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Interactive Multi Resolution 2D Cellular Automata Model for Tsunami Wave Propagation

E Syed Mohamed [1]

[1]Department of Computer Science & Engineering,
B.S.Abdur Rahman Crescent Institute of Science and Technology,
Chennai -48, INDIA

E-mail: syedmohamed@crescent.education

Abstract. Cellular automata models are powerful tools that offer outstanding amenability, flexibility and deliver accurate qualitative and quantitative behaviour of the complex phenomena. In this paper, we develop a multi-resolution discrete event of cellular space propagation model with multiple spatial resolution cells for predicting the rate of tsunami wave spread. Specifically, as the tsunami wave spreads along with the cellular space, cells close to the wave front becomes high resolution (smaller size) and cells far from the wave front change to lower resolution (large size). The spatial resolution of the cells dynamically and adaptively develops as the wave proceeds. The conceptual framework for the investigation of the simulation and early results are presented. A methodology that is both appropriate and able to throw light on such natural clarity is the challenge for investigation and decision making in unknown or dynamical environments.

1. Introduction

In numerous areas of computer graphics as well as geometric modelling, the idea of multi-resolution modelling had been used effectively [1] [2]. The model contains many temporal resolutions or many spatial resolutions or several stages of abstractions which might mean a multi-resolution model [3]. Even though there are many “levels of abstraction”, this paper concerns models with multiple spatial resolutions. Using multiple spatial resolution cells,we proposed a cellular space model. By means of the simulation, the transformation of cells’ spatial resolutions occurs energetically and become accustomed. Tsunami wave simulation is the background of this paper. Precisely, cells near to the tsunami wave transform to greater resolution (lesser spatial dimension) and cells far away from the tsunami wave transform to lesser resolution (greater spatial dimension), as the tsunami wave distributes next to the cellular space. The outcomes that rest on the precise selection completed need to be measured with caution and the normal conditions of actual dynamic fault or tsunami generation have measured of these edge conditions echo with reliability [4]. Java is used to design the tsunami wave simulation model in this paper. The tsunami wave under eight topological and wave behaviour of Homogeneous rate can be found using this model.

Founded on the notion of a kinematic perpendicular movement of seawater that is analogous to the ocean’s lowermost movement throughout a submarine earthquake and the use of a non-dispersive long-wave model to simulate its physical change as it emits outer from the starting region is a usual method in forming the spread of tsunami [5]. Thus, in demonstrating the few early topographical conditions, tsunami wave cell *Resolution* (dimension of the tsunami wave cell) influences the accuracy.

Subsequently, tsunami wave span simulation results are influenced by that cell resolution. Real spatial conditions representation is further corrected with the elevated cell resolution i.e., lesser dimension cells. But, effective computer simulation can be tested by handling with greater cell resolutions usually. To signify only the dynamic model cells as a substitute of stacking all the cells, commencing the very start of a tsunami wave simulation, a Dynamic Structure Cellular Automata (DSCA) technique, was introduced [6]. Cells are reset in a small resolution and then altered to great resolution when fetching dynamic resolution is the different approach introduced in this paper. In favour of the multi-resolution modelling plus simulation of ecological systems, we recommend a modeling and simulation which can offer numerous benefits [1] [2]. When it is prepared to change conditions, through distinct event simulation, a model does calculations only. As models of dissimilar resolutions will mechanically be staged corresponding to the following event period, there is an inherent synchronization in this approach. To be dynamically appended and/or deleted through simulation, the variable structure modelling ability admits models at various resolutions.

The remaining of this paper is ordered as follows: Section 2, about the conceptual framework aimed at reinforcing vibrant multi-resolution cellular space modelling, and it's associated numerous design concerns. Section 3 talks about the upkeep of cells' condition, coupling cells at diverse resolutions, and resolution modification mechanism of multi-resolution cells framework in the proposed algorithm are some execution concerns. Section 4 introduces the proposed algorithm implementation. Results of experiments are discussed in Section 5. Section 6 accomplishes the paper with the conclusion.

2. Cellular Automata Formulation

Adopts one state from a (usually finite) set in composed of a lattice of cells is cellular automaton (CA). Suitable to their capability to distinct period and stages, CA has been established to be a prevailing technique. By multi-resolution cellular automata (CA) for 2D modelling, an alternate approach is presented in this paper. For the resident neighbourhood cells to simulate the tsunami wave expand modelling, the model manages ordered grid cells as a distinct space for the CA arrangement and uses generic rules. To lessen the computational phase of 2D Cellular multi-resolution modelling, numerous methodologies have been tried [1] [6] [7].

2.1 The neighbourhood operator and cell neighbourhoods

The neighbourhood operator is an application V which allows the construction of all the cell of neighbourhoods by the same method. It is formalized by a series of n translation vectors (the relative offsets of indexes) allowing it, as long as it is applied to a cell I, to make all the cells of its neighbourhood as represents in Figure1 and Figure 2.

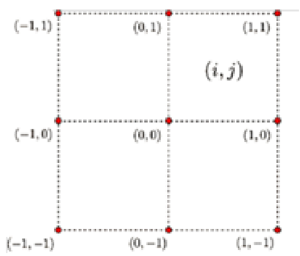


Figure1: The Moor's neighbourhood type

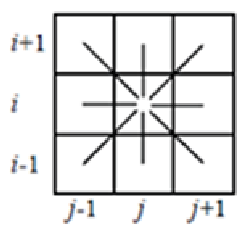


Figure 2: Eight directions of cells

V_8= ((-1, -1), (0, -1), (1, -1), (-1, 0), (1, 0), (-1, 1), (0, 1), (1, 1)), known as Moore's neighborhood enables access to the eight cells situated around the cell (i, j) of reference:

$V_8(i, j) = ((i\text{-}1, j\text{-}1), (i, j\text{-}1), (i+1, j\text{-}1), (i\text{-}1, j), (i+1, j), (i\text{-}1, j+1),(i, j+1), (i+1, j+1))$

We have choosen this mathematical model, which is very easy to implement in software and in hardware.For this, we divide a wave front in ocean into two dimensional arrays a way of identical square areas; each one of them stands for a cell of the 2D – CA. The states considered are 0 if the cell is not traversed or partially traversed and 1 if the cell is fully traversed. Further, the state of every cell evolves taking into account the states of eight nearest cells and its own state at a preceding time

2.2. The modelling and its idea of the automaton

The amplified geo computational time prerequisite for model standardization is one of the important glitches of growing spatial resolution in modelling. The mean geo computational time necessary to accomplish the model permissible for logging. From altering a 400m cell into four 200m cells was not more than quadruple the early time as might be anticipated, above doubled that the growth in the computational period, as the resolution was amplified from 400 to 200 meters are the outcomes shown by the model. Through the entire oceanic area, every cell comprises unchanging dimension cells and its extent by an unchanging wave pace. To simulate the wave span that is discovered in a normal wave, it was expected to span at eight ways through the ocean.

3 Proposed Algorithm

A grid frame is generated and a wave incidence is produced by epicentre through an algorithm for a grid comprising of m x n cells grounded on the matrix coordinates as an ocean expanse domain is introduced in this paper. A secondary wave span in blue colour displays tsunami wave spans portable and touches the target zone, and the ocean cell is signified by blue colour positioned at the centre. The cell where the prime tsunami wave spread happens is shown [8][9].

3.1. The multi-resolution mesh of ocean surface

Fundamentally unvarying grid or cell is operated by the earlier approaches of ocean surface mesh. Furthermore, we can increase the execution speed. The ordered mesh is suitable to make show list and vertex array by framework. Tiled Quad-tree has few benefits is the basis of the algorithm [1] [10] and displayed in Figure 3.

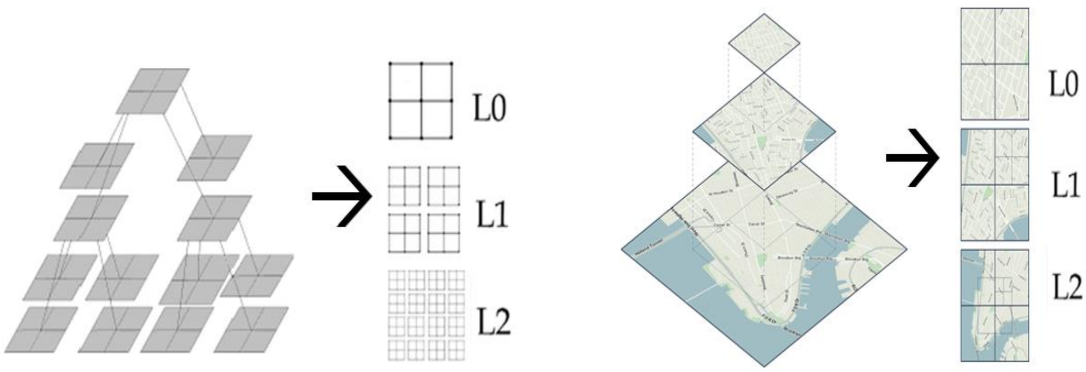


Figure3 & Figure 4. Tiled Quad-tree with different levels

In demonstrating and simulating the complexity of the multi-resolution procedures can offer an added level of information and comprehending of tsunami wave span shows capability by these novel models. Also, to define and measure influences of the future progress of the models have been exercised to expect and forecast future changes or tendencies of development.

3.2. Moore's automata

Cellular automata (CA) are discrete dynamical system formed by a set of identical objects called cells. These cells are endowed with a state, which changes at every discrete step of time according to a deterministic rule. One of the most important CA is two-dimensional finite CA. More precisely, a two-dimensional finite CA can be defined as a 4-uplet
A = (d, p, u, q), where C is the cellular space formed by a two- dimensional array of r x p identical objects called cells: $D = \{<i, j>, 0 \le i \le r-1, 0 \le j \le p-1\}$ such that each of them can assume a state. The state of each cell is an element of a finite or infinite state set, P; if P is finite and $|P| = k$ then S is taken to be $S_k = \{0,1,2,...,k-1\}$ .The state of the cell
< i , j > at time t is demoted by $a_{ij}^{(t)}$ .The set of indices of the 2D – CA is the ordered finite subset $U \subset S \cup S, |U| = M$, such that for every cell < i , j >, its neighborhood U_{ij} is the ordered sets of m cells given by
$\{<i+\alpha_1, j+\beta_1>, ..., <i+\alpha_M, j+\beta_M> : (\alpha_M, \beta_M) \in U\}$.
There are some classic types of neighborhoods, but in this work only the extended Moore neighborhood will be considered; that is, the neighborhood of every cell is given by the following set of Indies:
$U_M = \{(-1,-1), (-1,0), (0,0), (0,1), (1,-1), (1,0), (1,1), (-1,1), (0,-1)\}$ Graphically the extended Moore's neighborhood of a cell <i, j > can be seen as follows:

< i-1, j -1>	< i-1, j >	< i-1, j +1>
< i , j -1>	< i, j >	< i, j +1>
< i +1, j -1>	< i+1, j >	< i+1, j +1>

In this case, we can distinguish two types of neighbor cells of < i, j >: adjacent neighbor cells,
{< i-1, j >, < i, j +1> , < i+1, j > , < i, j -1> } ,which are given by U_M^{adj} ={(-1,0), (0,1), (1,0), (0,-1) }
and diagonal neighbor cells:
{ < i-1, j +1 > , < i+1, j +1> , < i+1, j - 1 > , < i-1, j -1> }
given by the set U_M^{diag} = {(-1,1), (1,1), (1,-1), (-1,-1) }.

The 2D – CA evolves deterministically in discrete time steps, changing the states of all cells according to a local transition function $f : P^9 \to P$. The updated state of the cell < i, j > depends on the nine variables of the local transition function, which are the previous states of the cells constituting its neighborhood, that is:

$$a_{i,j}^{(t+1)} = q\left(a_{i+\alpha_1, j+\beta_1}^{(t)}, ..., a_{i+\alpha_9, j+\beta_9}^{(t)}\right)$$

The matrix $D^{(t)} = \begin{pmatrix} a_{0,0}^{(t)} & \cdots & a_{0,p-1}^{(t)} \\ \vdots & \ddots & \vdots \\ a_{r-1,0}^{(t)} & \cdots & a_{r-1,p-1}^{(t)} \end{pmatrix}$ is called the configuration at time t of the 2D – CA, and $D^{(0)}$ is the initial configuration of the CA. Moreover the sequence $\{D^{(t)}\}_{0 \le t \le k}$ is called the evolution of order k of the 2D – CA.
As the number of cells of the 2D – CA is finite, boundary conditions must be considered in order to assure the well defined dynamics of the CA. One constant several boundary conditions are proved. But in this work, we will consider null boundary conditions:

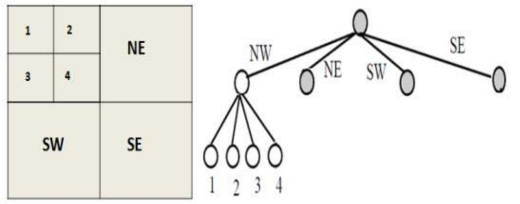
If $(i,j) \notin \{(u,v), 0 \le u \le r\text{-}1, 0 \le v \le p\text{-}1\}$, then $a_{ij}^{(t)} = 0$.A very important type of 2D – CA is linear 2D– CA, whose local transition function is as follows:

$$a_{ij}^{(t+1)} = \sum_{(\alpha,\beta)\in U_M} \mu_{\alpha\beta} a_{i+\alpha,j+\beta}^{(t)} \qquad (1)$$

where $\mu_{\alpha\beta} \in \mathbb{R}^+$ and $(\alpha,\beta) \in U_M$. Note that every CA endowed with a local transition function of the form given by (1), has an infinite state set: $P=[0,\infty)$ Nevertheless, if finite state sets must be considered, for example, $P=S_k$ then a discretization function must be used with the local transition function as follows:

$$a_{ij}^{(t+1)} = g\left(\sum_{(\alpha,\beta)\in U_M} \mu_{\alpha\beta} a_{i+\alpha,j+\beta}^{(t)}\right),$$

with $g:[0,\infty) \to S_K$. [19]



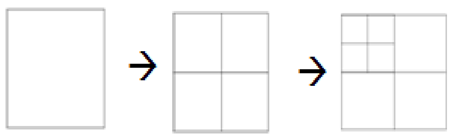
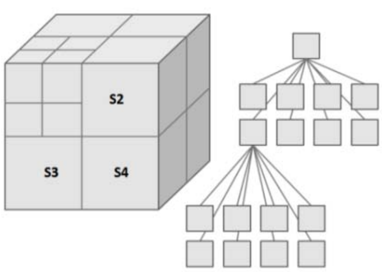


Figure 5. Transform quad-tree implementation in NW **Figure 6**. Steps of Transform quad-tree

Gravitation, wave speediness, wave path, underwater territory, and so on are several types of potencies define the drive of tsunami ocean surfs [11] [12] [13] [14]. However, for extensive sea surface automaton forward into added conditions *(t+1)* through the Mechanism: on the distinct point *t,* aimed at the automaton in the condition *s(t)* in the existing papers there is little information regarding approach of constructing the multi-resolution mesh

The contribution is to present a framework for real-time simulation and rendering of the large-scale ocean surface. Our framework divides the whole large-scale ocean surface into square blocks with different resolution and with those blocks created by a Tiled Quad-tree of the ocean surface.



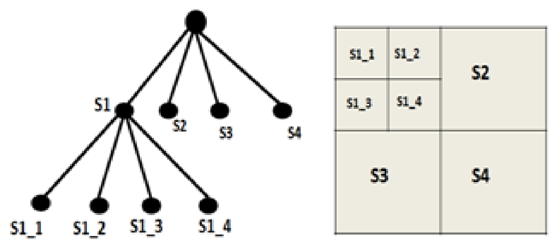


Figure 7. of 3D tiled quad-tree of ocean surface in MRCA
Figure 8. Stages of 2D tiled quad-tree of ocean surface in MRCA

Tree and physical representation of λ=(T,δ) with T={0000,0001,0010,0011,01,10,11}and δ={(0000,s1_1),(0001,s1_2),(0010,s1_3), (0011,s1_4)}.

Cellular automata (CA) and multi-resolution systems (MRS) are the preferred practices for applying great-resolution versions of spatial dynamics. We have broadened the idea of neighbourhood in fresh framework to comprise grid cells at diverse spatial resolutions in instruction to apply multi-resolution distinct simulations. The Quad-tree, form hierarchies grounded on spatial containment that are trees of customary multi-resolution structured geospatial data structures.

4. Experimental Framework

In ecological modelling and simulation, Multi-resolution models have been studied. Preferably, the model must be measured in the perspective of its specific spatial and temporal resolution by every procedure that we tried. For tsunami wave spread simulation, this paper emphases on cells' spatial resolution in a cellular space model. For "great traversed" zones, i.e., the cells around the tsunami wave range, to have small spatial resolution cells meant for "small traversed" zones, i.e., the cells distant from the tsunami wave range, this effort is to have great spatial resolution cells. The cells nearby the tsunami wave range are either traversing or stretching to traverse shortly, thus be worthy of more computation considerations, this is one of the cause.

From the tsunami wave range are either untraversed or previously traversed out, thus can be handled in short resolution by faraway cells. Great and short resolution cells will be dynamically augmented and amputated rendering to the place of tsunami wave range, as the tsunami wave range progresses throughout the simulation. Consequently, forming great resolution models (cells) from the very commencing is a great resolution simulation with this approach. Initially, tsunami wave spread cells (in rectangular form) at two spatial resolutions: a short resolution (with big cell size) and a great resolution (with petite cell size) considered by this paper. Through simulation, four great resolution cells will substitute a short resolution cell, if required. The main *cell* and the four fresh-founded great resolution cells are called as secondary *cells which* we referred them to a short resolution cell. The Produced cells from the same parent cell are mentioned to each other as *brother cells* by the four secondary cells.

4.1. Brief Review of a Multi-resolution tsunami wave Spread Model

In Figure 9, the key part of the cellular multi-resolution tsunami wave spread model built is abridged. A multi-resolution that comprises the depiction of the actual tsunami wave range in the computer and is split into tsunami wave spread cells of required size in the figure.

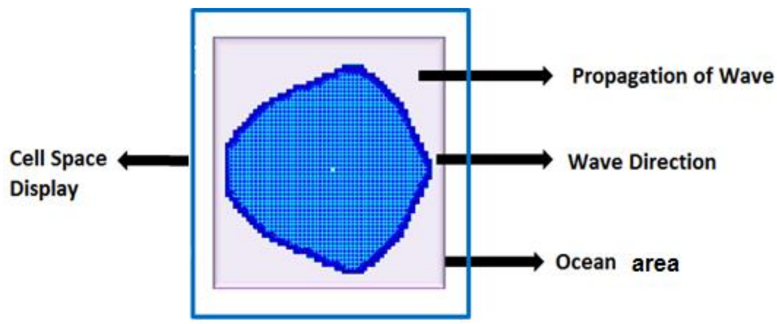


Figure 9. Summary of the multi-resolution cellular tsunami wave spread model

A multi-resolution model comprises the fundamental developing block of the tsunami wave spread. Cell Space is the tsunami wave spread cell. It is linked together via neighbour-to-neighbour couplings by the tsunami wave spread cells. In consistent ocean, the tsunami wave spread cell model supposes unvarying spread and topographical conditions. To calculate the highest advancing rate of tsunami wave spread and path in each tsunami wave spread cell, the new mathematical technique is utilized[11][9].

4.2. Cell State and Consistency Maintenance

A "replacement policy" to guarantee constant transition from the single cell's status to the multiple cells' statuses by dynamically substituting a single cell with numerous higher resolution cells (or vice versa) is required. As reviewed in [3], preserving such steadiness fits the consistency maintenance concern. Tsunami wave cells at diverse spatial resolutions are dealt with in this paper. For instance, when a short resolution cell *S* is swapped by four great resolution cells, *S1, S2, S3* plus *S4*, at time *t*, the four novel formed cells should be initialized to the states constant with the previous cell's state at time *t* as shown in Figure.10. When the four great resolution cells are swapped by a short resolution cell-like handling is necessary

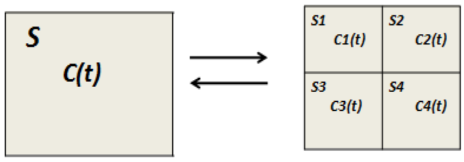


Figure 10. Consistency maintenance of cells' states

We have recognized the key characteristics of tsunami wave cells into four types to reinforce the constant transition of cells' conditions. For individual group, to confirm steady conversion of cells' states throughout resolution variation, we have discourse below how to dynamically initiate the state variables. *X_Cell_Dimension* and *yCell_Dimension*, which denote the *x* and *y* measurement of the cell are Cells' geometry features.

Four identical-sized great resolution cells will replace a short resolution cell in a square form in this paper. Thus, *x_Cell_Dimension* (and *y_Cell_Dimension*) is semi-value of the resultant short resolution cell's *x_Cell_Dimension* (and *y_Cell_Dimension*), when a great resolution cell is formed. When a short resolution cell is generated the reverse is correct. When a fresh cell (either great resolution or short resolution) is formed, its interactive state will be set to the similar interactive state as that of the previous cell(s). Cell's distinct interactive states are, for instance, *untraversed*, *traversing*, and *traversed* in general. These great resolution cells are set to *untraversed* as well once four *traversed* great resolution cells are swapped by a short resolution cell, and this short resolution cell is set to *traversed* as well when an *untraversed* short resolution cell is traded by four great resolution cells.

A transducer, Demonstrate modules, Epicenter tsunami wave cell, Wave flow model, and Tsunami wave Spreading cell Model are cell's eco-friendly characteristics. In general, the simulation models like GIS archives and weather report hubs, the values of these characteristics are acquired from outer resources [7]. Therefore, the values of its environmental characteristics can be got from those resources with mention of the "present" time, when a fresh cell is formed. Tsunami wave line strength, tsunami wave dispersion rapidity and path are cell's tsunami wave expanding characteristics. The standards of these characteristics are computed from tsunami wave expand models when a cell is traversing [16] [17] [18] [19]. To happen merely afore the cell is traversing or later the cell is entirely traversed out, we outline a cell's resolution change in this paper. So, when the cell is generated, a cell's tsunami wave expanding characteristics are not prepared

4.3. Coupling Cells at Different Resolutions

By way of couplings among cells' input/output ports, a cell act together with its bordering cells. Across eight output ports: *out_N, out_NE,out_E, out_SE, out_S, out_SW, out_W*, and *out_NW*, which denote eight tsunami wave expanding routes consistent to azimuth (degrees gaged clockwise from the northern side) of 0, 45, 90, 135, 180, 225, 270, and 315 degrees correspondingly, a cell influences its eight adjacent cells.

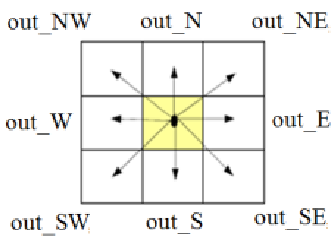


Figure 11. Moore's Neighboring cell in 2D Cellular automata with eight output ports.

Across eight input ports: *in_N, in_NE, in_E, in_SE, in_S, in_SW, in_W*, and *in_NW* a cell is influenced by its eight adjacent cells consequently. Couplings among this cell plus its adjacent cells can be simply founded on their relative locations if a cell and its adjacent cells are all in a similar resolution (either short or great resolution). A few departing couplings (represented by dashed markers) of *S1* and *S3,* and a fraction of a cellular space model with four short resolution cells: *S1*, *S2, S3, S4* is an instance as shown in Figure. 11(a).

Naturally, a cell's output port represents a particular tsunami wave and spreading direction is coupled to its neighbouring cells along that direction because all the four cells have the same resolution. *S2* is northern of *S4* for instance. Coupled to *S1's* output port *outN* by *S3's* input port *inN* accordingly to *S3*'s input port *inS, S1*'s output port *outN* is coupled, in the meantime. In a like way further couplings among cells can be founded.

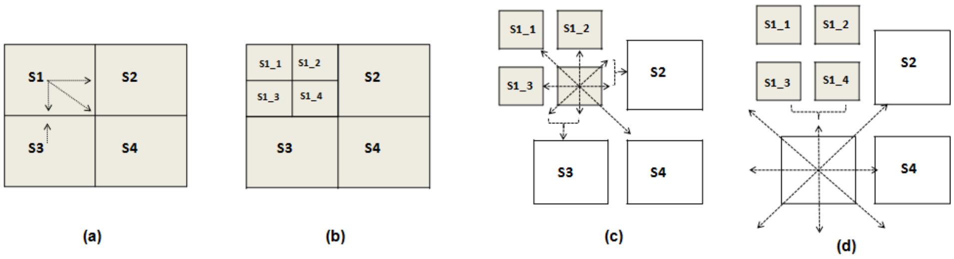


Figure 12 . Coupling between cells

When cells at diverse resolutions, adjacent to each other and operate jointly, the condition turn out to be further complex. Figure.12 (b) is swapped by four great resolution cells *S1_1, S1_2, S1_3*, and *S1_4* and the Figure.12 (b) displays a multi-resolution arrangement of the short resolution cell *S1*. The couplings among adjacent cells can be founded in a similar mode as explained above, for those cells that fit into a similar resolution in this method. But, coupling association is reliant on not merely the relative location of the two cells, nevertheless also the source/last stop cell's resolution, if two adjacent cells are in diverse resolutions.

For the model presented, Figure. 12(b), Figure.12(c) and Figure.12(d) portray the outward couplings of a great resolution cell *S1_3* and a short resolution cell *S3*, correspondingly to the explanation above. The great resolution cell's *together out_N* and *out_NE* (or *out_NW*, reliant on the position of the great resolution cell) ports will be coupled to the short resolution cell's *inS* port if a short resolution cell is northern of a great resolution cell in common. Together the two great resolution cells' *inN* ports by the short resolution cell's *outS* will be coupled in the meantime. Cell *S4_1*'s *outS* and *outSE* ports are coupled to cell *S3*'s *inN* port (here, not displayed in the figure, *S1_4*'s *outS* and *outSW* ports are too coupled to cell *S3*'s *inS* port) in Figure.8(c), as an example; together *S1_3* and *S1_4* as in Figure. 12(d), cell *S3*'s *outS* port is joined to the *inN* ports. If a short resolution is east (or south, or west) of a great resolution cell alike rubrics apply. Their couplings ensure the alike rubrics as those for lone resolution cells explained earlier, if the short resolution and great resolution cells' relative location is in a diagonal way, e.g., *S4* and *S1_4* in Figure.12(c).

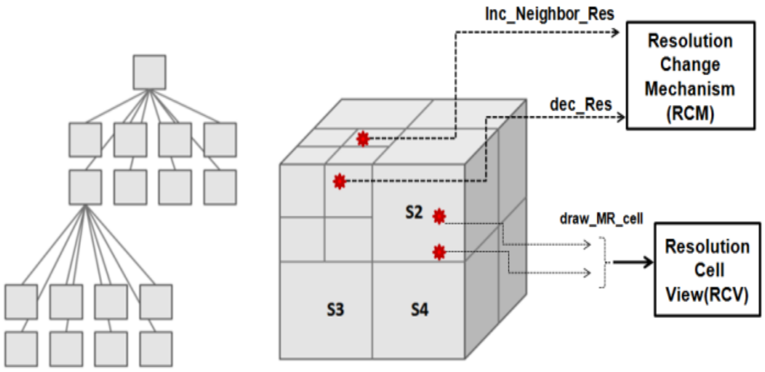


Figure 13.Resolution change mechanism (RCM)

Individual great resolution cell must distinguish its relative location, *i.e.*, highest-right, highest-left, base-right, base-left or in the space of its parent (short resolution) cell, to allow logical ways of dynamically adding cells' couplings throughout the simulation. To reinforce this, a tagging schema can be used. To decide a cell's resolution in addition to its precise location, this tagging schema, denoted by a cell's ID, would attain it comfortably. To asses a cell's adjacent cells and couplings among them grounded on their IDs, this ability is vital for the Resolution variation manager.

5. Implementation

5.1. Mechanism of Resolution Change

This part refers to the procedure of resolution variation, i.e., when, and in what way to conduct resolution variation, having conversed the constancy upholding of cells' statuses and the couplings among cells. Modifying resolution represented as green cell zone, and a resolution cell vision that shows the cell grid throughout simulation indicated as a red spot of cell part are the four main constituents implicated in resolution variation as displayed in figure 9. To reduce resolution for the cells that are either untraversed or previously traversed out, and the job of resolution variation to dynamically boost resolution aimed at the cells near to the tsunami wave range are stated earlier. Therefore, reducing resolution primarily means to reduce resolutions for those (great resolution) cells that are traversed out; untraversed cells are reset to short resolution in this effort. Transmitted out by the RCM and started by a cell as resolution varies. A cell transmits the RCM an "*inc_Neighbor_Res*" communication to appeal to intensify its neighbouring cells' resolution, as each and every time the cell begins to traverse (transfers into the *traversing* state) exclusively. A begin-to-traverse cell will quickly kindle its adjacent cells is the cause behind this. Therefore, adjacent cells are in great resolution by the tsunami wave extent grasps them when there is a sure rise in those adjacent cells' resolution. Afterwards obtaining the "*inc_Neighbor_Res*" appeal and raising their resolutions if required, the RCM will examine the related neighbouring cells. A cell transmits RCM a "*dec_Res*" communication to appeal to reduce its individual resolution. The RCM will test the behavioral conditions of the additional three *associate cells,* afterwards getting this appeal. The RCM will reduce their resolution by swapping them by a short resolution cell, simply as soon as the four associate cells are entirely traversed out. The RCM disregards the appeal else. Every cell is coupled to the RCM so as to bolster resolution variation illustrated above. Such couplings (represented through dashed arrows) aimed at single-cell as shown in Figure13.

5.2. Pseudocode for increasing resolution:

Pseudocode shows that after the four cells in the centre transit to the *traversing* state, the resolutions of their neighbouring cells are increased.

increaseNeighborResolution(myCell_ID) {

getNeighborCells(myCell_ID);

for (each neighbouring cell){

if (the cell is in low resolution) {

if (the cell is not in absorbing states){

create and initialize four new children cells;

add the four children cells;

remove the parent cell;

add couplings between cells and their neighbours;
add couplings with other models such as RCM, CellView;

}

}

}

}

By pursuing four-step jobs: *Produce fresh cells*, *Augment the fresh cells*, *Eliminate the previous cell*, *Augment couplings among the fresh cells and further cells,* utilizing the structure variation operations established in the JAVA environment, swapping a cell with numerous greater resolution cells can be achieved. Following are the pseudo-code of RCM for rising resolution and declining resolution with this ability.

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As in the pseudo-code for reducing resolution, *absorbing states* meaning the -behavioural states that will remain there endlessly, such as *untraversable*, *traversed* in the code. Cell_Resolution_View is liable for showing the multi-resolution cellular area along with the advancement of tsunami wave dispersal is the additional component presented in “declining resolution”.

To be capable to exhibit cells through many spatial dimensions, the Cell_ Resolution _View is constructed. As multi-resolution cells are added and/or removed dynamically, it reflects cells' resolution change in real-time for the time being. Every cell is joined to the Cell_ Resolution _View to favour the exhibition. For binary cells, Figure.11 exhibits such couplings. The ability to demonstrate several resolution cells and backing dynamical swapping of diverse resolution models are the key variations. The *resolution* Indicator stances for the indicator of the cell's resolution and individual cell, either in great resolution or in short resolution, has a distinctive ID *(x_coord, y_coord, resolution_Index)*, where *x_coord* and *y_coord* signify the cell's location in the double dimension cell space, in our execution.

5.3.Pseudocode for decreasing resolution:

decreaseResolution(myCell_ID) {

get the other three brother cells (myCell_ID);

if (all four cells are in the same absorbing state){

create a low-resolution cell;

initialize the cell to the current state;

add the cell;

remove the four high-resolution cells;

add couplings between the cell and its neighbours;

add couplings with other models such as RCM, CellView;

}

}

Cell's precise location and in sequence to effortlessly define a cell's resolution, a tagging schema is comprehended. Grounded on cell's comparative location and resolution this tagging schema allocates *resolution_Index* (an integer digit) with diverse values. Short resolution cell denotes to *resolution_Index* being 0 precisely. 1 means the top-right cell, 2 representing the top-left cell, 3 used for the bottom-right cell, and 4 meant for the bottom-left cell. are its values being 1 to 4 denotes to the four great resolution cells. In consequence, a cell's adjacent cells' resolutions plus locations, and the cell's resolution and location in the cell space can be established through this methodology. In Cell_ Resolution _View, which shows multi-resolution cells throughout simulation an alike tagging schema is used.

6. Experimental Results

By the advanced dynamic multi-resolution technique and simulation, initial findings were acquired. While the tsunami wave ranges progresses, two pictures of a simulation are demonstrated in figure 13. Through 30 x 30 cells altogether in short resolution begins the simulation. Once the cell (14, 8) is expanded, tsunami wave range begins. By 5 kph rapidity, the wave path is from south to north. 15.0 x 15.0 meters is the dimension of every cell. As signified by diverse colours, cells are set with diverse slopes. The cells preserve their short resolutions which are far away from the tsunami wave range.

The cells nearby the tsunami wave range dynamically intensify their resolutions, as the tsunami wave range travels as displayed in Figure. 14. Through swapping four great resolution cells by one short resolution cell, the cells that are previously traversed out (in the brown shade) reduce their resolutions in the meantime.

We completed the initial outcomes of three simulations by changing cells' resolutions whereas upholding all extra conditions alike, in order to quantitatively exhibit the advanced multi-resolution simulation. Simulation using all high-resolution cells (Figure. 14), simulation using dynamic resolution cells (Figure. 15), and simulations using all low-resolution cells (Figure.13) are the mentioned conditions. We study 20 x 20 cells including dimension 15.0 x 15.0 meters (40 x 40 cells including dimension 7.5 x 7.5 meters for the simulation by all great resolution cells) are all three simulations. Simulation period is identical for running all three experimentations.

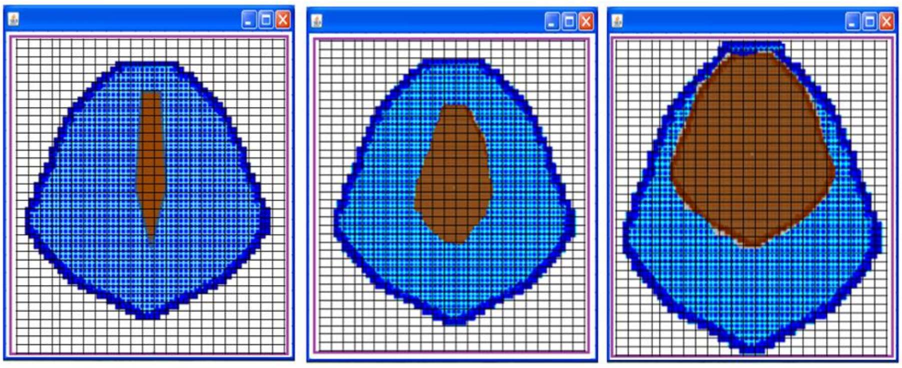

Figure 14 **Figure 15** **Figure 16**

Figure 14. Simulation using all low resolution cells

Figure 15. Simulation using all high resolution cells

Figure 16.Simulation dynamic resolution cells

Therefore, the results using entire great resolution cells and the vibrant resolution methodology are identical. The overall area (denoted by red plus black cells) influenced by the tsunami wave is (nearly) the identical as those from another two methods, the simulation employing entire short resolution cells as displayed in the figure.14. As denoted by the whole amount cells traversed out, it can be understood that the "*traversed out*" swiftness in the short resolution simulation is sluggish than that perceived in the further two simulations though.
The wave rapidity and path should influence the ocean wave range if there are certain weather conditions, if the uniform oceans with vertical wave movements, the topographic conditions need to be imitated in the dynamic wave range. The wave range needs to be of round shape in the early condition if the ocean is in homogeneous ocean. An algorithm using the Java Programs has been implemented for the computational and graphical representation of the wave spreads.

7. Conclusions

This paper introduces a multi-resolution cellular space model of tsunami wave simulation. Cells distant from the cellular space for a switch to short resolution (greater spatial dimension) dynamically plus cells near to the cellular front convert to greater resolution (lesser spatial dimension), as the tsunami wave ranges alongside the cellular space, by dynamic multi-resolution simulation. Certain experiment outcomes are portrayed and the conceptual framework of this effort is illustrated. In the uniform ocean zone, the developed dynamic multi-resolution simulation allows a great resolution simulation exclusive of creating great resolution models (cells) shown by the initial outcomes. A cell is in great resolution afore cell traversed assures by the "change ahead" scheme in the mechanism of resolution variation backs the correctness of this methodology. Build up algorithms to favor efficient simulation of great scale models for multi-resolution hexagonal cellular automata, employing this to larger scale snags, and to run different dynamic resolutions of GIS data are the building methods for future work of this research.

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