relaxation phenomenon and electrostrictive energy during pH mediated signal transduction phase. For this correlation DTREG has been used for the implementation of Datamining. For this analysis the type of model used in datamining is single tree for which the input data comprises of target and predictor variables. From the datamining result it is possible to conclude that the pH range (acidic) for all types of cancer is not unique and as such cancer has distinct specificity in respect of pH homeostasis. *Copyright © 2009 IFSA.*

**Keywords:** pH homeostasis, Capacitance relaxation phenomenon, Electrostrictive energy, DTREG

---

## 1. Introduction

The Electrostrictive energy in cancer cells is directly linked with capacitance relaxation phenomena [1, 17-19]. It is interesting to find that the electrostrictive energy decreases exponentially with the progression of metastasis of cancer cells [2, 9, 10, 12].

It is to be noted that the pH of the intracellular as well as the extracellular fluid has specific link with the metastatic phase in different cancers [28-30].

The Cancer cells live in a lower extracellular pH(Ecs) as compared with the normal cells. The low pH(Ecs) observed in cancer cells is attributed to the production of lactic acid under unaerobic conditions and to the hydrolysis of ATP in an environment concomitant with the status of the electrostrictive energy [3, 4].

It is to be noted that the intracellular and extracellular pH gradients and the relative intracellular and extracellular concentrations of the respective electrolyte is given by the expression

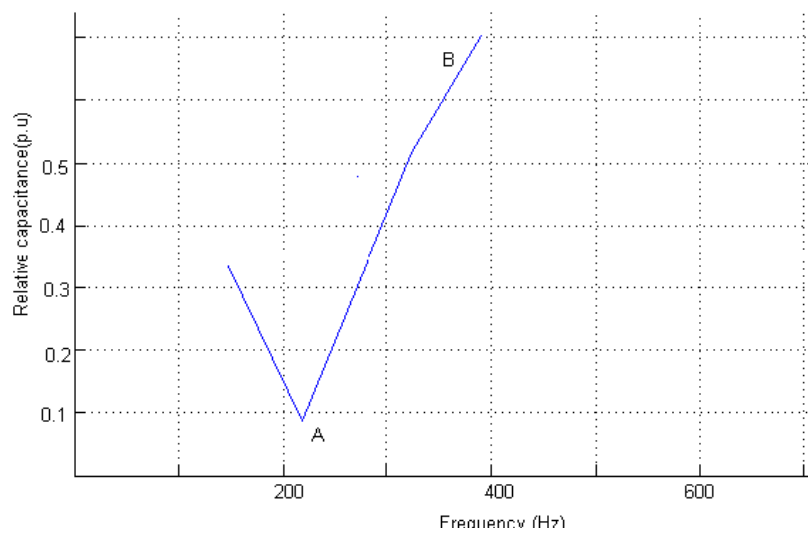
$$C_{ICF} / C_{ECF} = (1 + 10^{pH_{ICF} - PK_n}) / (1 + 10^{pH_{ECF} - PK_n})$$

$C_{ICF}$  represents the concentration of intracellular fluid and  $C_{ECF}$  represents the concentration of extracellular fluid. The value of  $PK_n$  for a neutral electrolyte at 37 °C is 5.1 [3, 4].

Intracellular acidification causes an increase in intracellular calcium ( $Ca^{2+}$ ) of epithelial cells [5]. Increase in the concentration of calcium leads to dephosphorylation of the epithelial cells. The intracellular proton concentration against time gradually drops in the epithelial layers during the process of angiogenesis and metastasis of cancer cells for which acidosis of the intracellular fluid gradually increases.

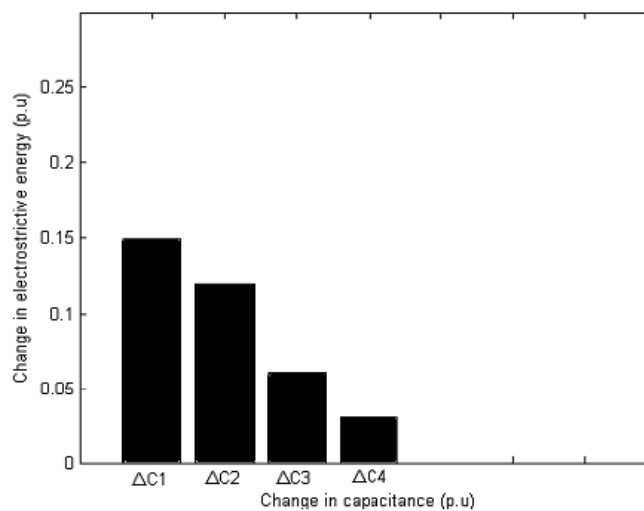
The electrostrictive process in cancer cell is a complex one for which the electrostatic surfaces surrounding the cell changes with the incremental changes in the capacitance present in the capacitance relaxation curve.[1, 6, 8, 9] From these incremental changes in capacitance, it is also possible to find out the electrostrictive energy of the cancer cell. It is interesting to note that the electrostrictive energy corresponding to the incremental changes in the capacitance is more in the first order system than that present in the second order system representing the equivalent configuration of the composite dielectric associated with the cell membrane. This is due the fact that during the process DNA synthesis and cell division the change in capacitance of the membrane for the first order system is relatively slow.

The representative interaction of pH homeostasis, Capacitance Relaxation phenomena (Fig. 1) and electrostrictive energy (Fig. 2) are shown in the Fig. 3 below. From the Fig. 3 it is also indicated that the different types of cancers corresponds to different interaction with these parameters mentioned above related to Capacitance Relaxation phenomena, electrostrictive energy and the pH of the intracellular and extracellular fluid.



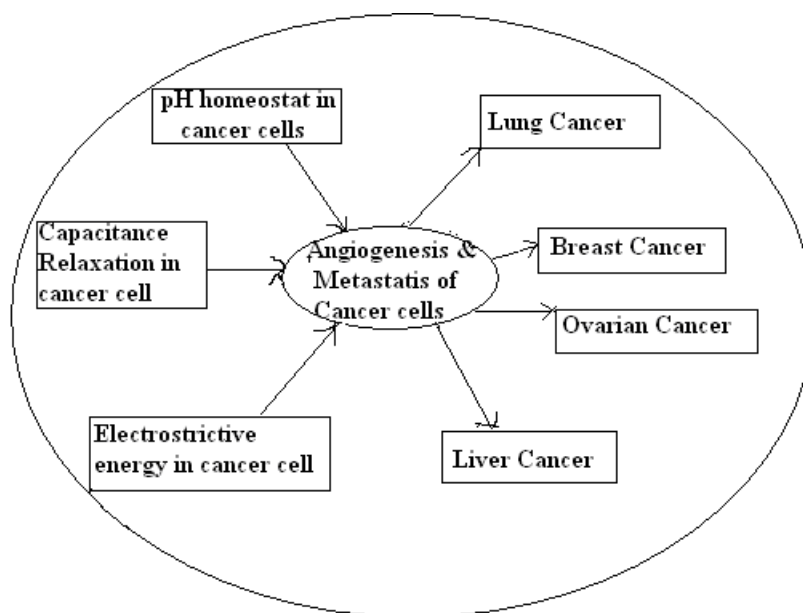
**Fig. 1.** Capacitance Relaxation Phenomena.

Electrostrictive energy in cancer cells is shown in the following figure.



**Fig. 2.** Status of Electrostrictive energy in cancer cells.

The interaction of the Capacitance Relaxation Phenomena, intracellular pH and Electrostrictive energy for different types of cancers is represented below.



**Fig. 3.** Representation of the interactive phenomena in cancer as mentioned above.

## 2. Data Mining

Data mining is a powerful statistical analysis program that generates classification and regression decision trees that model data and can be used to predict values. Data mining has been done by the software DTREG which is a robust application that is installed easily on any Windows system. DTREG reads Comma Separated Value (CSV) data files that are easily created from almost any data source. Through DTREG the classification of trees has been done through a particular option (single tree mode) present in the software where the target variable being predicted is categorical.

Datamining is based on Equation (1) for the pH homeostasis in cancer cells.

S. No	Intracellular pH Range	Misclassification	Disease
1	$\leq 5.52$	66 %	Breast Cancer
2	$\geq 5.52$ To $\leq 6.11$	0 %	Ovarian Cancer
3	$\geq 6.11$	55 %	Breast Cancer
4	$> 6.11$ To $\leq 6.95$	0 %	Breast Cancer
5	$> 6.95$	40 %	Lung Cancer
6	$\geq 6.95$ To $\leq 7.06$	0 %	Lung Cancer
7	$> 7.06$	0 %	Liver Cancer

S. No	Extracellular pH Range	Misclassification	Disease
1	$\leq 5.21$	66 %	Breast Cancer
2	$\geq 5.21$ To $\leq 5.47$	0 %	Ovarian Cancer
3	$> 5.47$	55 %	Breast Cancer
4	$> 5.47$ To $\leq 6.14$	0 %	Breast Cancer
5	$> 6.14$	40 %	Lung Cancer
6	$\geq 6.14$ To $\leq 6.70$	0 %	Lung Cancer
7	$> 6.70$	0 %	Liver Cancer



### 3. Discussions and Conclusions

The correlation of the capacitance relaxation phenomena, electrostrictive energy and pH homeostasis concerned with intracellular and extra cellular fluid can provide specificity in respect of angiogenesis and metastasis for different types of cancers. The data mining results are in conformity in respect of the status of the target variables concerned with intracellular and extra cellular compartments, since there is perfect matching of the target variables so far as misclassification (interpretation) is concerned in the present data mining.

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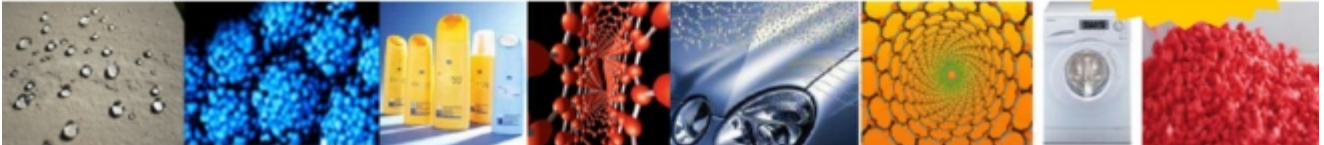
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*Sensors & Transducers Journal* (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In addition, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc.

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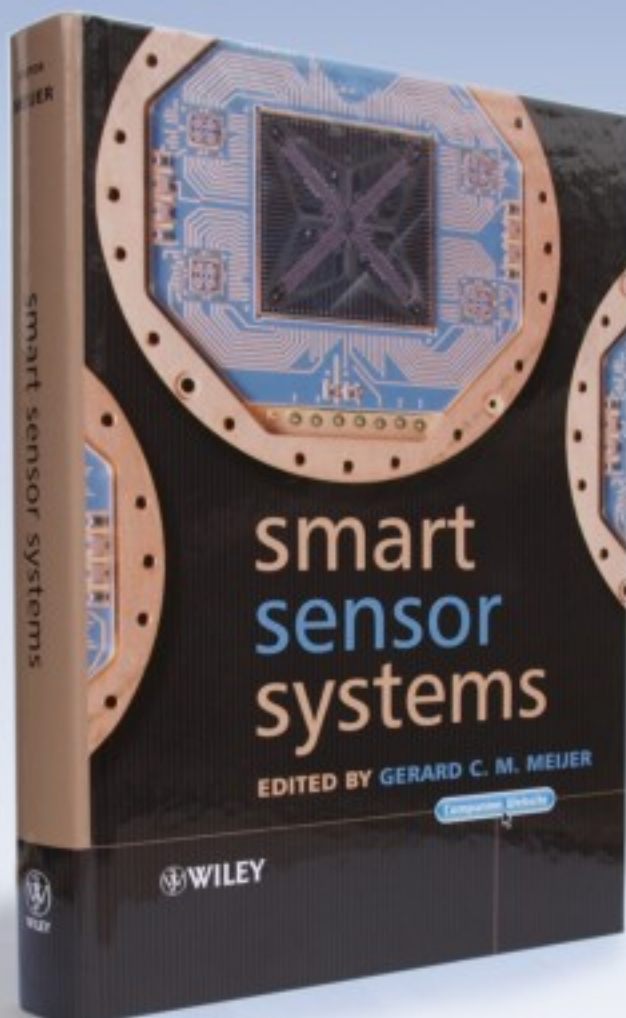
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