THREE DIMENSIONAL VISUALIZATION OF WATER PIPELINES

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ABSTRACT

The water pipeline industry is one of the key industries that serve the basic public needs of the society. Just like other essential utilities such as gas and electricity, underground cables are required to transport this vital human need from one part of the city to another. From Dubai to Paris, virtually all cities around the world have underground pipes serving the same purpose and the city of Kuantan isn't any different. Due to the importance of these water pipes, it is necessary to device reliable means of protecting them from various forms of damages.For a system that affects the human existence so much, a pipe failure would be disastrous, as would an extended repair outage. Experience has shown that many pipelines get damaged when construction workers accidentally strike pipes buried underground, during excavation or other tasks that require digging the earth's surface. This occurs due to the fact that most existing pipes are represented in two dimensional (2D) format and the information contained in 2D maps isn't entirely accurate. This limitation in 2D visualization makes it difficult to clearly understand or conceptualize the pipelines below the ground, hence, the need for a more effective way of visualizing the underground water pipes. Three dimensional (3D) visualization is increasingly being used to overcome these limitations, but not many individuals or organisations can afford the huge cost of most of the available packages and there is a growing demand for more affordable 3D visualization tools. This research has devised a means of visualizing underground water pipes using a series of software packages, including the ArcGIS 3D Analyst extension. The integration of datasets with these packages is vital to the actualization of the research objectives. This research will illustrate how such integration is possible using the ESRI geodatabase for data storage, and exporting the dataset into other environments for visualization purposes.

ABSTRAK

Industri air merupakan salah satu industri utama bagi keperluan awam.Lain-lain utiliti penting seperti gas dan elektrik, kabel atau paip bawah tanah diperlukan untuk pengangkutan kepada manusia daripada satu bandar ke bandar yang lain. Dari Dubai ke Paris, hampir semua bandar di seluruh dunia mempunyai paip-paip bawah tanah bagi tujuan yang sama dan bandar Kuantan tidak ketinggalan. Oleh kerana pentingnya paip air ini, kita perlu kepada peranti yang boleh dipercayai bagi melindungi daripada pelbagai bentuk kerosakan. Untuk sistem yang memberi kemudahan begitu banyak kepada manusia, kegagalan paip akan menjadi bencana, seperti dalam kerja-kerja pembaikan. Pengalaman menunjukkan bahawa banyak rangkaian paip rosak semasa pekerja membina paip terutama yang berada dibawah tanah. Hal ini terjadi kerana kebanyakan paip yang ada dipersembahkan dalam format dua-dimensi (2D) dan maklumat yang terkandung dalam peta 2D tidak begitu tepat. Keterbatasan visualisasi 2D sukar untuk memahami dengan jelas kedudukan paip bawah tanah, maka, keperluan visualisasi paip air bawah tanah dalam persembahan tiga-dimensi (3D) adalah jelas. Untuk ini, visualisasi 3D semakin sering digunakan. Penyelidikan ini telah menemui cara untuk mevisualisasikan paip air bawah tanah dengan menggunakan perisian, *3D Analyst*. Integrasi setdata dengan perisian ini sangat penting bagi tujuan kajian ini. Penyelidikan ini juga menggambarkan bagaimana integrasi *geodatabase* untuk simpanan data, dan ekspot setdata kepada persekitaran lain untuk keperluan visualisasi.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE	i
	DECLARATION	ii
	ACKNOWLEDGEMENTS	iii
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF APPENDICES	xiii
1	**INTRODUCTION**	1
	1.1 Introduction	1
	1.2 Background to the Problem	2
	1.3 Problem Statement	4
	1.4 Objectives	4
	1.5 Scope of Research	5
	1.6 Significances of Research	5
2	**LITERATURE REVIEW**	**7**
	2.1 Introduction	7
	2.2 Basic Concept of GIS	8
	2.2.1 Database	8
	2.3.2 Spatial Database	9
	2.2.3 Component of GIS	11
	2.2.3.1 Software	11
	2.3.3.2 Hardware	11

		2.2.3.3 Data	12
		2.2.3.3 People	13
	2.3	GIS Operation	13
	2.4	The evolution of 3D GIS	14
		2.4.1 Technological Advancement and the growth of 3D GIS	15
		2.4.2 3D Visualization and Analysis	16
	2.4	GIS and Pipeline Management	19
3		**RESEARCH METHODOLOGY**	**22**
	3.1	Introduction	22
	3.2	User Requirement Analysis	24
		3.2.1 Data Collection	26
		3.2.2 Development of Geodatabase	26
		3.2.2.1 Conceptual design	27
		3.2.2.2 Logical Design	31
		3.2.2.3 Physical Design	32
	3.3	Data Processing	32
		3.3.1 ArcScene	33
		3.3.2. VRML Plugins	36
		3.3.3 Autodesk 3DS Max	37
4		**RESULTS**	**38**
	4.1	Introduction	38
	4.2	3D Visualization of Pipes	38
		4.2.1 Viewing the pipes	39
	4.3	Queries	42
		4.3.1 Attribute Query	42
		4.3.2 Spatial Query	44
5		**CONCLUSION AND RECOMMENDATIONS**	**47**
	5.1	Discussion	47
	5.2	Conclusion	48
	5.3	Recommendation	48

REFERENCES 50

Appendices **A - B** 56- 65

LIST OF TABLES

TABLE NO	TITLE	PAGE
2.0	A Classification of GIS activities	14
3.1	Defining Relationships between objects	31
3.2	Primary data list	32

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
1.0	The Study Area	5
2.1	Spatial and attribute data	10
2.2	Feature Identifier	10
2.3	The Integration of GIS and CADD	17
2.4	Visualization of pipes	20
3.1	Research flowchart	23
3.2	Conceptual Design of Data Model	28
3.3	Setting the Field name and Data Type	29
3.4	Setting the Subtypes Properties	30
3.5	The workspace domain	30
3.6	2D Visualization of Pipelines	33
3.7	The Base Height Window	34
3.8	The extrusion parameter	34
3.9	Representing pipelines as walls in Arcscene	35

3.10	Viewing features in ArcScene	35
3.11	VRML Viewer	36
4.1	Exported pipelines underneath the lots	39
4.2	Viewing the pipes	39
4.3	Viewing the pipes from above the lots	40
4.4	The water Pipes	40
4.5	Structures on the lots with the pipelines beneath	41
4.6	Features in Sketch-up	41
4.7	Selection by attributes	43
4.8	Query to show selected attributes	44
4.9	Selection by location	45
4.10	Highlighted lots	45

APPENDICES

APPENDIX	TITLE	PAGE
A	Pipe Network Components	56
B	Cortona VRML 3D Viewer Manual	58

CHAPTER 1

INTRODUCTION

1.1 Introduction

The increase in the number of buried pipes and cables in the recent past was in direct response to demand for light, heat, clean water, sewerage, safe drainage and communications. These same demands exist today, and the continuous growth in the population of urban dwellers means the society has continued to demand more of these subsurface utilities (Duddeck, 1996).

Many of the existing gas, water mains, and sewers are reaching the end of their lives, and the development of new technologies such as broadband is also fuelling the demand for new underground utilities. In order to monitor these underground infrastructures, as well as predict the extent to which the construction of new utilities, facilities etc will affect them, it is essential to be able to visualize these underground pipes. Visualization of utility networks has always been on two dimensional (2D) maps, and the information therein is often misinterpreted , especially when made available to third parties or non-professionals (AbdulRahman et al, 2006).Such misinterpretations have led to severe accidents which include blind-cutting off of water, gas, heat supplied etc (Du, 2006). In order to solve these perennial problems, three dimensional (3D) visualization of utilities is most necessary (Zlatanova, 2004; Du, 2005; Chong, 2006). 3D visualization of pipelines has since been discovered to be a necessary tool for the development of urban pipe systems because it can clearly express the position and spatial relationship of all pipelines in a way that can be understood by all.

Furthermore, 3D visualization is useful in identifying likely conflicts that may occur among construction resources and underground pipe lines by simulating such construction operations before they are actually implemented (Kamat, 2006). Consequently, damages which hitherto were done to underground water pipelines during such construction projects will be drastically minimized. Thus, inconvenience to members of the public, as well as the loss of huge sums of money needed to repair the damaged pipelines is avoided.

1.2 Background to the Problem

The water pipeline industry is one of the key industries that serve the basic public needs of the society, and as urban populations increase there is a simultaneous increase in demand for water and other similar utilities (Duddeck, 1996). Providing such utilities ultimately leads to an increase in various construction projects, and planners and engineers realize the need to utilize 3D visualization as an important tool for assessing the likely impact of such projects on the buried pipes, examining numerous implementation options and ensuring health and safety requirements are met (Alistair, 2003). Therefore, the interest in 3D visualization is rapidly increasing.

The massive expansion and modernization of cities in recent times has necessitated the need to have reliable and accurate information about existing infrastructure. This need is even more crucial for underground infrastructure because they are buried and kept away from the public eye. As a result, they are more prone to damages and destruction if not properly visualized.

Every time a construction or utility company digs a hole in the road, there is a risk of damage to another utility's buried services (Costello, 2007). The water pipelines running across the length and breadth of Pahang are equally endangered because of the various construction projects going on around, as well as the possibility of future projects which are yet to be executed; and the best way to safeguard these pipelines is to be able to visualize them accurately before the commencement of any such projects. Recent investigations (Roberts et al , 2002) have revealed an increase in the number of accidents of various ranges and scales to these pipelines, and many governments have come to the conclusion that the visualization approach is indeed essential to improving the knowledge on the underground infrastructure (Chong, 2006).

In the past, 2D visualization was used to meet these needs, but 2D visualization of subsurface utilities has many limitations and draw-backs. 2D visualization for instance does not have the ability to display the 3D topological relationship among pipelines (Hu Zhuowei et al, 2005). In addition to this, map distance in 2D is significantly different from the real distance in 3D that is measured linearly along the pipe axis (Pubellier, 2003). Furthermore, since the pipeline positions are visualized on 2D maps, it is difficult and complicated to differentiate between pipelines with the same x,y coordinates, but different heights (Zlatanova et al, 2006). The implication of all these is that construction workers generally find it difficult to understand the actual positions of these pipes whenever they are working on them and this increases the chances of accidental cuts and damages to the buried pipes.

Visualizing various construction scenarios can provide significant insights that can be of immense benefit in effectively planning construction operations, thereby avoiding unnecessary accidents. Because simulation enables the planner and other personnel involved in the project to experiment with and evaluate different scenarios during the planning phase, the chances of mistakenly damaging the underground pipes when the project finally begins are very slim (Kamat, 2000).

1.3 Problem Statement

In view of the frequent damages to buried pipelines, there is a need for all parties involved in future construction projects to be able to accurately visualize the locations of these pipes(Gokhale et al, 1997) and determine the extent to which these pipes might be affected (Kamat, 2000). 3D visualization is the most effective communication tool which can be used to present and explain the impact on such buried pipes (Pubellier, 2003), and this is the reason for embarking on this project. Past research has shown that a major problem encountered while developing a functional 3D GIS is to device an ideal means of representing complex 3D objects like cylinders (Ekberg, 2007) and this research aims to address this problem.

1.4 Objectives of Research

The research objectives are as follows:

i To develop a database for the water pipelines in a selected area/vicinity.

ii To visualize these pipelines in a 3D environment, such that they can be clearly seen and understood by the layman.

1.5 Scope of Research

This study focuses on visualizing underground water pipelines in some selected areas of Kuantan, Pahang, in Peninsular Malaysia. The primary dataset used include the existing pipeline data, road layer and a land parcel layer. The created datasets were subsequently exported into a 3D environment for proper visualization.

Figure 1: The study area (Kuantan). Source: Adapted from Google pages

1.6 Significance of Research

Considering the increase in construction projects across most major cities, a well visualized pipeline network will be useful to civil engineers, town planners, government agencies, the water management authority, and all other stakeholders in viewing the actual location of pipelines prior to the commencement of any digging or excavation. This way, damages to pipelines will be avoided, and members of the public will not be subjected to the avoidable trauma of living without water supply.
Similarly, lots of money which were hitherto used to repair or replace damaged pipelines destroyed due to blind cutting during such construction works will equally be conserved.