Effect of Radio Waves on the Human Brain Cells using CA

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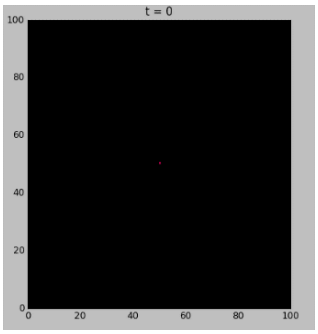
***Abstract*--The model uses Cellular Automata (CA) to represent the effect of radio waves emitted during the use of cell phones on its users.**

By the study of different subjects (reference from research papers; refer to reference section) it was observed that the use of cell phones for the first 30 minutes of the call duration is harmless, however, the extended use of cell phone emits high frequency electro-magnetic fields (EMF), that may be absorbed by certain brain cells.

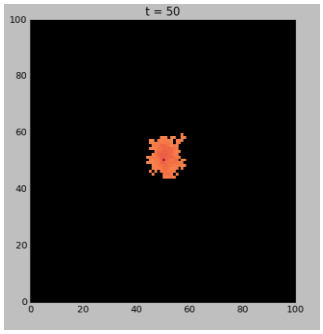
By using CA, the effect of radio waves on human brain cells is simulated with respect to time.

For the first 30 minutes (for the ease of simulation being represented by 30 steps; each step being considered as one minute), the brain cells remain unharmed, however, as time elapses beyond 30 minutes, the damage to the cell is initiated, which spreads out to multiple cells depending on the time duration of continuous usage.

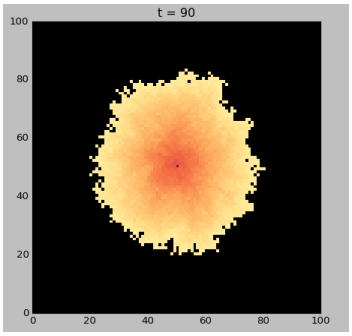
The figures below show different outputs of the model:



t=0



t=50



t = 90

I. INTRODUCTION

The number of cell phone users has increased rapidly. As of December 2014, there were more than 327.5 million cell phone subscribers in the United States, per the Cellular Telecommunications and Internet Association. This is a nearly threefold increase from the 110 million users in 2000. Globally, the International Telecommunications Union estimate the number of subscriptions to be 5 billion. [1] [2]

Over time, the number of cell phone calls per day, the length of each call, and the amount of time people use cell phones have increased.

Problems associated with cell phone use:

Cellular mobile phones (GSM, Global System for Mobile Communication) emit high frequency electro-magnetic fields (EMF). The proximity of a mobile phone to the user's head leads to the absorption of a part of the energy in the head and the brain. Conflicting effects of EMF have been reported in the electroencephalogram (EEG). Some studies have reported that exposure to EMF around 900 MHz have had effects on the EEG. [3]

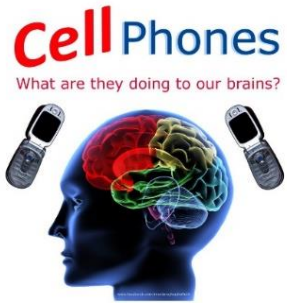
Fewer bars on the display panel of the cell phone indicate a weaker signal. A weaker signal means the cell phone will generate more power to maintain the connection. In fact, for each bar lost due to poor signal strength the cell phone will increase its power by 1000% to maintain the connection.

More power means greater exposure to the radiation for the user.

Damage from the cell phone comes from two sources. The first damaging source occurs from the near-field plume of radiation generated by the cell phone's antenna. This plume of radiation extends out at six or seven inches from the antenna in all directions. The near-field plume has been studied most extensively and contains the most intense energy. It can penetrate deep into the biological tissue. This radiation is absorbed when the cell phone is held near the body.

The second form of damage comes from a radio wave called the Information-Carrying Radio Wave, or ICRW. The cell phone signal is made up of two parts. The first part of the signal vibrates at 800 to 2200 megahertz. This wave is moving much too fast for the body to recognize and, as far as we can tell, is not causing any harm.

However, when a person speaks or sends a text message the information is packeted onto the first radio wave. This creates a second wave or signal which is called the information-carrying radio wave, or ICRW. It vibrates at a frequency down in the hertz range. In this range the ICRW is recognized by the body and it is this wave that is causing damage. [7]



II. EXPLANATION OF THE SYSTEM

Cellular Automata (CA) is used in the model to simulate the effect of cellular waves on human brain. [6]

What is CA?

CA is a discrete model studied in computability theory, mathematics, physics, complexity science, theoretical biology and microstructure modeling. Cellular automata are also called cellular spaces, tessellation automata, homogeneous structures, cellular structures, tessellation structures, and iterative arrays.

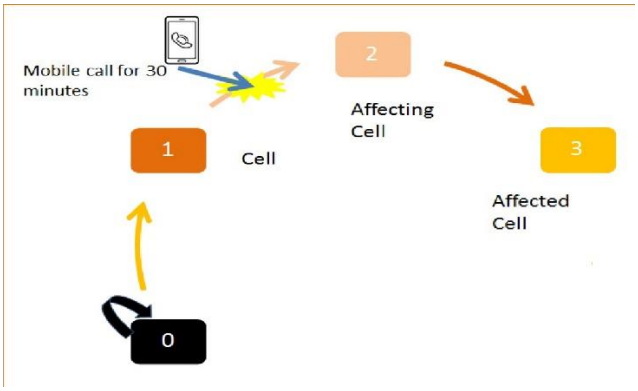
A cellular automaton consists of a regular grid of *cells*, each in one of a finite number of states, such as *on* and *off* (in contrast to a coupled map lattice). The grid can be in any finite number of dimensions. For each cell, a set of cells called its *neighborhood* is defined relative to the specified cell. An initial state (time $t = 0$) is selected by assigning a state for each cell. A new *generation* is created (advancing t by 1), according to some fixed *rule* (generally, a mathematical function) that determines the new state of each cell in terms of the current state of the cell and the states of the cells in its neighborhood. Typically, the rule for updating the state of cells is the same for each cell and does not change over time, and is applied to the whole grid simultaneously, though exceptions are known, such as the stochastic cellular automaton and asynchronous cellular automaton.

Cellular automata (CA) are a set of such automata arranged along a regular spatial grid, whose states are simultaneously updated by a uniformly applied state-transition function that refers to the states of their neighbors.

State set { □, ■ }[6]

III. EXPLANATION OF THE MODEL & ITS ASSUMPTIONS

The model constructed uses Cellular Automata (CA) to represent the effect of waves emitted using cell phones on cellular users. The model is as follows:



It is assumed (see assumptions below) that the use of a cell phone for the first 30 minutes of call duration is harmless, however, the extended use of cell phone emits high frequency electro-magnetic fields (EMF), that may be absorbed by the certain brain cells. [5]

By using CA, the effect of cellular waves on human brain cells is simulated with respect to time.

For the first 30 minutes, the brain cells remain unharmed, however, as the time elapses beyond 30 minutes, the damage to the cell is initiated, which spreads out to multiple cells depending on the time of continuous usage.

Assumptions:

The following assumptions were made:

The X-Y plane represents the cells of a human brain.

Under normal conditions, the black cells represent the cells that are unaffected by the radio/cellular waves.

The colored cells (other than black) represent the cells that are effected by the radio/cellular waves.

There is no effect of radio/cellular waves on the user for the first 30 minutes of usage.

The cell in the center of the plane is assumed to be the first one to encounter the radio waves.

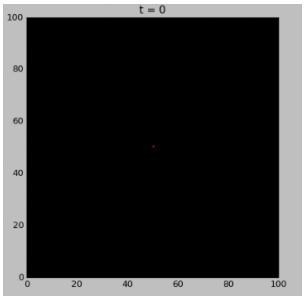
Two scenarios are considered while simulating the model that are: cell phone being used when receiving good network coverage and cell phone being used while receiving poor network coverage, we assume that the cellular waves reach out to greater number of brain cells when the cell is being used under poor network coverage as compared to good network coverage.

Explanation of Experiments:

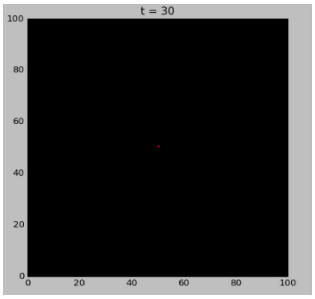
The assumption that the brain cells remain unaffected during first 30 minutes of the call holds true for the different scenarios of the model.

The above statement implies that the state of the model at time, t = 0 remains same as at t = 30.

The figure below shows the output at t=0 & t=30.



t = 0



t = 30

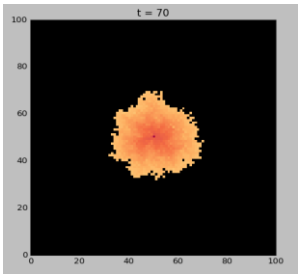
The different scenarios considered for the model are:

Use of cell phone under good network coverage.

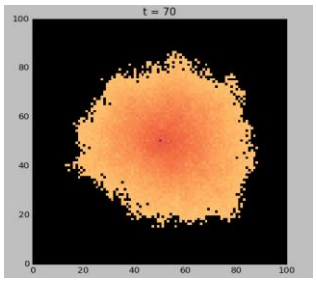
Use of cell phone under bad network coverage.

Let us now compare the outputs of these two scenarios.

Recall that we have assumed that the radio/cellular waves affect more of the brain cells if the phone is being used during poor network coverage as compared to use of cell phone during strong coverage. The outputs for these two scenarios are displayed in figure below for time t=70:



Good Reception (t = 70)



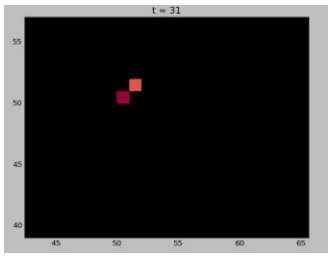
Bad Reception (t = 70)

The output for both the scenarios make it clear that the radio/cellular waves reach out to more of the cells when the cell is being used under poor coverage scenario as compared to good coverage scenario. The color shade of the spread depicts the proximity of the affected cell from the first point of contact (center). The darker the shade, the closer is the location of that

cell from the center, the lighter the shade becomes, the farther is the location of the affected cell from the center. Thus, how far the radio waves cover the region depending on different call durations can be observed.

(-1,-1)	(O,-1)	(+1,-1)
(-1,O)	(O,O)	(+1,O)
(-1,+1)	(O,+1)	(+1,+1)

Moore Neighborhood (I.C[4])



State Transition based on Moore Neighborhood

The model follows Moore Neighborhood. Moore Neighborhood is defined on a two-dimensional square lattice that is composed of a central cell and the eight cells which surround it. This is the first state where the first cell that has been affected can be seen which is (+1, -1) at time t=31.

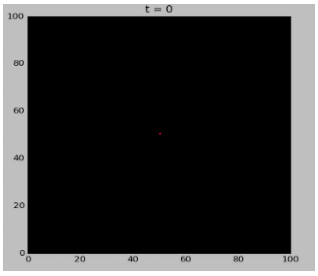
IV. RESULTS

The simulation is obtained considering different scenarios. The results for these different scenarios are shown below:

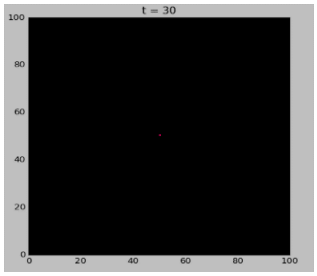
If the cell phone is getting good reception: The effect of radio/cellular waves on human brain is comparatively lower if the cell phone is receiving good or strong network coverage.

If the cell phone is receiving bad coverage: The effect of radio/cellular waves on human brain is comparatively higher if the cell phone is receiving bad or low network coverage. The following figures show the output for low/bad coverage at time, t = 50, t = 70 & t = 90.

For t = 0 & t = 30, the output will remain the same as shown before.

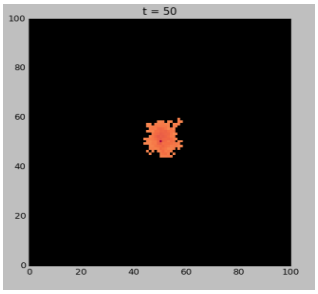


t = 0



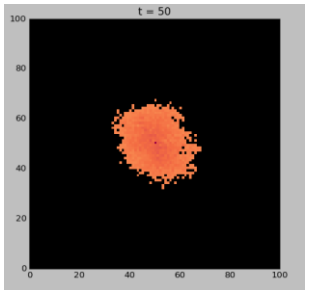
t = 30

(Shows no effect for both types of reception)



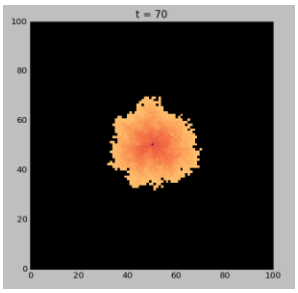
t = 50

(Good Reception)



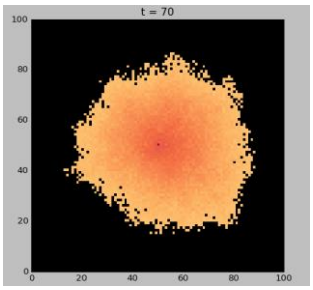
t = 50

(Bad Reception)



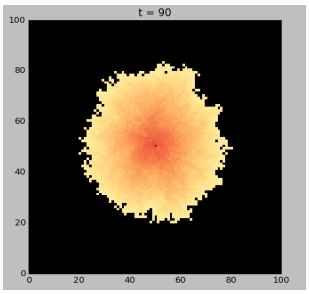
t = 70

(Good Reception)



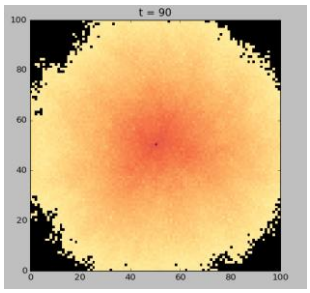
t = 70

(Bad Reception)



t = 90

(Good Reception)



t = 90

(Bad Reception)

V. CONCLUSION:

Cellular Automata (CA) can be used to successfully simulate the model of human brain depicting the effect of radio/cellular waves on brain cells.

The human cells remain unaffected for the first 30 minutes of cell phone use and hence the CA cells remain black in color, post 30 minutes the damage of brain cells is simulated using CA by a change in color of cells of the automata.

The model comes to a halt at 50,70 and 90 minutes, because of our call duration being set to the respective values.

The call durations mentioned can be adjusted depending upon different cases to be simulated.

REFERENCES:

[1] "IARC classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans" *(PDF)*. World Health Organization *press release N° 208 (Press release)*. International Agency for Research on Cancer. *31 May 2011. Retrieved 2 June 2011.*

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[3] "GSM phone signal analysis" (pdf)

[4] "Introduction to the Modeling and Analysis of Complex Systems". Hiroki Sayama, Binghamton University, SUNY

[5] https://en.wikipedia.org/wiki/Mobile_phone_radiation_and_healthrg/wiki/Mobile_phone_radiation_and_health.

[6] https://en.wikipedia.org/wiki/Cellular_automaton

[7] http://www.bibliotecapleyades.net/scalar_tech/esp_scalartech_cellphonesmicrowave17.htm