Product Development for Presentation of Temporal GIS Results for Non GIS Specialists

- A Case Study Application to Present Terrorist Activities and Government Humanitarian Efforts, Sri Lanka

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Abstract: Geographic Information Systems incorporate spatial information as a layered data set to facilitate the generation of information for rational resource management. Incorporation of temporal data and analysis of time series data in a geographic information system and therefore requires a specialized GIS operators to produce outputs. GIS is useful to managers, decision makers and for the general public to visualize and capture spatial information. This requires GIS products to be developed for the use of non GIS personnel and to function as independent products. This paper presents the development of such *a* product through a case study of a public information dataset in a GIS and then to presenting the same in a sequence. The work systematically approached the database creation using ArcGIS software. GIS software generated outputs were exported to Macromedia Flash trial version and animation layout and presentation sequence etc., were designed. Product was tested at different user tiers to ensure suitability for management objectives. Case study incorporated representation of the spatial distribution of terrorist activities and the government humanitarian efforts. The web presentation identified and incorporated specific temporal milestone of events and provided the user to evaluate the sequence for management directives. The present application enables a user to incorporate the methodologies and issues for many similar applications of web presentation of GIS data products.

Keywords: GIS, Temporal, Animation, Methodology, Terrorist, Humanitarian, Visualization, Tool

1. Introduction

The decision makers very often require to view and study the temporal variation of spatially varied or spatially distributed events. Such temporal mapping enables understanding the patterns of change, facilitates monitoring of progress, observing the rate of progress, accounting the components yet to be achieved etc. Repetitive viewing of temporal variations pertaining to spatial events by an audience is often recommended for better understanding of such events and associated environments. Therefore in case of monitoring temporal variation pertaining to spatially distributed events, the output products would need to be repeatedly viewed at short intervals, at different forums and at different locations. Such spatially varying data are best displayed using Geographic Information Systems (GIS) since they are the present day tools that are commonly used to accurately map spatially distributed events or resources ([2], Anand & Minakshi [21]). GIS tools support the execution of map based tasks ranging from making georeferenced maps, carrying out straightforward simple calculations such as adding, subtracting, computing area, perimeter etc., and to performing complex mathematical operations for spatial overlay models. Often temporally distributed spatial data are also prepared as GIS map layers but GIS outputs are usually time frozen or static. Though GIS has the potential to carryout spatial data computations almost at will, capability to incorporate temporal variations in GIS is still limited and require expert efforts. When it is necessary to produce scaled maps with time variations, it is quite common for trained GIS personnel to carry out such tasks. In situations where there are no trained GIS personnel in abundance, which is the common situation in Sri Lanka, a decision maker would prefer to have a well designed specific GIS output converted to an animated object, thus relieving the GIS resource person for

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other work. Though this would appear to easily solve the problem, the development of a product to correctly display GIS outputs at a level satisfying the decision makers, a GIS expert is required to carryout careful planning, design and development of the product. Such a product should ensure the capability to display accurate spatial information through GIS outputs that are suitably designed to a particular audience but without the assistance of a GIS expert. The product should also be carefully designed to achieve the objective of spatial data display, giving due consideration to the cross section of the audience, their aspirations and knowledge.

Tools or products for visualization of temporal variations can be best developed as animations. Since animation developers are generally not trained in GIS, it is always important for GIS experts to prepare or guide the preparation of such visualization products. In the present day context it is not possible to find web based animations that satisfy target audiences. The web based animations commonly available are either a sequence of static map layers, a web map server that is presenting several maps, or animations done with the use of proprietary software (*[2], Anand & Minakshi [21]*). When tools which need development with proprietary software are proposed, then prior to commencement, it is necessary to carefully assess the resource requirements to acquire such software. In cases of animating sequentially generated GIS data frames, to avoid positioning errors etc., the base maps need to be repeatedly utilized, thereby increasing the file size of output products. Therefore it is important that GIS based animations are prepared in a structured, reliable manner for the users to be confident in their use. The present work describes the development of a product for the presentation of temporal GIS results, pertaining to the spread of Liberation Tigers of Tamil Elam (LTTE) aggressions and the spatial variation of Government of Sri Lanka (GOSL) humanitarian efforts. The paper describes the methodologies adopted for the development of the product and highlights the ways by which the user requirements were achieved.

2. Objective

The objective of the study is to develop an animation of GIS data layers for presentation to Non GIS specialists, through a case study of humanitarian efforts carried out by the Government of Sri Lanka in relation to the terrorist activities. The case study to clearly indicate the methodology for similar works to be carried out in a systematic manner ensuring optimum use of resources.

3. Methodology and Results

3.1 Process and Platforms

Methodology used for the development of the GIS animation is presented in Figure 1. It is broadly separated in to two sections as, GIS layer preparation and Animation preparation. After carrying out a user requirement assessment and the literature survey, the base maps were prepared on the ArcGIS platform. A literature survey was carried out to identify the state of the art of GIS based animation preparation. As indicated in the introduction, the availability of methods and tools for the needs of the desired work were partially satisfying the objectives. ArcGIS was used as the software for the development of base data layers, since it had been identified as the most commonly used GIS software ([1], Cahan [22]), ([2], Wijesekara [20]). In order to create animations, a comparison of available software was carried out. Several software such as Maya, 3D Max, Macromedia Flash, Moho ([3], cetintuker.com [11]), ([3], newenglandfilm.com [12]), ([3], flashkit.com [13]) could be identified during the search. Considering the capabilities of each software, it was identified that some are suitable for 3D animations, architectural animations or animations pertaining to cartoons ([3], newenglandfilm.com [12]). Enhanced Metafile file format of the GIS outputs with extension .emf was found as the most desirable format to transport data to the animation software because this format enables internal compartmentalization of components such as polygons, lines or points. Considering its capability to recognize .emf file format, Macromedia Flash Software was selected for the product development. It was noted that Macromedia flash provides another added advantage to developers who are looking for appropriate software for product development. In case of Macromedia flash, instead of making an up front financial commitment, a user could work with the evaluation version for

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experimentation and development, thus enabling a developer to make a decision of financial commitment after a self evaluation of the capabilities.

3.2 Product Layout

Requirement assessment for the product development consisted of an identification of basic needs to ensure visual attraction, clarity of expression and speed of animation ([1], Sommerville [4]), ([1], Yeung [2]). A questionnaire was prepared enabling the respondents to tick guided multiple choice answers. User requirement questions for map understanding and need for animations were on a semantic scale where the level of importance was captured. Location selection, information designed to be displayed, visual attraction to capture important features, clarity of expression, selection of colour variations, animation timing etc., were identified by capturing user responses through a set of questions designed with the method described as fixed alternative type ([1], Willie [1]). Summery of user preferences which were weighted according to Rank sum method ([1], Malczewski [5]) (Figure 1) captured the needs corresponding to (i) five onscreen layout preferences, (ii) two preferences with regards to understanding, and (iii) two on the quality of output (Table 1). The animation output form layout design was commenced with the incorporation of user assessment results, which identified the approximate layout positioning and colour distribution, selection of appropriate geographic extent, and the map layout. Based on an initial survey of available static map representation of similar events, geographic extent of the entire island was selected to display the incidents. In the map layout the Title blocks, Title text, North arrow, Scale bar, and Legend were added as a surround block. Presentation feature map layout design was done with the development of several alternative templates. These alternatives were tested against cartographic constraints along with the application requirements identified at the requirement assessment stage. Use of colour selection to ensure that the map is visually distinguishable, the use of text area, font etc., considering the topographical characteristics was carried out using cartographic guidelines ([1], Yeung [2]). User preferences of text placements were extracted from the survey

questionnaire and the guidelines for label placements given in Yeung (2002) were incorporated to identify the optimum design.

Table 2: Summary of User Requirement Assessment

Question No	Description	Characteristics	Option Selection	Weighted Response
1	Importance of an computer animation to Express temporal variations	u	High	79%
2	Time duration to present 61 events	u	5minutes	64%
3	Need of a landmark spatial coverage as default display map	u	Yes	87%.
4	Meed of a scaled map for expression of Activity sequence	Q	Very High	63%
5	Display method/location for incident description text labels	Q	Designated place with a pointing arrow	72%.
6	Colour selection of shading of occupied Area of LTTE and GOSL	L	Standard colours LTTE-Red GOSL-Blue	65%
7	Use of firm colours or transparent shades for Representation of • spatial occupation	L	Firm Colours	82%.
8	Colour selection for GOSL area other than North and East	L	Base map colour	79%
9	Icon type selection for display of Incidents	L	Popup	93%
10	Allocation of a separate place to display already animated events	L	Yes	48%

Q - Quality of the Output
U - Understandability
L - On Screen Layout

$$W_i = \frac{n - r_i + 1}{\sum (n - r_k + 1)}$$

W_i - Normalized weight for i^{th} Criterion
n - Number of criterion
r_i – Rank position

3.3 GIS Component

Collection of necessary data to be incorporated in the GIS was extracted from books, world wide web (www) and other sources (Table 2). Lists of incidents extracted from the mentioned sources were identified only with location names. Locations were identified from the Sri Lanka place names map created at Sri Lanka Urban Development Authority and these points were plotted on the 1:1,000,000 scale map of Sri Lanka. Out of several available maps of Sri Lanka, the Survey Department (1988) map was selected through an evaluation criteria considering the scale of projection, adequacy of details, background colour, appropriateness to objective and less obstruction, and clear information on map. A self evaluation which was followed by user assessments identified the map with the highest rank as the base map for the product. Spatial visualization of the events were planned, considering the scale of the map proposed to be animated on computer screen. Divisional Secretary administrative Divisions (DSD) were selected as the spatial unit to visually indicate places where a spread of LTTE activity was to be marked. The spatial unit demarcation in the map expressed that it indicated a spread of activities in that spatial entity either corresponding to the LTTE or to the GOSL. This was considered as the best option to show spatial distribution of point information to suit the objectives at a display scale of the entire map of Sri Lanka on a Computer screen. Shading in the product outputs was restricted to activities of North and East of the Country but selected incidents that were reported from many parts of the country were demarcated with an arrow and a popup icon indicating the nearest location described in the data source and corresponding to that on the place names map ([3], survey-dept.slt.lk [23]).

Selection of incidents from the extracted list pertaining to the available literature was carried out by ensuring the intention of presenting the spread of LTTE activities, the GOSL liberation efforts, reversals and spatial recapturing. Selected incidents were entered as a GIS point theme and then corresponding DSD were identified by the select by location function applied to point feature layer and polygon feature layer.

GIS database development activities also covered polygon shading, development of

Table 2: Data used for the Product

	Data Description	Data Source
1	LTTE incidents and GOSL efforts 1981-1999	Sri Lanka Army "50 years on" 1949 - 1999 (SL Army 1999) [3]
2	LTTE incidents and GOSL efforts 1981-2008	www.defense.lk, www.army.lk, www.navy.lk, www.airforce.lk, www.police.lk
3	Sri Lanka background map 1:1,000,000	Scanned image of National Atlas (Survey 1988) [7]
4	Sri Lanka DSD map 1:1,000,000	Survey Department Digital data [23]
5	Place_names.shp file	Survey Department Digital data [23]

layout configuration including scale bar, grid coordinates etc. Once the accuracy check of the data set was satisfactory at the product development stage, a user evaluation was performed with a self select sample of expected users. The evaluation assessed the sequence, layout, GIS contribution, and degree of understanding. As a result of evaluations with expected users it was identified that a suitable display of percentage change of occupation areas in the North and East would create an additional user impact. Area of occupation in North and East by GOSL and LTTE as interpreted from literature (Table 2), and their temporal changes were computed using GIS tools and were added to display layout.

3.4 Temporal Animation

Successfully evaluated dataset thus prepared on the ArcGIS platform was exported in Enhanced Meta File format (.emf) facilitating the presentation of GIS characteristics within the Macromedia Flash environment. Animation development commenced in Macromedia Flash with the import of three Enhanced Meta File format files consisting of project area background map, project area polygon map and the map with selected incidents. Required animation frames were developed according to the temporal sequence of the events. Along with the same, positioning of text, arrows and popup icons were finalized.

Animation product files created with Macromedia Flash were first tested for display time and the clarity of identification. Initial user survey indicated that approximately 64%
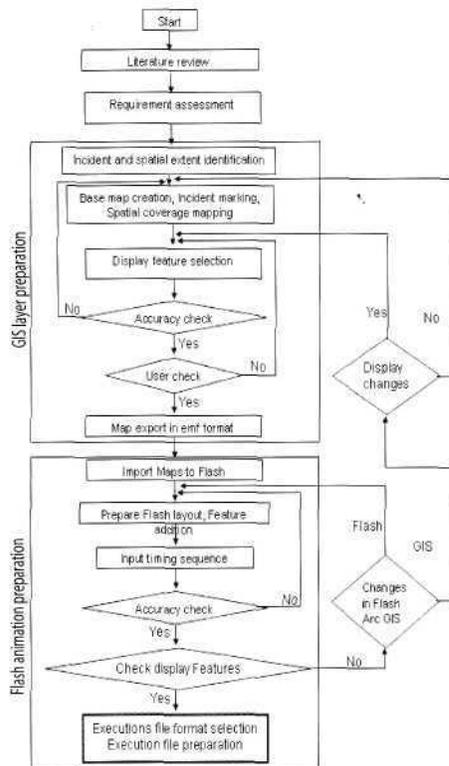
Table: 2 Summery of User Requirement Assessment

requested that 61 temporal events be animated within about 5 minutes. This was considered as the starting speed of animation product. Several product versions were tested with a self selected GIS user sample of 11 persons. Accuracy, layout, and colour selections were evaluated for user satisfaction which identified desired modifications by means of written comments for assessing the level of understanding. Initial GIS based developments tried out transparent colour selection for polygon shading so that the background map details could be easily identified by the viewers. Though this was evaluated as very satisfactory on computer monitor, the multimedia projectors failed to project a satisfactorily coloured image on projector screen. This was partly due to incompatibilities between the computer and the projector. In order to achieve a satisfactory projection, the selected colour schemes avoided the use of transparent colour arrangements. Furthermore, subsequent tool developments were carried out with the use of a multimedia projector to display tool modification outputs on screen.

3.5 Iterative Development

A series of product evaluations with the self selected sample of users necessitated modifications to both animation and the GIS map representations. Changes that were

identified consisted of changes to map boundary presentations, inclusion of additional events for clarity enhancements, several spatial coverage modifications, layout and font changes and popup icon size enlargements. The changes identified at evaluations were carried out through an iterative process (Figure 2) which upon identification, carried out modifications to concerns such as sequence, colour, labeling, pointers, popup icons within the Macromedia Flash environment whereas changes to output map, proportion, legend, scale bar, North arrow etc., were carried out within the ArcGIS platform. The inclusion of those who participated in the development was to comparatively assess the improvements to the product.

The user evaluation on the final display feature was carried out with a questionnaire survey using a probable user community consisting of a mix of GIS users, general public and defense officials. This user community had a majority of fresh viewers while several were those who participated at the evaluations during development of the product.

A questionnaire distributed after each presentation captured the level of appreciations. Questionnaire was broadly divided into three main sections. (i) On Screen Layout, (ii) Understandability of Material, and (iii) Quality of Output. Users were tested with 8, 3, and 3 sub questions on each for the above mentioned main categories.

The questionnaire provided space to capture individual acceptance of product and any suggested improvements with regards to future developments.

The questions were evaluated for accuracy of information capture by allocating an equally weighted marking scheme for each section. On average the user understandability of material was 93.3%, Quality of output and On Screen layout arrangement achieved scores of 93.3%, *92.7%* respectively. User acceptance and appreciations of the tool was 99.1%. Changes requested included a suggestion to incorporate a background sounds and this was incorporated after evaluating the suitability of the available instrumental music. Senior defense officials requested a speedy version of the product whereas some viewers showed their preferences for a slower version to capture the output

details. As a result three product executions versions were developed for timing of 1, 5 and 15 minutes. Sample projection layouts pertaining to startup screen, an intermittent temporal animation and the end of presentation are in Figure 3, Figure 4 and Figure 5.

4. Discussion

The product development highlighted a systematic approach to achieve a well accepted product representing spatial and temporal variations pertaining to a sequence of activities. The process through a case study presents a methodology that may be adopted by GIS experts to develop outputs from GIS data sets, which could be presented without the assistance of GIS experts.

The tool achieved excellent user ratings in case of Understandability, Quality of Output and Layout presentation. User acceptance and appreciation was a very high value probably due to the number of well designed evaluations carried out during the development process
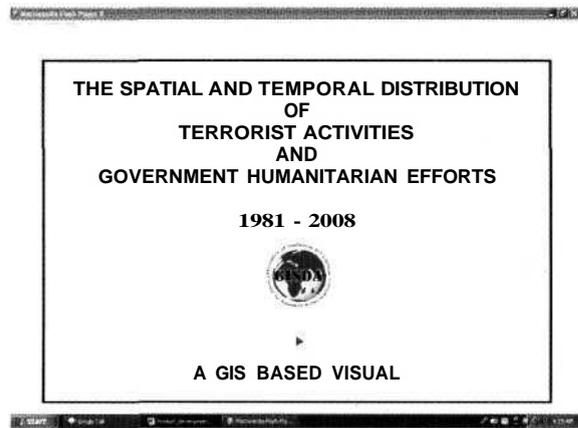

Figure 3: An Intermittent Layout of the Product

Figure 4: The Last (End) Screen of the Product

Figure 2: Commencement Layout of the Product

even with a small self selected samples. It is recommended that for improved outputs it may be suitable to follow the described methodology with larger samples of different user classes.

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The work attempts to highlight the need of performing not only accuracy checks and proper visual arrangements according to guidelines, but also the need of suitable user group evaluations. Evaluation success measures need to be based on user aspirations carried out at the beginning and checked intermittently with structured questionnaires to extract quantitative evaluations.

Availability, usage and user friendliness of .emf file format and operating system based colour, font selections were found very useful. These were considered a key factor in the product development. Working on a GIS platform identified the ease of achieving maps without distortion, exact coverage, computation of spatial extents and producing temporal frames to suit any product duration. Appropriate scale bars, co-ordinate indicators, administrative boundary demarcations as provinces and other changes to visually presented spatial units as DSD were easily carried out on the GIS platform. The interactive use between the GIS
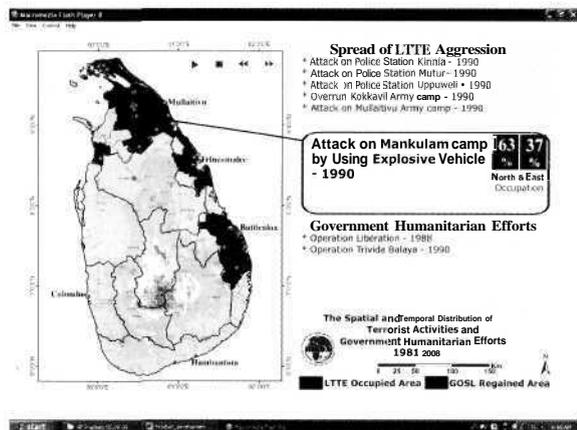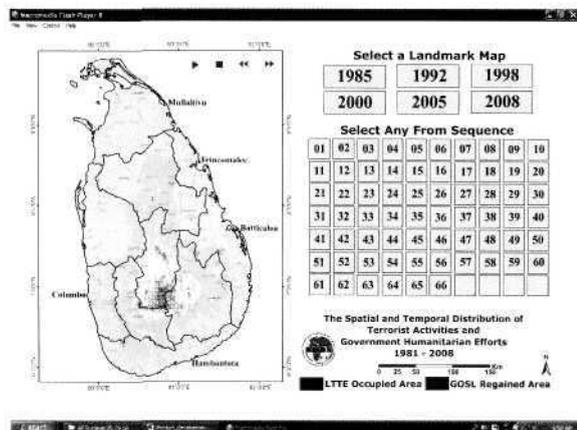
and animation tools provided a significant ease in GIS map development and computations, when carrying out numerous user changes desired at various stages of evaluations.

5. Conclusions

1. Presenting temporal distribution of spatially distributed activities was successfully carried out using and interactive use of GIS and Visualization tools. Which is presently not possible in off the shelf GIS software.

2. Excellent results were indicated at the user evaluations carried out on the final product and hence it can be concluded that the product was successfully developed.

3. Methodology for the study followed rational systematic process and this can be taken as a guideline for similar developments.

4. GIS enables a scaled representation with accurate computations and hence use of GIS while adhering to guidelines is extremely helpful to present spatial variations to user satisfaction.

5. A systematic approach with staged evaluations is important to identify user needs and then to develop a suitable product.

6. Acknowledgement

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