Application of Geographical Information System for Analyzing and Managing Geospatial Commands: A Case of Editing and Checking of Land Parcels' Boundary

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Abstract

This study aims to analyze and manage commands using Geographical Information System (GIS) techniques, were used for editing and checking boundaries of land parcel in form of digitized GIS data from satellite and aerial imagery. The study area was focused on Kham Sakae Saeng district where establishes in Nakhon Ratchasima (NK) province of Thailand. For method, ArcGIS ModelBuilder was used for modeling GIS tools. Firstly, we planned the workflow from the concerned Department of Lands (DOL) officers that was divided into three groups: editor tool, reshape tool and topology tool. Then, the used GIS tools in each group were represented in form of diagram on ArcGIS ModelBuilder including running and validating model. In three diagrams of ArcGIS ModelBuilder, using reshape tool and topology tool have the high accuracy that 92.02% and 81.07% respectively. Using editor tool has the lowest accuracy (60%). This study suggests increasing of accuracy that should have to expand the details of the sequent process of caused tool. For this approach, the ArcGIS ModelBuilder tool is advantageous for automating the process; this also allows easy updates on data and analyses of checking shape of land parcel boundary. This automated checking is a flexible, time-saving, and cost-effective tool for screening large areas for the DOL practical officers.

Keywords: Geographical Information System, Geospatial Commands, ModelBuilder, Land Parcel.

1. Introduction

From the 20-year National Strategy between 2018 and 2037, there is one strategy on developing public management systems under the government sector, especially data and information are always developed and up to date based on digital system. For developing the digital land parcels, Department of Lands (DOL) has been creating land parcels' boundary from paper to digital format. Therefore, DOL has used Geographical Information System (GIS) for these works above. Generally, GIS is a geospatial tool that uses for manipulating and analyzing between spatial datasets and the purpose of solving geographic problems. In the same way, the GIS technology has become particularly useful to create and implement models for problems of spatial nature [1]. Moreover, the successful GIS analysis requires selecting the most appropriate tools to operate on your data and several major benefits to automating makes work easier, faster and more accurate [2]. In this creating of land parcel boundaries, DOL has hired Thai universities to assist in this work and then DOL will check such land parcel' boundaries before will be stored in geodatabase further.

As mentioned above, this study would like to contribute the concerned DOL officers for automatically editing and checking boundaries of land parcel in form of digitized GIS data from satellite and aerial imagery. Actually, these works already have done by DOL officers based on using ArcGIS program. However, it is not an easy-to-use application for checking land parcels' boundary because we do not have running workflow containing a sequence of tools. For benefits,

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this will help DOL officers because ModelBuilder allows them to string together multiple steps of a process by building a diagram that depicts their desired workflow. If they're familiar with graphical programming environments, or visual programming languages that use block diagrams, then they may find ModelBuilder to be similar. On the other words, this advantage of ArcGIS ModelBuilder that is good for users who are not familiar with commands or icon for checking land parcels' boundary. Similarly, users have spent the past decade using command-line interfaces to write macros and for-loops, so when they learned about ModelBuilder, we were intrigued by Lavery [3]. In this study, we will try to learn that it's a great way to make DOL officers' workflow repeatable while also making a great visual representation of the whole sequence. If they want to automate a multi-step geoprocessing workflow, we encourage them to use ModelBuilder. Thus, this study contributes to produce the geoprocessing workflows for editing and checking boundary of land parcels to DOL. This geoprocessing workflow will help to save time because visualization of workflow sequence as an easy-to-understand diagram, adding and connection data and tools, iteratively process every feature class, and sharing or using Python scripting and other models. In addition to having a stored process, they'll also get and share a visual representation their geoprocessing workflow to exchange commands together for developing land parcels further.

2. Theoretical background and related researches

2.1 GIS data model

GIS is designed to capture, manipulate, store, analyze, and manage data [4]. In other words, GIS is both a database system with specific capabilities for spatially-referenced data as well as a set of operations for working with the data [5]. In order to visualize natural phenomena, one must first determine how to best represent geographic space [6]. The spatial objects in the real world can be thought of as occurring as three easily identifiable types: points, lines, areas or polygons, and volume or surface [7], [8], [5] and can show as Figure 1.

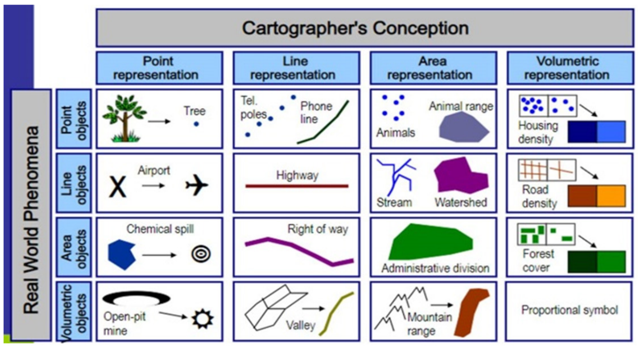

Figure 1. *Cartographer's conception [9].*

In addition, a range of vector data structures include three basic types [8] and shown in Figure 2: (1) spaghetti models, (2) topological models, and (3) vector chain codes. The spaghetti model is a one-for-one translation of a graphical map image that is natural and logical because the map is maintained as the conceptual model [10]. The topological model is conceptualized as a one-for-one translation of the analog map with the geometric relationships (topology) among objects [8]. Lastly, the vector chain codes are created by the U.S. Census Bureau to automate the storage of street map data for the decennial census [11]. In this model each segment ends when it either changes direction or intersects another line, and the nodes are identified by codes.

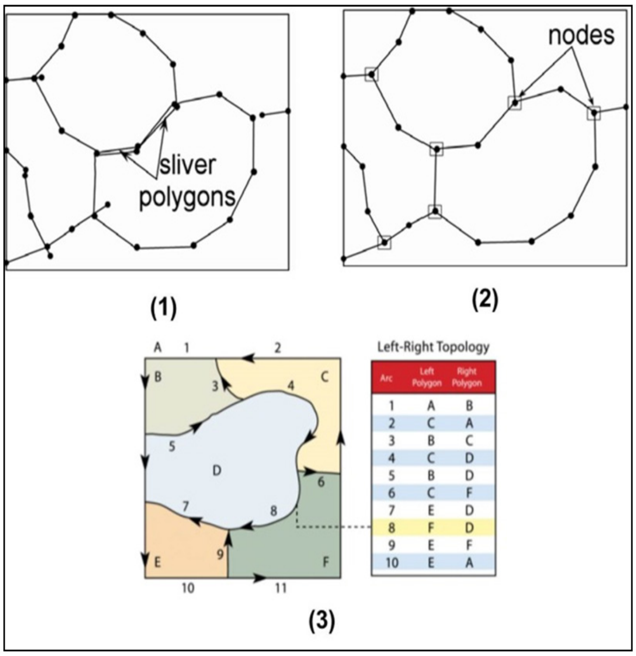

Figure 2. *The range of vector data structures, (1) spaghetti models [12], (2) topological models [12] and (3) vector chain codes [6].*

2.2 ArcGIS ModelBuilder for land parcel

ArcGIS ModelBuilder is a visual programming language for building geoprocessing workflows that geoprocessing models automate and document the spatial analysis and data management processes [13], [14], [15]. Similarly, Vu et al. [16] mentioned to the ArcGIS ModelBuilder tool, was advantageous for automating the estimation process; this also allows easy updates on data and analyses of impact on groundwater extraction from land use change. ArcGIS ModelBuilder, can create, edit, and manage models [15] and can be represented as a diagram, flowchart, or workflow that chains together sequences of processes and geoprocessing tools, using the output of one process as the input to another process [13]. This study has studied ArcGIS Modelbuilder of Boden [17], is able to be briefed by the simple six approached steps for starting as follows:

1) Plan the workflow: List the data input, identify the required geoprocessing tools, and describe the desired output.

2) Create the Model Shell: When you create a new project, a toolbox with the same name as the project is automatically created.

3) Add tools and set parameters: First, you will need to understand ModelBuilder vocabulary. A model consists of one or more processes. A process consists of three elements: data input, commands for operation and data output. Each output can become input for the next process.

4) Validate the model: After you've added all the tools and set their parameters, it's time to ensure the model will run properly by validating it. Validation is easy-just click the Validate button with the green check mark on the ModelBuilder tab. During validation, if there's an error, processing will cease at the process with the problem.

5) Run the model: There are two options for running a model that are inside or outside ModelBuilder. A model inside is run by clicking the Run button and the model outside is run by running the model as a tool or service.

6) Run it again (optional): A model's final output may raise a question.

In addition, another advantage of the ModelBuilder is that the user can export the Arc GIS models directly to the Python scripts and the user then can make necessary changes in the script itself, if any, and run the script directly from the command line options [18]. ModelBuilder was chosen as the main platform for data manipulation and analysis for its versatility e.g., the different workflows for creating and cutting down the time on opening and running separate tools, the visual workflow creator for a flexible interface, providing easy editing, streamlining automation of frequently run processes and assessing conservation criteria individually and together with users etc. [1].

Using ArcGIS ModelBuilder for land parcels, there are various papers that show application of ArcGIS ModelBuilder, for example, Vu et al. [16] used for easy updating on data and analysing of impact on groundwater extraction from land use change; Soylu et al. [19] offered for a user interface to enter the input parameters interactively by the user; Domazetovic et al. [20] used for susceptibility modelling-based multicriteria analysis.

In addition, there are various papers that using GIS techniques for creating and editing shape of land parcels as follows:

ESRI [21] identified the most valuable parcels to protect. The tool, the Land Priority Protection Model (LPPM), utilizes ModelBuilder in ArcMap 10.x to identify areas of land best suited for conservation. It applies conservation criteria to private land to weight, rank, and strategically score parcels. The decision support criteria are the fundamental components of LPPM.

Bozeman et al. [22] calculated runoff over land parcels using ArcMap ModelBuilder for building model to calculate the average runoff expected to flow over each undeveloped parcel in the city of Bluffdale.

Elsheikh et al. [23] studied Agriculture Land Suitability Evaluator (ALSE) for a decision and planning support tool for tropical and subtropical crops using ArcGIS ModelBuilder for evaluating land model from the basic layers up to the final suitability layer.

Schaller and Mattos [1] applied ArcGIS ModelBuilder for landscape development planning in the region of Munich, Bavaria using GIS models implemented with ModelBuilder were initially developed to describe the relationships between resource potentials and sensitivity of impacts. Each conceptual model was detailed, incorporating scientific assessment criteria from literature and expert ratings. The 'potential maps' were overlaid with the land use map to identify and quantify conflicts between land use and resource functions. 'Goal maps' were created based on the intensity of conflicts identified in relation to the pre-defined development goals.

3. Research Methodology

3.1 Study area

This study focused on Kham Sakae Saeng district where establishes in Nakhon Ratchasima (NK) province of Thailand (Figure 3). It is the north of Muang Nakhonratchasima district. The study area covers 3.11 sq.km (1,946 rai) that includes population 5,480 residents. Geographically, study area locates between 190000-240000 (x-UTM coordinate) and 1680000-1750000 (y-UTM coordinate).

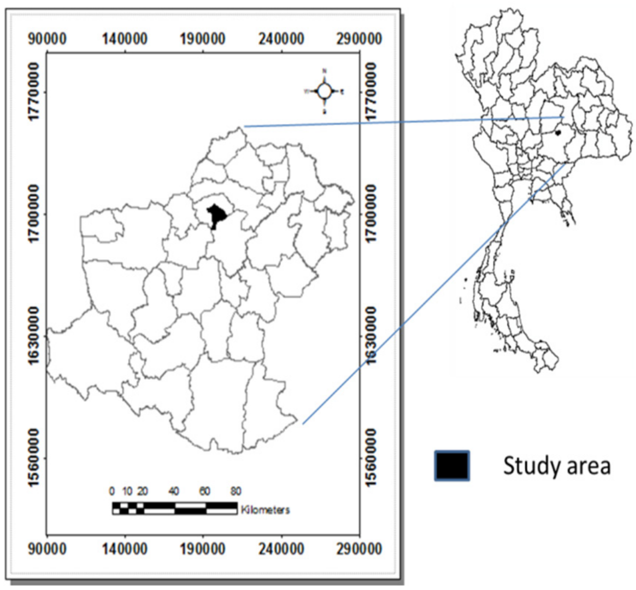

Figure 3. Kham Sakae Saeng district.

3.2 ArcGIS ModelBuilder applications for Checking land parcels' Boundary

This study used guideline of Boden [17] for designing and modifying ArcGIS ModelBuilder application as follows:

3.2.1 Planning the workflow

Data input was listed by using the required geoprocessing tools and the desired output as follows:

1) Data input included aerial photos, the formal deed documents, the digitized-GIS layers from Mapping Technology Division of DOL.

2) The required geoprocessing tools were collected from DOL officers such as ArcGIS tools and commands, is used the real work for checking boundary of land parcels. There are main three ArcGIS tools (as Figure 4): (1) editor tool for adjacent land parcel and does not have gap each other (Figure 4a), (2) reshape tool for single land parcel (Figure 4b), and (3) topology tool for adjacent land parcel and does have gap each other (Figure 4c). Therefore, ModelBuilder was created by using such three tools above.

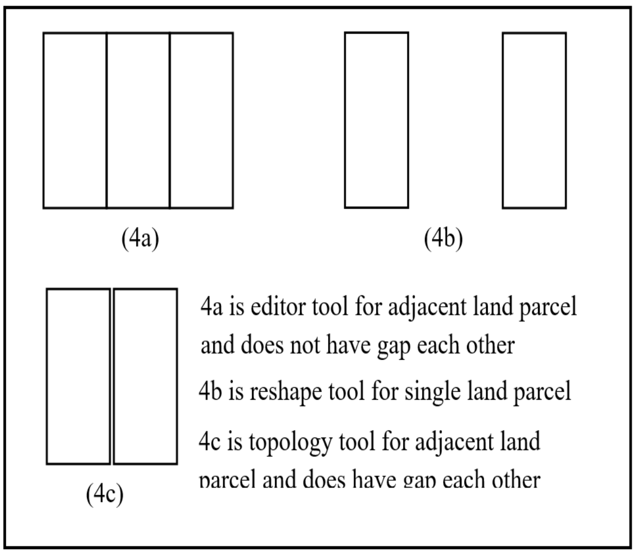

***Figure 4.** Characteristic of land parcels-based using ArcGIS tools from DOL officers.*

3) The desired output requires the formal GIS boundaries of land parcel that are presented on DOL web (http://dolwms.dol.go.th/tvwebp/) [24]

3.2.2 Modeling ArcGIS ModelBuilder

1) Preparing GIS data

In this GIS modeling, we selected layer of 885 polygon that was accurately checked in field already. For reason, their polygons had to be used for validating results of ArcGIS ModelBuilder. Therefore, we prepared 2 GIS layers: (1) one digitized layer that it was not checked (layer of 885-polygon for modeling) in field and (2) one digitized layer that it was accurately checked in field already (layer of 885-polygon for validating). In such 2 GIS layers above, they were selected and exported into three layers according to group of using three-ArcGIS-tool: (1) layer of 190-polygon for using editor tool, (2) layer of 489-polygon for using reshape tool, and (3) layer of 206-polygon for using topology tool.

2) Creating and validating ModelBuilder

This study used to process checking boundary of land parcels that was digitized on aerial photos and satellite data. These boundaries were validated with the polygon-layer that was investigated in field already. The steps are for creating and validating ModelBuilder in ArcGIS (modified from ESRI [15] as follows:

2.1) There were three new toolboxes: editor tool, reshape tool and topology tool that were created and modeled (they were represented as a diagram that chains together sequences of processes and geoprocessing tools, using the output of one process as the input to another process). Each group of such three tools consisted of geoprocessing tools as Table1.

2.2) Results of ModelBuilder in 2.1) were run and validated by using feature compare (data management) with process of ESRI [25]. Firstly, we open ArcGIS program and prepare data for validation as follows:

- Input base feature: the digitized layers but they are not checked.

- Input test feature: the digitized layers but they are accurately checked in field.

- Sort field: The field or fields used to sort records in the Input Base Features and the Input Test Features.

Table 1. *The group of geoprocessing tools for this study.*

No.	Groups of created tool and Geoprocessing tools
1	Editor tool included gap/overlap, edit vertices, continue features tool, cut polygon tool, copy/paste, open attribute table (edit data: Land_NO; PINCODE; UTMMAP1)
2	Reshape tool included copy/paste, advanced editing (replace geometry tool), open attribute table (edit data: Land_NO; PINCODE; UTMMAP1)
3	Topology tool included topology (validate topology in current, gap, error inspector, visible extent only

- Compare Type (Optional): the comparison type. The default is all, which will compare all properties of the features being compared.

- Ignore Options (Optional): these options were not be compared e.g, Ignore Ms, Ignore Zs, Ignore PointIDs etc.

- XY, M and Z Tolerance: the default XY tolerance is. 001 meters, or 1 millimeter.

- Attribute Tolerance: the numeric value that determines the range in which attribute values are considered equal. This only applies to numeric field types.

- Omit Fields: The field or fields that will be omitted during comparison. The field definitions and the tabular values for these fields will be ignored.

- Continue Comparison: comparison between checked and unchecked properties.

- Output compare file: this file will contain all similarities and differences between the input base features and the input test features.

- Derived output: The compare statuses were be 'true' when no differences are found and 'false' when differences are detected.

4. Results and Discussions

4.1 Layer of 190 polygons for using editor tool

Using editor tool, there is 114 polygons for true (60%) and 76 polygons for false (40%). Such false polygons are caused by creating topology and continue feature tool. Creating topology may try other topology tools such as validate topology in current extent and setting. For continue feature tool, we have to expand the details of the sequent process of the tool. In addition, this study found that step of creating topology and continues feature tool used to take a lot of time in run output and shown in Figure 5.

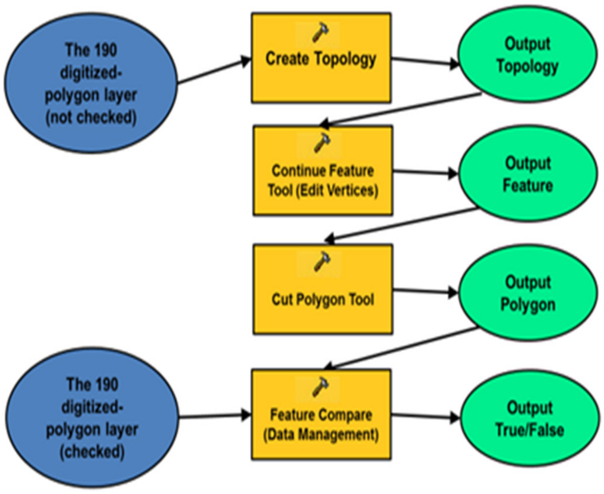

Figure 5. *ModelBuilder for using editor tool.*

4.2 Layer of 489 polygons for using reshape tool

Using reshape tool, there is 450 polygons for true (92.02%) and 39 polygons for false (7.98%). This reshape tool has highly accurate because each polygon locates single or does not have continuous. Therefore, we do not worry gaps among the continuous polygons. Such false polygons are caused by advanced editing. Thus, we have to expand the details of the sequent process of advanced editing and shown in Figure 6.

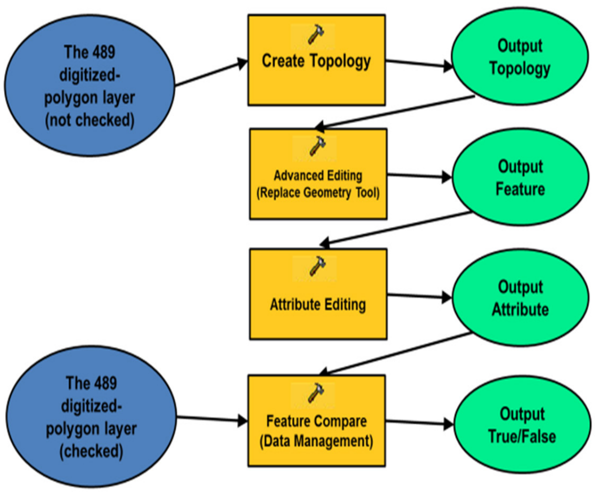

Figure 6. *ModelBuilder for using reshape tool.*

4.3 Layer of 206 polygons for using topology tool

Using topology tool, there is 167 polygons for true (81.07%) and 39 polygons for false (18.93%). This topology tool has highly accurate because this tool helps to eliminate gap among polygons. Such false polygons are caused by error inspector so we may expand the details of the sequent process and shown in Figure 7.

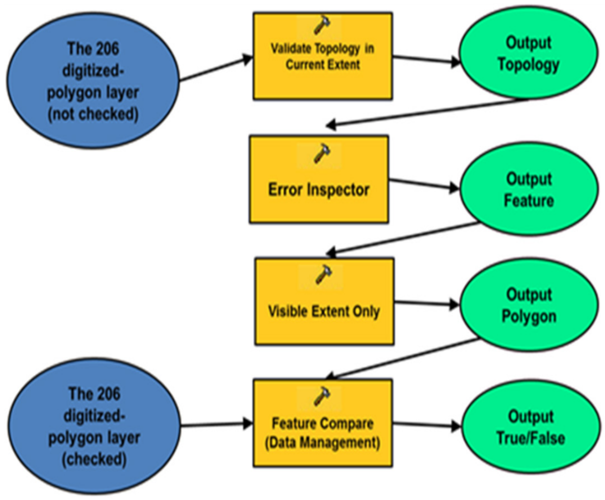

Figure 7. *ModelBuilder for using topology tool.*

Moreover, workflow of ModelBuilder can help time saving from 0.5-1 day to 1-2 hours for new DOL officers who are not familiar with commands or icon for editing and checking land parcels' boundary in ArcGIS (from direct inquiries to the 6-DOL staffs responsible for this work) as Figure 8.

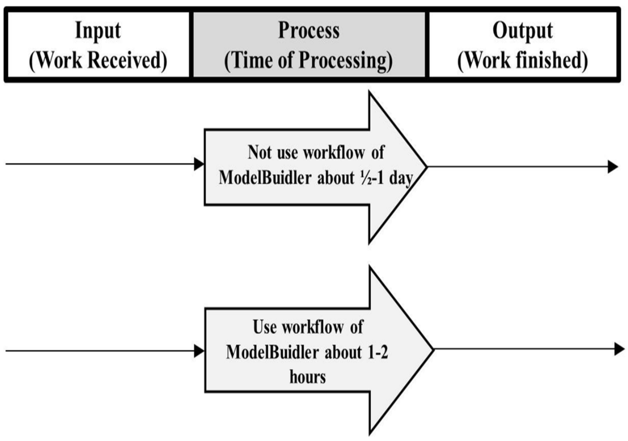

Figure 8. *Using time of processing for editing and checking land parcels' boundary in ArcGIS.*

5. Conclusions

In three diagrams of ArcGIS ModelBuilder, using reshape tool and topology tool have the high accuracy that 92.02% and 81.07% respectively. Using editor tool has the lowest accuracy (60%). This study suggests increasing of accuracy that should have to expand or cut the details of the sequent process of caused tool (such as details of using edit vertices that they should add or delete vertices and segments). Moreover, if the sequent process (commands) is added or reduced, it will support to define them in term of using differently or more flexibly.

For this approach, the ArcGIS ModelBuilder tool is advantageous for automating the process; this also allows easy updates on data and analyses of checking shape of land parcel boundary. This automated checking is a flexible, time-saving, and cost-effective tool for screening large areas.

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