Modification of User Friendliness into a HydroGIS Tool

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Abstract— In present context venders have developed fewer number of GIS software to perform advanced GIS manipulations with customised tools for specific uses. Nevertheless those provide general functions, whilst the real world-applications demand advanced geospatial calculation in customised ways. The automation of hydrological model for decision making in urban development is one of such areas which needs customised GIS tools. Such tools are to be handled by non-GIS experts; hence software developers have to develop user-friendly GIS extensions. However at the present there is no proper guideline to develop user- friendly Hydrological-GIS (HydroGIS) tools, hence it becomes a considerable time consuming process. Then main objective of this research is to find the important areas which the developers must pay the maximum attention to result the user-friendly HydroGIS tools. For that, in line with present software development guidelines which found through comprehensive literature survey, a HydroGIS tool was developed. Then it had been tested with the potential users for user-friendliness. Based on the user responses, the repetitive design and development process was practised to achieve the saturated level of user satisfaction. When such, the work able to isolate; the Easy GIS Operational capability, Information Security, Spatial Data Error handling & Accuracy Confirmation, On-Screen Capability, Continuity in Operation and Tested and Verified Results as the main areas to be considered in HydroGIS tool development. The works demonstrated the requirement of specific guidelines to achieve the higher user-friendliness when developing software for specific models.

Keywords*— User Friendliness, GIS Automation, HydroGIS*

I. INTRODUCTION

A. Background

User friendliness is a sine-quo-none of the present day IT systems. Since the first popular GUI development out in 1995 with the release of Windows 95, computers became day to day use equipment. Today the users are very particular about their requirements and if such do not satisfied, they refuse entire systems even if the architecture of a system is the best. Therefore the user friendliness is very much important.

The studies revealed that a strong ergonomic characteristic of users, where it is emphasised that "Users feel User Interface is the System" (Veer & Vliet, 2001) Therefore in the development of a user friendly UI, there are many requirements to understand human factors and related issues.

Same as the other practical IT systems, user groups of the Geographic Information System (GIS) are also changing from IT expert to less experienced people who experts in geo-analysis. Due to the use of highly technical analyses In GIS, the system usability becomes a crucial issue and the user interface plays the main role in searching for solutions for that. Therefore in order to design suitable GIS interfaces it needs to identify how people think about their application requirement and space domain and how user attempt to solve their space-related problems (Riedemann & Kuhn, 1999)

B. Literature Review

In the initial stages the accounted GIS-GUI issues were related to navigation, scale, symbology, legends and map editing. Even present day such geographic visualization issues were not answered properly and further it has raised another issues related to real geographic query language, compatibility and portability. Furthermore researches highlighted the GIS software are carrying usability and usability evaluation issues. Usability issues arisen, partially due to their intrinsic complexity but also due to their interfaces and the difficulties that arise when operating them. Usability evaluation issues arisen due to; lack of consistency and cross verification between evaluated results, domain orientation and proper guideline ((Urdang, 1992), (BEST-GIS, n.d.), (Haklay & Jones, 2008), (Masud & Hossain, 2009), (Rafique et al., 2012)). Nevertheless, all these studies based on development of the user interface of the main GIS software.

WebGIS interface development is another area of the study, however the users and usage of the WebGIS is differ from the interest of the present work. Nevertheless when summarising the available guidelines, the WebGIS interface development research's guidelines were also considered. (Skarlatidou et al., 2013).

But when consider the present day comprehensive GIS analysis need for critical decision making, the requirement is to customise the GIS software due to knowledge workers need quickly and accurately assess a situation and act accordingly. As well potential users of such GIS applications are not GIS professionals and are lacking time to learn such specific field. To satisfy the non-GIS users with spatial solutions, developers need to build domain specific user-friendly comprehensive GIS applications. Development of a GIS tool from the scratch is to be a definite time consuming overwhelming development effort which not cost-effective. (ArcGIS Engine, 2004), (Merkel et al., 2008).

Adaptation made to a generic system to satisfy individual specification is called as Customisation. Because of the GIS application diversity, GIS software developers are concerning on developing a generic suite GIS analysis tools, together with facility of customisation programming capability. Then the application developers could able to create domain specific vertical applications. In such developments modification to the standard GUI of GIS can be observed. Nevertheless it does not obstruct the sophisticated users and they are allowed to access the underlying core GIS capabilities/database with capability to extend the core class libraries or reuse objects within their own programs. Traditionally, GIS software provide their own programming languages, but allow to develop tools with other programming language such as .net, Visual Basic, Visual C++, Java and etc. (Maguire, 2005)

Hydrological decision making is a one of such GIS knowledge urged domain. Use of GIS to urban flood management is a demanding application of the urban authorities. Diversion of Storm water from urban housing allotments directly to the road drains has been recognised as the major cause for urban flooding. Due to the land developments in the form of changes to slope, soil and land cover, it increases surface runoff which overloading of urban drains. Hence GIS could be utilised to calculate the surface runoff increases due to modification and reduce affect by introducing detention pit option. Nevertheless these comprehensive hydrological calculations are to be handled by the technical persons who are not GIS professionals as well as hydrologist. In order to support these non-technical urban land managers, the present work carried out the development of a Hydro-GIS tool. Due to the different extreme specialist knowledge usage the proposed tools has to 100% user friendly. To achieve the higher level of user friendliness, it has to follow systematic development methodology with specific guidelines. Nevertheless at the present there are no proper guidelines to develop user-friendly customised HydroGIS tools.

After a comprehensive literature survey to identify the available user interface development best practises and guidelines, the important requirements and recommendations interpreted or extracted are shown in Table 1. As per the researches, to achieve maximum user acceptance and the usability of product, it should practise the iterative design and development methodology ((GNOME, 2004), (Nielsen, 1993), (Sullivan, 1997)). Nevertheless, whilst the tool developing it has realised that these guidelines are not guided to gain the higher level of user satisfaction.

C. Objective

Therefore the main objective of the present work is to identify important characters which the developers must pay the maximum attention to result the user-friendly customised GIS tools which applicable to Hydrology domain.

II. METHODOLOGY

A. Tool Development

A hydro-GIS tool was developed for compare storm generation at the pre and post urban development scenarios and suggests dynamic detention storage to minimise if affect due to modification. To the tool development, ESRI's ArcGIS software was selected as the parent GIS software and Visual Basic 6.0 was selected as the coding language. User testing was done for the suitability of interface design and then to assess the user friendliness (Nielsen, 1993), (Pradeep & Wijesekera, 2008).

Table 1: Summary of Available Guidelines and Principles

Guideline / Principle	Incorporated Tool Considerations
General Principle for GIS GUI development	
Ease of navigation	Identified popular GIS software and checked availability of required functions. Identified capability to incorporate extensions to GIS software, and Capability to allow other functions simultaneously were incorporated
Zooming and panning	
Scale facility	
Permit the user to navigate while keeping track of current reference frame	
Provide tools for capturing, editing, and printing maps	
Map in a larger percentage of the screen area	A relatively smaller dialog box was incorporated minimizing obstruction of the map display area.
General Principle for GUI development	
User centred design	Identified user needs and appropriateness of GIS functions
Visual clarity	Simple GUI, less screen area, operating as the Top most window, Ability to minimize and operation
Iterative design process	formative and summative testing of the prototype and semi developed product
Consistency	Supporting GIS software short keys, meaning of the standard functions etc. Zero disturbance to other operations on parent software
Explicitness	Use of appropriate screen sequences and metaphors User survey carried out to identify the explicitness of tool execution
Appropriate functionality	Command buttons labelling done with GIS terminology and appropriate GIS compatible functions including balloon help to facilitate user confidence.
Flexibility and control	Incorporation of Capability of on-screen operation (Draw, Select)
	Hard coding of GIS functions that provide for reliability and consistency.
Error prevention and correction	Permit user verification of results and incorporation of undo facility with testing on repeats.
Compatibility	Checking the ease of installation and operation without conflicts
User guidance and support	Simple and clear error and informative/ help message, user guides and admin guide with Result shown in the map interface
Informative feedback	

B. Iterative Design and Development Process

In order to develop a user friendlily tool, the development methodology was design to identify and fix usability problems throughout the tool development process. The evaluations consisted of testing and modifications. These were done in repetitive two stages which can broadly identify as Formative and Summative Evaluation (Pew & Mavor, 2007). In the development process, the evaluation used a methodology as shown in the Figure 1 which is an iterative design and development process. The objective is to isolate the most important areas in Hydro-GIS to satisfy the user needs and then gain the user-friendliness.

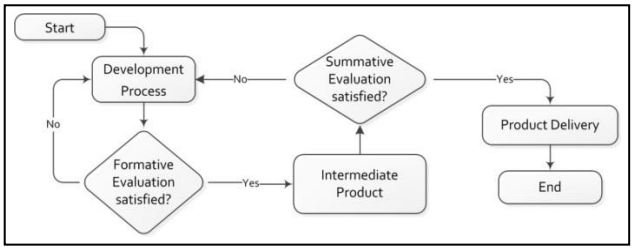


Figure 1: Iterative Design and Development Process

C. Identification of important factors on Hydro-GIS User-friendliness

Through the repetitive design and development process numbers of intermediate products are evaluated against the user friendliness. The initial design is done with the available guidelines. Each the feature which user observed or informed as dissatisfied in the evaluation is taken as new consideration. The formative evaluations were done until no new consideration arises as well as the overall level of satisfaction is reach to at least 80% for each and every consideration. Then all the considerations were taken as the important factors in achieving Hydro-GIS user friendliness, when the maximum user satisfaction resulted from evaluations.

D. Formative evaluation

An adequacy test for the tool was done during the development. A user sample of 33 persons from various fields of GIS was asked to execute the same exercise using the tool. During the operation of each step of the exercise, a feedback was taken. This feedback was very useful to develop a better customised product as it enabled obtaining a better understanding of user needs and provided opportunity to refine requirements while monitoring how closely the modified designs match the user needs (Pew & Mavor, 2007). In the next steps the tool was evaluated against the objectives using a structured questionnaire. The second version's GUI was

changed significantly due to influence of the results of first formative questionnaire. The questionnaire contained qualitative statements and allowed to express a user's qualitative feeling through a five scale Likert scale. Further questionnaire enabled the users to give their personnel opinion in each statement. The test was done twice with user samples of 34 and 31 for version 1 and 2 respectively.

E. Summative evaluation

Summative tests at the end of development were to have a formal acceptance criteria derived from the usability requirements (Pew & Mavor, 2007). This evaluation was done just prior to the product delivery. It was tested with 34 potential users who did not participate in formative evaluation.

F. Knowledge acquisition through User questionnaire

Questionnaires were developed to acquire the user satisfaction based on three basic requirements and to update the tool accordingly. The three basic requirements and the statements/questions developed to assess user satisfaction are shown in the Table 2.

Table 2: Basic Requirements gathered from the questionnaires

Basic Requirement	Question target to acquire the Users' satisfaction on
Assess the achievement of Objectives	Installation of the tool, Start the tool , Layer selection, Modify the selected layers and attributes, Update modifications , Modification of onscreen map and attributes, Do the modification in all four layers, Printed outputs generation, Secure the operation
Assess the usability of the developed GUI with GIS concepts / usage	Ease of navigation, Zooming and panning, Scale facility, Permit the user to navigate while keeping track of current reference frame, Provide tools for capturing, editing, and printing maps, Map in a larger percentage of the screen area
Assess the General Principles of GUI development	User centred design , Visual clarity, Consistency, Explicitness, Appropriate functionality, Flexibility and control, Error prevention and correction, Compatibility / Portability, User guidance and support, Informative feedback

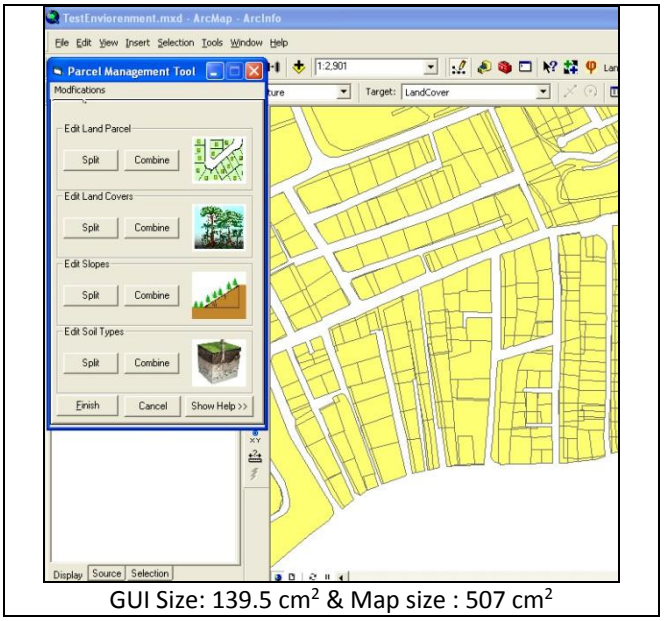
Table 3: Evaluations Result

Srl	Main Considerations and attributes	User Friendliness Evaluations			
		1st	2nd	3rd	4nd
1	**Continuity in Operation**				
	Process Liberty of other GIS functions	70%	70%	78%	90%
2	**Error handling & Accuracy Confirmation**				
	Error prevention and correction	70%	72%	78%	98%
3	**GIS software version Compatibility**				
	Compatibility / Portability	70%	78%	78%	99%
4	**Information Security**				
	Spatial Data Security	0%	0%	35%	89%
5	**Non-GIS User Operation Capability**				
	Update modifications	80%	80%	80%	97%
	Flexibility and control	70%	70%	79%	88%
	Appropriate functionality	68%	70%	77%	90%
	Modify the selected layers and attributes	68%	77%	77%	97%
	Explicitness	67%	75%	76%	97%
6	**Easy operation Capability**				
	User cantered design	65%	65%	73%	88%
	Consistency	55%	69%	71%	89%
	Informative feedback	5%	68%	70%	99%
	User guidance and support	3%	40%	49%	90%
	Printed outputs generation	3%	30%	43%	95%
	Provide tools for capturing, editing, and printing maps	3%	30%	43%	91%
7	**On-Screen Operational Capability**				
	Ease of navigation	70%	75%	78%	86%
	Scale facility	69%	75%	78%	90%
	Zooming and panning	68%	75%	78%	89%
	Modification of onscreen map and attributes	67%	72%	75%	93%
	Visual clarity	65%	68%	73%	98%
	Map display size	5%	65%	67%	89%
8	**Tested and Verified Results**				
	Modification in all required layers	65%	70%	75%	85%
Average		50%	63%	70%	92%

III. RESULT

A 92% user friendly Hydro-GIS tool was developed following the repetitive design and development model. The tool has undergone 4 evaluations until reach to minimum of 85% user friendliness as shown in the Table 3. The tool through staged evaluations has isolated 8 important considerations with 22 attributes in to ensure user friendliness of the Hydro-GIS tool. All the eight important considerations and those attributes are shown in the Table 3.

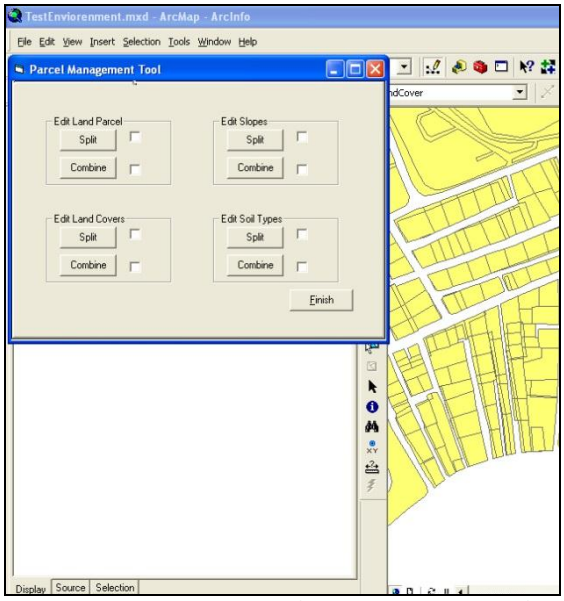
The 1st evaluation significantly effect on the User Interfaces as shown in the Figure 2. The 2nd evaluation highlighted the requirement of the security option for the data and tool. Then the tool was developed with access control mechanism and data security feature as shown in the Figure 3. The 3rd evaluation no new areas were highlighted and only modifications were requested by the users. After the 4th evaluation it observed that overall user friendliness has increased to 92%, and then conclude the development.



GUI Size: 139.5 cm^2 & Map size : 507 cm^2

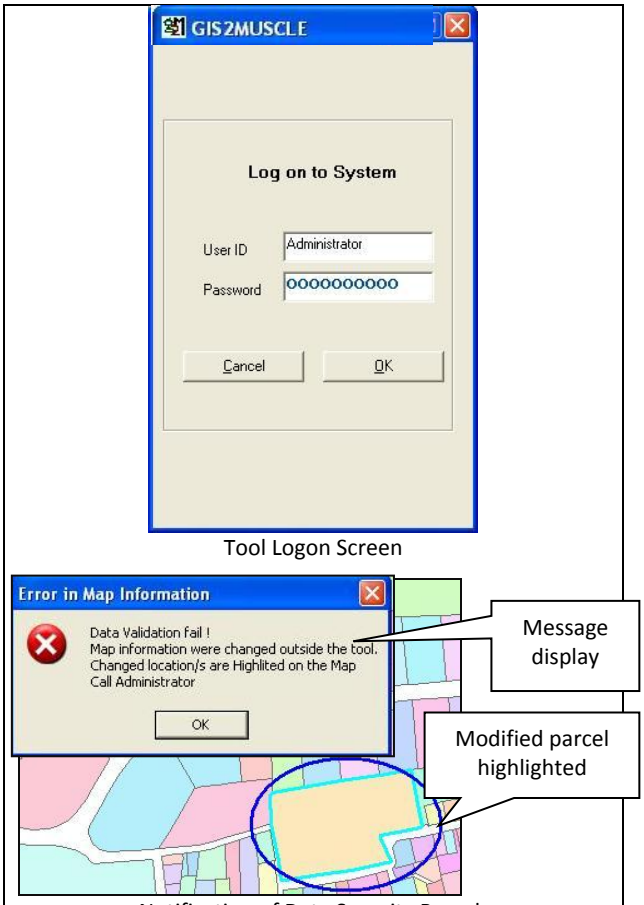
Figure 2: Effect of Evaluations over GUI

GUI - Before the 1st evaluation



GUI Size : 182.125 cm^2 & Map size: 390 cm^2

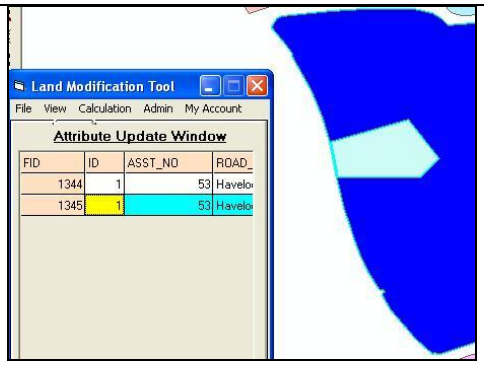
GUI - After the 1st evaluation



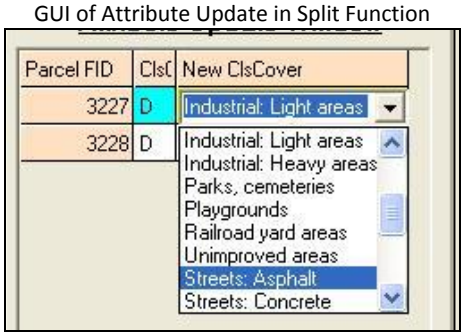
Tool Logon Screen

Notification of Data Security Breach

Figure 3: Security feature of the Tool



GUI of Attribute Update in Split Function

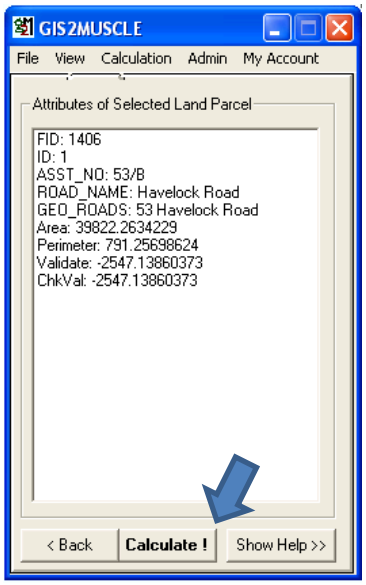


GUI Display Easy Attribute Update Capability

Figure 4: Few Easy operational capabilities of on-screen modification

The tool basically provide the on-screen modification of layers such as split, modify and combine. Tool facilitates to easy layer modification and attribute updates as shown in Figure 4.

Figure 5 shows an instance of tool capability to assist non-GIS user to carry out all required GIS functions with a single click of a button and that showed the potential for non-GIS users to carry out a complex series of GIS operations dealing with land parcel modifications.



GUI for Start the Calculation

UI Showing Steps of GIS Processes after click the Calculation button

Figure 5: Encapsulate the complex GIS routings in the tool

To gain a more customization tool provide the dynamic function of decision making. The Figure 6 shows easy detention storage pit dimension changing capability with affect visualisation on the same GUI.

IV. DISCUSSION AND CONLUSION

The Hydro-GIS application developments encounter two main knowledge areas, i.e. Software Application development and Application oriented knowledge. Hence the present work needed to carry out a thorough study of the ways of achieving the user friendliness. First of all the study identified the users and their knowledge and develops the initial tool. Then the tool subjected to adequacy test with the properly selected users. Staring from this, the user friendliness of the tool was achieved by the repetitive development and evaluation methodology adopted by the tool development.

The research on the development of GUIs for GIS customization is very scarce. Hence the present work had to develop techniques for GUI development by referring to available research and guidelines. The developed techniques were tested with the present tool and it proved that the methodologies could result the required user-friendly GUI for the GIS tool.

The Environmental Survey and Research Institute (ESRI) the proprietor of parent GIS software has withdrawn Visual Basic (VB) support after release of version 10. However the time tested VB programming with 9.x versions is still backed by its user community. Nevertheless this work expected to find the most important factors development of Hydro-GIS applications. Hence the GIS software and programming language do not have considerable share in the objective. Therefore the tool was developed for ArcMap 9 versions (9.0, 9.1, 9.2 & 9.3) using VB 6.0.

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