

ESTIMATION OF THE LANDSLIDE, A CASE STUDY OF THE NORTH-WEST VIETNAM

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ABSTRACT

The rain fall-triggered landslide and flash-flood disaster in the North-West Vietnam are frequently serious disasters for human life and society, specially a case in mountain areas in the north-west Vietnam. In this paper we present estimation and prediction method for landslide our method are based on the combination of the fuzzy logic for thematic maps in GIS environment. In addition, technique also used weight and probability methods for estimating information of thematic maps. Data collection in the field work of study area with the big help of Remote Sensing digital images. We demonstrate our model to create levels of landslide hazard map.

1. INTRODUCTION

The catastrophe for modern geology in general and landslide in particular which has caused considerable damage for human and property in many countries in the world, specially in mountainous areas of Vietnam. In Vietnam, although it is studied in nearly time, it is still dispersed and using the traditional methods mainly. From that, the composed application of modern researching method, especially with the help of method for informatics - mathematics in researching for this specific catastrophe is very urgent. For this reason, the authors concentrated on study method for fuzzy expert system in design a prediction model for landslide. In addition, the using of combination of other important methods: The traditional approaching methods; GIS, Remote Sensing (RS) and other ones. The combination of development and applied methods is new and a lot; the results of the set of various maps and tables are very good in the period of estimating, prediction for landslide, especially in mountainous areas. In this paper, we only present the most main contents.

2. METHODOLOGY

2.1. Introduction for expert systems and fuzzy expert systems.

a. Expert Systems is a important property of artificial intelligence (a branch of computer science, which has capacity to implement and calculate in computer, to carry out the period of intelligent process, usually the processing belongs to human intelligence), and is a computer program shape to solve problems in which it requires to have knowledge and skill as well as experiences of human and so on. For the nature, they are programs which built from rules to analyze information, help the period of analysis problems and introduce an active process of researchers....

The basic component of a expert system is a knowledge base (KB) or KB and a “deductive machine” is usually established in a set of rules, typically is the structure “if-then” that called “rule of production”. The deductive machine makes expert system can give reasonableness from rules in KB. Supposing that, *if KB contains the rules of production “if x then y” and “if y then z”, Deductive machine can infer “if x then z”*. And then, expert system

can query users “if x is **true**, what we can give comment on? ”. A simple appearance is: *Does an area can landslide in July? If an answer is defined, system will continuously infer z).*

b. *The fuzzy expert system* is an expert system which uses a set of fuzzy member function and rules to instead of Boolean to be argument for data. The contrary of other expert systems “that main the argument machine for icon is the main”, the fuzzy expert systems concentrated on processing digital. The rules often have shape:

If x is low and y is high then z = medium

With x, y are input variables, z is output variable, low is a component function (a fuzzy subset) they are defined on x, high is a component function it is defined on y and medium is a component function it is defined on z. The role of rule between “if” and “then” is hypothesis and premise of rule. This is a fuzzy logic expression; it is such described that rule to be applied. The role of rule after “then” is conclusion (a resultant clause). This role of rule defined a component function for one or more output variables. Almost all tools work with fuzzy expert systems to allow more conclusion than one per rule. The total of rule groups concentrated as if a rule basic or a knowledge one. The rules in a fuzzy expert system it often has a shape as: 1) Fuzziness; 2) Under the inference (the truth value with hypothesis of each of rule are calculated and supplied to conclusion part of a rule, usually used MIN or PRODUCT); 3) Under the composed operation (All of fuzzy subsets defined for one of output variable which are combined with each other to create a simple fuzzy subset for each of output variable, often used MAX or SUM); 4) option (fuzzy dispossession; has more than 30 methods but methods of CENTROID and MAXIMUM mainly).

Supposing that the variables of z, y and z they all obtained values in [0, 10], the member functions and rules are defined as follow:

$$\text{low}(t) = 1 - (t / 10)$$

$$\text{high}(t) = t / 10$$

2.2. Geographical Information System (GIS) and Remote Sensing (RS)

GIS develops strongly to base on computer technology, computer graphics, the analysis of spatial data and database administration. The authors developed thorough diversified and useful function of GIS [10], such as:

a. *The question and answer and search* function are implemented to base on the special subject natures, topology geometry, algebra, statistics and logic (AND, OR, XOR, NOT).

b. *The spatial analysis function with purpose* is presented the answer for spatial questions and problems for space, include of:

+ The attribute and geodetic functions are in order to create or change attribute but no change their spatial position and create a new spatial element.

+ The Digital and logic overlapping function (Boolean). The emotional area for landslide can be: 1) High rainfall, 2) Slope topography, 3) The original stone has a phan phien structure and a slope angle it has a big position, 4) The land cover is loose and thick, 5) A thin vegetational cover, 6) Fault action and so on. To implement the overlapping function will find out converging area of factors to lead to landslide above. However, depend on a specific case which the effect role of factors for landslide is different.

+ The neighbouring function that is developed 3 function groups in which is search, topography (especially the slope angle and slope direction) and interpolate. By these function groups, the authors designed Digital Elevation Model (DEM) and various uses.

+ The serial function in order to succeed space between positions to process attributes data.

RS is a valuable data that contributed an important part to enrich input information to solve problems for landslide. [3, 4].

2.3. Method for combination of information layers

With the help of information technology, it is easy to use the relational data very much. To combination of information, the authors used methods: *To calculate directly on information layers and digital weight of those information ones; theory of probabilities, the noron network of the reverse transmission and fuzzy logic.*

The map of sensitive levels for the prediction results of flood-landslide, it is researched by: Carrara and other people, 11, van Westen and nnk, 1997, Ercanoglu & Gokceoglu, 2002 and so on. All of estimation methods for flood-landslide are feasible, except from some of factors not sure to occur on areas where deprived of information, knowledge and capacity. Because of estimating for flood-landslide area to require potentiality and simplification, although this estimation is complicated. According to Zadeh, fuzzy logic is one of the formulas that are used to solve difficult problems above. The opinion of fuzzy logic is examination of the spatial objects on map as if the members of set and attends to the opinion of those member functions.

To describe the level of fuzzy member function with aspect of distribution of researching object, with map, common distribution of researching area which are calculated in a unconnected distance, the member function have relations with mapping layers and on the contrary these mapping layers have the member values are fuzzy. The fuzzy logic are not only distributed and installed on information layers of map but also used data of every rate to calculate its digital weight and expert's experiences. The method for fuzzy logic allows to combining many flexible types toward kind of digital weight maps, and can enforce in GIS easily and then can control by programming. Unlike the type of data controlled as if the digital weight of a sign or logic recurrence, using of the position was knew the same objects such as geological catastrophe for landslide to estimate digital weight or coefficient.

The opinion of fuzzy logic in map is catastrophe position which considered as spatial objects on map and also as the member of set.

We can calculate the member functions $\mu(x)$ for each of information layer.

$$\eta(x) = \frac{EDF - R}{EDF - R + \overline{EDF - NR}} \quad (1)$$

In this formula, $EDF-R$ is a function of experience distribution of areas which are acted again and $\overline{EDF - NR}$ is a function of experience distribution of areas where not be active again of catastrophe.

The special maps can mention such as: Topography elevation, slope surface, rainfall, stream-river network and different levels of the weathered layer. They are classified and rate to base on knowledge and experiences of researching periods for factors and their effects on catastrophe.

The function of member presented 2 or more special maps for a set, the difference between operators can present to combine the member values (this member is according to GIS meaning which is a layer or a special map) Zimmerman (1996) described the difference of the combination values and 5 operators is called the fuzzy combination operators of AND, OR, PRODUCT, SUM and GRAMMA. In the study, we used the fuzzy gramma operator to combination with fuzzy member functions. Gramma operator is defined in terms of fuzzy algebra it has sum is:

$$\mu_{combination} = (\text{Fuzzy algebraic sum})^y * (\text{Fuzzy algebraic product})^{1-y} \quad (2)$$

When ...value is a fuzzy member function, y is parameter that selected in distance $[0,1]$, and the sum of fuzzy algebra and multiplication of fuzzy algebra are calculated to use correlative formulas (2) and (3 và 4):

$$\mu_{Product} = 1 - \prod_{t=1}^n (1 - \mu_i) \quad (3) \quad \mu_{sum} = 1 - \prod_{t=1}^n \mu_i \quad (4)$$

With μ_1 is a fuzzy member function for i map ($i=1,2,..n$) And combined with each other. Using of fuzzy gramma operator when y is combination as the sum combination of the fuzzy algebra and on the contrary if value is 0, the value after combination as the combination formula of fuzzy product operator. The choice the value of y is an output value ensure definitely will increase or decrease in values of fuzzy sum or fuzzy product components.

3. APPLICATION AND RESULTS

The estimation and prediction problem for landslide is rather complicated, mainly analysis, calculation and integration all of information and result of each method in order to make a regional map and general prediction which represent for all of information. The basic component to impact on landslide phenomenon is data collection according to basic maps include of: 1) rainfall, 2) Topography (slope angle, segment and so on), 3) the original stone, 4) Distribution of loose land cover and their using process, 5) Vegetational cover, 6) tectonics, 7) The stream-river systems in a area, ... as component layers with **shp** sets (that is a standard set of digital information layers). We used a standard set is designed by Environment System Research Institute – ESRI, in addition, also build DEM and integrate to maps have the same projecting grid. The result of problem that solved above, apart from depend on selected method, programming skill, also depends on database very much.

Although GIS can supply tools and features in calculating progressing, to lead for technology and will be appropriate with special condition of Vietnam. The authors are programmed by Visual C++ language in GIS environment of sets of special maps they are digitalized with nuclear and combined to base on fuzzy operators and fuzzy rule of maps.

In a special map, to approve the fuzzy logic and landslide positions (is the members of set), as if the spatial objects. The progressing of implementing to install a prediction model is showed Fig 1.

To install software, authors programmed by open source tool. The function of software allows to opening a Vector file (shp file), read a database file and programming to calculate with Raster data type. The function of GIS is not only useful to determine topographical slope, current and slope directions; but also supply for programmer to create the operational functions to calculate the important information layers of a problem. Fig 2 showed to create grid and describe a current.

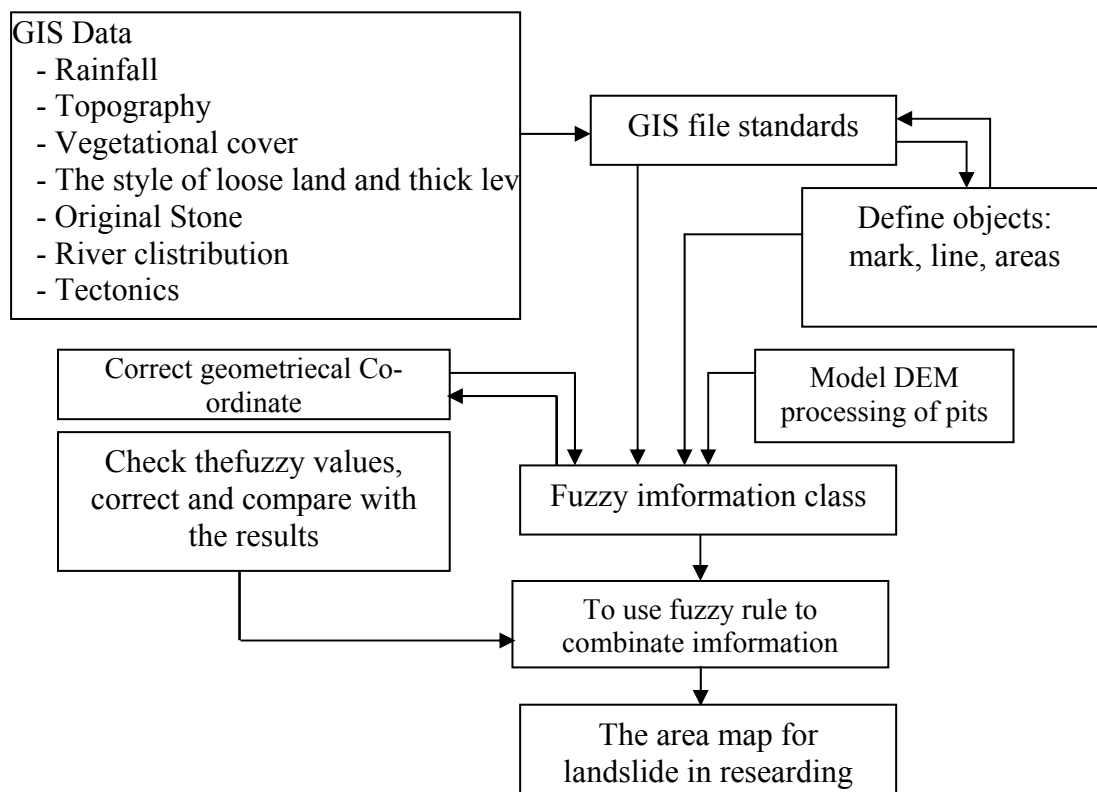


Fig 1. To implement toinstall the prediction model

Open Source help to read and record a **shape** standard file, include of **shx**, **dbf** and **shp** files, can download from network free and refer to in Websites:

1. <http://freegis.org>.
2. http://www.forestapal.com/Toolbox_GPS.html

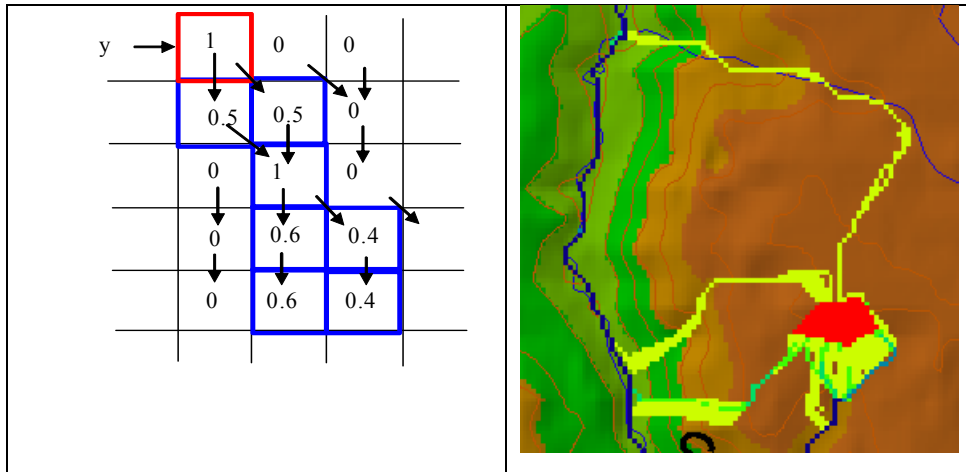


Fig 2. The diagram illustrates to estimate grid, describe a cuurrentriver

The functions:

Read a vector data file of map

Read and record header file *static void SHPWriteHeader (SHPhandle psSHP)*

Read and record vector data file: *SHPhandle SHPOpen (const char*pszLayer, const char*pszAccess)*

Allow to creating file Shp *SHPhandle SHPCreate (const char*pszLayer, int nShapeType)*

The part of reading database

Transfer from vector file to Raster

Allow to overlap Raster and Vector (Fig 3)

The result of prediction model is showed in Fig 3

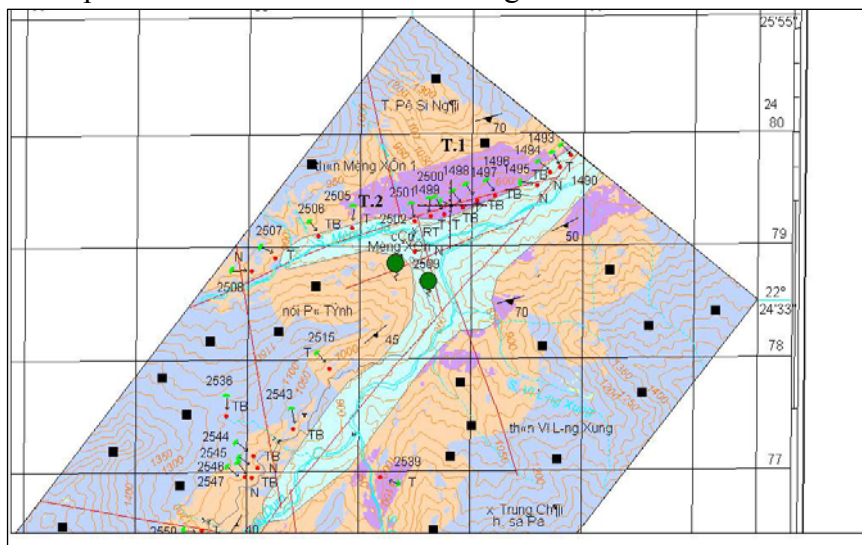


Fig 3. An angle of the sensitive regional map for landslide

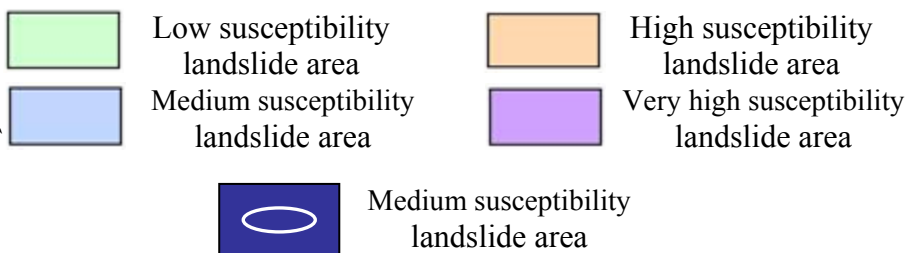


Fig 3 on the map, it localized the sensitive areas for landslide in researching region is a mountainous area.

After having the result and going out in the field to update information, showed that the area where happened to landslide was recorded by the result of running a model and happened to landslide in the fact (often attached flood) or usually coincided with area where have a road system to divide into water in a high level, a less vegetational cover, the weathered land layer is loose and thick. Can consider: the result of obtaining from model is very appreciate to the fact.

4. CONCLUSION AND EXCHANGE

In Vietnam, the problems of estimation and prediction research for changes of geological environment in general, landslide in particular is interested in studying by institutes and a group of scientists. We belong to among the authors to present to compose researching from tradition to modern. The enforcement of method combination is very high and can apply for many territorial regions. However, one of algorithm has an individual degree of accuracy and influence by experiences in fact and the skill of researchers. The input data is also very important, if sufficient and comprehensive; ensure that will have a good result.

Through of studying, finding out and exchanging; with the initial opinions, we proposed several solutions to prevent, reduce damage because of landslide (included of flood) as follow:

- + It is necessary to have a plan, using, reasonable development for land, forest and residential area, and so on.

- + The application of comprehensive and effective measures to prevent and control catastrophe, specially build a following system, geodesy and so on, and invested in technology appropriately.

- + To build a database strongly and applied the modern methods; in which information technology played an important role to manage, monitor, process and help fast to present a decision.

- + It is necessary to deploy an applied informatics project, specially design a set of management software, reproduce, predict for landslide, and flood in particular and modern geological catastrophe in general.

The problems which authors mentioned above is very complicated, relative with many special fields, the authors wish to co-operate with specialists in many fields in order to have the most satisfactory results.

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