THE FLUID CITY

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THE FLUID CITY

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ABSTRACT

Maps are abstract objects symbolically representing actual places and objects. Information richness or a multivariate map indicates relationships within itself, thus enabling comparison to add the meaningfulness of the map. This thesis describes the conceptualization, design, and implementation of a multilayered, public, and dynamic 3D map system that allows users to participate in its construction through collection and input of the data needed for the task. In aiming to provide a historic framework for the project "The Fluid City", a brief history of cartography and types of maps, geographic information systems, digital elevation models, information visualization techniques for geographic and elevation data, as well as a survey history of Istanbul and her historic maps are briefly explained. The project proposes an alternative reading of the city of Istanbul, her dreams, and the personal mythologies of her many inhabitants.

ÖZET

Haritalar yeryüzü mekanlarını ve nesnelerini sembolik öğelerden yararlanarak sunan soyut araçlardır. Bilgi zengini ya da çok değişkenli haritalar, sunduğu nesneler arasındaki ilişkileri kıyaslama olanağı verdikleri ölçüde anlam kazanırlar. Bu tez, kullanıcılarının veri toplama/ giriş yöntemleri ile hazırlanışına katkıda bulundukları, dinamik, çok katmanlı ve 3 boyutlu bir harita sisteminin kavramsallaştırma, tasarım ve uygulama safhalarını anlatmaktadır. "Akışkan Şehir" projesini tarihsel bir çervevede sunabilmek için; haritacılık ve harita çeşitleri, coğrafi bilgi sistemleri , sayısal yükseklik modelleri, coğrafi ve yükseklik verilerini görselleştirme teknikleri, İstanbul tarihi ve tarihsel haritaları konularından kısaca bahsedilmiştir. Proje'de amaçlanan, İstanbul şehrinin, hayallerinin, sakinlerinin, kişisel söylencelerinin alternatif bir method ile okunabilmesidir.

DEDICATION

"For my fiancée and my family, who offered me immeasurable love and support throughout the course of this thesis."

ACKNOWLEDGEMENTS

It is my pleasure to thank the many people who made this thesis possible.

My deepest gratitude is to my main supervisor, Elif Emine Ayiter, who made me interested in visual communication design; moreover, it was she who gave me the opportunity to jump into a new field. Not everyone would give such a chance to someone so new to visual communication design. I could not have imagined a better advisor and mentor on the road to my graduate degree, and without her common-sense, knowledge, perceptiveness, I would never have finished my thesis.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TABLE OF ABBREVIATIONS

GIS	Geographic Information System
DEM	Digital Elevation Model
SRTM	Shuttle Radar Topography Mission
2D	Two dimensional
3D	Three dimensional
ESRI	Environmental Systems Research Institute
WGS84	World Geodetic System 1984
UTM	Universal Transverse Mercator
LOD	Level of detail

1 INTRODUCTION

Cartography originated from cave paintings locating ground game, downwarding to 15000 BC, and a discipline integrating science, technology, and art. Maps are works of art conveying the intended messages of scientific and historical studies by visualizing the outcomes, using the accumulated wisdom of cartography. By means of new thriving methods such as geographic information system (GIS), cartography has been acquiring strength along with requirements of rich artistic graphical representations. As H. Robinson, an American cartographer, stated if the design of a map is not proper, "it will be a cartographic failure". [8]

This thesis describes the conceptualization, design and implementation of a multilayered, public, and dynamic 3D map system that allows its users to be part of the construction by means of the collection and input of the data needed for the task. Wishing to provide a historical framework for the project "The Fluid City", a brief history of cartography and types of maps, geographic information systems, digital elevation models, information visualization techniques for geographic and elevation data, and a survey history of Istanbul and her historic maps are briefly explained.

2 CARTOGRAPHY

2.1 Definition and History

Cartography is the art or technique of making maps. A map is a graphic representation of spatial concepts. Spatial data defines any information conveying the locations, shapes, and relationships of geographic features upon the earth's surface, and is visualized through maps. In general, a database is used to accumulate encoded spatial data inputs, allowing researchers to decode the data for different objectives. "The cartographic process rests on the premise that there is an objective reality and that we can make reliable representations of that reality by adding levels of abstraction”. [1]

Maps "have been made for some particular purpose or set of purposes". [9] Although maps have been used primarily for navigational purposes they have also played an integral role in symbolizing and narrating events that were considered important for the societies that produced them. One other function of maps over the ages seems to have been the phenomenon of presenting scientific concepts, such as climate, habitation or astronomical data in a concrete and concise visual form, what we today term as data visualization or information visualization.

2.2 Maps for Navigation and Survey

Representations of territory that resemble western maps in function have existed in indigenous cultures. Although oral and ritual means may have been used frequently to express spatial information rather than formal ways of mapmaking, utilization of mnemonic symbols exists in some cultures. For instance, Marshall Islanders created stick charts describing locations of ocean waves and their patterns to teach navigation in canoe sailing. [2]

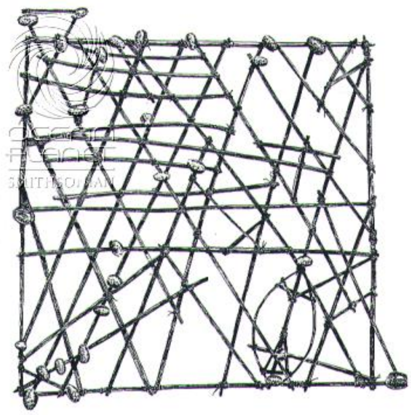


Figure 2.1 Marshall Island Stick Chart: Shells represent islands and curved sticks represent ocean swells and currents. [3]

Navigational maps have followed a long history of development that forms the mainstream of cartography from the world map of Babylonia of 500 BC., the oldest world map known, in which the world is represented as a flat disk surrounded by sea, as in many other ancient maps and consistent with Homer's descriptions in the *Iliad*. Even though few maps remain from ancient Egypt, it is obvious that some wall paintings and manuscripts of instruments used for overhauling houses and restoring field borders after the annual flooding of the Nile had swept them away. [2]

Figure 2.2 Babylonian World Map (700-500 BC). [4]

The Notion of a spherical Earth is first introduced at the school of Pythagoras. Segmenting the Earth into zones of climates is built on Aristotle's work, who had also proposed a spherical Earth on geometric grounds. Greek geography was explained in the books of Strabo's Geography; after all it was Ptolemy who proposed a structure to construct maps for the inhabited world, framing a system of coordinates based upon latitude and longitude as well as a differentiation between atlases (geography) and regional maps (chorography). [2]

Figure 2.3 Claudius Ptolemy, Cosmographic World Map (1482). [5]

In contrast to the mathematical and theoretical aspects of mapmaking of the Greeks, Romans focused on military and administrative needs, and following the fall of Rome, curtailed geographic thought and research. However, “as way-finding devices maps probably took second place to written itineraries for use on sea or land, the survival of a much later version of the drawn itineraries, known as the Tabula Peutingeriana points to this genre as having existed”. [2] Tabula Peutingeriana is a very schematic map showing many Roman settlements, the roads connecting them, rivers, mountains, forests, seas, and the distances between the settlements. [6]

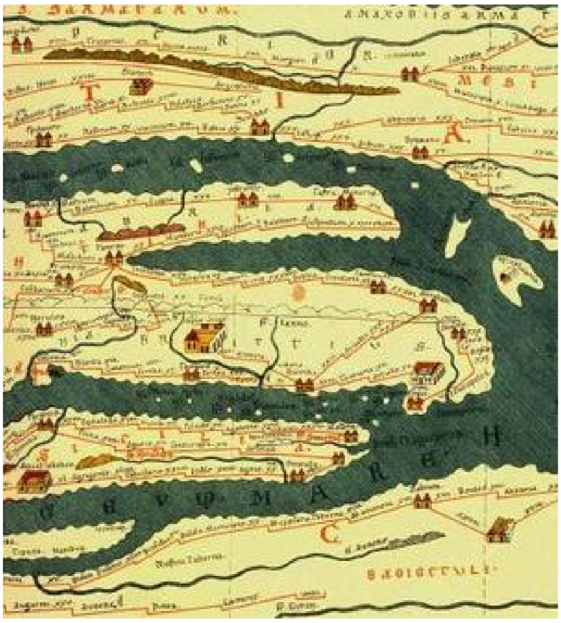


Figure 2.4 *Tabula Peutingeriana*: Dalmatian Coast, Adriatic Sea, Southern Italy, Sicily, African Mediterranean Coast [6]

The Islamic tradition of mapmaking was driven in by the necessity of facing Kaaba in Mecca during the ritual prayer, and by the need to properly orient mosques facing Mecca for the Muslims. Islamic cartographers adapted Ptolemy’s basic fundamentals within their astrological researches, and developed a sexigesimal system based on spherical trigonometry. “The fragments of two world maps (1513 and 1528) by the Turkish admiral Piri Re'is follow a Western chart-making style. Similarly, Piri Re'is's extensive book of harbour charts, the *Kitabi Bahriye*, suggests heavy influence from the European island books.” [2]

Figure 2.5 The Piri Re’is Map [7]

During the 15th century, amazing achievements were made in cartography resulting from journeys around the globe to discover new trade routes. The ideas of the Greeks and Ptolemy were preserved in Arabic translation. Additional information based on trade in the East was used to update the Ptolemaic maps using theoretical methods on compilation of longitude and latitude observations. Moreover, Ptolemy's geography was published and widely accepted by means of invention of the printing press in the West. [2] Major contributions to mapmaking were made by Gerardus Mercator who made many new maps and globes. He is best known for his world map (1569), yet his greatest contribution to cartography was the Mercator projection, which can be described as a cylindrical projection that must be derived mathematically. [10]

Figure 2.6 Gerard Mercator: World Map (1587) [12]

European map production center was Antwerp. In 1560s Antwerp was a centre of modern atlas production, where Abraham Ortelius publicized 'Theatrum Orbis Terrarum' in 1570 and marked a new era in mapmaking. It was the first truly modern printed atlas that essentially superseded Ptolemy's cartographical image of the world. Theatrum was directly influenced by Mercator's map. [11]

Figure 2.7 *Theatrum Orbis Terrarum* [13]

Two-dimensional representation of a three-dimensional land surface is called topographic map. Demands from military and administrative units caused topographic maps to be developed during the 18th century. The first large-scale topographic mapping was the Carte de Cassini of France, made by Giovanni Domenico Cassin. "Carte de Cassini was published in 1793 and was the first accurate topographic map of an entire country". [14] Similarly, Ordnance Survey was set up to survey the land and produce maps for military use in 1791 in England. From the late 18th century, road, canal, and rail developments might be accompanied by maps; therefore precise instruments were needed to bring about rapid improvements in cartography. However, none of these new instruments gave rise to any new principle. "It was not until the 20th century that revolutionary surveying tools were systematically employed." [2]

Figure 2.8 The First Ordnance Survey Map [15]

In 1850s, air photography was introduced to cartography. Balloons, kites and even pigeons were used to take air photography. The first successful attempt in air photography was accomplished by Gaspar Felix Tournachon or "Nadar" in 1858 when he took photographs of the houses of a French village from a balloon. By the First World War, its value had become well established, French planes “were printing as many as 10,000 photographs a night during periods of peak activity”. [16] From then, new revolutions occurred in map-making by means of improvements in technology, electronics, and especially spacecraft.

Figure 2.9 Boston From a Captive Balloon (1860): The oldest conserved aerial photograph as Nadar's first works were lost. [17]

Another important area of mapping, called remote sensing gained significance in 1950s. It was mainly “collecting data using instruments aboard aircraft or satellites” [18]. At the beginning of 1960s, the US Landsat program used many satellite-borne remote sensing systems. “The manned spaceflights of the 1960's and 70's yielded spectacular photographs of the earth's surface and facilitated the first use of multi-spectral and microwave instruments from space.” [17] Usage of these multi-spectral sensors to capture data in both visible and non-visible portions of the electromagnetic spectrum, remote sensing has brought a new dimension to cartography.

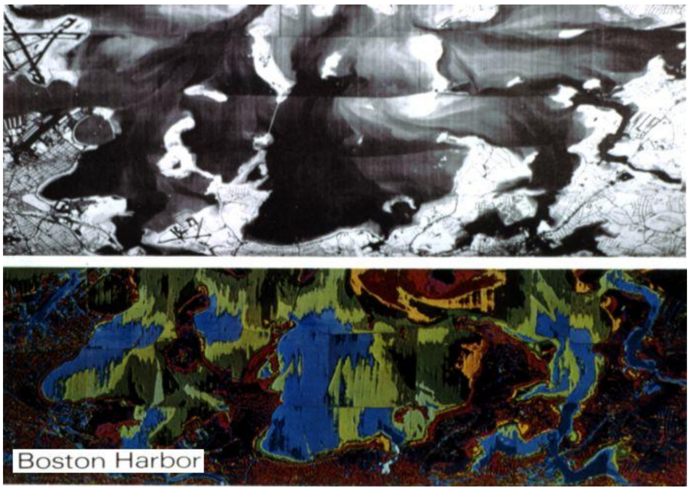


Figure 2.10 Boston Harbor Thermal Map (1969) [19]

2.3 Maps for Symbol and Narrative

Maps of indigenous cultures overturned the whole idea of a map, and shared cross-cultural distinctiveness. They were different from the Western ways of representing the world, and visualized narrations of migration routes, spirit capitals, dances, astronomical events, and battles instead of the measured, geometric representations. Indigenous maps frequently measured distance in time rather than space, however the representation of time and space was occasionally melted, and that caused events expanded in time to be adjoined on the same map. In Australia, aboriginal bark paintings often explain the story of how something began or was created, based on ancestors’ legends, called Dreaming. Dreamings represented relationship between inhabitants and the environment, such as food, water-holes, animals, and tracks. “Sacred and secular uses were often merged, so that a representation of the cardinal directions in the cosmos could be embodied in the plan of a village or house”. [2]

Figure 2.11 A Dreaming Showing Three Large Waterholes [20]

Similar to Dreamings, the medieval European maps attempted to portray legends and stories from biblical and classical literature instead of geographic distances. Medieval world maps frequently illustrated “the Earth as a record of a sequence of divinely planned historical events from its Creation and salvation to the Last Judgment”. [2] Europe was located at the center of the world, and importance of people or places was related to their distance from the center on the map.

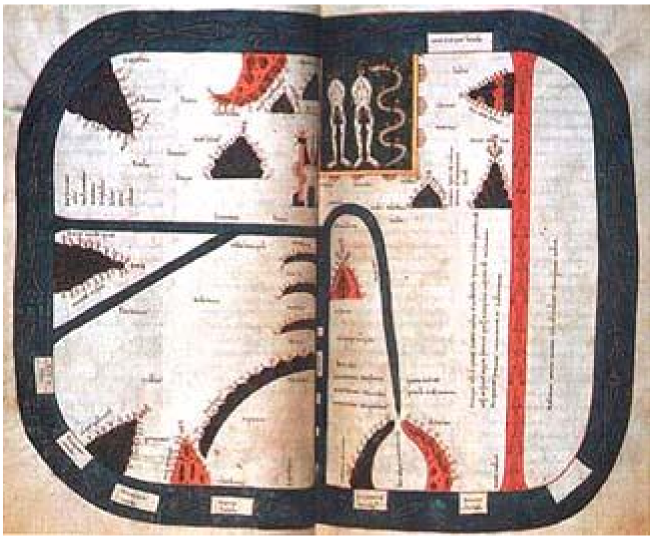


Figure 2.12 The Beatus World Map (1106): Adam and Eve are one of many common biblical references in such maps. [21]

On the other hand, Chinese world maps centralized the emperor's empire and represented other countries as islands and sprinkled around the outside edges. Therefore these maps ~~were~~ illustrated the power of the emperor in a symbolic way. In China, states had to collect maps and submit them to the emperor as a symbol of loyalty. "A legendary scene in the tombs of the Han dynasty shows such a map being used to conceal a dagger intended to assassinate the first emperor of Qin, Shi Huangdi, in 227 BC." [2]

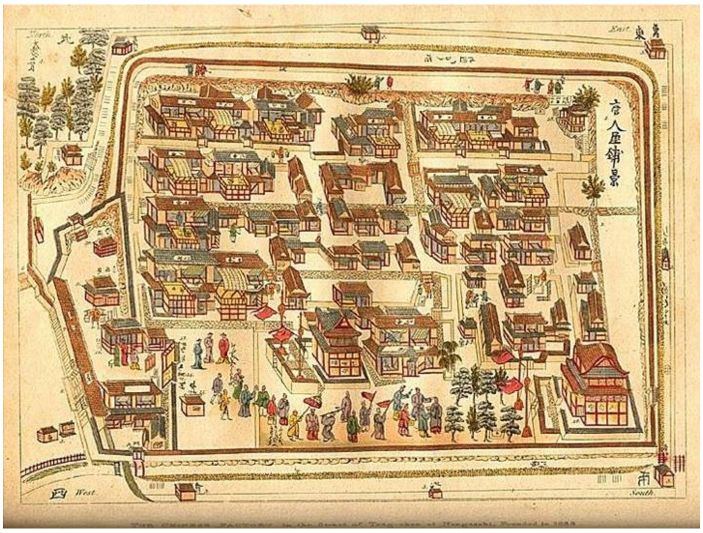


Figure 2.13 China, Feng Shui

2.4 Maps for Scientific Visualization

A thematic map shows the spatial distribution of specific data themes over a geographic area, such as temperature, humidity, population density etc. For thematic map making the visual variables play a major role, since the user's attention has to be guided to the important information. [24] First samples of thematic mapping were zonal or climatic maps developed in Medieval Europe. Zonal maps divided the world in frigid, temperate, and torrid zones proposed by Aristotle, and the torrid zone was considered uninhabitable. "It took the voyages of Portuguese sailors down the coast of Africa in the Thirteenth Century to prove, once and for all, that people passing through the torrid zone would not be killed by coming to close to the sun". [22]

Figure 2.14 Macrobian Zonal World Map (1483) [22]

Beginning from 18th century, thematic mapping found an essential place in cartography when studies in areas of social sciences, history, philology and other fields gradually demanded effective visualization of the spatial data collected from measurements. For instance, the first national census in Europe was undertaken in 1801 in England. In the mid-1850s, Dr. John Snow used thematic mapping techniques to confirm that the transmission of cholera in the London disease occurred by swallowing contaminated water or food, not by inhaling the infected air. [2]

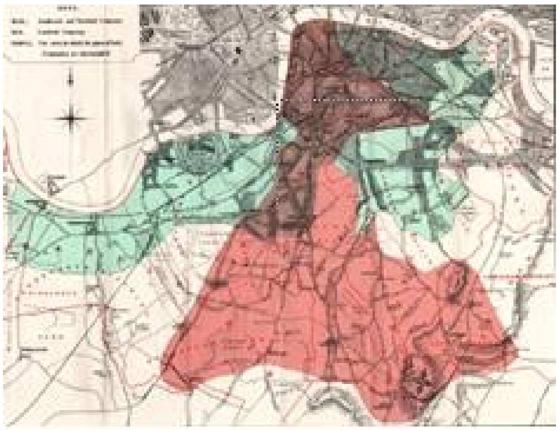


Figure 2.15 Dr. Snow's Map of the Grand Experiment of 1854 compares Cholera mortality among persons consuming contaminated water [23]

“It was the 19th century that witnessed an explosion in proficiency and creativity related to thematic maps”. [25] Between 1835 and 1855, thematic mapping was in its “golden age”, and all the fundamental techniques of graphical and statistical ways of data representation for thematic maps had been outlined by 1855. [26] For instance, Irish Railway Commissioners designed a report including series of maps in which many significant thematic mapping techniques were used for the first time. Henry Drury Harness created railway maps representing city populations by graduated circles; density of populations were designated by shading, flow lines indicated movement patterns, and thickness of lines correlated with the number of travelers. [25] Another interesting usage of thematic mapping was Duchatelet’s mapping of prostitutes in Paris, constructed by extensive data tabulation.

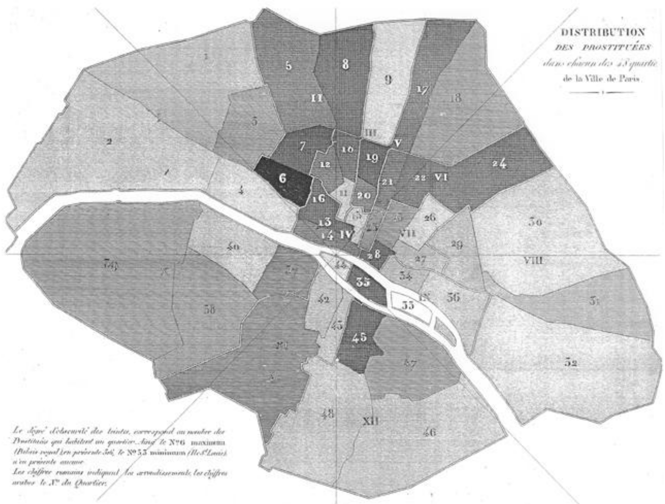


Figure 2.16 Duchatelet's Thematic Map (1836): Showing distribution of prostitutes in Paris [27]

2.4.1 Geographical Information Systems

A geographic information system is a “system for managing spatial data and associated attributes”. [28] GIS allows users to create interactive queries, analyze the spatial information, and edit data. When viewed within a historical context however, GIS is a contemporary version of the thematic map, albeit one that is interactive, conducive to user input, modification, and analysis. GIS systems “can transform information into an understanding of the complex nature of spatial problems, which, in turn, can lead to viable decisions”. [30]

The Canadian government was the first to build a GIS system known as the "Canadian GIS" in 1967 to analyze data collected for the Canada Land Inventory. It was mapping of various data about agriculture, wildlife, soils, waterfowl etc. in order to find out land capability of rural Canada. [28] Soon other governments and university laboratories constructed similar GIS systems; however they were prevalent in general use until 1980s since capabilities of GIS were limited due to the lack of technological knowledge and the very high cost of computers.

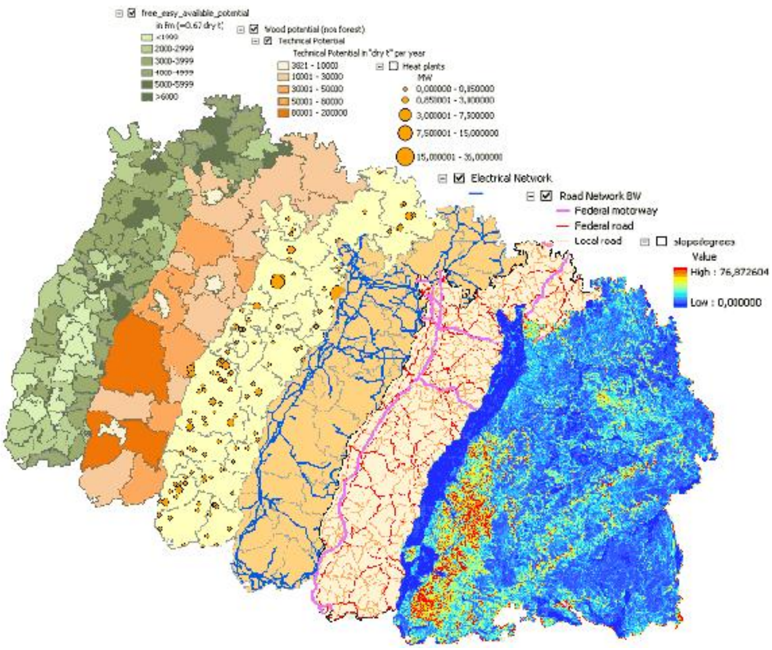


Figure 2.17 GIS Example: Maps determining the best locations to build wood-fired station [29]

Developments in technology and growth of industry instigated GIS usage in 1980s and 1990s. By the end of the 20th century, the rapid growth in various GIS systems had been strengthened and users were beginning to export the concept of viewing GIS data over the Internet, that required standardizations of data format and transfer protocols. [28]

GIS data consists of two basic data types. The primary source data, called spatial data, describes the absolute and relative location of geographic features. In general, locations are defined by x, y, and z coordinates corresponding to longitude, latitude, and elevation information. Attribute data is the other division of GIS data, and describes characteristics of the spatial features. Attribute data is equivalent to tabular data, and can be quantitative and/ or qualitative. For example, the coordinate location of districts of a city would be spatial data, while the characteristics of those districts would be attribute data, such as population density, number of schools, rainfall amounts. Such a map stores information about the city as a collection of thematic layers linked together by geography. “This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from tracking delivery vehicles, to recording details of planning applications”. [31]

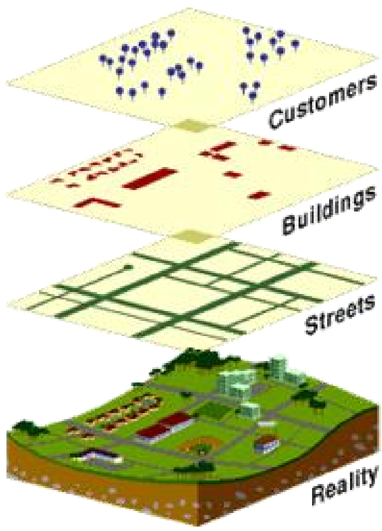


Figure 2.18 GIS Layers: Stores information about the features and events in a collection of thematic layers [32]

Topological information is increasingly required and used in the spatial analysis and visualization of 3D terrain, and has become one of the most important fundamental data for GIS. “A GIS can recognize and analyze the spatial relationships that exist within digitally stored spatial data. These topological relationships allow complex spatial modelling and analysis to be performed. Topological relationships between geometric entities traditionally include adjacency (what adjoins what), containment (what encloses what), and proximity (how close something is to something else).” [28]

2.4.2 Digital Elevation Models

Terrain data easily can be converted into representations in GIS, and Digital Elevation Models (DEMs) are a type of raster GIS layer. A DEM is a digital representation of any surface, in which elevations of ground positions of the surface are regularly measured and collected at horizontal intervals. In other words, the surface area is divided into rectangular pixels and elevation information of each pixel is stored in DEM data. Although Digital elevation models may be constructed in a number of ways, remote sensing is the common method to obtain data. A DEM data of the whole world is available to public use, but its quality is inconsistent and for some areas it is very poor. The quality of a DEM is related to accurate elevation of each pixel. "A much higher quality DEM from the Shuttle Radar Topography Mission (SRTM) is also freely available for most of the globe and represents elevation at a 3 arc-second resolution (around 90m)". [33]

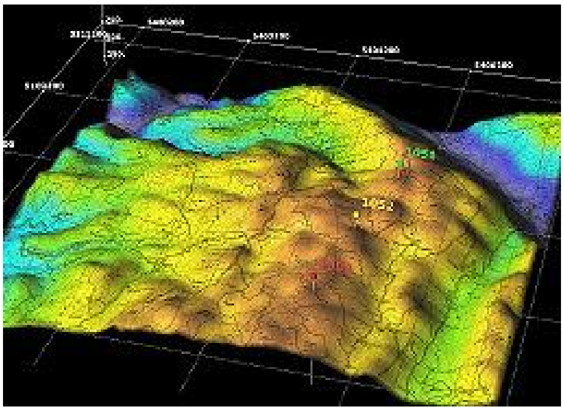


Figure 2.19 DEM: Adding more data layers to GIS [34]

3 INFORMATION VISUALIZATION

3.1 Definition and History

Information visualization, as a branch of computer science, mathematics, and statistics, is a method of presenting data or information in non-traditional, interactive graphical forms allowing users to navigate through it. Although it has enormous background in literature, information visualization has not been accepted as a stand-alone research area until 1990s.

William Playfair who formulated a universal visual language applicable to science by the end of 18th century constructed a whole new paradigm of looking at data, together with essentials of graphical designs. His book "Commercial and Political Atlas and his Statistical Breviary" is the most important work in the entire history of statistics and data visualization, in which origin of the modern graphical forms such as pie chart, bar chart, line graph can be found. He made the data speak to the eye. [35]

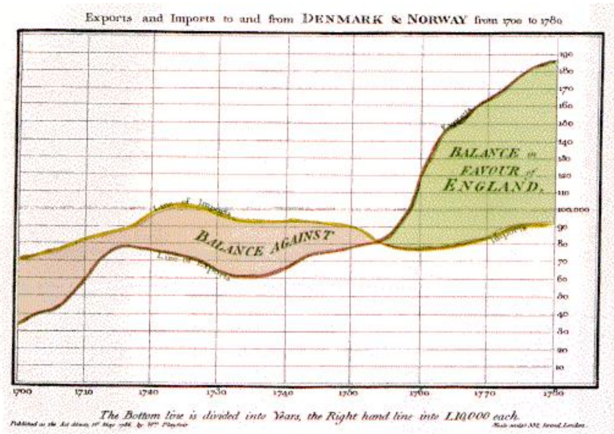


Figure 3.1 William Playfair, Balance of Trade [35]

Charles Joseph Minard created one of the most effective data visualizations in his map of Napoleon's assault on Russia in 1812, which was a combination of different types of graphic representation of multidimensional data. The map was six-dimensional and presented time, location, direction of movement, size of army, and temperature.

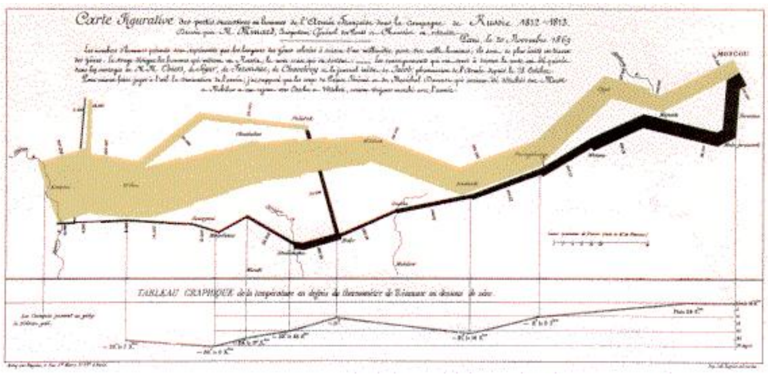


Figure 3.2 Minard's Depiction of the Fate of Napoleon's Army [35]

Recently, Jacques Bertin and Edward Tufte have made other significant contributions to information visualization. Bertin was a French cartographer, and in 1967, he proposed a theory of information visualization by identifying the basic elements of diagrams and described a framework for graphics design. Meanwhile, Tufte published his theory of data graphics that focused on the maximization of the density of useful information in graphics in 1983. [36]

3.2 Essentials in Information Visualization

Before implementing information visualization techniques, one has to consider several essential issues. First one is “the problem”, which defines what has to be presented. “The nature of the data” is another issue to be considered. Data types could be numerical, ordinal (data having a conventional ordering), or categorical (data with no order). Next essential issue is “number of data dimensions”. Depending on the number of dimensions, representations can handle data including one, two, three, or more attributes or variables. “Structure of the data” has to be considered as well. Data structure could be linear (tables, lists etc.), temporal (varieties by time), spatial or geographic, hierarchical, or network (nodes with relations). Last issue is “type of interaction”, that defines whether the representation will be static, transformable (users can manipulate the representation by zooming or filtering), or manipulable (users may control parameters and can change the representation). [36]

3.3 Techniques for Representing Data

3.3.1 Techniques for Representing One and Two Dimensional Data

One or two dimensional data can be easily represented within a single image using scatterplots, charts, and histograms. For two dimensional data, scatterplots are very useful since users can evaluate underlying relationship between the two plotted variables; on the other hand, histograms are more appropriate to reflect comparisons between the values of a dimension.

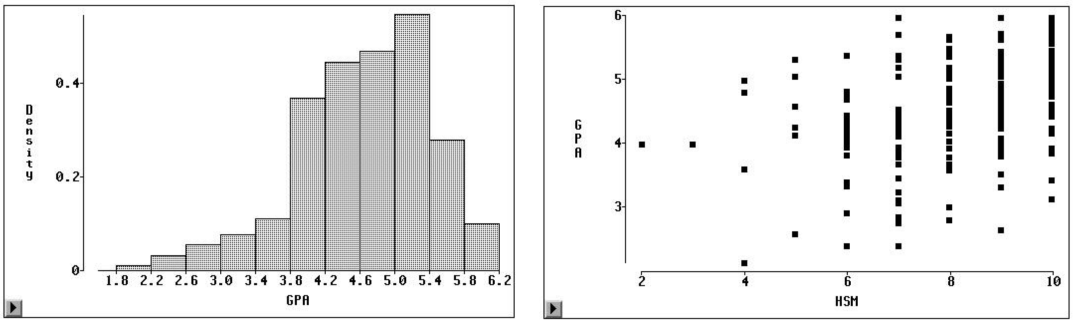


Figure 3.3 Histogram and Scatterplot [37]

3.3.2 Techniques for Representing Three Dimensional Data

It is possible to represent three-dimensional data using a three dimensional space, as our world is three-dimensional. However the mediums for representations such as a printed image or a computer screen are still two dimensional, so that some approximations should be carried out. [38] To solve this problem, values on the 3rd dimension can be projected on the other dimensions, or one of the dimensions can be visualized using different shapes. The following figure shows an example 3D scatterplot, representing data about students' discussions throughout a course. Time, topics and students are three dimensions. A new thread of discussion is represented using a sphere, initiated by the student on a specified date and topic.

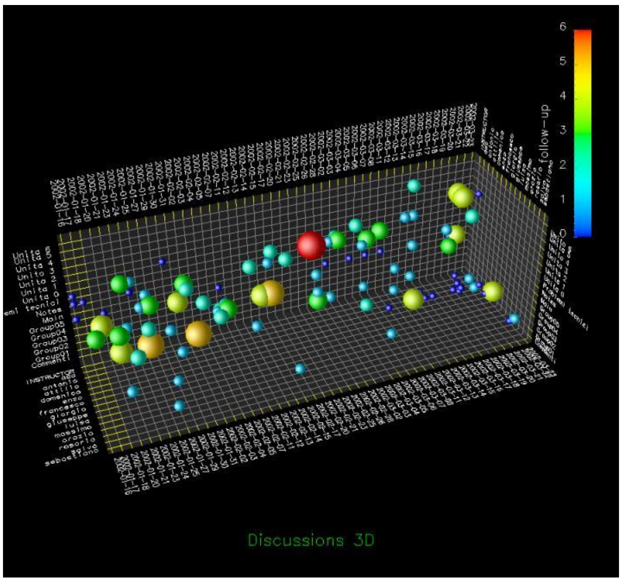


Figure 3.4 Three Dimensional Scatterplot [39]

3.3.3 Techniques for Representing Multidimensional Data

In most cases of the real world, relationships between more than three variables need to be analyzed. For example, consider the case of a bank that wants to analyze profitability by customer and product, using customer, product, time, geography, as variable factors. Following table, constructed by Mazza [36], shows some methods have been suggested to distinguish these dimensions.

Methods	Description	Some known techniques
Geometric	Transforms and projects data in a geometric space.	Scatterplot matrix, Hyperslice, Prosection views, Surface and volume plots, Parallel coordinates, Textures and rasters.
Icon	Relies on a geometric figure (the icon) where the values of an attribute are associated with one features of this, such as the color, a shape, the orientation.	Chernoff faces, Stick Figure, Color icon, Glyphs and Autoglyph.
Pixel	Uses pixel as basic representation unit, and manipulate pixels to represent data.	Space fillings and Mosaic plots.
Hierarchical	Includes trees and hierarchies and is useful when the data has some hierarchical or network structure.	Hierarchical axes, Dimension stacking, Threes, Worlds within worlds, Infocube.
Distorsion	Proposes to distort the tree-dimensional space to allow more information to be visualised.	Perspective Wall, Pivot table and table lens, Fish eye view, Hyperbolic trees, Hyperbox.
Graph based	Represents data using nods and edges and is adopted when the large graphs should be represented.	Basic graph, Hyperbolic graph.

Table 1 Techniques for Representing Multidimensional Data

Detailed descriptions of these techniques can be found in works of Sachinopoulou [40], Card [41], Spence [38], and Chen [42].

3.3.4 Techniques for Representing Spatial Data

The spatial data describes the location of a feature and the possible topological relationships among features. The best way of representing spatial information is to treat spatial data as a dimension of design of the graphics. [36] Spatial data can be represented by points, lines, and area symbols. By varying their shapes and colors, or changing the value of areas, it is possible to distinguish between different spatial objects. The Napoleon's army route in Figure 3.2 is an outstanding example of spatial data representation.

3.4 View Transformations

View transformations are used to change the view or perspective onto the visual representation. Many information visualizations have to display too many things placed in limited space at once. As Spence stated, "too much data, too little display area" is a common problem. [38] Several techniques have been proposed to overcome this problem, such as zooming, panning, scrolling, focus+contex, and magic lenses. Zooming is closing in on, or backing out of/ adding distance to, a certain area of representations. Panning is a technique where the camera is moved to follow a moving subject, keeping it in the same position in the viewfinder. Scrolling is moving through a representation either up and down or sideways, in a continuous and smooth movement. Focus+context is "to illustrate at the same time the overall picture (the context) and to see details of immediate interests (the focus)". [38] Magic Lenses, such as magnifying glasses, show a modified view of the selected area, while the rest of the visualization remains unaffected.

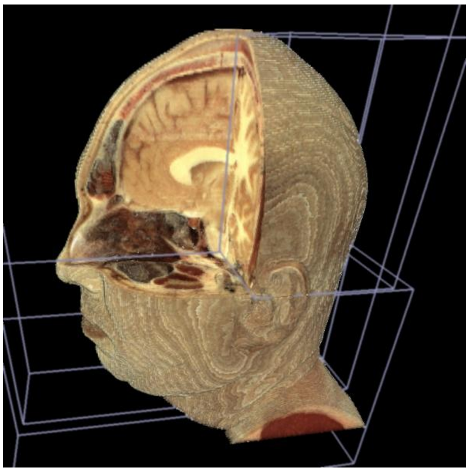


Figure 3.5 Biomedical Imaging Visualization: Data may be arbitrarily sliced, sectioned, panned, zoomed in/ out, or filtered to better reveal the regions of interest [43]

4 THE FLUID CITY

The Fluid City is a GIS constructed upon the terrain of Istanbul. As such, it is essentially a thematic map, comprised of data such as demographical data, structural/ architectural data and the like. However, The Fluid City combines these with historic data and particularly narrative, thus incorporating the tradition of narrative mapping into an interactive, user input built interface. Indeed, documenting and visualizing the narrative, i.e. the dreams, stories and projections of Istanbul'ites are the initial concepts of this map.

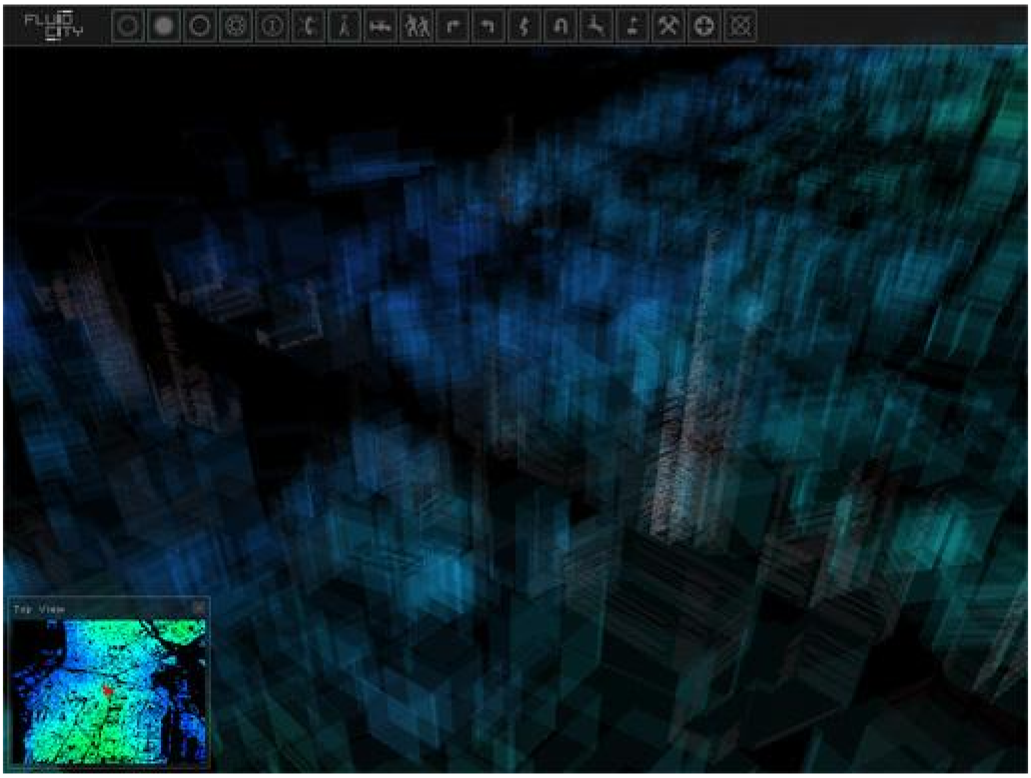


Figure 4.1 Fluid City: An overview from Kadikoy

The project takes as its basic premise the data classification and data visualization of the city of Istanbul, utilizing a system of user input that will culminate in a navigable three dimensional interface, constructed of structures of type that follow the outlines of building ground plans. It takes one of its inspirations from a Turkish counterpart of Wikipedia, the much used *Ekşi Sözlük*, an online dictionary in Turkey.

4.1 Motivation and Background

The Fluid Map started out as a university course project, the aim of which was to enable computer scientists and artists/ designers to collaborate on joint projects of equal merit, both creatively and in terms of programming. The initial version of the project was the construction of a city out of Lego-like structural elements, in the building process of which the general public could participate. The structural information needed for the building process had to be embedded into a database. Users would access the database by the input of the co-ordinates of their location on a 2D map and then proceed to build their buildings out of the Lego-like elements.

Upon completion of the initial Lego based project, I wished to pursue the idea of a map that was constructed upon user input and finding correlations between its concept of structural data input and the concept of textual data input embraced by online reference portals such as Wikipedia decided to supplant the "building bricks", i.e. the Lego-like structural elements with textual data, one that would not simulate the outward architecture of the city, but rather undertake the task of revealing the soul within the structures, creating a fluid, ever changing, virtual architectural whole.

4.2 Ekşi Sözlük

The Turkish counterpart to Wikipedia is the vastly popular *Ekşi Sözlük*. The user input to *Ekşi Sözlük* differs from Wikipedia-like portals in that, in addition to factual data the input can also be, and very often is, irreverent, funny, interpretative, subjective and protest oriented. From its foundation in 1999 the *Ekşi Sözlük* has had a contribution of over 5.500.000 entries, covering close to 1.200.000 topics. [44] This database gave the initial inspiration to the "Dreams" layer of the Fluid Map - a three dimensional environment of dream texts, but one, which also gave references to the geographical location of the "dreamers" within the city itself. Do dreams differ from neighborhood to neighborhood? Do the inhabitants of Istanbul think more about the city center or the outskirts? Are parks or inner city alleys more conducive to thought and reflection? Once the "Dreams" layer was thought of, the “History" and "Demographics" layers were deemed to be of integral value to the understanding of the city and thought processes of her inhabitants and were added onto the project.

Figure 4.2 *Ekşi Sözlük* [44]

4.3 The Layers

Istanbul combines sublime beauty and a history rich in tradition with the chaotic degeneration of an entire system of values from architectural aesthetics to lifestyles. As such, Istanbul can be, and inevitably is, very confusing not only to her many visitors, but also her inhabitants. It is one of the aims of the Fluid Map to make sense of the city, to understand the underlying shifts in demographics and culture that can result in such havoc over the surface, oftentimes heedlessly ruining entire neighborhoods not only structurally and aesthetically, but also from a historic and ecological perspective.

In terms of content, the map is constructed of four separate input layers, conveying separate data: One entire layer is devoted to the history of Istanbul and enables the user to read the historic data pertaining to buildings. A second layer is the demographics layer, which is subdivided into three layers; giving educational status, level of income and time of residency in the city of the occupants of the building. A third layer is about structural information, deemed particularly important, given the earthquake history of the city and the fact that a major earthquake is expected within the next couple of decades. A final and most important layer is devoted entirely to the dreams and aspirations of the inhabitants of a particular location and/ or building.

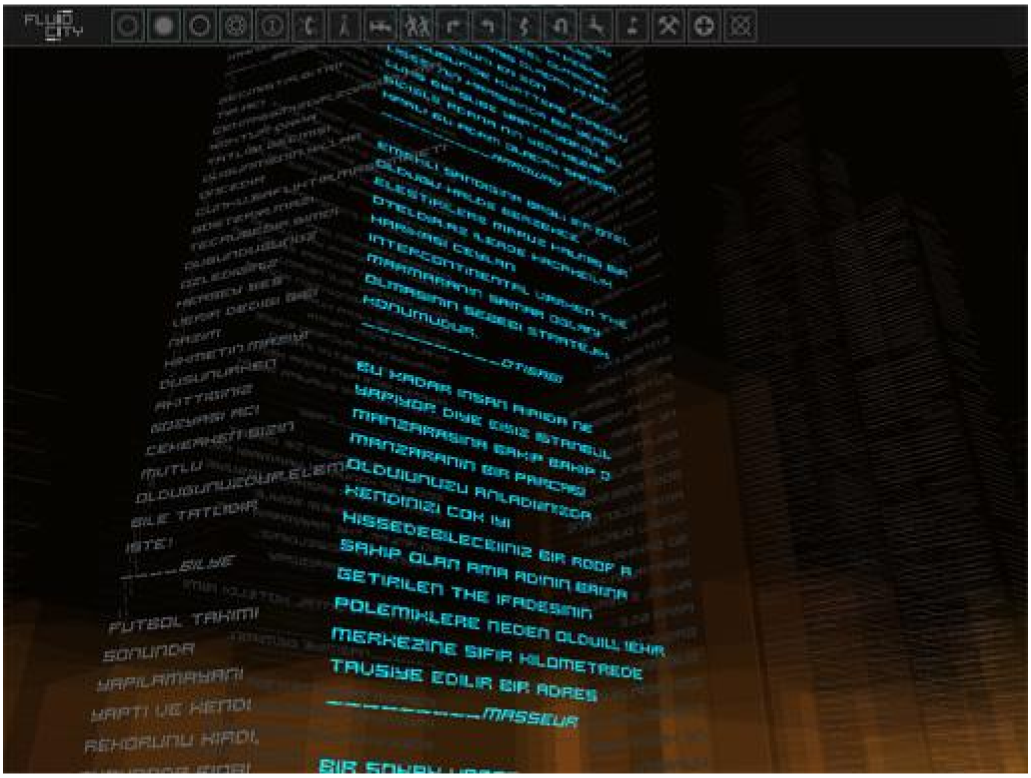


Figure 4.3 A building constructed by the dreams of inhabitants

The user input, such as the construction period, ownership, demographic data of its current and past occupants, which pertains to the particular buildings its contributors have knowledge of, either having lived or worked at that location or by other means such as scholarly interest, is used to construct a three dimensional, navigable, typographic map, which has numerous sub-layers that are color coded and can be viewed or traveled separately or as a whole, thus enabling students of Istanbul to grasp the demographic, historic, and cultural structure of the city. The more data there is available on a particular site or building the taller that building will grow, thus also graphing citizenship consciousness, collaborative spirit, as well as internet access and usage of occupants/ contributors - vital information for further demographic studies concerning the city.

A birds eye view gives an overview of data distribution by location and neighborhood, utilizing color fields, whereas traversing the streets lets the user "read" the city; demographically, culturally, historically - overlaid by the dreams and tales of its inhabitants. Just like Istanbul itself, this fluid city will continuously re-invent and re-structure itself by the input of new data that will constitute its building blocks. This flux will reflect the essence of the city whilst creating an alternative architecture that operates in its own climate: an architecture both of facts and of dreams.

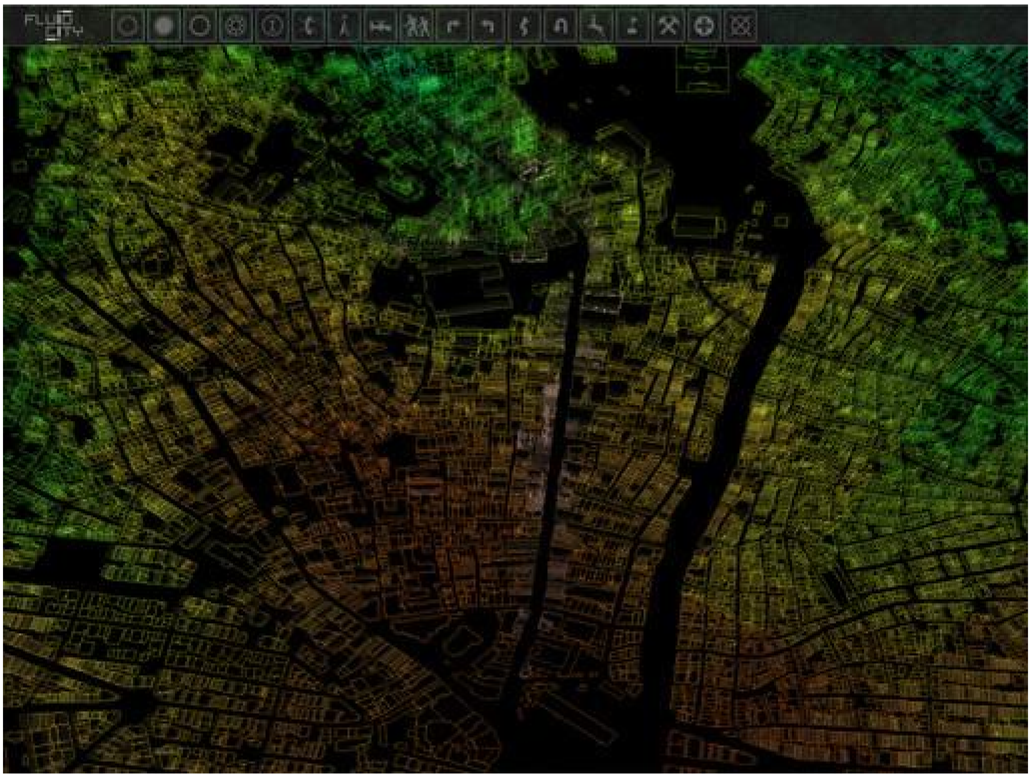


Figure 4.4 Birds Eye View of Istiklal Caddesi, Beyoglu

For the time being, only Dreams and Structural layers can be built, thanks to Ekşi Sözlük and İki Nokta company that provided data. Demographics layer can not be demonstrated due to lack of data, since demographic information such as educational status, level of income are not public, and hard to simulate.

4.3.1 The History Layer

Istanbul, known as the capital of capital cities, is the only city in the world to straddle two continents, and the only one to have been a capital during two consecutive empires. Ancient and modern, spiritual and secular, Asia and Europe, mystic and worldly all co-exist in Istanbul. The Roman emperor Constantine the Great constructed the city of Byzantium on the Golden Horn as the capital city of the Eastern Roman Empire (the Byzantine Empire), and named it Constantinople in 324. Istanbul was at a strategic position since it was possible to control the routes between Asia and Europe, Black Sea and the Mediterranean Sea. Until the time Ottomans conquered the city, several nations had tried to get the city, such as the Arabs, the Bulgarians, and the Crusade armies. However, Istanbul became the capital city of the Ottomans in 1453. [45]

Figure 4.5 Constantinople: The capital of capital cities [47]

The city of Istanbul had been moved to another cultural climate during the Ottoman period, from “an imperial Byzantine city to an Ottoman Islamic one”. [48] Sultans, the wives and the mothers of Sultans have constructed Mosques around the city to signify the power and control of Sultans. While the Ottoman architecture, arts of ceramics, and calligraphy flourished the city, beliefs of Sufi that were prevalent in the Islamic world domiciled in the capital. The city had become the capital of the Ottoman

Empire until 1923, when the newly founded Turkish Republic declared the city of Ankara as the capital. Name of the city was officially changed to Istanbul in 1930. [46]

One particularly interesting footnote to the history of Istanbul, from our perspective, are the maps of the city created by Jacques Pervititch in the 1920's and 30's: An insurance salesman, Pervititch created detailed street maps of Istanbul, which incorporated the names of residents and their professions, for sales purposes - an early visualization of one of the concepts of the Fluid City.

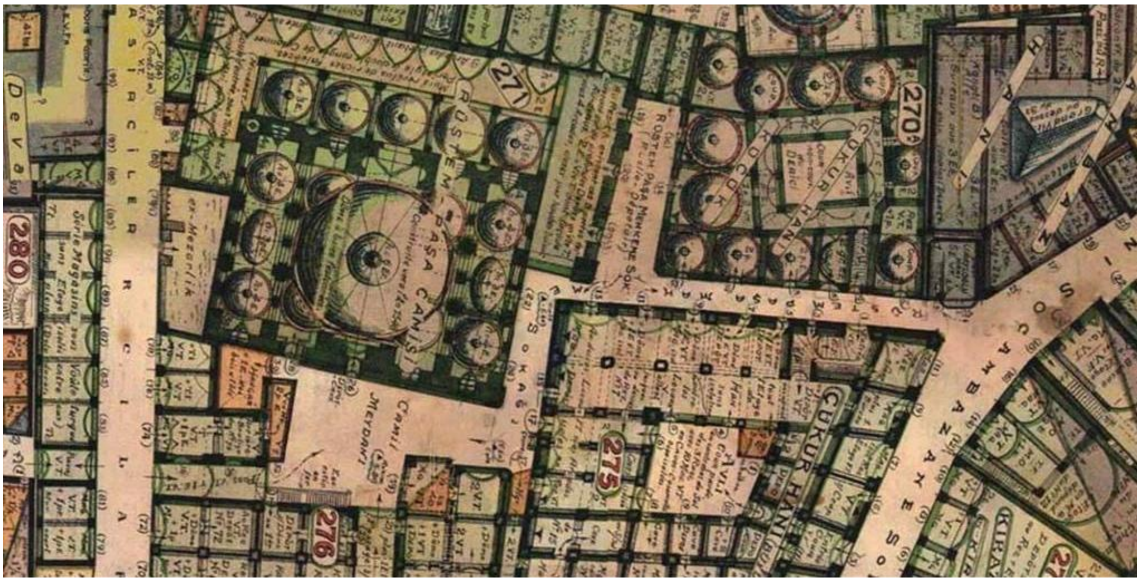


Figure 4.6 The Map of Istanbul, Jacques Pervititch

Due to bulky migrations from Anatolia to Istanbul in 1970s, population of Istanbul has swiftly enlarged. People of Anatolia moved to the city in order to find jobs in the new factories constructed on the borders of the city. More increase in the population means increase in settling areas. Distant villages of the city have defragmented to the greater metropolis of Istanbul. Today's large districts of Istanbul such as Maltepe, Kartal, Pendik, and Tuzla are sparsely populated, rural, and tranquil places in memories of middle-age inhabitants of Istanbul. [45]

It is of course a given that in building the Fluid Map, the history of the terrain plays an integral part considering the richness of the history of Istanbul. When viewed within this context the historic peninsula of Istanbul, which architecturally is rather flat since the building regulations do not allow for structures over five stories to be erected is expected to soar into typographic edifices that can be hundreds of stories high, depending upon user input. Thus the Topkapı Palace, itself only two stories high, should end up being one of the tallest structures of the entire city, when viewed from the history layer, whereas the skyscrapers of Maslak will only merit a couple of lines, i.e. "floors", when viewed from the same data layer, having only been erected over the past fifteen years.

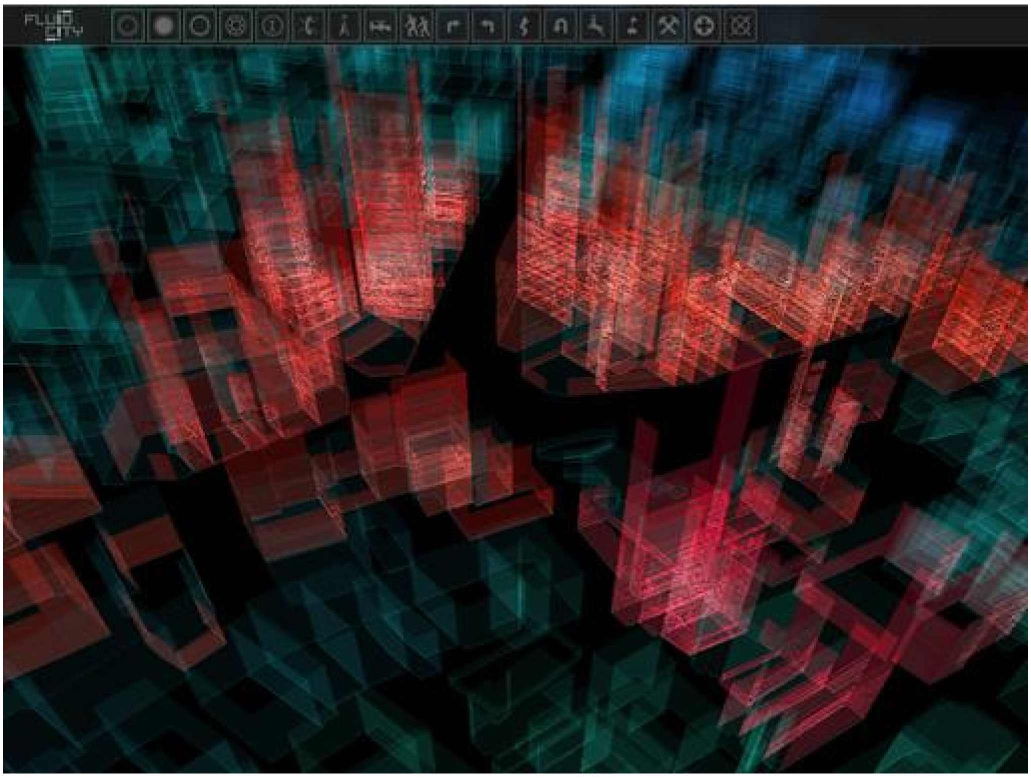


Figure 4.7 Floating Silhouettes by Layer

4.3.2 The Demographic and Structural Layers

Istanbul is a city of vast and diverse historic background. Between 657 BC when she was founded and now, the city has hosted and assimilated a multitude of cultures. Furthermore, Istanbul is a city that continually reinvents and restructures itself; architecturally, culturally, and demographically and as such, provides a dramatic framework for the project: A city of flux.

In a frenzy of growth, entire neighborhoods are transformed, buildings are torn down only to be replaced by others, vast shifts in population occur - all more or less within a timeframe of decades if not years or indeed seasons. Whilst dynamic and challenging on the one hand, the ensuing change very often results in architectural cacophony and chaos, which the movers and shakers of this transformation seem to be completely unaware of. Economic necessity dictates pragmatism and unfortunately the historic as well as natural beauty of the city has fallen victim to haphazard development, manifesting itself as "gecekondu" - the concrete structures that are erected almost literally overnight and that today are lining both sides of the Bosphorus -- possibly one of the most beautiful straits of the world. Compounding the tragedy is the fact that more often than not, the building craze results in the erection of gecekondus that “represents half of all the city’s constructions”, and are structurally unsafe which, in view of the impending major earthquake that geophysicists are warning the city of, is highly alarming. [49]

Figure 4.8 A City of Flux: Sublime beauty and grace side by side with architectural/ cultural devastation

Making sense of the city and its frenzy of change is a major need for every concerned Istanbul’ites. Needless to say, the pace of change and growth is dictated by the growth in population, which stands at 3.5% per annum, an influx from rural

Anatolia, not to mention the input from neighboring countries such as the former Soviet Union, Africa, and the Middle East. [50] The educational, medical and employment needs of the incomers to the city stretch already thin resources to their utmost limit. Infrastructure and public transportation are amongst the city's biggest concerns: A one-hour traffic jam on the Bosphorus Bridge is something that most Istanbul'ites take in their daily stride. However, the biggest challenge that contemporary Istanbul presents to her inhabitants is the necessity of a co-existence of many diverse cultures: Muslims, Christians, and Jews, rich and poor, and ultimately that of the indigenous population with incomers, the latter pitting an old time bourgeoisie against the energy of a young and hungry populace, coming from a multitude of ethnic backgrounds.

Figure 4.9 A City of Flux: Necessity of co-existence of diverse cultures

4.3.3 The Dreams Layer

Istanbul is a city of dreams: The yearly growth brings with it personal/ cultural mythologies and tales, which flow into an ever changing and chaotic, oftentimes poignant, sometimes uplifting but always astounding whole; sometimes blending and more often than not, clashing with the tales and myths of long time Istanbulites.

So diverse are the dreams of a fast growing metropolis of almost 20 million; 75% of whom are estimated to be below the age of 35; that a separate layer will be devoted to the dreams, projections and tales of the contributors. [50]

Figure 4.10 A City of Dreams

5 DESIGINING THE MAP

Maps are abstract objects representing actual places and objects by use of symbolization. Information richness or a multivariate map indicates relationships within the map, thus enabling comparison, which adds to the meaningfulness of the map. The aim of the fluid map is to generate hypothesis and stimulate ideas and further research. In order to convey the message of the map, the map must be designed in a manner, which would aid the reader in the overall understanding of its purpose.

5.1 The Logo

Designing a logo was the front line of the project process. The mark of a good logo is its legibility and recognition. Therefore I wanted a logo that would reflect the mass structure of buildings and streets of a city, in a simple and outlined way. Using a clear Mini typeface was ideal, but was not sufficient to function as a standalone identity. I added two straight lines on top and bottom of the typeface, which allowed turning a common typeface into a unique and representative logo, and moreover, strengthened the feeling of a city outline. I also tried different colors and contrast on some of the letters, but the monotone color turned out to be a better choice because contrast was unnecessary and use of only one actual color would make the logo fit into every form of visualization of the fluid map.

Figure 5.1 Project Logo

5.2 The Interface

Particular time and effort have being devoted to researching the interface of the application into which the map is embedde. The interface is expected to be comprehensible, allowing for navigation as well as search engine palettes. Additionally, many layers exist as diverse data should be accessed with ease. Thus, what has been aimed for a semi-transparent interface with pulldown menus and draggable palettes, following the essential principles of the now universally used *Windows* interface, and whose color and typographic scheme are consistent with the actual map and yet remain sufficiently differentiated. The user interface is in English; however, a Turkish interface is also provided since the bulk of the users are expected to be Turks.

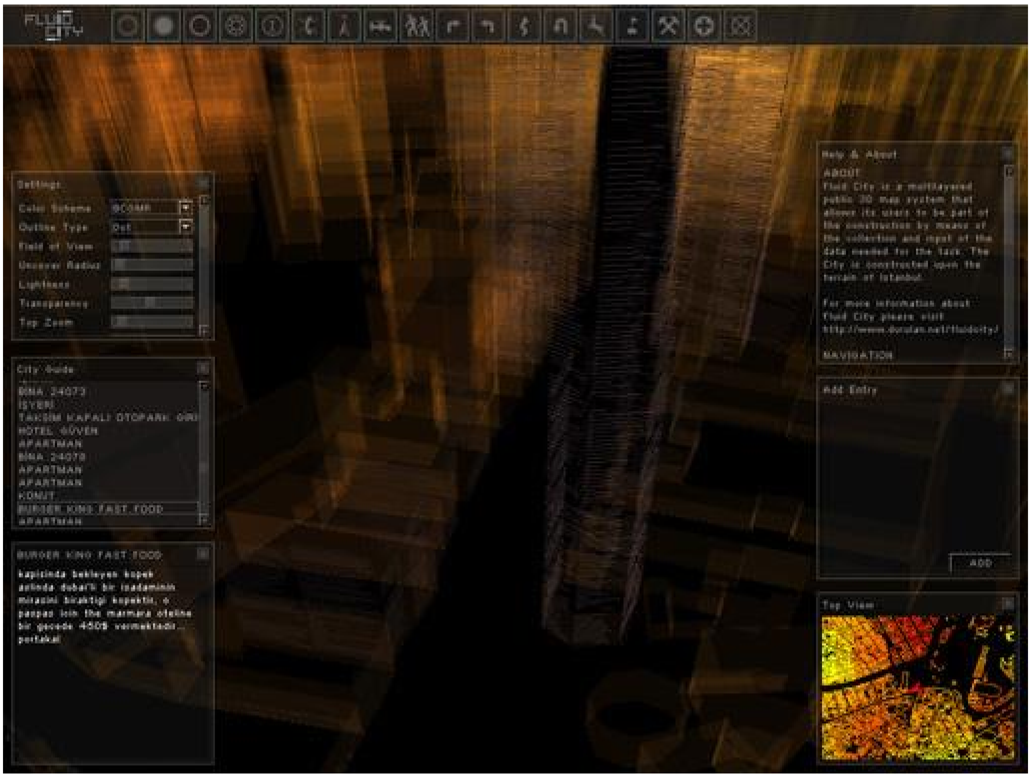


Figure 5.2 User Interface

5.2.1 Main Menu

The main menu is a simple, draggable, and semi-transparent toolbar containing the logo and several buttons related to options, which assist in the operation of the fluid map. The design of the buttons is inspired by the collection of generic symbols, shapes, and elements used in cartography such as utilities, military, hazardous, transportation, and electrical, to convey the appropriate message for a specific function. The function of each button is described below.

Figure 5.3 Main Menu

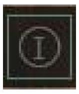
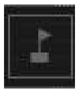
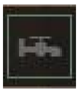
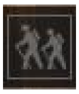
	Text layer		Next edge
	Actual layer		Previous edge
	Box layer		Next building
	Outline layer		Previous building
	Building information		Random building
	City Guide		Building marks
	Top view		Settings
	Add entry		Help
	Search		Quit

Table 2 Main Menu

5.2.2 Building Information Palette

Building the information palette is one of key components of the interface that enables the user of the map to read the 3 dimensional textual data as straight and editable text. The palette lets the user gather information on selected building, including the title of the building and highlighted entries. Anti-aliased Arial font type is chosen for the information presented; because Arial is the best font that gives sufficient contrast between the text and the background to put information onto a small space.

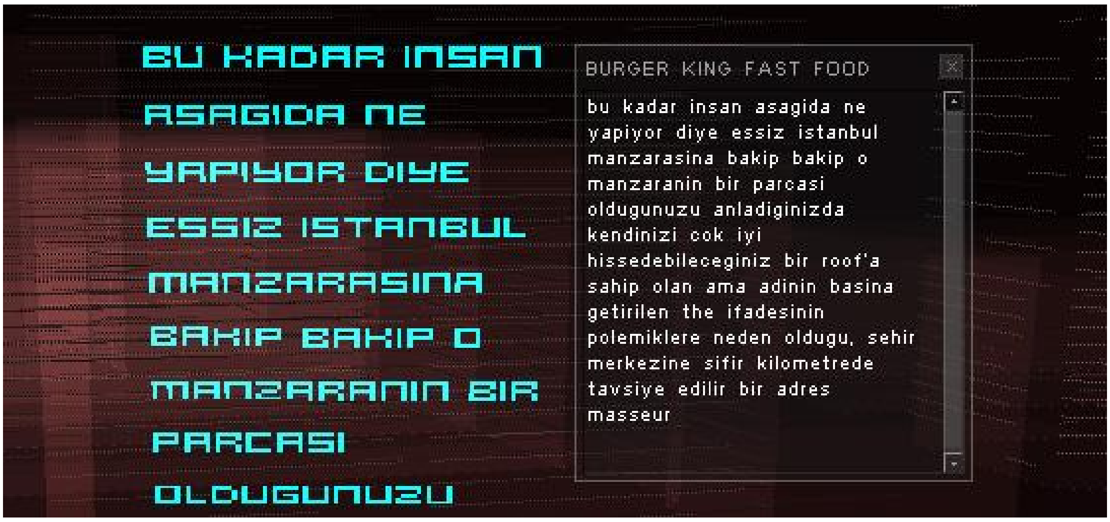


Figure 5.4 Building Information Palette

5.2.3 City Guide Palette

The City Guide Palette was created in order to provide the user with a complete list of buildings and structures of the city. The palette has a list box menu; users select the building they wish to view from the list box; and the camera flies from the current location to the location of requested building on the Fluid Map.

Figure 5.5 City Guide Palette

5.2.4 Settings Palette

The Settings Palette contains view management, fluid map manipulation, and statistic tools. The palette allows users to create unique visualizations of the fluid city. Users can change structural coefficients of the city, color schemes of the fluid map, control the light and transparency levels, adjust cameras, as well as obtain statistics on memory and CPU usage of the program by using the Settings Palette.

Figure 5.6 Settings Palette

5.2.5 Top View Palette

The Top View Palette enables consistent comparison of the entire city; while indicating locations and direction of the user on the map, and giving an overview of topographical data. The top view shows the fluid map in 2D manner; however, color scale supplements the third dimension as well.

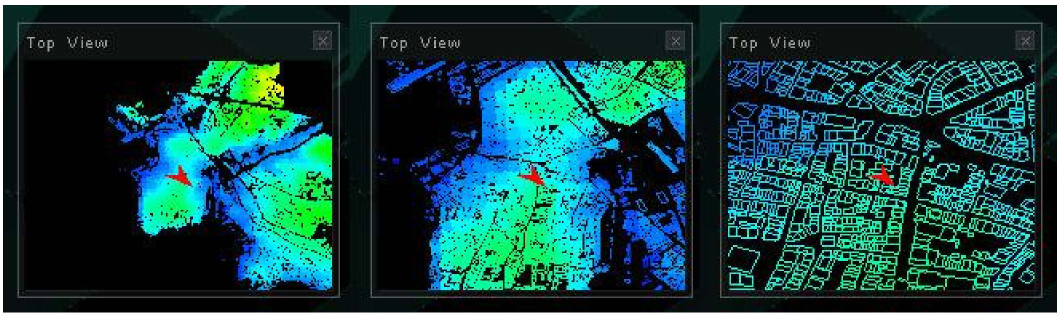


Figure 5.7 Top View Palette: Zooming in

5.3 Navigation

One primary goals of the project is to provide navigation quickly and accurately locates specific data within an overall structure without the user getting lost. City guide and top view palettes are designed to enable the user-view the entire chains of buildings as well as read individual buildings in detail. Moreover, several global navigation tools are implemented that provide unique viewing and interacting with the map. These tools allow users to see the data from all perspectives. The point of view of a user changes according to his position around the city. In other words, users navigate through the city, in a way that is similar to flying, and this flight is controlled by mouse and keyboard. Navigation tools are used for rotating, zooming in and out around the buildings. It is also possible to read the data wrapped around the buildings by scrolling the mouse wheel in reading 2D text. The main menu contains several buttons for navigation, such as next edge, previous edge, next building, and previous building buttons, similar to surfing tools of the internet browsers.

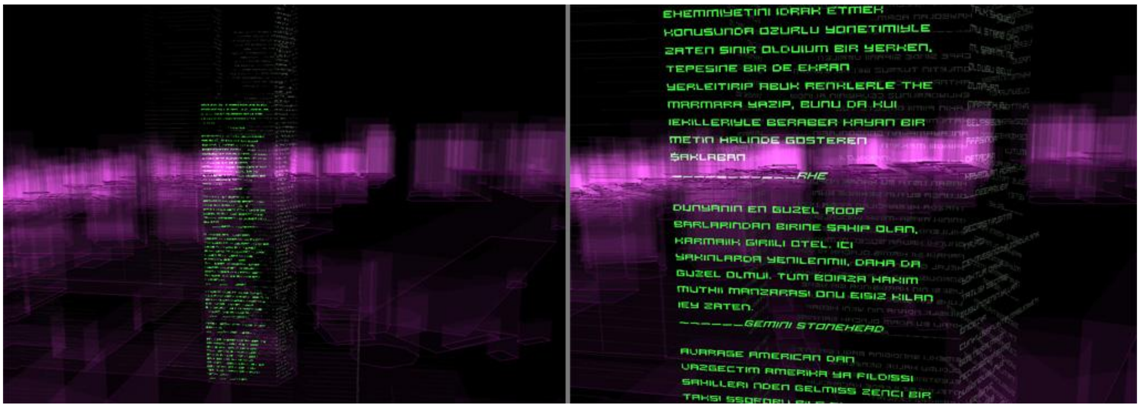


Figure 5.8 Global Navigation: Zoom In/ Out

5.4 Figure Ground

The principle of figure-ground refers to the notion of engaging the user fully in active viewing by presenting a clear presentation, leaving no confusion concerning the purpose of the ma, that will enhance the user's experience and keep his attention. If the user is unable to identify what is being demonstrated in a reasonable fashion, the map may be regarded as useless. Thus the concepts of differentiation, closure, centrality, articulation, abstraction, and good contour are incorporated into the 3 dimensional design as follows:

5.4.1 Typography

A simple typographic scheme has been employed to minimize distraction. The type of uniform pointsize and typeface is arranged flush left to ensure clean contours on structures, however is left ragged right to enable correct kerning and reading. The typeface chosen is Mini for its clean square structure, which does not only minimize polygon count and ease rendering, but also adds the simplicity of the overall design. The speed of the fluid map directly depends on chosen typeface that determines the number of polygons used in the creation of the 3D text. The more polygons a character has, the more time is required to render it. Characters of the Mini typeface are also aligned horizontally and vertically on a square pixel grid, allowing switching between sets for complex, yet highly legible type treatments.

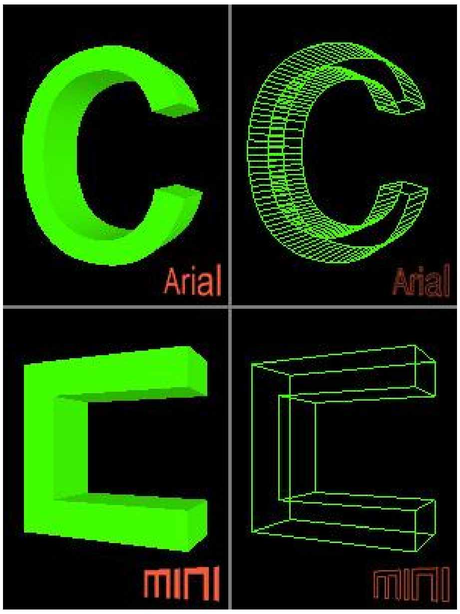


Figure 5.9 Comparing Mini to Arial: Letter 'C'

Further simplifications that would ease the 3D rendering were also necessary; thus a system was formulated whereby the textual data transforms itself into simple lines that correspond to actual sentence lengths when viewed from a distance and only renders itself as type upon proximity. Users can adjust the distance from the settings palette using the “uncover radius” slider according to speed of their computers.

Figure 5.10 Uncovering a Building / Transforming a Building into Lines

However, uncovering large amount of textual data at once is not performed as expected within the terms of legibility. Using transformed lines indeed assists on distinguishing the 3D texts. The best visualizations are composed where only the selected building and a few neighbors are uncovered and those in the distance remain transformed. The reason is that as the distance becomes larger, the textual data falls far from the eye and starts to look alike dashed lines, which causes the simplicity of the map to deteriorate.

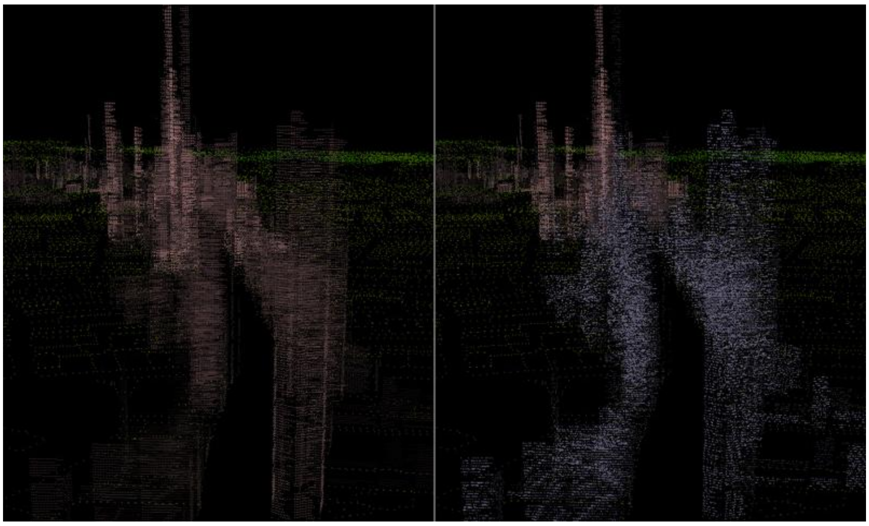


Figure 5.11 Effect of Uncover Radius on Legibility

5.4.2 Color

In cartography, color provides very helpful visual clues to the users. There are different types of color schemes to show various features on maps. The ones often used are the diverging color schemes (two colors with different light-to-dark values progress outward from a critical midpoint) and monochromatic color scheme (one color, with different light-to-dark values). For the fluid map, several color schemes are provided while the background is always kept as a simple black to emphasize and differentiate the many different colors defined in the schemes. The color schemes are dynamically created by mapping pre-defined color ramps between the lowest and highest elevations of the city. Each color scheme is precisely designed so that it leaves little room for ground distraction, and ensures prominence of the figure, i.e. the typographic data. The color schemes are illustrated below:

	Blue → Cyan → Green → Magenta → Red
	Blue → Red
	Grey Scale
	Red → Yellow → Green → Cyan → Blue → Magenta → Red
	Green → Yellow
	Green → Magenta
	Blue → Green → Red → Green→ Blue
	White → Black → White
	Red → Blue → Cyan → Magenta
	Blue → Cyan → Green → Yellow → Red → White
	Dark brown → Lighter brown
	Green → Brown → Yellow
	Yellow → Red
	Blue → Cyan → Green → Yellow → Brown → White

Table 3 Color Schemes

In each color scheme, outline and actual colors are consistently calculated according to corresponding height values in color ramps, yet textual layers have completely contrast colors. Also transparency enables the figures to cohabitate with all its neighbors hence transparency assures giving the illusion of depth to a flat surface. The level of transparency, strength of the light, and active color scheme may be controlled from the settings palette.

5.4.3 Abstraction

The principal premise of the design, whereby the buildings are not simulated, but presented as text based abstractions, creates a level of abstraction that veers away from the illustrative to the symbolic, a movement which again is expected to contribute to the clarity of the figure ground by eliminating superfluous detail and aiding in the focus toward the actual content of the map (i.e. the narrative).

Streets, squares, green belts, and parks; as well as the shoreline and the actual sea (an integral part of the beauty of Istanbul) are left blank, again to aid simplicity and the concept of good contouring integral to figure ground.

5.5 Process

In terms of the programming/ design process, the fluid map, as a massively ambitious project, requiring design and implementing with ease, user friendliness and simplicity that ensure the contribution of the dwellers of a major metropolis, is composed of 4 layers, separate from and not to be confused with the data input layers mentioned above: the text layer, the GIS shape layer, the terrain layer, and the box layer. Each building in the city is a combination of specific information that comes from each of these three layers. The GIS shape layer defines location and outlines of the buildings. The terrain layer defines topological information of the area under the building. The text layer defines texts that wrap the buildings. The box layer is used for statistical purposes. More detailed information of each layer is as follows:

5.5.1 The GIS Shape Layer

Whereas in the original Lego Map, the data input could only be achieved by means of a manual method based upon the selection of coordinates on a 2D map, for the fluid city, GIS technologies were used instead. Boundaries of the buildings of the fluid map were created by using one or more ESRI Shape Files which were then embedded into a module that was subsequently called the GIS Layer. These files are a format developed by ESRI and used in GIS packages. A Shape File is a digital vector (non-topological) storage format for storing geometric location and associated attribute information. It is thus possible to load the positions and boundaries of all the structures in a given neighborhood at one time. Furthermore, structural changes are automatically updated as they occur - an added bonus of GIS.

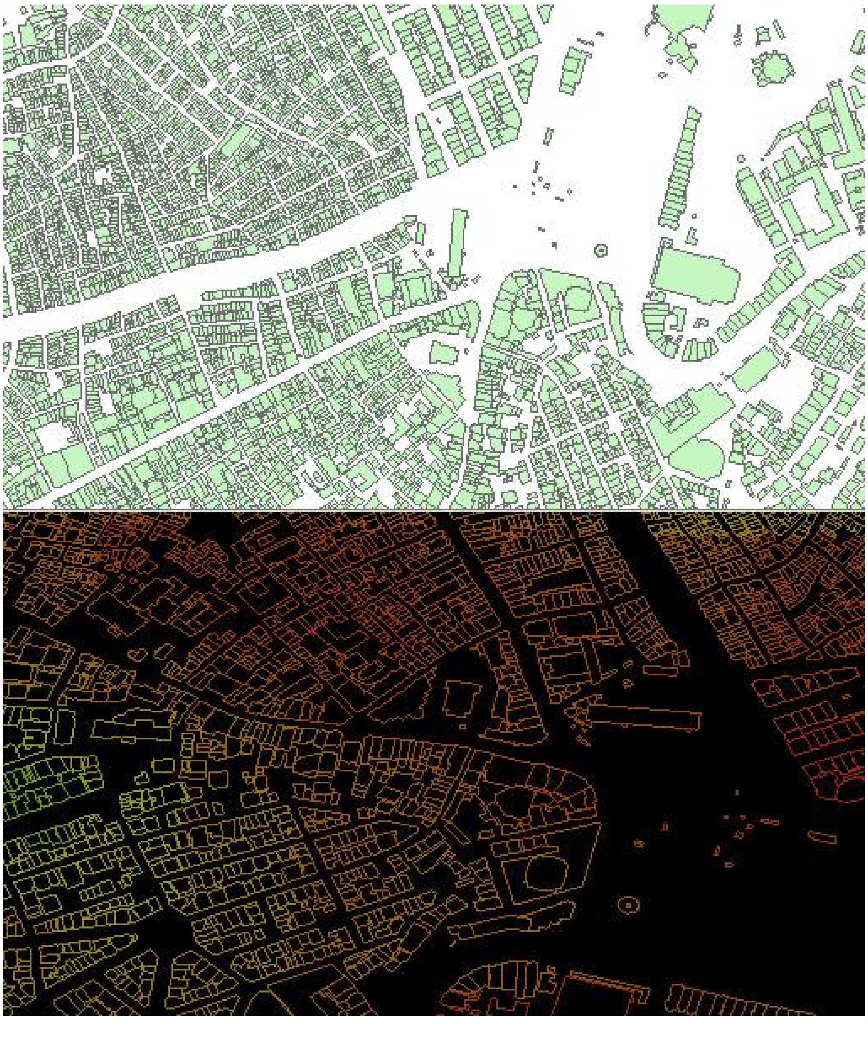


Figure 5.12 A Section of Beyoglu on GIS Data vs. on that the Fluid Map

The Shape Files of Kadikoy and Beyoglu were used to build a sample part of the fluid city to test the second module. The example Shape Files and datasets were provided by the İki Nokta Company (Istanbul). These datasets were used strictly for experimental purposes. All values in this dataset correspond to WGS84 (World Geodetic System 1984), which is an earth fixed global reference frame used for defining coordinates in surveying. Since the buildings of the fluid map are placed with WGS84 data, they correspond exactly to their location in the real world in terms of coordinate systems. The building structures are polygons and the lengths of the side of the polygons give the structure its shape. GIS data also provide height (number of floors) and title information for the buildings. In conclusion, the GIS Shape Layer is the sum total of the polygons that provide the structural framework upon which the textual data is wrapped. Again, in order to enhance real-time performance, only the visible structures are rendered and the level of detail of the rendering is based upon the proximity to camera.

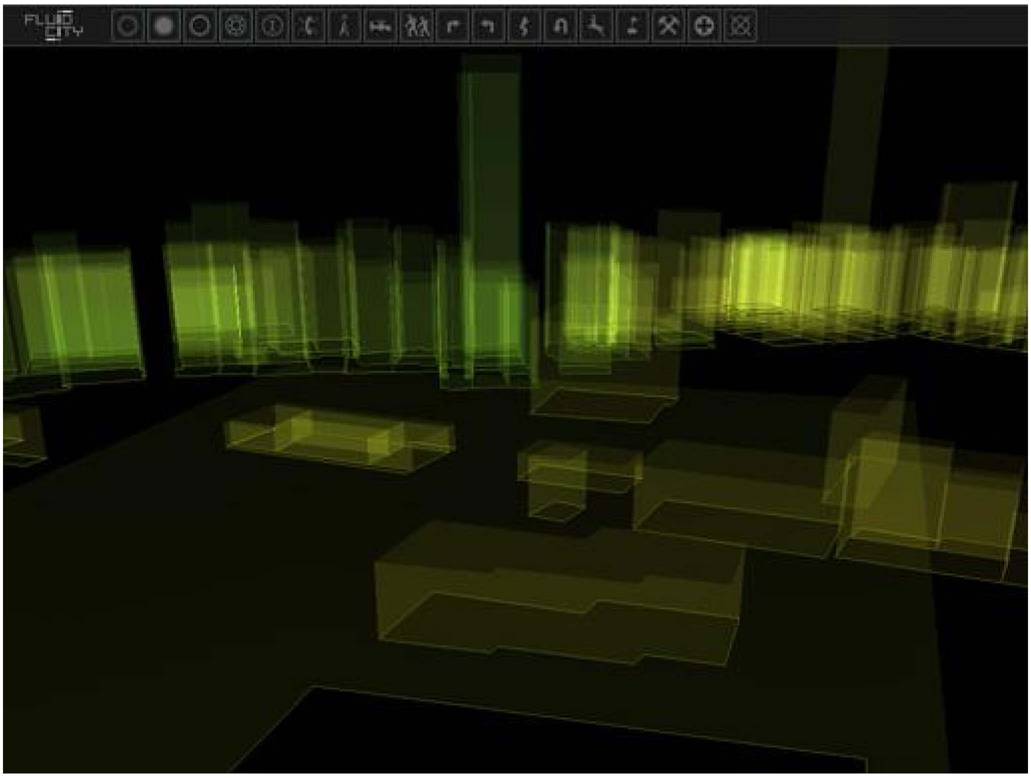


Figure 5.13 GIS Shape Layer

5.5.2 The Terrain Layer

Although the GIS Layer is instrumental in formulating the structures of the buildings, it does look like 3D information pertaining to terrain. Since it is deemed desirable that the Fluid City is shaped upon the topographic data of Istanbul, this information is derived from SRTM Height Map files that correspond to the location of Istanbul. These are available for downloading from the Shuttle Radar Topography Mission website at NASA. SRTM data are organized into individual rasterized cells, or tiles, each covering one degree by one degree in latitude and longitude. Sample spacing for individual data points is either 1 arc-second or 3 arc-seconds, referred to as SRTM-1 and SRTM-3, respectively. Since one arc-second at the equator corresponds to roughly 30 meters in horizontal extent, the sets are sometimes referred to as "30 meter" or "90 meter" data.

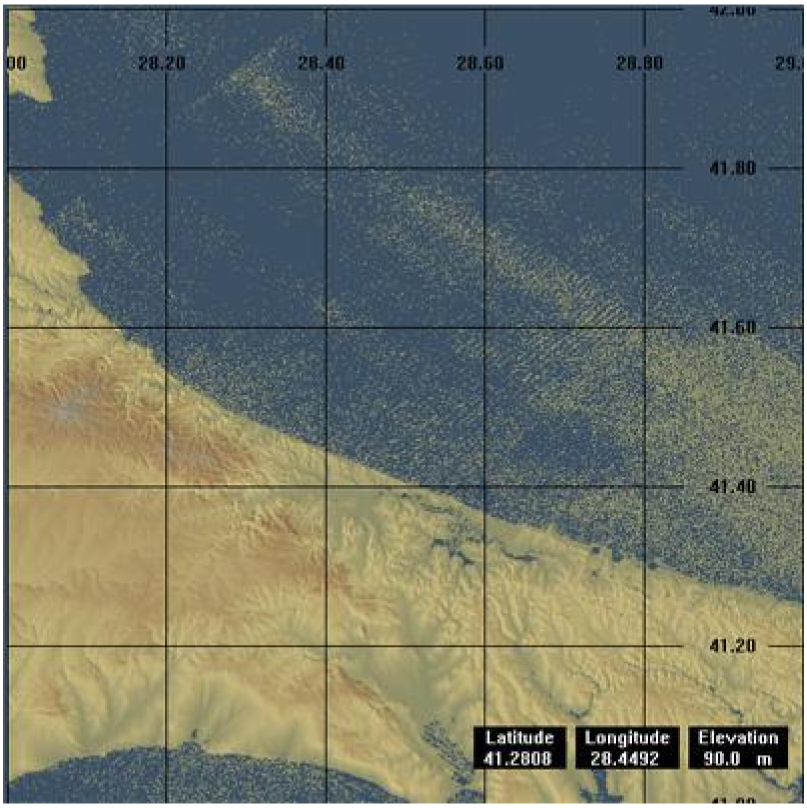


Figure 5.14 SRTM-3 data for 41° Northing – 28° Easting (North West of Turkey)

Instead of designing a separate terrain layer, terrain information is merged into the GIS shape layer and outline of the city. Since the terrain layer adds height information to the GIS data, the structures derived by means of the GIS data must be repositioned onto the map. The data that the terrain layer provides a SRTM-3 data set composed of the UTM (Universal Transverse Mercator) zone coordinates. Thus, merging of the GIS and Terrain Layers can only be accomplished by translating the UTM data to WGS 84.

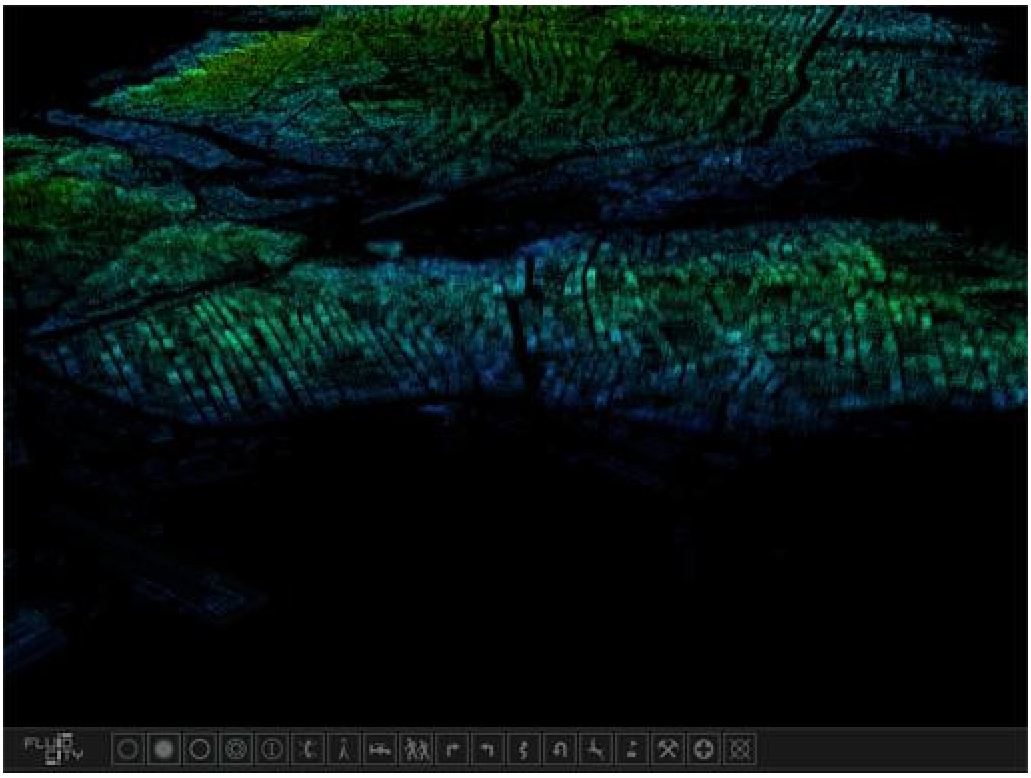


Figure 5.15 Terrain Layer: A View from Kadikoy Port

5.5.3 The Text Layer

The first problem encountered in the project was the creation of a perpetually changing and self generating 3D environment that derived its building blocks from a text input database. To this end, the module that we subsequently referred to as the Text Layer was developed. This module has the ability to take the text data and wrap it around various polygonal 3D structures, i.e. buildings, taking into account their geometric requirements by ensuring correct line breaks etc. The Text Layer, is the sum total of the text wrapped around the buildings of the city. All buildings are able to accommodate more than one type of textual data, such as historic, demographic, and dreams. These texts will eventually be collated by means of public input via the actual interface as well as web forms.

Figure 5.16 Public Input via the User Interface

The buildings are shaped by the textual entries in the database. Thus, the text can be likened to actual building bricks. Needless to say, the more text there is, the higher that particular structure will grow. However, the structure of edges affects the height of the structure. The structures with longer edges and larger number of edges will rise slowly, since more textual data are needed to add a new storey of line while wrapping the data around the edges. That's to say, a building with larger volumes will be lower than a building with smaller volumes although both of the buildings have the same amount of textual data. Additionally, the size of the typeface directly affects the height of the structures. The smaller font size means the structures will be lower even though they can hold more textural data in the same volume. Users can adjust size of the typeface and minimum edge width to wrap with the setting palette.

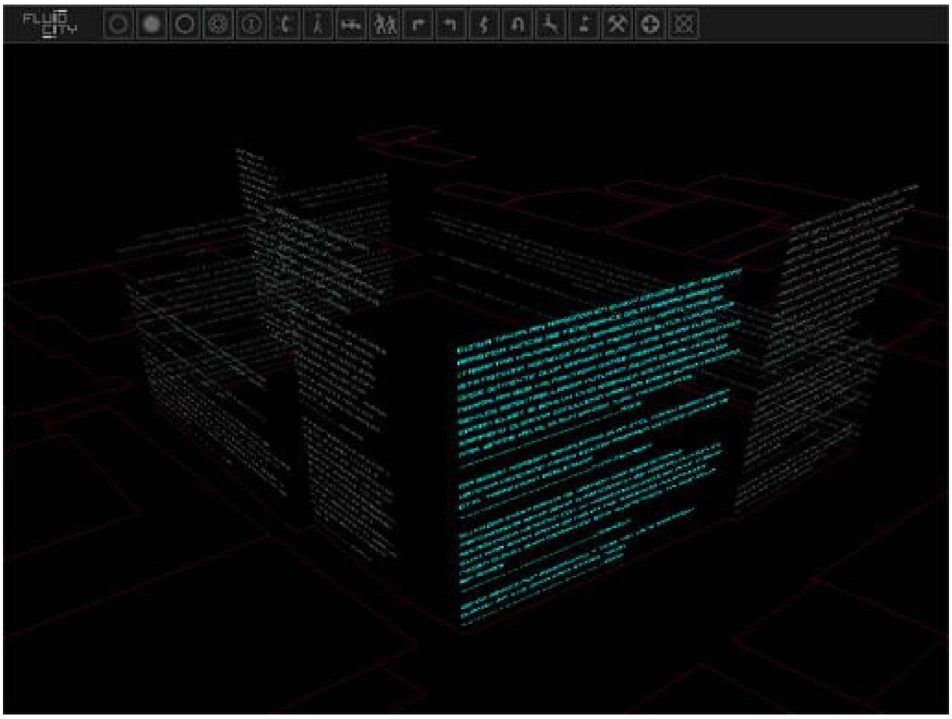


Figure 5.17 Edge with Effects Height

5.5.4 The Box Layer

The Box Layer is designed for highlighting the textual height of the structures in order to distinguish the textual layer from the GIS layer by using contrast colors of the GIS shapes. It is kind of a histogram used to graphically summarize and display the distribution of the textual data.

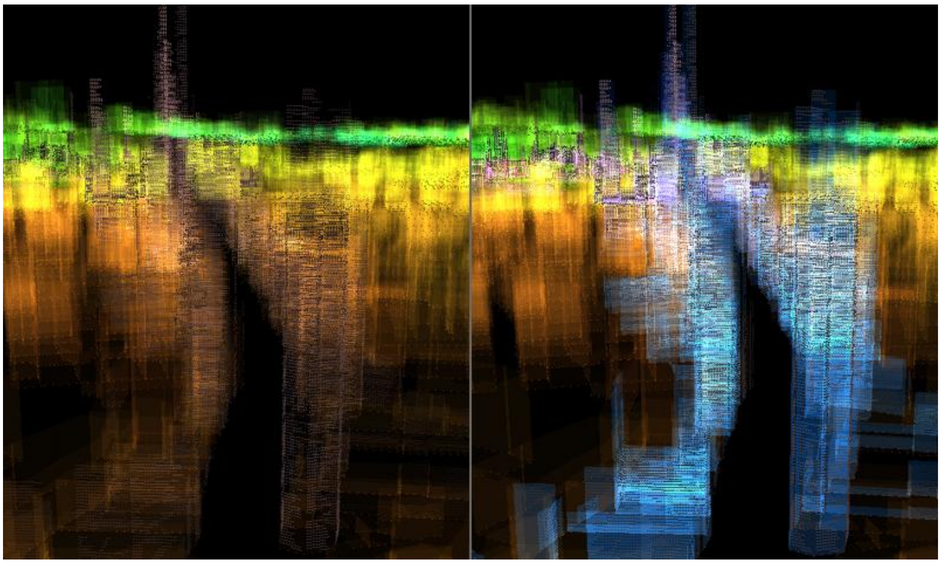


Figure 5.18 The Box Layer

6 PROGRAMMING ENVIRONMENT

The visualization is created using the OpenGL libraries and C++, utilizing object orientated design techniques and the evolutionary method for the implementation. OpenGL is used since it is device independent, simple, and efficient. [51]

The MySQL database engine is used to access and manipulate the Fluid City data quickly due to the fact that it is an Open Source (GPL) Standard Query Language (SQL) database that is fast, reliable, easy to use, and suitable for applications of any size. [52]

The user interface is implemented using the Guichan Graphical User Interface Library. Guichan is a C++ based class library for building Graphical User Interfaces. Guichan is used for its platform independence, and the application will be easily imported to other platforms, simply by recompiling the library. [53]

7 CONCLUSION

I am fully aware that the aesthetic premises of this project may be severely criticized, especially by our fellow Istanbulites: Istanbul is a city unique in its beauty, geographical location, and cultural diversity. I am reducing all of the above to a uniform, textual abstraction as far as the visual aspect of this project is concerned. Furthermore the typographic towers will inevitably resemble a generic nighttime cityscape, which will inevitably rob the actual city of Istanbul of her architectural individuality.

The project does not wish to propose an alternative architecture. Nor do I wish to replace the beautiful minarets and towers that grace our nighttime sky with structures that emulate the New York skyline. What I do wish and aim for is an alternative reading of the city; of her dreams, of the personal mythologies of her many inhabitants. Istanbul'ites need to understand the socially as well as aesthetically devastating changes to which their city has been systematically subjected; thus, to be able to fully comprehend the underlying motivations, aspirations - the subtext. The Fluid Map hopes to be a potential aid in this understanding. As with so many major metropolis, in this vast city of contradictions and hectic pace, we either totally miss and/ or mishear each other’s tales and dreams. If we have the chance to read each other we may understand each other. It is to this end that this project is dedicated.

7.1 Discussion and Future Projection

Other conveniences such as a network layer, enabling the users of the Fluid City to chat online and a Link Layer that will set up interactive relationships between the text data and hence the interactive navigation from one building to another based upon contextual relationships are also planned for completion.

REFERENCES

[1] Wikipedia. “Marshall cartography”. *Wikimedia Foundation, Inc.* Retrived on 27/07/2006 from: http://en.wikipedia.org/wiki/Cartography

[2] MSN Encarta. “History of cartography”. *Microsoft Coorperation.* Retrived on 27/07/2006 from: http://uk.encarta.msn.com/encyclopedia_781534525/Cartography_History_of.html

[3] Wikipedia. “Marshall Islands stick chart”. *Wikimedia Foundation, Inc.* Retrived on 27/07/2006 from: http://en.wikipedia.org/wiki/Marshall_Islands_stick_chart

[4] Ancientx. “Map of The World”. Retrived on 27/07/2006 from: http://www.ancientx.com/nm/anmviewer.asp?a=4&z=1

[5] Places and Spaces. “Claudius Ptolemy, Cosmographia World Map”. *Indiana University School of Library and Information Science.* Retrived on 27/07/2006 from: http://vw.indiana.edu/places&spaces/dev/big_thumb.php?map_id=20

[6] Wikipedia. “Tabula Peutingeriana”. *Wikimedia Foundation, Inc.* Retrived on 27/07/2006 from: http://en.wikipedia.org/wiki/Tabula_Peutingeriana

[7] Wikipedia. “Piri Reis Map”. *Wikimedia Foundation, Inc.* Retrived on 27/07/2006 from: http://en.wikipedia.org/wiki/Piri_Reis_map

[8] Robinson, A.H. “Elements of Cartography”. *New York: John Wiley & Sons, Inc.*, 1953. pp. 120-125.

[9] Robinson, A.H. “Early Thematic Mapping In the History of Cartography”. *Chicago: The University of Chicago Press*, 1982. pp 3-5.

[10] Encyclopædia Britannica. “Mercator Projection”. *Encyclopædia Britannica, Inc.* Retrived on 28/07/2006 from: http://www.britannica.com/eb/article-9052078

[11] Meurer, Peter H. “Fontes cartographici Orteliani: das Theatrum orbis terrarum von Abraham Ortelius und seine Kartenquellen”. *Weinheim: VCH,* 1991. pp. 10-35.

[12] Frenz, Thomas. “The Golden Age of Dutch Cartography”. *Faculty of Philosopy,U niversitat Passau.* Retrived on 28/07/2006 from: http://www.phil.uni-passau.de/histhw/tutcarto/english/4-6-eng.html

[13] Finn's Fine Books. "Theatrum Orbis Terrarum". *Finn Business Services Pty. Ltd.* Retrived on 28/07/2006 from: http://www.finns-books.com/orbis.htm

[14] How Products Are Made. "Topographic Map". *Thomson Gale.* Retrived on 28/07/2006 from: http://www.madehow.com/Volume-4/Topographic-Map.html

[15] National Maritime Museum. "The Ordnance Survey". *National Maritime Museum, Greenwich.* Retrived on 28/07/2006 from: http://www.nmm.ac.uk/server/show/nav.005001005001001

[16] AerialArts. "History of Aerial Photography". Retrived on 28/07/2006 from: http://www.aerialarts.com/History/history.htm

[17] Benton , Charles C. "History A Bit of History: Aerial Perspectives Imagined and Real". *Kite Aerial Photography.* Retrived 28/07/2006 from: http://arch.ced.berkeley.edu/kap/background/history.html

[18] Agrecon. "Remote Sensing". *Agricultural Reconnaissance Technologies.* Retrived on 28/07/2006 from: http://www.agrecon.canberra.edu.au/Remote/Remote.htm

[19] Hemphill, Jeffrey J. "Introduction to Thermal Infrared Remote Sensing". *Santa Barbara Department of Geograph, University of California.* Retrived on 28/07/2006 from: http://www.geog.ucsb.edu/~jeff/115a/remote_sensing/thermal/thermalirinfo.html

[20] Art Sans Frontieres. "Original Aboriginal Paintings by Australian Aboriginal Artists". *Ocean Feather Internet Marketing.* Retrived on 29/07/2006 from: http://www.artsansfrontieres.com.au/abor.html

[21] Johnson, Margeret. "Comparing Medieval Maps from Around the Globe". *Britannia*. Retrived on 29/07/2006 from: http://www.britannia.com/history/herefords/mapmundi.html

[22] Livingston, Michael. "Modern Medieval Map Myths: The Flat World, Ancient Sea-Kings, and Dragons". *Strange Horizons.* Retrived on 29/07/2006 from: http://www.strangehorizons.com/2002/20020610/medieval_maps.shtml

[23] John Snow. "John Snow's map". *UCLA School of Public Health.* Retreived on 29/07/2006 from: http://www.ph.ucla.edu/epi/snow.html

[24] Dent, Borden D. "Principles of thematic map design". *Iowa: Wm. C. Brown Publishers,* 1990.

[25] Friendly, M, and D.J. Denis. "Milestones in the history of thematic cartography, statistical graphics, and data visualization". *York University,* 2003.

[26] Robinson, Arthur H. "The 1837 maps of Henry Drury Harness". *Geographical Journal,* 1955. pp. 440-450.

[27] Gallery of Data Visualization. “Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization”*. York University.* Retreived on 30/07/2006 from: http://www.ph.ucla.edu/epi/snow.html

[28] Wikipedia. “Geographic Information System”. *Wikimedia Foundation, Inc.* Retreived on 30/07/2006 from: http://en.wikipedia.org/wiki/Geographic_information_system

[29] Jumel, Stéphanie. “Models for Environment”*. European Institute for Energy Research.* Retreived on 30/07/2006 from: http://www.eifer.uni-karlsruhe.de/212.php

[30] Berry, J.K. “Beyond Mapping: Concepts, Algorithms and Issues in GIS”. *Fort Collins, CO: GIS World Books,* 1993.

[31] GIS Premier. “Fundamental Concepts”*. Innovative GIS Solutions Inc.* Retreived on 30/07/2006 from: http://www.innovativegis.com/basis/primer/concepts.html

[32] The Geographic Information Services Division. “What is GIS?”*. City of Fort Collins.* Retreived on 30/07/2006 from: http://www.ci.fort-collins.co.us/gis/what-is.php

[33] Wikipedia. “Digital Elevation Model”. *Wikimedia Foundation, Inc.* Retrived on 30/07/2006 from: http://en.wikipedia.org/wiki/Digital_elevation_model

[34] Geo Surface3D PRO. “Advanced 3D graphics for Geographic Information System”. *ScienceGL.* Retrived on 30/07/2006 from: http://www.sciencegl.com/gis_dem/index.html

[35] Friendly, Michael. “Gallery of Data Visualization”. *Statistical Consulting Service and Psychology Department, York University.* Retrived on 30/07/2006 from: http://www.math.yorku.ca/SCS/Gallery/noframes.html

[36] Mazza, Riccardo. “Introduction to Information Visualisation”. *Faculty of Communication Sciences, University of Lugano,* 2004.

[37] SAS/INSIGHT User's Guide. “Moving and Sizing”. *SAS Institute Inc.* Retrived on 30/07/2006 from: http://www.csc.fi/cschelp/sovellukset/stat/sas/sasdoc/sashtml/insight/chap25/sect4.htm

[38] Spence, R. “Information Visualisation”. *Addison-Wesley,* 2001.

[39] Mazza, Riccardo. “CourseVis - Discussions Plot”. *Faculty of Communication Sciences, University of Lugano.* Retrived on 30/07/2006 from: http://www.istituti.usilu.net/mazzar/Web/Projects/CourseVis/discussion_plot.html

[40] Sachinopoulou, A. “Multidimensional visualization”. *Technical Research Centre of Finland*. Retrived on 30/07/2006 from: http://www.inf.vtt.fi/pdf/tiedotteet/2001/T2114.pdf

[41] Card, K. S., Mackinlay, J. D., and Shneiderman, B. “Readings in Information Visualization, using vision to think”. *California:Morgan Kaufmann,* 1999.

[42] Chen, C. “Information Visualisation and Virtual Environments”. *Springer,* 1999.

[43] Advanced Visualization Lab. “Advanced Visualization for the INGEN IT Core”. *The Trustees of Indiana University*. Retrived on 31/07/2006 from: http://www.inf.vtt.fi/pdf/tiedotteet/2001/T2114.pdf

[44] Ekşi Sözlük. “Genel İstatistikler”. *Sourtimes Entertainment*. Retrived on 31/07/2006 from: http://sozluk.sourtimes.org/

[45] Wikipedia. “Istanbul”. *Wikimedia Foundation, Inc*. Retrived on 01/08/2006 from: http://en.wikipedia.org/wiki/Istanbul

[46] MSN Encarta. “Istanbul”. *Microsoft Coorperation*. Retrived on 27/07/2006 from: http://uk.encarta.msn.com/encyclopedia_761552870/%C4%B0stanbul.html

[47] Orthodox Multimedia Gallery. “Map of Constantinopolis”. *4homepages.de*. Retrived on 01/08/2006 from: http://www.trinitylight.net/4images/details.php?image_id=396&sessionid=98596f237718afbc078a9ec1ce7f9a13

[48] Reference.com. “Istanbul”. *Lexico Publishing Group, LLC*. Retrived on 01/08/2006 from: http://www.reference.com/browse/wiki/Istanbul

[49] Pérouse , Jean-François. “Deconstructing the Gecekondu”. *European Journal of Turkish Studies, Thematic Issue N°1*. Retrived on 01/08/2006 from: http://www.ejts.org/document195.html

[50] TUIK. “Nüfus İstatistikleri ve Projeksiyonlar”. *Türkiye İstatistik Kurumu*. Retrived on 27/07/2006 from: http://www.tuik.gov.tr/

[51] OpenGL. Retrived on 02/08/2006 from http://www.opengl.org/

[52] MySQL. Retrived on 02/08/2006 from: http://www.mysql.org/

[53] Guichan. Retrived on 02/08/2006 from: http://guichan.sourceforge.net/