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Two Dimensional Finite Difference Time Domain Tool for Cancer Detection on Scilab

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Abstract— Cancer is the world's most proliferating and dangerous disease. Due to lack of proper knowledge of cancer, it is spreading among the people and a large number of people are dying from cancers such as lung, blood, breast, palm, liver, stomach, colorectal, prostate, bladder, pancreatic cancer etc. There were an estimated 14.1 million cancer cases around the world in 2012 and out of these 7.4 million and 6.7 million cases were in men and women respectively [21,22,23]. Cancer cells continue to increase new abnormal cells, many cellular changes have been reported to be associated with malignant process till date. For cancer detection a versatile method such as finite difference time domain is very frequently used in this era. In this paper we propose a two-dimensional finite difference time domain (FDTD) numerical simulation technique using Scilab, for early detection of cancer tissue, early phase can provide more treatment options, less invasive surgery and increases the survival rate.

Keywords— Finite Difference Time domain (FDTD), Cancer detection, Ultra wide Band, Scilab

I. Introduction

Human body produces new cells according to requirement. There is group of some cells that grow uncontrollably and develop. These cells are called cancer cells. These cells are two types in which the first benign tumor. Which is called non cancerous. And second malignant tumor is called cancerous. The edge of the benign tumor cells is very slow, It does not spread. Malignant tumor cells grow rapidly and also destroy common tissues near them. They spread thought out the body. The word cancer is used when a malignant tumor occurred. Which begins to affect the human body with its unlimited edge to and to send cancer cells to human tissues. Not all tumors are cancerous. The abnormal increase of liver cancer or liver cells, tissues structure in the liver tissue are called hepatic cellular carcinoma [21-23].

People dying a lot of cancerous such as lung cancer, blood cancer, breast cancer, palm cancer, stomach, colorectal, prostate, bladder, pancreatic etc. There were an estimated 14.1 million cancer cases around the world in 2012, of these 7.4 and 6.7 million cases founded in the men and women respectably. Some individual figure for men and women here 13.0 % in lung cancer, 11.9 % in breast cancer, 9.7 % in colorectal cancer, 7.9 % in prostate cancer, 6.8 % in stomach cancer and 5.6 % in liver cancer etc[23]. In India according to India Council of Medical Research (ICMR) said, in 2016 the number of new cancer cases is expected to be around 14.5 hundred thousand in figure is likely to reach nearly17.3 hundred thousand new cases in 2020. Cancer tissues also revealed that is 12.5 percent patients come for treatment in early stages of the disease. Over 7.36 hundred thousand people to succumb to cancer in 2016. In 2017, an estimated 2,55,180 new cases of invasive breast cancer are expected to be diagnosed in men and women, along with new cases of non-invasive breast cancer. About 40,610 women are expected to die in 2017 from breast cancer, though there has been decrease in death rate since 1989 because of increased awareness, early detection through screening and treatments advancements [20,21,23,24].

To get the diagnosis of cancer, many studies have been carried out to find out, low cost, lossless biological tissue imaging technique in medical imaging. It is still a tough task to reckoning and examines cancer. Now a day, a lot of methods that are commonly used for cancer diagnose, X-ray, computerized tomography (CT), Magnetic resonance Imaging (MRI), Ultrasonic Imaging (UI) and Position Emission Tomography (PET).

II. The FDTD Method

Finite Difference Time Domain method (FDTD) is nowadays one of the most democratic technique for the solution of electromagnetic problems. It has been easily and simply applied to an extremely wide variety of complications, such as scattering from metal objects, dielectrics, antennas, micro strip circuits, and electromagnetic soaking up in the mortal body exposed to radiation. The main reason of the victory of the FDTD technique occupy in the fact that the technique itself is really very simple.

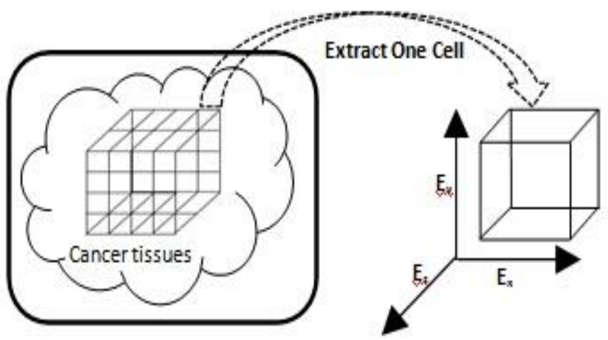


Figure.1 Basic Yee's cell.
(Electric field vectors have been shown aligned with the Edges of the cell and megnatic field vectors are taken normal at the centre of faces of the cell)

Figure 1 illustrates the position of electric and magnetic field components about a unit cell of FDTD grid in cartesian co-ordinates. Each magnetic field vector component is surrounded by for circulating electric field vector components and vice versa. As expressed, FDTD [1,2,3,20] is a straight solution of Maxwell's time-dependent curl equations. It's second-order accurate central difference approximations for the space and time derivatives of electric and magnetic sector straightforward to the respective differential operators of the curl equations and own simplicity. We can used FDTD method in these structures to be modelled has an extremely complex surface shape and internal structure, in its most straightforward and popular form, was mostly electromagnetic scattering problem solved by Finite Difference Time domain (FDTD) method because it can be inhomogeneous arbitrary shape object. It is a time dependent based numeral technique for solving Maxwell's equations. The Maxwell's equations are discretized in time and shape. In practical terms, finite differential time domain simulation involves the dissection of spatial domain as well as volatile domains. It's achieved by mapping volume of interest onto orthogonal or rectangular grid where the unknown field parts are placed in apiece cell. Maxwell's curl equations using central finite differences in both time and space, or FDTD grid is framed by rectangular boxes called Yee cells Grid box edge is an electric field location and grid face is a magnetic field location. Rectangular grid is opted since making computing for each grid is extremely fast and allows accurate approximations to the real geometry forcible. FDTD method is a time stride processes, inputs are time tried analog signals and computing the electric and magnetic field at each step time, fields are propagated throughout the framework. The domain of interest is break into a lattice of cubes and the electric field (E) at the centers of each of the faces is related to the magnetic field (H) of the just pervious half step of time. In the same way, a similar grid is formed, with the cubes being a half pitch off in time and space, but such time changing the magnetic field (H) using the electric field (E) of the exact previous half time step. Using the two meshes substitute, and beginning from time t=0, we can step forward in time, utilize any inflammation by setting certain values with in the field at each time step. Because of the artificial boundaries introduced in the application of the method, non-physical reflections of the electromagnetic signals incline to occur. There are a lot of number of methods for reducing cutting down from the applied boundary of the fields of interest. In this work the simplest methods were applied, that of a first order boundary condition [4,7,8,9]. The materials involve to be specified throughout the utilized domain. In general, the material will be either metal, dielectrics, free-space (air), and can be another material to be used, as long as the characteristic of permeability, permittivity, and conductivity can be specified. [5,6,7] Once the environment of computing domain and the lattice material are demonstrated, the excitation or source is specified. The source can be occurrence plane wave, a current on a wire, or a potential difference. Since the electric(E) and magnetic (H) fields are find out directly, the output of the simulation environment is usually H or E sector at a point or a series of points within the computational domain, or the E of H field at certain points, viewed with respect to time [5,7,15].

Differential time dependent equations are given by,

$$\varepsilon \frac{\partial \vec{E}}{\partial x} = \nabla \times \vec{H} \tag{1}$$

$$\mu \frac{\partial \vec{H}}{\partial x} = -\nabla \times \vec{E} \tag{2}$$

Where H is the magnetic field, E is the electric field, μ is the magnetic permeability, ε is the electric permittivity. FDTD simulations to developing is main aim of H and E fields are unknown and moreover other quantities are given at every in space point. The equations symbolize 6 partial differential equations; there for example the derivative of the x, y, and z component of the electric field E with respect to time is given by Equation (3) and Equation (4) in following,

$$\varepsilon\frac{\partial\vec{E}}{\partial x} = \nabla\times\vec{H} \Rightarrow \begin{cases} \varepsilon_x\dfrac{\partial E_x}{\partial t} = \dfrac{\partial H_z}{\partial y} - \dfrac{\partial H_y}{\partial z} \\ \varepsilon_y\dfrac{\partial E_y}{\partial t} = \dfrac{\partial H_x}{\partial z} - \dfrac{\partial H_z}{\partial x} \\ \varepsilon_z\dfrac{\partial E_z}{\partial t} = \dfrac{\partial H_y}{\partial x} - \dfrac{\partial H_x}{\partial y} \end{cases} \quad (3)$$

$$\mu\frac{\partial\vec{H}}{\partial x} = -\nabla\times\vec{E} \Rightarrow \begin{cases} \mu_x\dfrac{\partial H_x}{\partial t} = \dfrac{\partial E_y}{\partial z} - \dfrac{\partial E_z}{\partial y} \\ \mu_y\dfrac{\partial H_y}{\partial t} = \dfrac{\partial E_z}{\partial x} - \dfrac{\partial E_x}{\partial z} \\ \mu_z\dfrac{\partial H_z}{\partial t} = \dfrac{\partial E_x}{\partial y} - \dfrac{\partial E_y}{\partial x} \end{cases} \quad (4)$$

As expressed, FDTD [1,7,9,10,15,16,20] is a direct solution of Maxwell's time dependent curl equations. Now we are taken 1D so neglect magnetic and electric losses, assume simple and take free space. With this, Linear polarized wave along x-axis exciting an electric field which has E_x only (E_y= $E_y = 0$) propagation along z-axis no variation in the x-y plane, i.e.

$$E/E_x = E/E_y = 0.$$

Maxwell's Equations are simplifying

$$\frac{\partial E_x}{\partial t} = 0 \qquad \frac{\partial H_x}{\partial t} = 0 \quad (5)$$

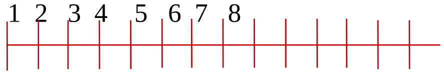
$$\frac{\partial E_y}{\partial t} = -\frac{1}{\varepsilon}\frac{\partial H_z}{\partial x} \qquad \frac{\partial H_y}{\partial t} = -\frac{1}{\mu}\frac{\partial E_z}{\partial x} \quad (6)$$

$$\frac{\partial E_z}{\partial t} = -\frac{1}{\varepsilon}\frac{\partial H_y}{\partial x} \qquad \frac{\partial H_z}{\partial t} = -\frac{1}{\mu}\frac{\partial E_y}{\partial x} \quad (7)$$

And reduce to 2 equations for 2-D FDTD want to solve these equations at different locations and time in solution space. For this, discretize both in time and space.

Space discretization size Δz

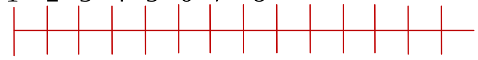
Running index k 1 2 3 4 5 6 7 8



Discretization in space

Time discretization size Δt

Running index n 1 2 3 4 5 6 7 8



Discretization in time

From the 3rd equation:

$$\frac{E_x^{n+\frac{1}{2}}(k) - E_x^{n-\frac{1}{2}}(k)}{\Delta t} = \frac{1}{\varepsilon_0}\frac{H_y^n\left(k+\frac{1}{2}\right) - H_y^n\left(k-\frac{1}{2}\right)}{\Delta x} \quad (8)$$

From the 4th equation:

$$\frac{H_y^{n+1}\left(k+\frac{1}{2}\right) - H_y^n\left(k+\frac{1}{2}\right)}{\Delta t} = \frac{1}{\mu_0}\frac{E_x^{n+\frac{1}{2}}(k+1) - E_x^{n+\frac{1}{2}}(k)}{\Delta x} \quad (9)$$

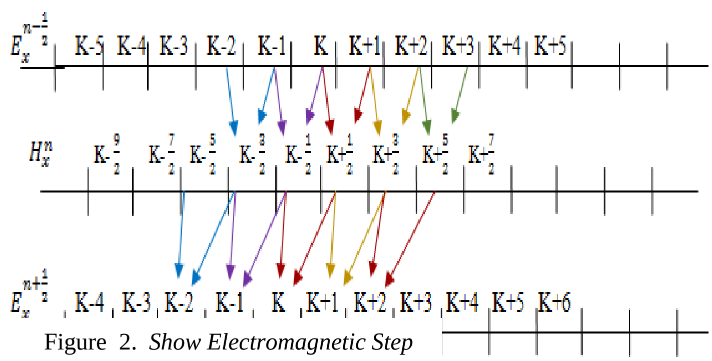


Figure 2. *Show Electromagnetic Step*

In this equation increment all the time and space steps by ½ which can be repeatedly updated in loop and obtain values of $E_x(k, n+\frac{1}{2})$ and $H_y(k+\frac{1}{2}, n+1)$ following Figure 2.

Some limitation of maximum time step, Electromagnetic wave cannot allow moving more than a free cell during a time step. Also, distance moved by EM wave over the time interval *t* will be more than *z* EM wave will leave out next node or cell and FDTD cell not casually interconnected.

From equations 8 and 9, we can write computer equations following

$$H_y[\mathrm{k}] = H_y[\mathrm{k}] + 0.5 * (E_x[\mathrm{k}] - E_x[\mathrm{k}+1]) \quad (10)$$

$$E_x[k] = E_x[k] + C_b[k] * (H_y[k-1] - H_y[k]) \quad (11)$$

Where $C_b = \frac{0.5}{epsilon}$ over those of k that specify the dielectric material.

A. Fdtd Stability

EM wave scattering in light smoothly and fast than free space. For this we well know Courant Condition [1,6,7,15,16] Like

$$\Delta t < \frac{1}{C_0\sqrt{\frac{1}{(\Delta x)^2} + \frac{1}{(\Delta y)^2}\frac{1}{(\Delta z)^2}}}$$

And solution for this $\Delta t = \frac{1}{\sqrt{n}C_0}$ where n is dimensional. And for a one cell, minimum time required time

$$\Delta t = \frac{\Delta x}{C_0}$$

B. Majoring Cell Size

Selecting the cell size to be used in an FDTD formula is similar to any approximation procedure, the number of points wavelengths is portaged on lot of factors. However, an ample rule of thumb is 10 points per wavelength. Knowledge has shown this to be adequate, with inaccuracies appearing earliest possible to sampling drops underneath this rate.

Naturally, we must use a worst-case scenario, suppose we are running simulations with 400 MHz's. In free space, EM energy will propagate at the wavelength

$$\lambda_0 = \frac{C_0}{400} MHZ$$
$$= \frac{3*10^8 m/s}{4*10^8 s^{-2}}$$
$$= 0.75 \text{ m}$$

if chose free space, $\Delta x = \frac{\lambda_0}{10}$ putting the value of λ_0 from equation,

$$\lambda_0 = \frac{\lambda_0}{10} = \frac{.75}{10} = 7.5\, m.$$

Sometime, simulating EM scattering in biological tissues [13,14,15,16,20], for muscle instance, has a relative dielectric constant of about 50 at 400 MHz, so

$$\lambda_0 = \frac{C_0 * \sqrt{50}\ m/s}{4*10^8\ s^{-2}}$$
$$=10.6 \text{ cm}$$

So we would approximate select a cell size of 1 cm.

III. Simulation And Discussion

Matlab is an interpreted language with the permission to perform mathematical calculations, and visualizes the results without the need of rarified and time-consuming programming. Matlab expensive and off-source. Scilab is open source compared to Matlab. uses some of the state of the art packages like ODEPACK and DASSL, which can not be available in Matlab. As a result, Scilab may actually be better than the matlab at some point. So here I am very happy to use Scilab, compared to Matlab. Figure 2 shows the simulation of FDTD with Scilab, which I have been given below.

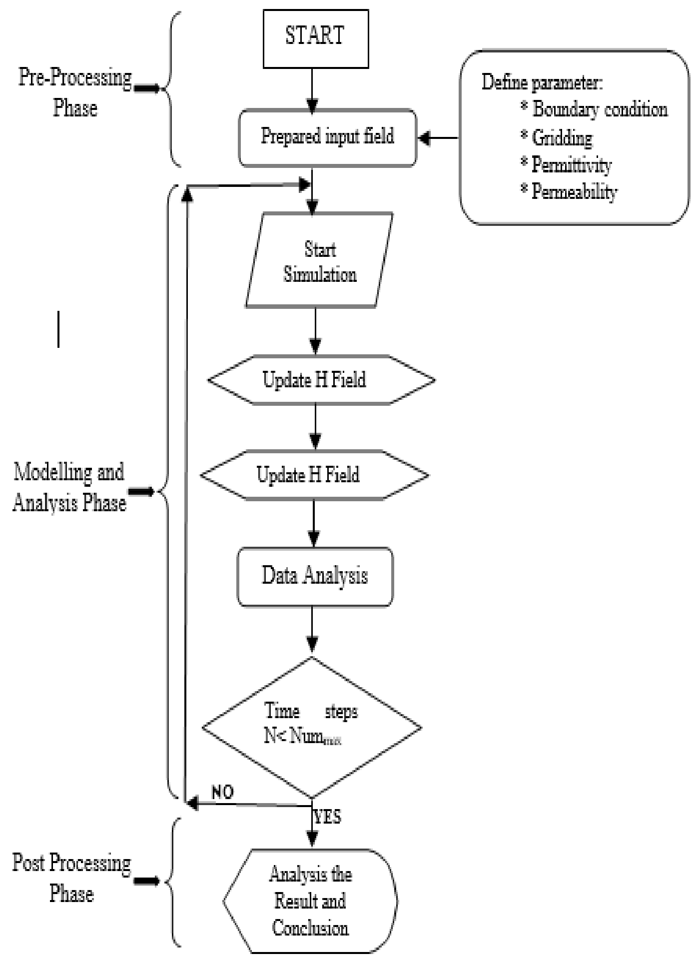


Figure 3. Diagram for FDTD simulation with Scilab

simulation environment with a dielectric medium having a relative dielectric constant of 4.

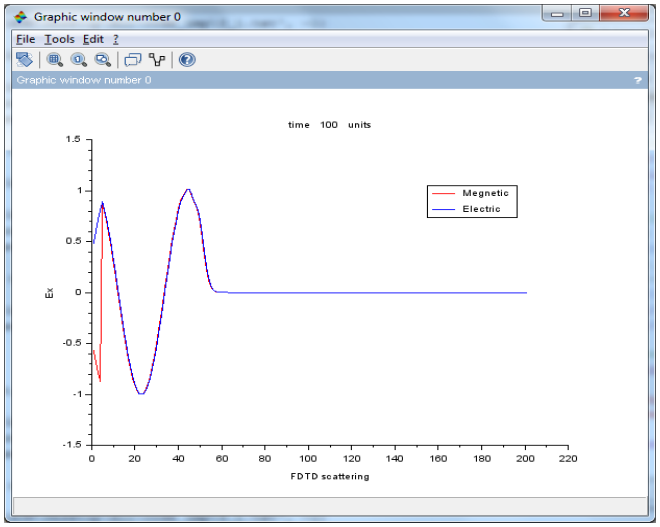


Figure 4. FDTD simulation environment for dielectric constant 4 with time step 100

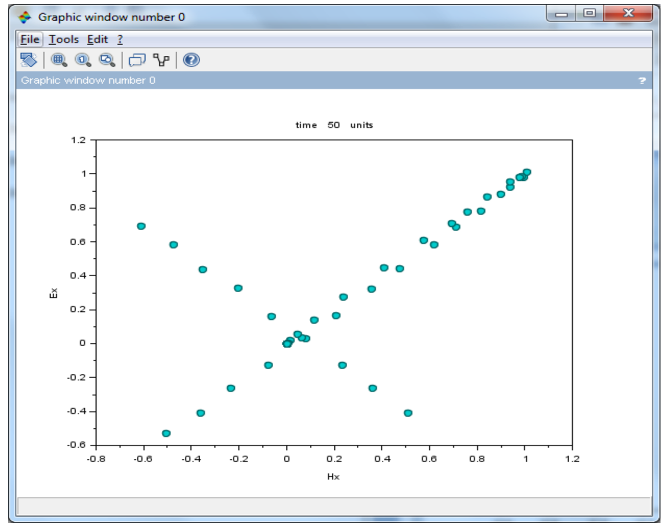


Figure 6. FDTD simulation in free space with cell at 5

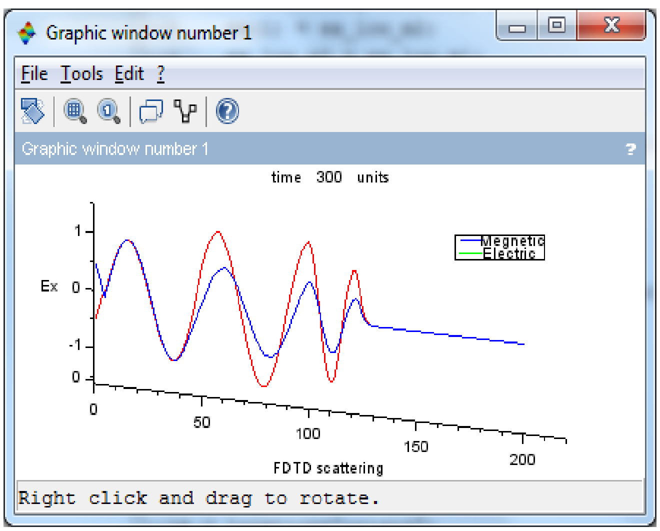


Figure 5. FDTD simulation with dielectric constant 4 with time step 300

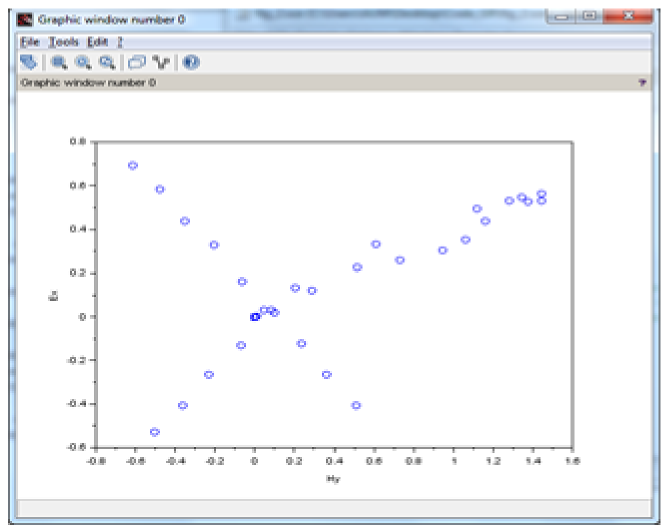


Figure 7. FDTD simulation with cell at 5

After observation for one portion of the pulse propagates into the medium at 10 positions and the other is reflected, in keeping with basic EM scattering in which I have been mention below figure 6 and 7.

Two Dimension simulations have pointed the possibility of distinguishing between benign and malignant tumors (no matter of the dielectric properties of benign tumors) by tapping the morphology-dependent spectral and polarization characteristics of their FDTD simulation in Scilab**.** We are currently taking the FDTD simulation on a large scale in research.

IV. CONCLUSION

After the study of several papers, early cancer tissues have been shown in the research by 2D FDTD program. By detecting the symptoms of the fatal disease like cancer, early treatment becomes very easy. Although the information of the patient can play a very important role, to make the cancer diagnosis process successful and the patient can be fortunate in achieving the hope of living his full life. Yet at the same time, some progress has been achieved, electronic equipment needs to be developed to get the symptoms of cancer early or to make better. In addition to this presentation, the flexibility and simplicity of the FDTD trades as well. With the initial results of cancer being excitement, more research is required to further expose the image of cancer. And along with the accuracy, there is a need to develop strict measures for further improvement.

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