Three-Dimensional (3D) Dynamic Water Infiltration Hierarchically on Multilayer of Soil according to Voronoi Sequence Nodes based on Three-Dimensional Triangular Irregular Network (3D TIN)

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Abstract Understanding soil water infiltration movement has acquired extensive interest and concern in the last few decades. The arrangement of particles (i.e. structures and size) and the interaction between soil and soil water have a profound effect on the soil water infiltration. The challenging task in soil fluid modelling is the indeterminate spatial extent that have no specific boundaries and difficult to sense. Plenty investigations and studies have been conducted to measure the water movement. However, less focus were given on the movement of dynamic soil water infiltration. This paper will focus on modelling the three-dimensional (3D) soil water infiltrations that flow downward due to gravitational factor and gradient pressure. The 3D hierarchical soil water infiltration model proposed the integration of techniques which include Tree-map to isolate the depth of the soil that act as a route of soil water flow from the surface of the terrain to subsurface flow. Moreover, 3D Gosper curve was used to represent the soil water flow pattern that based on the law of gravity and Horton equation control the flow of soil water in the model. The curves that consist of series of nodes adopt Three-Dimensional Triangular Irregular Network (3D TIN) which creates a network of flow direction that allows the water pass through the nodes according to a predetermined sequence. The study area has average of 8.5 mm total rain and -5 meter water level. The soil is divided into a few layers to represent the flow of soil water according to sequence of nodes. The soil depth (40 cm, 80 cm, 120 cm, 160 cm and 200 cm) isolation in form of Voronoi shaped polygon nodes allowing the soil water flowing down where the depth is chosen based on the soil wetting range of subsurface soil.

Keywords: Soil Water, Infiltration, Three-Dimensional (3D),
Fluid Modelling

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1.0 Introduction

The study on streamflow gaining much attention nowadays as the knowledge is essential in studies related to hydrology, geology, environment and hazard management. The research on streamflow includes the studies that focus on the flow of the stream, stream flow direction, stream management and also the process that generate stream. The process that generate stream can be divided into Infiltration Excess Overland Flow (IEOF), Saturation Excess Overland Flow (SEOF), Shallow Subsurface Flow (SSF), Direct Precipitation onto Stream Surface (DPOSS), percolation, evapotranspiration and ground water (GW). Infiltration happens in most of the process of stream generation and it is important in hydrological studies and the process involves several mathematical equation and formulas.

Among the earliest study on water movement is by Barnes and Allison (1987) that trace water movement in the saturated zones using stable isotopes of hydrogen and oxygen. In 1941, Hursh and Brater come out with the studies on the role of the subsurface storm flow where they showed the stream hydrograph response to storm rainfall that was composed of two main components which are channel precipitation and subsurface stormflow. The study on streamflow continued by Hoover and Hursh and Brater (1943) and they showed that soil depth, topography, and hydrologic characteristics associated with different elevations that influenced by peak discharge. Dunne and Black (1970) in the other hand, point out that the most important transition between flow systems seems to be at the soil surface, when water is released from the extreme damping effect of subsurface flow. There are several method used to detect the movement of water such as by using stable-isotope and chloride tracers (Newman *et. al.*, 1997), hydrogen and oxygen isotopes, chloride, and chlorine-36 (Liu *et. al*, 1995) and gravimetric sampling (Nielsen, 1964).

The use of three-dimension (3D) in hydrology has received increasing attention in the present studies but only for visualization purpose. However, it is very difficult to see the focus of study that used temporal data to create a 3D model that used to represent soil water infiltration process that happen underneath the soil. The previous study on soil water movement and 3D model mostly carried out separately. Thus, this study will proposed the advancement from graft and mathematical representation model of soil water infiltration that used 3D model to show the dynamic movement soil water movement through static pattern of sequence that represent spaces in soil. The nature of the soil water which is in form of liquid state, resulted in the decision on using 3D dynamic fluid flow model according to voronoi sequence grids nodes hierarchically based on multilayer of soil. The soil water that flow within soil particles required further research on the suitability of these data model to cater the acquired 3D soil water movement. This research is not only focus on visualization solely but translate and convert temporal data of rainfall and dynamic data of soil water flow into 3D model. The natural process of soil water flow required 3D because soil water not only move downward but also horizontly in any direction which depends on soil water potential. Static object can be represent and analyze in 2 Dimension (2D). However, the dynamic nature of soil water does not suitable to be represent in 2D because soil water flow constantly and need depth information (z). In addition, the geometric representation of soil which involve volume of water required 3D representation. The method used in this study explained in Section 3.

The reviews on the role of GIS in soil water infiltration studies, the advancement of 2D into 3D soil water movement and practical relationship between intended 3D modelling with dynamic water infiltration that show the contribution of 3D GIS to the studies related to soil water movement discussed in section 2. Whereas, the methodology part will (Section 3) discussed and explains on the relevant of chosen methods for the development of 3D model. Treemap is used to give hierarchy to the depth of the soil and tree algorithm shows how the isolation done. 3D Gosper curve chosen to represent soil water flow pattern that best suit the direction of soil water and the infiltration and volume of soil water depends on Horton equation.

2.0 Literature Review

This section describes the related issues and information on the role of GIS in soil water infiltration studies which show the needs of 3D modelling for soil water infiltration movement with the help of the advancement of 2D into 3D.

2.1 The role of GIS in soil water infiltration studies

Soil related studies using GIS technologies mostly focuses on water balanced (Alemaw & Chaoka, 2003; Ju *et. al.*, 2010; Pimenta, 2000; Portoghese *et. al.*, 2005), real time flood prediction (Al-Sabhan, et. al., 2003), characterized maximum infiltration rate (Brito et. al., 2006) and distributed rainfall-runoff model (Zollweg *et. al.*,1996; Jain et. al, 2004). One of the examples of GIS and soil water studies is done by Chen *et. al.* (2008) that implement 3S-based hydro-geological model for conducting a studies of an effective assessment of regional rainfall-induced landslide in order to investigate shallow landslide in watershed. In this research 3S is refer to Geographic Information System (GIS), Global Positioning System (GPS) and Remote Sensing (RS) framework that essential in establish physical, mechanical, geological and hydraulic properties. TRIGRS model help in analysing the response of transient pore-pressure during a rainfall event that also estimate the result for landslide susceptibility while Kringing interpolation method used to analyse rainfall intensity distribution. 3S-based hydrological model provide the effective assessment of regional rainfall-induced landslide where every system give huge contribution to the studies.

With the advent of increasing GIS technique and computing power, robust innovative physical-based hydrologic modeling has become important in contemporary hydrology to evaluate the impact of human intervention or possible climatic change on basin hydrology and water resources but most of the design are less suitable for real time application and usually not well integrated with spatial datasets for example GIS (Alemaw & Chaoka, 2003; Al-Sabhan et al., 2003).

Although the awareness on the importance of GIS technologies is rising but the studies that concentrate on soil water infiltration is less emphasized even though it is very important in hydrological process. Infiltration is an important soil feature that controls runoff, leaching and crop water availability. Besides soil water infiltration also become triggering factors to hazard like soil erosion, flood and landslide. As soil water infiltration contribute to surface terrain changes, it is relevant to adapt the used of GIS in soil water studies.

Attention towards this research received less attention even the soil water infiltration leads to many hazard such as flood and landslide.

Aspects of the real world objects can be described and represented in a computer by data model which is comprises of a set of constructions or rules. Geographic space representation should be first identified in order to visualize natural phenomena. GIS can best represent either geographic objects or surfaces as data by mathematical construction. The evolution of data model proves the advance and proliferation in computer technology and the competitive nature of the GIS. Vector, raster and TIN data model are example of data model with different types of geography representation used in GIS. Simple spatial features represented as a collection of point, line and polygon in vector data model. Vector data model can be processed, access and interpreted by the computer by organizing geometric objects and their spatial relationships into digital data files. However, in raster data model, geography is represented as cell matrixes which store numeric values where this model is a better option to represent continuous phenomena that use regular grid in order to cover the space. TIN data model in the other hand represent geography as set of contiguous non overlapping triangles.

Since the soil water infiltrations occur underneath the soil and the flow direction is unpredictable, the dynamic flow required better representation and analysis which is in form of 3D models. Apart from the used of GIS techniques, the indeterminate spatial extend of soil water infiltration needs 3D to show its dynamic movement based on precipitation data. The advancement of 2D into 3D soil water movement discussed next.

2.2 The advancement of 2D into 3D soil water movement

According to MacEachren and Kraak (1997), the concept of visualization is a key issue in the changing nature and using of maps in science as a consequence of the growing need of geo-referenced data and rapidly evolving technologies that can provide this information in more innovative ways. This technology evolution also important and give huge contribution in the field of hydrology. As stated by Fuhrmann (2000) the spread of modern information and communication technologies within the last three decades has led to an increased collection, availability and use of spatial and temporal digital hydrological data. Therefore the key issue for both public authorities and scientists is the needs and essential for visualization and regionalization of hydrological data and particularly temporal and spatial aspect of hydrological modelling.

This section reviews some of the studies that involve 3D in hydrological related studies. In 2002, Drogue *et. al.* applying GIS by using ArcView as a 3D visualization tools and Hydrological Recursive Model (HRM), a conceptual rainfall-runoff model that represent downstream variation of daily streamflow where 3D spatio-temporal cartography of mean annual high raw and specific discharges are illustrated. Spatial analyst in ArcView was used to determined hydromorphometric data, land cover data and geological data for every catchment. The obtained regional parameter set in this study was used for model transposition and production of realistic streamflow mapping in combination with the 3D module of ArcView.

The linear spatialization and 3D mapping of the hydrograph is an important issues in hydrological analysis because it allow visualization and a temporal survey of streamflow in any point of the drainage network and is helpful from a pedagogical point of view for river management, as well as for the identification of runoff generating areas and critical influences in a drainage basin (Drogue *et. al,* 2002). As the demand from GIS applications in the 3D environment increases, the basic form (e.g. single z-value for an x and y location) of data representation are no longer adequate (Raper and Kelk, 1991). Stream and other flowing soft geo-object can be simulated in 3D by using various technique such as the combination of GIS flow element (FE) and GIS soft voxel (SV) which were applied in simulating soil erosion and overland flow (Shen *et. al.*, 2006) and using 3D Volumetric Soft Geo-object (VSG) data model to visualize areas and overland flow volume generated from IEOF process dynamically, driven by Green-Ampt infiltration equation (Izham *et. al.*, 2010). Spatial data representations may be describe as surface-based (grid, shape model, boundary representation (b-rep and facet model) and volume-based (3D array, octree, constructive solid geometry (CSG) and 3D TIN)) (Li, 1994) where surface based of an object was represented by surface primitive while volume-based describe as object’s interior that describe by solid information.

2.3 Practical relationship between intended 3D modelling and dynamic water infiltration

The research on soil water usually involves mathematical model, graph representation or 2D soil moisture profile. As the study involve soil water infiltration focus more on 2D model, this study shows the importance and relevance of the advancement into 3D model that able to show the movement of fluid according to appropriate pattern as a result of gravity forces. The previous studies of integrated hydrology and 3D GIS includes 3D model for stream water, flood, over land flow and IEOF. This research attempt to emphasize the 3D modelling of liquid movement under the soil surface that use soil water and subsurface flow as the representation of the liquid movement in the model. Apart from showing the dynamic movement of soil water and subsurface flow, this model create a geometric representation of soil that consist of pores that provides the path for the water flow.

Since soil water infiltrates dynamically with uncertain direction, and the movement is influence by volume of precipitation and soil characteristics, the best way to show the dynamic movement of soil water is through 3D modelling. Besides, the movement of water into the soil is difficult to describe with text or represent solely by equation. However, the equation can be used to control the movement of liquid that represent the soil water in the 3D model. This study shows the relationships between mathematical equation (Horton), soil water infiltration and soil water direction movement (treemap and 3D Gosper curve) that used to create the 3D model which applied 3D TIN for representing the sequence of soil water flow direction. Precipitations, rate of infiltration, rate of water accumulate in soil and volumes of water that become subsurface flow are the dynamic data that modeled in form of fluid flow in the model. The triggering factor of this model is precipitation. The soil water infiltration does not stop although the precipitation stops, but always moving with the times due to the present of gravity force that continue to move the water. Thus, the used of 3D model in this research can shows the movement of soil water that receive less attention in most hydrological model.

3.0 Methodology

This section explains the relevant of method chosen based on previous related studies that highlight the ways to divide layers in the soil. Appropriate algorithm, curve and equation used for 3D soil water infiltration modelling also included.

3.1 Determination of soil water infiltration using Digital Terrain model (DTM)

According to Brito *et al.* (2006), the area with sandy soil types, vegetated land used and have no slope have high infiltration while the area with steep slope of greater than 25%, clay soil, and an impervious land use have poor infiltration. The location of the study area is at N 05, 33.113 E 101, 21.253 at KM 70.52, East West Gerik-Jeli Highway, a cut slope sides of the highway heading to Kelantan, Malaysia (Figure 1). The surface terrain is compute from ASCII format data to 2.5 Dimension of surface representation by using Global Mapper 14. The study area consists of clayey soil and covered by grass and trees and has -5 m water level and 8.5 mm total rain. The soil water infiltration determination is based on soil types, soil surface (DTM), slope percentage and temporal precipitation.

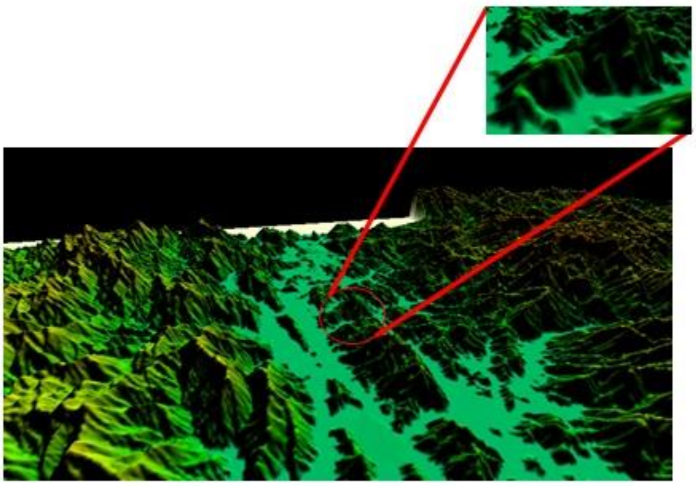

Fig. 1 Study area of East West Gerik-Jeli Highway

3.2 Isolation layer of indeterminate spatial extend of soil water movement using 3D Gosper curve

Distribution of water in soil is one of the indeterminate spatial extend which is difficult to sense and have no specific boundary. Other examples of indeterminate spatial extend are smoke, soil type and temperature. However, this paper will discuss on the soil water movement that important in streamflow generating process and hazard management. A Gosper curve that originally generate shapes to facilitate visualization and navigation of hierarchy (Auber *et. al*., 2013) is converted into 3D Gosper curve that able to show sequence of water flow infiltration that move into the soil with voronoi shaped polygon nodes sequence. The algorithm created able to isolate areas according to depth of corresponding nodes that represent the wetting area of soil after precipitation. In the other word, this paper focuses on the isolation of soil layer in form of 3D vertically where soil water move downward through soil particles due to gravity force. The tree-map used and linear arrangement of leave is modified according to appropriateness of the model. Soil water distribution pattern, flow arrangement and the explanation the output discussed in Section 4. Since the soil water involves dynamic movement of fluid underneath the soil surface, the water flow in the model that influenced by temporal data of precipitation stored and manages using dynamic data structure which allow the grow of data.

3.3 Tree-map and algorithm used to isolate the soil layer

Human tend to give respond differently to description that is delivered through a different method. The ability to identify the spatial configuration of element in form of picture and can be solve quickly. Besides, human also have ability to notice the relationship between those elements easily. Visual ability enable people to get the content of the picture faster than those represent in form of text (Kamada and Kawai, 1991).

Hierarchical information usually presenting by a method called Tree-Maps, is expected to be able to produce similar visualization techniques achieved in other areas (Johnson and

Shneiderman, 1991) where the hierarchical information represent in form of rectangular 2D display in a space-filling manner. The Tree-Map allows interactive control that can display both content and structural information. Every point of the Tree-map is corresponds to a node in the hierarchy. The siblings nodes will never overlap due to the node's bounding box that completely encloses the bounding boxes belong to its children. The method of Tree-maps include slice and dice, Squarified treemap, Strip layout, Quantum treemap, Mixed treemap, Voronoi treemaps and Rectangle Hillbert treemap (Auber *et. al*., 2013).

Large hierarchies contribute to the problem of navigation and visualization. The algorithm designed preserve region containment based on the hierarchy. GosperMap create boundaries as contour lines that mark the region that have similar altitude which have the same level of hierarchy. The method that usually used to visualize hierarchies is tree representations that slice information that display a different hierarchy by using a single image and the solution is based on 2D space-filling curves (SFC).

Every curve has its own advantages and disadvantages. Researcher need to consider the needs of their research in order to select the most appropriate curve. The study by Asano *et. al.*, (1997) combines several recursive and general SFC namely Recursive SFC (RSFC) that improve the number of seek operation. SFC is ways on mapping multi-dimensional space in 1 Dimensional (1D) space where it functioning as the route that passes through every cell available in a cell element to ensure that every cell is visited exactly once (Mokbel, 2003). There are many kinds of SFC that available that has different way of mapping to 1D space such as z-order, Hillbert's curve, Gray code and Snake code (Asano *et. al.*, 1997). The shape of the curve is shown in Figure 2.

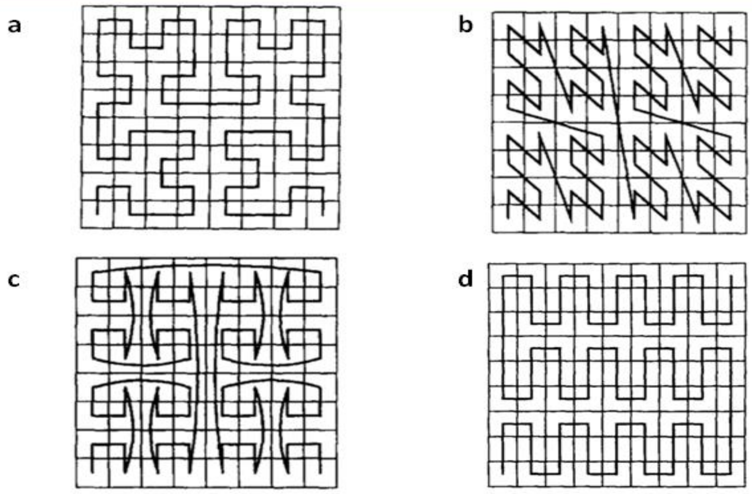

Fig. 2 Categories of space-Filling curve (a) Hillbert's curve (b) z-curve (c) Grey code curve (d) Snake curve. Image from (Asano *et. al.*, 1997)

A non-standard database system consider the important if query performance and the used of SFC is for a multidimensional data structure is to map multidimensional points to one dimension which produce two points in data structure. Nevertheless, research by Uznir *et. al.* (2013) present an opponent data technique of 3D Hilbert curve that used to represent 3D City Model. These new technique that extend Hillbert SFC into a higher dimension prove the improvement in data retrieval time.

This study proposed the used of Tree-map for dividing soils into several stages of depth in order to represent the flow of soil water infiltration. The Tree-map as explain previously able to isolate information with boundaries. Tree-map capabilities in doing this isolation give an inspiration to apply these techniques for 3D soil depth segregation. 3D Hillbert SFC curve by Uznir et. al. (2013) proves that the curve can be upgraded into 3D. However, these studies proposed the use of Gosper curve to meet the requirement of the studies instead of using Hillbert curve where Gosper curve represent the hierarchical depth of the soil in form of 3D. The results of using Tree-map, Gospers curve, Horton equation and Tulips describe in Section

4. The overview of the methodology summarize in the chart below (Figure 3)

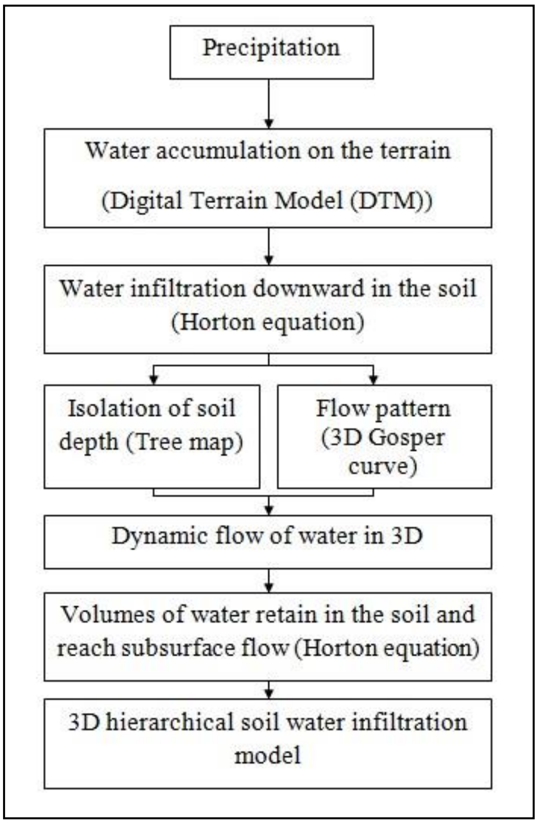

Fig. 3 The flow of methodology

4.0 Result and Analysis

The Tree-map is used to represent every depth of the soil from the surface of the terrain to the subsurface flow suitable with its capabilities to divide plane from the top of the tree to the bottom. The overview of the algorithm is shown in Figure 4 (a). The green node represent parent, other colour represent child and the blue numbered nodes are linear arrangement on the leaves.

The depth of the soil created from Tree-map is represent by number's that belongs to every parent's and child as shown in Figure 4 (a). The isolation of soil depth represent well in Tree-map. The arrangement of leave represented in Figure 4 (b) where the pattern is applied from Gosper curve. The colour of number and boxes represent the colour of the nodes before. There are one open source software that can be used to show the interesting visualization representation of Tree-map namely Tulip.

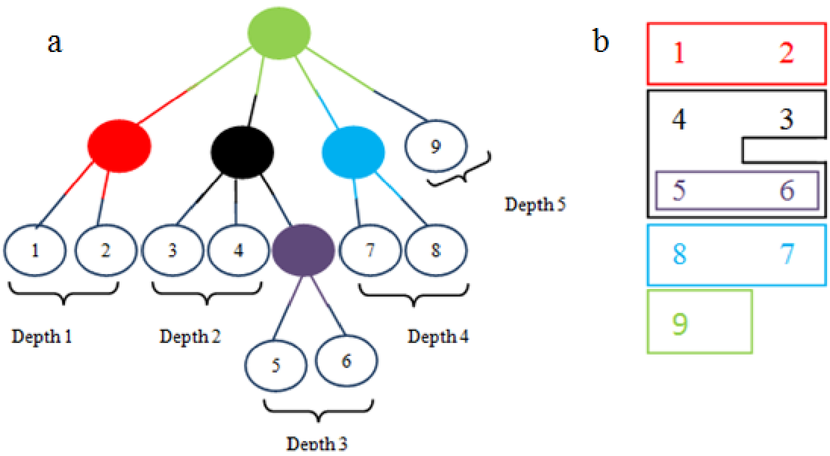

Fig. 4(a) The overview of the algorithm with soil depth isolation in Tree-map (b) Leaves arrangement

Tulip is capable in visualizing a framework of information for analyzing and visualizing relational data that support the design of interactive information visualization. The model as mention before divided into five layers with respective depth of 40 cm, 80 cm, 120 cm, 160 cm and 200 cm where the depth of water flow is depending on the volume of precipitation. The isolation of depth is in form of Voronoi shaped polygon nodes that allow the soil water flowing down where the depth is chosen based on the soil wetting range of subsurface soil. For clayey soil, Dingman (2002) stated that at steady water input rate, with 0.50 Φ porosity the water infiltrate to 10 cm at 8.3 hours and 33 cm after 83 hours where the infiltration increase with time. Thus, the wetting range from 0 cm to 200 cm is suitable for modeling soil water infiltration for subsurface flow since the soil water start to fulfill the soil composition started at the depth of 125 cm onwards (Juma, 1999). Precipitation that fall on dry soil will wet the layer of soil from present water content to the lower layers. In order to visualize the prototype of the depth information of soil water flow, Tulip is used to show some of the interactive graphic visualization of soil water according to a predetermined depth (Figure 5).

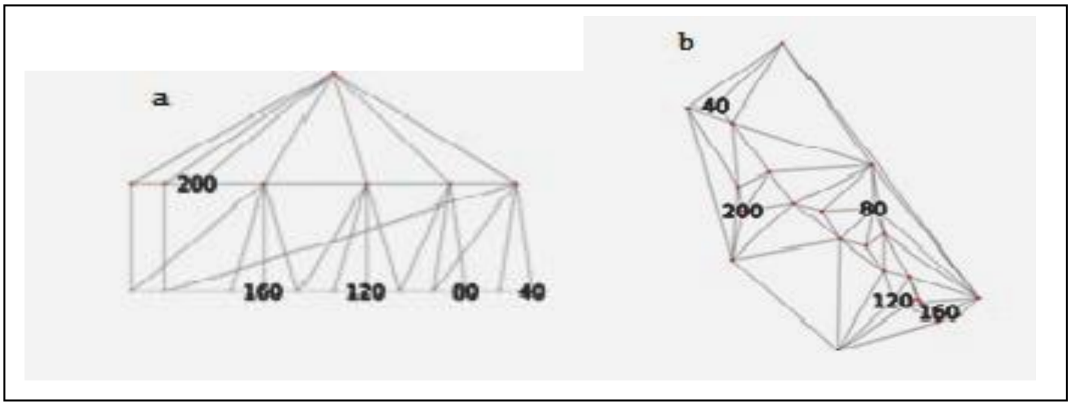

Fig. 5 Interactive information visualization by Tulips
(a) Hierarchy tree (b) Delaunay triangle

As mentioned before, Gosper Curve (Figure 6a) is chosen to represent the pattern of soil water flow. As mention by Asano *et. al.*, (1997), this curve divide plane into hexagons where the obtuse angles lead to smoother boundaries and the curve has the locality of property, with $c = \sqrt{6.34}$. However, the linear arrangement that represent the pattern of soil water flow (Figure 6b) changed slightly according to the Tree-map created before where the curve does not make repetition upward to comply with the soil water that moves downward due to gravity. In addition, the curve is not represented in planar form but vertically down to meet the requirement of 3D modelling.

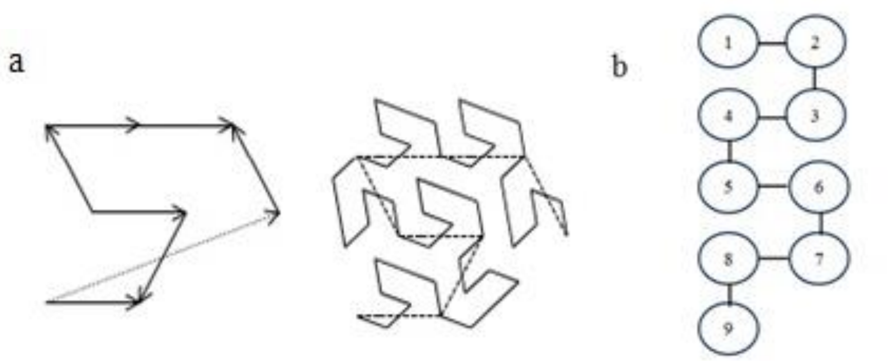

Fig. 6 (a) Gosper Curve (b) Linear arrangement of the leaves

Figure 7a shows the position of nodes along Gosper curve, where the image include the soil surface, soil water flow direction, subsurface flow and depth that represent by each nodes. Based on the arrangement of nodes, the flow pattern can be seen in Figure 7b. Water from precipitation that reach node 1 infiltrated into the soil and then flow to the next nodes depends on the rate of precipitation. Low precipitation rate may result in the absorption of water will not reach 200 meter and accumulate as subsurface flow in consequence of which there are water remains in the soil before continuing downward trend. The rate of precipitation will not be the same with the volume of water that reach subsurface flow due to soil characteristic that retain some of the water that flow through it. The number of nodes that occupied by soil water is determined by calculating soil wetting depth. In order to calculate the depth of wetting, it is necessary to calculate the storage capacity on a mass as well as on a volume basis (Juma, 1999) shown as follow.

Storage capacity on a gravimetric basis (Θ_m)
= Field capacity - present water content

Storage capacity on volumetric basis (Θ)
= Θ_m x (Bulk density of soil / density of water)

Depth of wetting
= Volume of rain/ volume of water stored per cm of soil

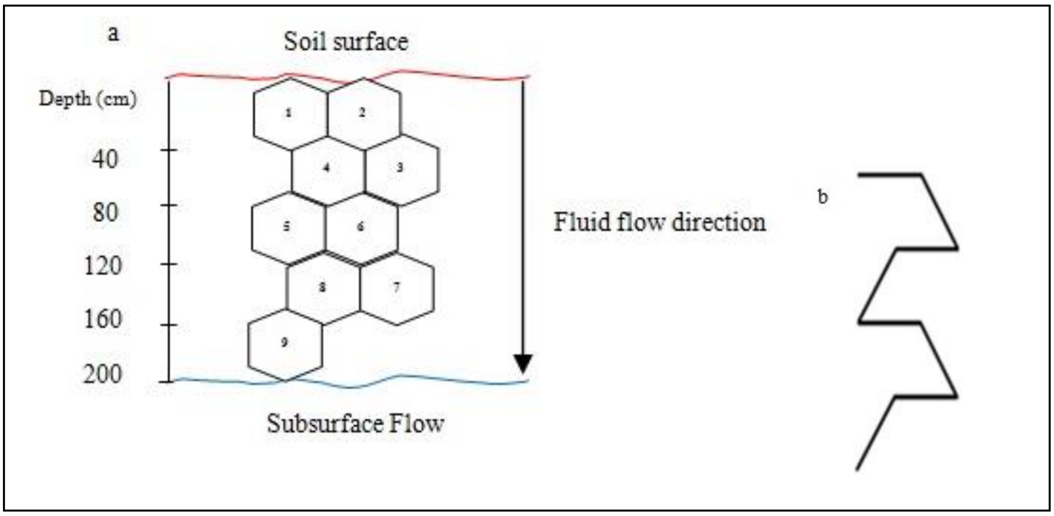

Fig. 7 (a) position of nodes along Gosper's curve (b) soil water pattern

Each and every Voronoi shaped nodes illustrated in Figure 8 which known as mask (3 x 3 x 3). The water infiltrated in the nodes does not enter and flow through the empty nodes but it flow through a series of TIN that produced 3D TIN. However, this study used 3D TIN application in Voronoi polygon instead of using square.

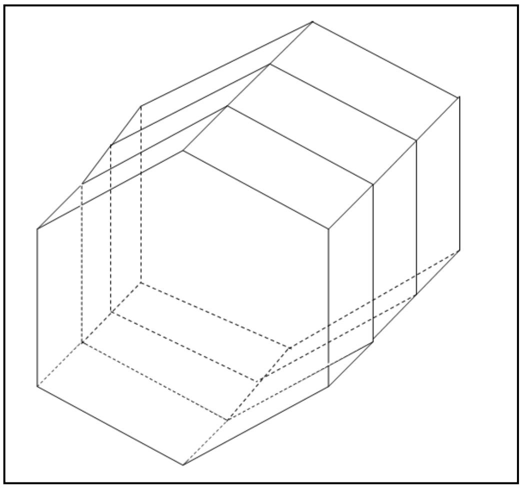

Fig. 8 A mask for each voronoi shape polygon nodes

The principle of 3D Triangular Irregular Network (3D TIN) adopted in order to create the 3D flow sequence of soil water in each 3D Gosper node. The mask of 3 x 3 x 3 were numbered and have 16 voxel elements (Figure 9). The mask divided into 4 section of triangle, where each triangle divided into three non-overlapping tetrahedra. Thus, every 3D Gosper node consists of 12 tetrahedra (Figure 9 (a), (b), (c) and (d)) that represent the flow sequence and path of the soil water movement. As mention before, there are 9 nodes in 3D Gosper curve and the number of tetrahedral for this model is 109. This non overlapping tetrahedra form a 3D TIN that create a network of flow direction that allow the water pass through the nodes according to a predetermined sequence. This 3D TIN structure was design for subsurface soil water flow.

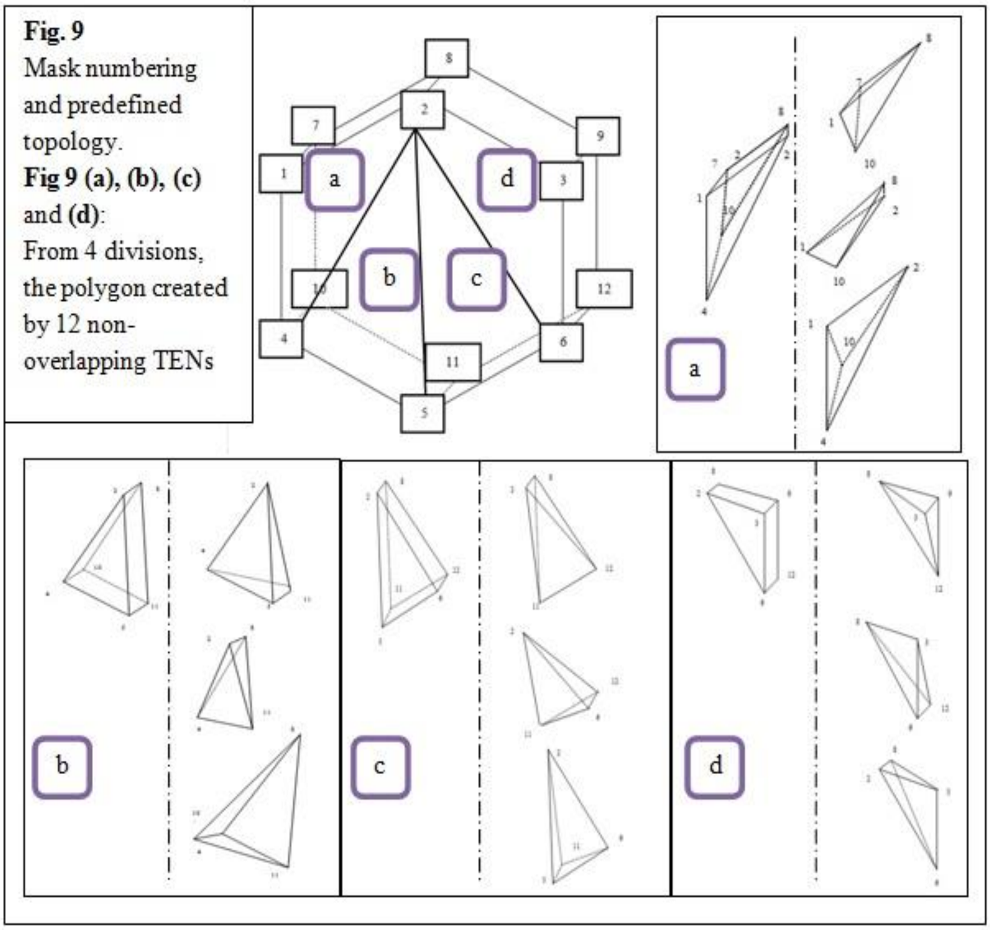

Fig. 9
Mask numbering and predefined topology.
Fig 9 (a), (b), (c) and **(d)**:
From 4 divisions, the polygon created by 12 non-overlapping TENs

In contrast of the used of Gosper curve that laying out the hierarchical data and visualized in 2D map, this study adopted the use of Gosper curve to isolate layers of soil horizontally that form a 3D pattern of dynamic soil water flow. In this model, the subsurface soil is represented by nodes that arrange in sequence of number 1 to 9. The nodes is in Voronoi shaped polygon use Voronoi tessellation to create convex polygon (Auber *et. al*., 2013). For modelling part, Voronoi shaped polygon used to retain water underneath nodes 1, 3, 5 and 7 from flowing down to subsurface flow as a representation of water that retain in the soil. The water starts its infiltration process when it reaches every first node of the 3D Gosper's curve and the water flow according to the sequence number of the nodes. The remaining water that stop moving collected to calculate the overall volume of subsurface flow. The rate of infiltration of water in porous media of soil calculated by using Horton equation (Horton, 1933):

$$f_t = f_c + (f_0 - f_c)e^{-kt}$$

Where:

f_t	infiltration rate at time *t*
f_0	initial infiltration rate or maximum infiltration rate
f_c	constant or equilibrium infiltration rate after the soil has been saturated or minimum infiltration rate
k	decay constant specific to the soil

The advantage of using Horton is that it can also be used to calculate the volume of infiltration (F) after a certain amount of time (t):

$$F_t = f_c t + \frac{(f_0 - f_c)}{k}\left(1 - e^{-kt}\right)$$

Infiltration rate and infiltration volume are both essential in determined the flow of water in the nodes of soil water flow. The time it takes for the water to flow in each nodes, volume of water remain in the nodes, volume of water that reach the subsurface flow layer, amount of accumulation of subsurface flow in the 3D model depends on these equation. The used of Tree-map for hierarchical soil depth determination, Gosper curve that represent soil water flow pattern which is based on water flow accordance with the law of gravity and the use of Horton equation that influence the water flow showed the suitable integration to develop a model of 3D soil water infiltrations.

5.0 Concluding Remarks

This study aims to enliven the 3D research that burgeoning and the focus of the study is on 3D modelling of soil water infiltration in porous media of soil. Environmental related studies have started to show an improvement on the use of GIS for analyzing part. As we know, the process that happen naturally required appropriate modelling methods as some of the process sometimes lead to hazard that are life-threatening, damaging property and disrupting ecosystems. A proper and accurate modelling is needed and the most appropriate model that can handle dynamic and temporal data is 3D GIS geospatial modelling. Integration of 3D GIS with mathematical method can produce a better model for environmental studies. Tree-map that used to show the hierarchical depth of soil modified form its original used that group together the similar information from a high number of data. Besides, by adopting the idea of Gosper curve, the 3D pattern of the soil water movement was introduced to represent the flow route of soil water infiltration. The application of 3D TIN in Voronoi shaped Gosper nodes explain the route and sequence direction of soil water flow in the model. The non-overlapping tetrahedral that form a 3D TIN helps in representing the flow in multilayered of soils. TIN that used to connect three neighbouring (2D TIN) adopted similar principle for 3D TIN where in this study, the 3D TIN constructed to provide sequence of soil water flow in the Voronoi shaped polygon of 3D Gosper curve. 3D TIN used to give coordinate for each nodes of the tetrahedral that represent the location of infiltration occurred. This model beneficial for those who need to know the soil water content, soil water distribution, soil water movement and subsurface water that required in their research. 3D GIS are needed to facilitate the dynamic flow of water that not simply flows linear down the soil but also towards unpredictable direction. The information of water content in certain depth of soil can also being predicted using this model that often change over time. Spatial data model is needed to define the content and structure of data that can be used to carry out the task and operations for the purpose of identifying soil water infiltration.

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