Development of disaster prevention education teaching aid using localized torrential rain flooding simulation

KAGAWA UNIVERSITY
Crisis & Risk Management Research Center

Purpose of this education teaching aid

Recently, a localized torrential rainfall frequently occurs in various parts of Japan. The feature of this rainfall occurs suddenly, and makes a lot of rain fall in a short time. Therefore, damage often becomes aggravated. In this study, a flood damage diffusing simulation system for the localized torrential rainfall is developed for using disaster prevention training and the evacuation drill, etc. The multi-media leaning material that uses the disaster prevention literacy of the generation mechanism of localized torrential rain and the function etc. of the disaster prevention facilities to study is developed. And, the localized torrential rain flood simulation that can discuss a grasp of the vulnerability in the region and an effective protection against localized torrential rain is developed. The simulation is used for the disaster prevention education teaching aid.

Outline of simulation

- Purpose of development
  - This simulation is used to discuss effective hard and soft disaster measures.
  - It is used for the teaching aid of localized torrential rain.
  - Improving disaster awareness for learners .
- Simulation method
  - Cellular automaton(CA) : This simulation method is optimal in the simulation of complex systems.
- Simulation area
  - Nibancho area in Takamatsu City
- Rainfall condition
  - 50mm per hour and 100mm per hour
- Utilization of simulation
  - Grasp of flood situation
  - Confirmation of dangerous part
  - Confirmation of effect such as drain pumps

Features of CA model

◆**Discrete lattice cells**

The system substrate consists of one-, two- or three-dimensional lattice of cells.

◆**Homogeneity**

All cells are equivalent.

◆**Discrete states**

Each cell takes on one of a finite number of possible discrete states.

◆**Local interactions**

Each cell interacts only with cells that are in its local neighborhood.

◆**Discrete dynamics**

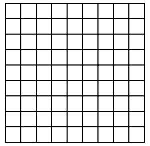
At each discrete unit time, each cell updates its current state according to a transition rule taking into account the states of cells in its neighborhood.

Setting for Hazard model

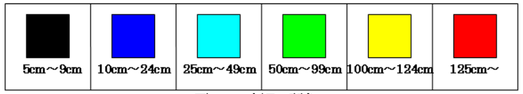
- Modeling of object space
  - Type of CA
    - two-dimensional model
  - Shape of cell
    - lattice type
  - Size of cell
    - one side with 4m

■ State of each cell
- ◆Flood
- ◆ Altitude
- ◆Sand bag
- ◆Drain pump
- ◆Kennel

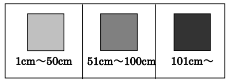
■Correspondence of real time and 1 step of simulation
- ◆1Step = 1.76 second



Space lattice



Flood depth for each cell (Color segmentation)



Height of a sand bag for each cell (Color segmentation)

Basic rule of flood diffusion

- Rain is always supplied to the target area of the simulation.
- The quantity supplied of water is decided in consideration of the amount of rainfall per hour, the cell size, and the time that corresponds to one step of the simulation.
- The state of the cell is decided by total value.
  Total value = Altitude + Sand bag + depth (see Fig.1)
- The moving direction of seawater is decided by total value.
- If there are two or more cells of the lowest value, one is selected from among those cells at random.
- Total value of a current cell and the selected cell is adjusted to the same value.

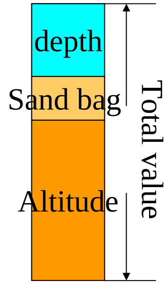
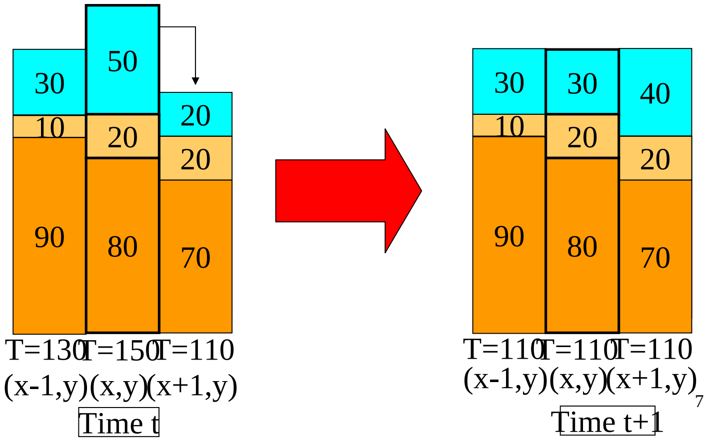


Fig.1

Example of state change in cell (Vertical section)

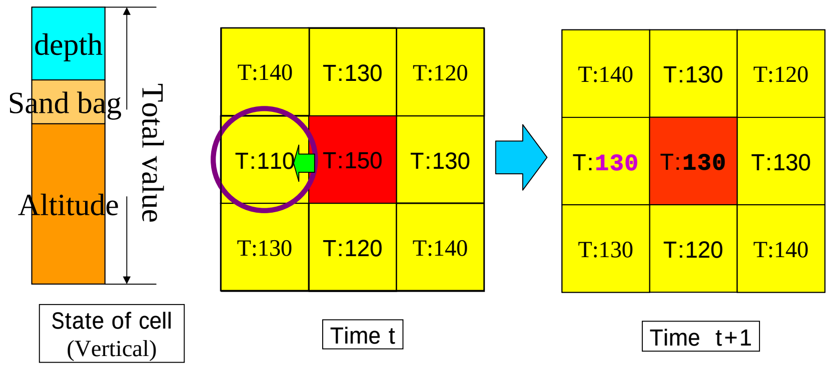
- The water of cell position (x,y) moves to (x+1,y).



Example of state change in cell (Horizontal section)

- Diffusion rule of water
  Total value(T) = Altitude (H)+ Sand bag(D) + depth (M)

  Total value(T) of eight cells at time t is compared, and the cell that T is minimum value is chosen. Depth(M) is adjusted so that T is the same value at time t+1.



Rule of Flood diffusion simulation
（Precipitation, Drain pump, Kennel）

・**Precipitation**

・Case 1(50mm per hour):per 1cell, per 1step

50mm × 1.67sec.÷3600 sec.＝0.0232 mm

・Case 2(100mm per hour):per 1cell , per 1step

100mm × 1.67sec.÷3600sec.＝0.0464 mm

These values are added to depth of each cell.

・Drain pump

・When the drain capacity is 150 m^3/min （1step）

150 × 1.67÷60 = 4.175 m^3

4.175÷16≒0.26m（Decrement per cell）

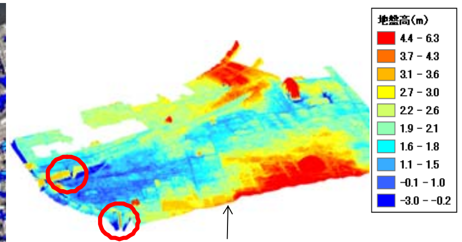
The value of M is decreased by 0.06m in the center cell, is decreased by 0.025m in neighborhood cells.

・Kennel

・Depth of the cell is adjusted to 0.

Example of simulation result①

Simulation result (100mm per hour, 30 minutes after)



Altitude chart of this area
(The part of the red circle sign is the lowest part.)

In this result, water has gathered in the lowest part in this region.

Disaster prevention education teaching aid for localized torrential rain (Feature of teaching aid)

・The disaster prevention education teaching aid is a digital teaching aid made by using Power Point.

＜ Device in teaching aid＞

・The teaching aid of the power pointer and animation was made.

・ The user can select a necessary teaching aid.

・The content of each region can be changed.

・Everyone can browse for using server.

・The instruction animation is prepared.

The main term of teaching aid

1． Definition and generation mechanism of localized torrential rain

1) Generation mechanism of localized torrential rain

2) Generation and growth mechanism of cumulonimbus

3) Phenomenon(by cumulonimbus)

4) Feature of localized torrential rain and regional heavy rain

5) Downpour experience using car with precipitation system

2． Feature of occurring disaster

1) Inundation by river water and inundation inside the levee

2) Cliff crumble

3． Kind and role of disaster prevention equipments

1) Drain pump

2) Water sealing plate

4． Disaster prevention measures technique

1) How to make breastwork

5． Accessible measures

1) The feature in the region is understood

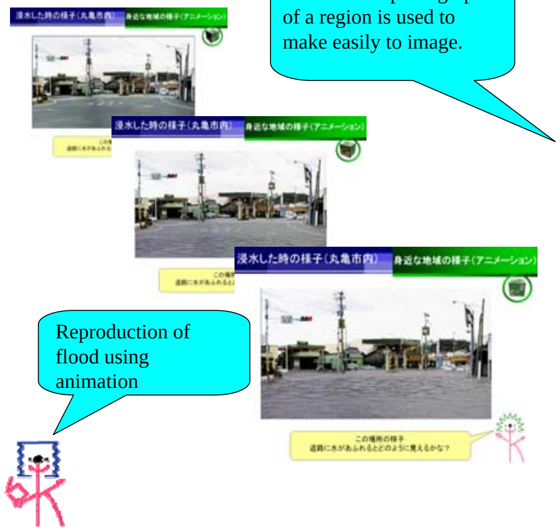
2) Standard of rainfall

3) Method of gathering information

4) Method of evacuation

5) Corrective action on change of weather conditions

Local conditions are used for the teaching aid



The familiar photograph of a region is used to make easily to image.

Reproduction of flood using animation

Use of simulation result

- The change in the flood situation can be confirmed by the simulation. The hazardous area can be understood using the simulation result.

Normal state

10 minutes after