THE DEPARTMENT OF
COMPUTER SCIENCE
& ENGINEERING
計算機科學及工程學系

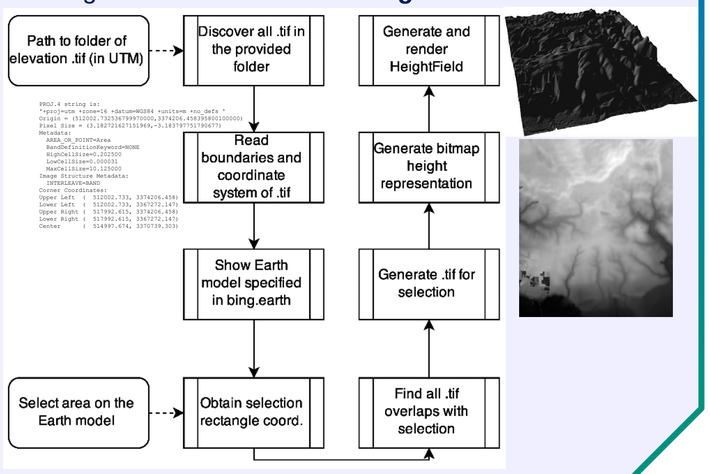
Flooding Simulation
with Improved Tools and Features

Lee Hon Lam (Bob), Kong Tsz Hin (Kelvin), Chu Kin Fung (Kenny), Poon Lok Wing (Wing)
Advised by: Prof. Ke YI

Physically realistic simulation of floods is possible with the help of computer algorithms. We designed a software to find out how floods propagate on real terrains over a period of time. The software constructs terrains from **real-world elevation datasets** and computes how water flows on the terrains. Floods caused by dam break, rainfall and tsunami can be simulated by the software.

Terrain Loader

Users provide their own set of elevation data in **GeoTiff** (`.tif`) format with Universal Transverse Mercator (UTM) as the coordinate system. Once the area of interest is confirmed, required `.tif` files are merged and converted to a **height field**.



Flood Propagation Algorithm

Our algorithm is based on the **shallow water equations**:

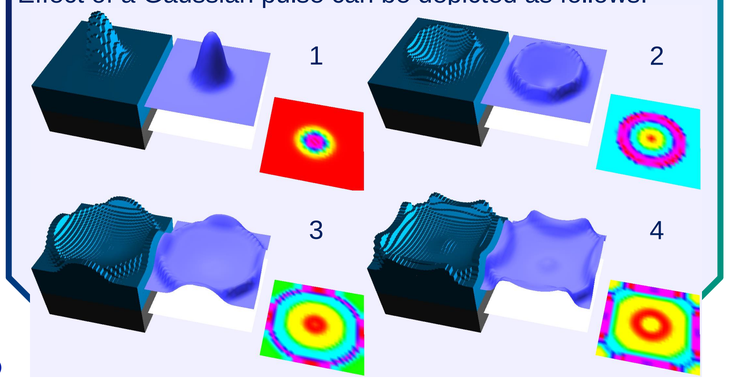
$$\begin{cases} \dfrac{Dh}{Dt} = -h\dfrac{\partial u_i}{\partial x_i} \\ \dfrac{Du_i}{Dt} = -g\dfrac{\partial(z_0+h)}{\partial x_i} \end{cases}$$

$$\begin{aligned} & i = 1,2 \\ & u_i = velocity\ field\ of\ the\ fluid \\ & x_i = position\ on\ terrain \\ & h:\ water\ column\ height \\ & z_0 = bed\ height \\ & g:\ gravity \end{aligned}$$

The equations are evaluated using finite difference method. The simulation space is discretized into a **staggered grid**, in which each cell has its own water height and velocity defined. The following function is iterated to update the grid:

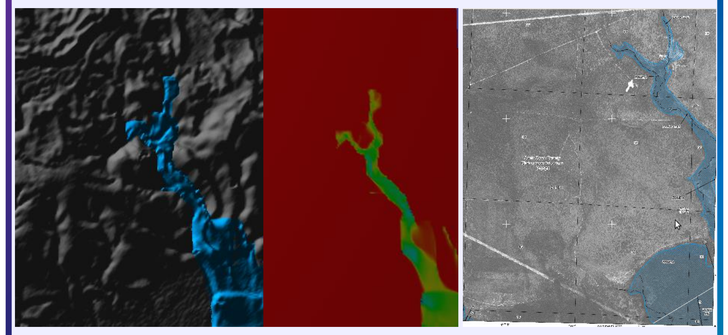
Data: *Grid*
Result: *Grid* with the configuration Δt time later
Function $AdvanceOneTimeStep(\Delta t)$**:**
  $ApplyAdvection(\Delta t)$;
  $UpdateWaterHeights(\Delta t)$;
  $UpdateVelocities(\Delta t)$;
end

Effect of a Gaussian pulse can be depicted as follows:



Official Flooding Data

We compared our simulation results with the **official flood map** (right) of an area in Florida, USA. The flooding in the eastern river matches with the flood map.



Tsunami

When water wave enters a shallow region, **speed and wavelength reduces** while amplitude increases, explaining why tsunami is barely noticeable at the center of the ocean. We could replicate the reduction in wave speed and wavelength using our software.