TSD Algorithm to Design CA Based Expert System for Pipelining to Stop Urban Flood

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Abstract

Flood is a frequent disaster disturbing the daily life and sometimes found deadly. Out of all kind of floods, urban flood is avoidable through quick exit of drainage. Urban flood starts water logging that can be eliminated by efficient pipeline structure. A dedicated drainage pipeline structure may facilitate better during urban flood. A Cellular Automata is a theoretical computer science tool used to solve complex problems as well as to design structures. In these days, applications of CA continuously increasing, out of which an application of designing a flood avoidance drainage mechanism using CA based structure presented in this paper. To generate knowledge for an expert system to design a flood free city in initial stage of development of a city this paper presents a structure for maximum way of exit. This structure including tanks connected at every corner to minimize the dependency on ground water and reuse the rainwater. In order to avoid flood, minimum size of tanks has been calculated by proposed Tank Size Descriptor (TSD) algorithm with the help of actual rainfall data. With the help of TSD algorithm any expert system of civil engineering will be able to suggest a design of a flood free city using hexagonal shapes within the cellular automata.

Keywords: Hexagonal cell, Cellular Automata (CA), Urban Flood, Optimization and Pipeline design.

1. Introduction

Since last few years, urban flood is a problem that is avoidable by installation of planned drainage mechanism in initial phase of developing a city. This paper presents a solution, using cellulyrly designed plain and drainage mechanism for a city. Rectangle based design is popular to develop a new city in India, but it can be an improved with the help of a cellular automata (CA) based design with other patterns than rectangle. In this regard, the way of exit to discharge logged water, rectangle and hexagon shapes in cellular automata examined here. This paper presents an analysis to find out impact of these shapes on way of exit and amount of discharge through a pipeline using comparisons. At the end, paper provides Tank Size Descriptor (TSD) algorithm useful to gain knowledge about the size of tank involved in the design for an expert system. These tanks are involved in pipelining to increase survivability of victims during an urban flood. For a real life application, A CA is a geographical structure made by a finite number of elements, called cells which are characterized by a number of properties (i.e. color, shape etc.) known as tuples. A CA is mathematical models, in which many properties can work together to make the change in position of a cell with the consideration of its impact on others. For a inundation modeling in a urban flood, cell updated with the water level in its neighborhood. These neighborhoods are referred as the Von Neumann and Moore neighborhoods. These types of neighborhoods are possible in any shape of cellular automata. Authors used Moore neighborhood in design to find out maximum routes for discharging logged water.

Claims:

Claim 1: Hexagonal CA based pipelining will be better to discharge the logged water. Unplanned urbanization without water management is the cause behind a water logging. A plan of urbanization is possible with a grid structure of hexagon than the rectangle, which is generally adopted in India. The Hexagonal grid structure is able to provide maximum way of exit for the discharged water after considering slope of plain for a flood free city.

Fig. 1(a): Rectangle

Fig. 1(b): Hexagon

Claim 2:

In proposed approach, a cellular automaton assumed to work in layers according to the slope of a geographic plain to ensure the movement of water downward. Sometimes, in high rainfall, a situation of flash flood may exist, so, to avoid the flash flood pools assumed to be installed in design; and size of pools will be affected by layers. These tank and pools will be responsible to provide delay in water movement as well as able to ensure the availability of water for reuse. These pools/ tanks will increase survivability of possible victims.
To check the both discussed claims, a methodology shown in figure 2, is to be performed in several steps as:
1. Finding out the grid design pattern of plain by maximum exit way to discharge maximum amount of water in minimum time.
2. Pipeline modeling for the optimal plain structure to discharge maximum amount of logged water in minimum duration.
3. Find out the impact of layers on tank size.

Let us consider the designs to test within a CA for plain and drainage piping mechanism as:

![Diagram showing the procedure to flood avoidance](image)

**Fig. 2:** Procedure to flood avoidance

In this paper, relative work of section 2 indicates various works done by researchers to maximum discharge by calculating rainfall or pipelining. In this, authors found people performed their effort on rehabilitation and maintenance of water supply system to avoid the mishapening due to water. Section 3 indicates How CA can be used to design a pipeline for better drainage mechanism. Section 4 says why we have selected hexagonal shape among all the shapes in our cellular automata, this section also shows our avoidance strategy using plain modeling. The motive of section 4 is to represent the importance of the grid type to avoid a flood or water logging, authors draws an attention towards hexagonal shape grids pattern to stop the urban flood and water logging. Section 5, discussed result found after comparing hexagonal cellular design with rectangular with the impact on layer on tank size using TSD algorithm. Section 6 presents conclusion after the analysis and discussion.

**2. Relative Research**

In rainy season, many Indian metro cities including Satna, Mumbai and Chennai suffer by urban flood or water logging. Few researchers worked to solve such kind of problems discussed below: S.croci et al [3] has been presented characteristics of URBFE model, they have described its ability to represent behavior of urban catchments by the result obtained on urban area. They have considered few cities in study including Cermenate, Saronno, Caronno Pertusella and Seregno with the help of physically distributed model based on hydrograph. They have considered rain as an input on the basis of curve of Depth-duration and Frequency (DDF) in their model.

Albert S. Chen et al [2] discussed modeling of sewer discharge by displacement of manhole during flood using 1D/2D SIPSON/P-DWave dual drainage simulation. In this model they coupled the 2D Parallel Diffusive Wave and the 1D SIPSON models as their dual-drainage model. They have considered flow condition of surface but not focused on design architecture perspective.

H. Mala et al. [7] discussed their model for distribution network of WimmeraMallee region of western Victoria, Australia, at there this project pronounced as “Wimmera-Mallee Domestic and Stock Supply System”. They have described the model with input and output modeling and control rules. It has model outputs including flow, pressure, quality, pump operation, valve operation and water storage operation.

Hwisu et al [12] proposed rehabilitation model for pipeline systems, in which they have used a GA for optimization. For estimation they have used pipe failure rate, system cost, renovation and replacement cost. Their work helps for model estimation.

MMA Sayeed Rushd [11] tried to calculate pressure loss that affects pressure in a pipeline which is an important factor for a water movement in pipeline.

**3. Cellular Design for Flood Avoidance**

Proposed flood avoidance strategy is based on Cellular Automata (CA) described by Neeraj et al [1] that is used to develop a flood free plain as well as drainage pipeline. A CA can be defined as:

\[ CA(C) = \{ U, U_0, U_b, \delta, S, k \} \]  

Where,  
- \( U \) = Set of cells;  
- \( U_0 \) = Cell at zeroth level;  
- \( U_b \) = Cell at final height;  
- \( \delta \) = Set of parameters to change the position of cell  
- \( S \) = Transition rules to change one state to another  
- \( k \) = Number of cells considered in CA.

\[ U_{a,b} = \text{Flow sending from one to other cell i.e. cell a to cell b.} \]

**3.1. Properties of Cellular Automata**

In case of flood modeling CA follows rule of totalistic where the amount of discharge must be going to the neighboring cell, to sum up their flood amount if there is a rainfall. These rules are applicable for every type of grid used.

\[ \text{Outflow fluxes direction from the central cell having} \]

\[ U_{i,j}^{+1} = f \left[ U_{i,j-1}^t U_{i,j}^t U_{i,j+1}^t U_{i+1,j}^t U_{i-1,j}^t U_{i,j}^t \right] \]  

Structure explained with CA is for new developing site perspective, in which plain is assumed to be divided into a pattern of hexagon grid in CA. Figure 3-5 represents a layer-wise plain design.
according to the height of layers with the assumption that the water flows downward from the top cell of the structure. Figure shows 2D Automata with in layer 1 to 1+n-1 from bottom to top; here, numbers presents cell ranks.

Diffusive approximation: For an actual flood event, as per Horritt et al [6] and Yu et al [13], the diffusive equations provides good results in their models. For pipeline modeling, we have assumed discharge passing strategy discussed Dottori et al [4] as, if two cells in a CA are adjacent to each other then discharge water will release from higher to lower cell and also will depend on the contact area of both, Q_{j+1} in this case, can be computed as:

\[ Q_{j+1} = \frac{bh_j^{3/2}}{n} \left( \frac{H_{j+1} - H_j}{\Delta x} \right)^{1/2} \]  \hspace{1cm} (3)

Where,

- \( Q_{j+1} \) = Discharge amount from the cell I to J,J = i+n-1; J=i+n-2;
- \( H_j \) = Water level stage on i+n-1 layer;
- \( H_j \) = Water level stage on i+n-2 layer;
- \( \Delta x \) = Distance between centroids of two adjacent cells;
- b = Width of the contact face between two adjacent cell;
- \( h_m \) = Arithmetic mean between water heights in the two cells.
- N = Manning roughness coefficient;

Model uses the Euler explicit computation scheme where first calculated discharges between cells that are computed according to equation (4); by summing incoming and outgoing discharges from i+n-1th to i+n-2th or highest node to lowest cells situated in the linear direction. Now it is a time to calculate the total discharge from highest cell to lowest cell of linear direction according to the policy given by [8]. This discharge is shown as Q:

\[ \text{Total discharge, } Q = \frac{\Delta V}{\Delta t} = \sum_{j=1}^{n} Q_{j+1} \]  \hspace{1cm} (4)

3.2. Flood Avoidance Pipelining System

The proposed structure of pipeline is used to examine the claims. This pipelining having more outflow lines for water discharge than the existing rectangle shaped pipelines. More pipelines may be possible with pentagonal grid or octagonal grid but pentagonal and octagonal grid creates complexity in design by making a hybrid structure with triangle and rectangle respectively, on every layer. On the other hand shape of hexagon based pipeline only made with hexagons without creating any hybrid structure. That is a reason to choose pipelining with hexagonal structure. This pipelining is useful to fast exit of discharge and this discharged water flows to be collected at a reservoir to its reuse. Figure 6 indicating the structure proposed.

Hexagon based Structure of Pipeline

In the proposed design shown by 6, the boundary of cell is assumed to route water flow within a pipeline or path. In this structure, the tanks will be situated on every corner which collects drained water to reuse and supply to network, reservoir if its excess amount collected. These tanks will be used to minimize demand of groundwater by reusing collected rainwater. Figure 7 showing the numbering with cell starting from the bottom to top while reservoir situated on layer zero. This figure indicating direction of water flow from top to down i.e. from layer i+n-1 to layer i and 0. In this figure, lines indicating pipelines, Blue bubbles on joints indicating tanks while colorful arrow indicating a direction towards a reservoir. Here, in the height to design two tanks of consecutive layers, in which upper tank got water collected as a rainwater while lower tank intakes overflow water of this tank when this cell not having rainfall.

Fig. 5: Direction of slope (elevation)

Fig. 6: The gap between tanks

Fig. 7: A node with its parts including underground tank and upper tank

An overflow maintains a constant level of tank 2(UG tank) to upper tank, to ensure flood avoidance through networked pipelining in the unnatural direction with the help of water in well / UG tank. These tanks can be equipped with WSN discussed in [10] or with Sensing mechanism discussed by [14] and [15] to inform the situation of overflow and danger.

3.3. Hydro-dynamics over Pipeline

The Bernoulli equation

Elevation, speed, and pressure are the three basic elements which are involved in Hydrodynamics. Because of these three elements three kinds of energy generated in the fluid as:

- Kinetic energy is generated by movement of water with velocity and can represent as:
  \[ E_k = \frac{w^2}{2} \]  \hspace{1cm} (5)

- Potential energy depends on the position of water in the case of our problem this will be the elevation of the pipeline at a node. While \( E_p \) can be expressed as:
  \[ E_p = wz \]  \hspace{1cm} (6)

- Flow Energy is essential to move water from one position to other, while depends on pressure:
  \[ E_A = \frac{wp}{g} \]  \hspace{1cm} (7)

Here, w indicates the weight of water while 9.807 is a specific weight of water on earth at 4°C. Z indicates elevation, g indicate specific weight while p is the pressure.

So, the hydrodynamics having energy which is the combination of these three as:
\[ E_h = E_a + E_p + E_A \]  \hspace{1cm} (8)

So, on two different points, energy will be:

\[ E_1 = E_2 \]  \hspace{1cm} (9)

\[ \frac{P_4}{E} + z_1 + 2E = \frac{P_4}{E} + z_2 + 2E = 9.807 + z_1 + 2 \times 9.807 = 9.807 + z_2 + 2 \times 9.807 \]  \hspace{1cm} (10)

Here, mutual elimination of weight has been performed before equation (10), this equation called Bernoulli equation for a water supply.

4. Performance Analysis

Performance analysis of design will depend on factors including complexity, maximum way of exit and impact of layers and grid type on tank size which is responsible to avoid the flood and making delay in flood.

4.1. Impact of Grid Topology on Plain Modeling

The performance of a water drainage mechanism in various shapes has calculated with the help of finding out the way of exit in from top layer in different kind of networks.

- When Plain Has Linear Elevation

In this case, water flowing in one side of plain, where two exit points exist for square grid and three exit points meets in hexagon grid at top layer.

<table>
<thead>
<tr>
<th>Grid type / layer</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>With square of Hanoi Network [16]</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>With hexagon of CA</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

- When Plain Has Bilinear Elevation

In this case, water flowing in one side of plain and 75 % plain is elevated, where three exit point exist for square grid and four exit points meets in hexagon grid at top layer.

\[ \text{Table 2: Exit way on grid per layer} \]

<table>
<thead>
<tr>
<th>Grid type / layer</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>With square of Hanoi Network [16]</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>With hexagon of CA</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>

4.2 Impacts on Tank Size

For sake of simplicity, we have assumed equal area for all cells in a cellular plain. Tank with UG tank or well at every corner is situated to provide delay in flash flood, as well as to reuse the water.

At this stage what should be the size of tanks, is an important question. So, to find out size of tanks for different layer, TSD algorithm presented. In layered structure, \( L(i) \) assumed for a layer \( i \), where \( i = 0, 1, 2, 3, 4, 5, \ldots n \), and so on, in our example we have considered 3 to 5 layers. Assumed \( A(i) \) is an area of a cell at \( i \)th layer, maximum rainfall for day and hour denoted here by \( R_{\text{day}} \) and \( R_{\text{max}} \).

(A) Calculation of Maximum Rainfall Per Hour \( R_{\text{max}} \) (hr)

**Input:** 100 years of rainfall data of particular area

**Output:** \( R_{\text{max}} \) (hr)

**Start:**

1. Find out maximum rainfall in a day.
2. Calculate maximum hourly rainfall
3. Convert this mm rainfall into meter.
4. \( R_{\text{max}} \) (hr) = Data of step 5.

**End**

**Calculation of Maximum rainfall per hour \( R_{\text{max}} \) (hr) for Mumbai by historical data [5]**

**Step 1:** Find out maximum rainfall in a day from history = 944

**Step 2:** Calculate maximum hourly rainfall

Max hourly rainfall = 944 / 24 = 39.33

**Step 3:** Convert this mm rainfall into meter.

Maximum hourly rainfall (mtr) = 0.03933 m

**Step 4:** \( R_{\text{max}} \) (hr) = Data of step 3

i.e. \( R_{\text{max}} \) (hr) = 0.03933 m.

(B) Tank Size Descriptor (TSD) Algorithm

Tank Size Descriptor algorithm is applicable for all the real time case to design an urban flood free city in a flood prone region like Mumbai (India) with the help of a maximum possible per hour rainfall of a city.

**Start**

1. Step 1: Calculation of a rainy area for a cell (i)

   Suppose rainy area of a cell at layer i stored in variable \( A \)

   For (i =0, n=5;  i < n;  n - - )

   \[
   \{ A_{\text{min}} = n \times A(i); \}
   \]

   **Step 2:** Minimum rainfall per hour

   \[
   \text{Amount} \ [R_{\text{max}}] = \frac{A_{\text{rain}} \times R_{\text{day}}}{24}
   \]

   **Step 3:** Impact of layers on tank size for flood free survival

   No. of tanks in a cell inhaling water at a layer (i)

   if (choice == Hexagon)

   \[
   \{ \text{If ( layer == (n-1) )} \}
   \]
   \[
   \{ \text{Tank no. = 4;} \}
   \]
   \[
   \text{else if (layer == n) \}
   \]
   \[
   \{ \text{Tank no. = 6;} \}
   \]
   \[
   \text{else \}
   \]
   \[
   \{ \text{Tank no. = 3;} \}
   \]
elseif (choice == rectangle) {
    if (layer == n) {
        Tank no. = 4;
    }
    else {
        Tank no. = 2;
    }
}

Step 4: minimum tank size when distribution not possible

Step 5: Minimum tank size when distribution of water possible 
For (i=1, n=max; i < n; n = ) 
Minimum tank size when discharge not possible / ni;

5. Simulation of TSD Algorithm

Simulation of this algorithm shown with the principle of replication [9], and applied same for the different layers from three to five. Here maximum rainfall per hour assumed is 0.03933 m/hr.

(i) For 3 layered city: Assume that a cell of 1 km² area having linear slop in a single direction, and layer of first iteration assumed as 3. Now, minimum tank size assumed with the TSD algorithm as:

Table 3: Impact of 3 layers on tank size for with Hexagon grid

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution not possible Hexagon</th>
<th>Tank size when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39330</td>
<td>58995</td>
</tr>
<tr>
<td>2</td>
<td>139665</td>
<td>39330</td>
</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
</tbody>
</table>

Table 4: Impact of 3 layers on tank size for with rectangle grid

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution not possible Hexagon</th>
<th>Tank size when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
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<td>139665</td>
<td>39330</td>
</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
</tbody>
</table>

Table 5: Comparison between tank size in both schemes (when discharge not distributable)

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Min. Tank size (m³) when water distribution not possible Hexagon</th>
<th>Min. Tank size (m³) when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39330</td>
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<tr>
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<td>39330</td>
</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
</tbody>
</table>

(ii) For 4 layered city: Assume that a cell of 1 km² area having linear slop in a single direction, and layer of first iteration assumed as 4. Now minimum tank size calculated by TSD algorithm as:

For Hexagon shaped CA

Table 7: Impact of 4 layers on tank size

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution not possible Hexagon</th>
<th>Tank size when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
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<td>139665</td>
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</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Impact of 4 layers on tank size

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution not possible Hexagon</th>
<th>Tank size when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39330</td>
<td>58995</td>
</tr>
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<td>139665</td>
<td>39330</td>
</tr>
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<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Comparison between tank size in both schemes (When discharge not distributable)

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Min. Tank size (m³) when water distribution not possible Hexagon</th>
<th>Min. Tank size (m³) when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39330</td>
<td>58995</td>
</tr>
<tr>
<td>2</td>
<td>139665</td>
<td>39330</td>
</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
</tbody>
</table>

(iii) For 5 layered city: A cell assumed with 1 km² area having linear slop in single direction, and layer of first iteration assumed as 5. So, TSD algorithm provides minimum tank size as:

For Hexagon shaped CA

Table 11: Impact of 5 layers on tank size

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution not possible Hexagon</th>
<th>Tank size when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39330</td>
<td>58995</td>
</tr>
<tr>
<td>2</td>
<td>139665</td>
<td>39330</td>
</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12: Impact of 5 layers on tank size

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution not possible Hexagon</th>
<th>Tank size when water distribution not possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39330</td>
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<tr>
<td>2</td>
<td>139665</td>
<td>39330</td>
</tr>
<tr>
<td>3</td>
<td>6555</td>
<td>98325</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13: Comparison between tank size in both schemes (When discharge not distributable)
Table 14: Comparison between tank size in both schemes (When discharge distributable)

<table>
<thead>
<tr>
<th>Cell in Linear (i)</th>
<th>Tank size when water distribution possible hexagon</th>
<th>Tank size when water distribution possible rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13110</td>
<td>19655</td>
</tr>
<tr>
<td>2</td>
<td>13110</td>
<td>19655</td>
</tr>
<tr>
<td>3</td>
<td>13110</td>
<td>14748.75</td>
</tr>
<tr>
<td>4</td>
<td>9832.5</td>
<td>9321.25</td>
</tr>
<tr>
<td>5</td>
<td>6555</td>
<td>2458.125</td>
</tr>
</tbody>
</table>

6. Result and Discussion

With the help of analysis performed, we are now able to draw statistical properties of hexagonal grid pattern and rectangle grid pattern to provide better way of exit a water discharge. As per figure 10 and figure 11, this is easy to say that in layers hexagonal grid pattern provides more way of exit to the discharge than the rectangle pattern. In both cases, when plain is on slope of 50% or when it has slope of 75% hexagonal shape pattern plays well to provide way of exit, and it is a fact that more way of exit will be better to discharge huge amount of water than the less way of exit.

Fig. 10: Exit way in unilinear elevation

Fig. 11: Exit way in bilinear elevation

Fig. 12: Comparison chart for tank size between non-distributed discharge for 3 layer

Fig. 13: Comparison chart for tank size between distributed discharges for 3 layer

Fig. 14: Comparison chart for tank size in non-distributed discharge for 4 layers

Fig. 15: Comparison chart for tank size in distributed discharge for 4 layer

Fig. 16: Comparison chart for tank size in non-distributed discharge for 5 layers

Fig. 17: Comparison chart for tank size in distributed discharge for 5 layer

7. Conclusion

Statistical data provides us a basis to conclude results in form of outcomes including the fact that hexagonal grids having benefit over others. Figure 10 and 11 helps us to conclude the importance of structure as the hexagonal cellular automata base pipeline modeling is better than the any rectangle base scheme. TSD algorithm provides data calculate the tank size in different scenarios including a case when all the tanks are networked and authorities are able to transfer water from a tank to another; and a second case when there is not any way to transfer the water from one tank to second by other way than natural slope. Figure 12 to figure 17, all are provides impacts on tank size in various cases of data found by the use of tank size descriptor (TSD) algorithm from tables 5,6; 9,10 and 13,14 respectively. These figures showing the impact of layer on size while area was assumed to calculation is 1 Km². Results are elaborating the importance of hexagonal cellular automata with its use in plain and pipeline modeling. Hexagonal CA
based modeling of plain and pipelining are found more efficient than rectangle based as per results shown by comparing way of exits and maximum water discharge in minimum resources. The use of hexagonal CA for plain modeling to design a flood free city while pipelining is used to improve drainage mechanism with the help of tanks at every junction point to provide delay in water discharge to go to the lower layer; here tanks assumed as a helpful way to reuse the water. So, in other words, more exit ways makes it more efficient than earlier planning methodology. In this work, we have extended use of hexa-cellular automata from inundation modeling to pipeline modeling to design a flood free city. Earlier, square grid or rectangle grid of plain modeling was in use, that is why here the comparison of exit paths are discussed between both topologies. In this regard, two concepts have been discussed in the paper, first is the effect of various cell shapes on way of exits that directly affects the services of avoiding the flood. Storage situation or plain’s geography is basically main factors behind a flood. In the analysis, the first concept shows the effect of a square grid and hexagonal grid on exits paths which shows the difference in exit paths in various schemes. It shows the impact of various pipelines in two schemes. As per the architecture, the maximization of paths with the tank design will enhance the latency of water flow from one cell to another cell while tank’s position will provide help to decrease velocity of water by which water of upper cell will not be able to affect instantly to the lower cell area and in this time duration the water stored in the tank of lower cell can easily shift to another place of network. The second concept showing the impact of layers on tank size for anyone scheme to flow water to exit from a specific cell, which is a way to design a flood free zone for new city development.

The discussed optimization of exits using cellular automata is applicable for all kind of plain even it is partially applicable for hill area because this topology of pipelining will provide delay to flood or will create obstacle in form of tanks however we have unable to calculate correctly due to logical division of plain not real.

References