3D Analysis of Makkah

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Abstract

The task of the Development Commission for Makkah, Madina and the Holy Sites (DCOMMM) is to coordinate the development in this region in order to secure a fulfilling experience of visitors and pilgrims to the holy sites in Saudi Arabia. As a major tool for this task an enterprise GIS has been established at the Commission. Topography including natural and man made structures play an important role in the spiritual experience of millions of pilgrims coming from all over the world. In this research, the change of the center of Makkah has been analyzed. Time series covering the last 40 years when the most significant changes occurred and a scenario for the next 30 years have been created. The results have been presented using different 3D tools of ArcGIS. These results show the decreasing importance of the Holy Mosque in comparison with the adjacent man made structures.

1- Introduction

As is well known, Islam consists of five pillars: 1) Profession of faith, 2) Performance of prayers, 3) Almsgiving (support of the needy), 4) Fasting the month of Ramadan, and 5) Hajj (pilgrimage) to Ka'aba for every able-bodied Muslim who can afford to do so (at least once in his/her lifetime).

Hajj is performed in Dhul-Hijja, the twelfth month of the Islamic calendar. During the Hajj 1427 (corresponding to 2007 G) at least 3.07 million people performed Hajj, 1.51 million of them originated from within the Kingdom of Saudi Arabia (Saudi citizens and non-Saudi residents) while the rest (1.56 million) came from countries around the globe (Hajj Research Institute, 2007). The pilgrims come from very diverse ethnic, cultural, and educational backgrounds and a significant percentage of them are in the higher age categories.

In February 2004, the formation of the Development Commission of Makkah, Madinah and the Holy Sites (DCOMMM) was ordered by a royal decree of the king of the Kingdom of Saudi Arabia. DCOMMM is be headed by Prince Miteb Ibn Abdul Aziz, the Minister of Municipal and Rural Affairs. The Governor of Makkah region, the Governor of Madinah region, and the minister of Hajj are the members of the DCOMMM's council. The foundation of the DCOMMM was announced shortly after a deadly incident happened within the boundaries of the Holy Sites. A stampede occurred when a number of pilgrims fell down as a result of heavy scrambling among pilgrims while they were throwing stones at the great Aqaba and as a consequence 244 pilgrims died. There is a strong will to reduce risks and enhance the whole infrastructure that will help pilgrims to perform Hajj and Umrah in a safer way.

DCOMMM will work out the development plan for Makkah, Madinah and the Holy Sites. It has to report directly to the King, make recommendations and call on local and foreign expertise and the resources of all government facilities and research centers. In order to draw up comprehensive plans that meet the needs of pilgrims over the next 20 years it will have a special budget. GIS is the framework for planning works of DCOMMM. Additional tools

might be used as long as they can communicate with the GIS in a reasonable way.

In GIS, integration of three-dimensional models with georeferenced databases holds great promise for physical planning and design. It allows for simulation, visualization, shadow studies, urban wind effects, and neighborhood compatibility studies. DCOMMM's GIS is mainly based on ESRI technology that has made significant strides in the functionality of the ArcGIS 3D Analyst extension (which includes the ArcScene and ArcGlobe applications). Interoperability with dedicated three-dimensional modeling software packages, such as Google SketchUp, provide even more opportunities for real-time and interactive analyses.

GIS is associated with data overlaying and relational databases for community-level visualization and analysis in two dimensions. Architectural visualization emphasizes the representation and analysis of form, space, and material. While GIS uses layers to subdivide datasets, layering systems in architectural design typically reference material components and a language of line-weights, colors, and textures. Integration of both systems still is a major challenge.

2- Objectives

The objective of this research is to show how the image of the Holy Mosque in Makkah by its relationship with the center of the city has changed dramatically. Time series covering the last 40 years when the most significant changes occurred and a scenario for the next 30 years have been created. The results have been presented using different 3D tools of ArcGIS.

3- Methodology

DCOMMM has been working hard during the past year to build a comprehensive database build on ESRI and ORACLE technology including data from many governmental and private organizations. Recently, the database reached a status that supports sophisticated 3D modeling of many parts of Makkah. In the following, the usage of some layers of the database is explained in more detail.

3.1 Data and Data Preparation

3.1.1 Topographic Map from 1967

A topographic map showing the center of Makkah that was published by Ministry of Interior, Town Planning Office, in 1967 had been scanned and vectorized. This map had been selected because it showed the structure of the city with most of buildings designed and constructed in the traditional way. After the map had been projected to the projection system used by DCOMMM the number of floors for each building were added to the attribute table.

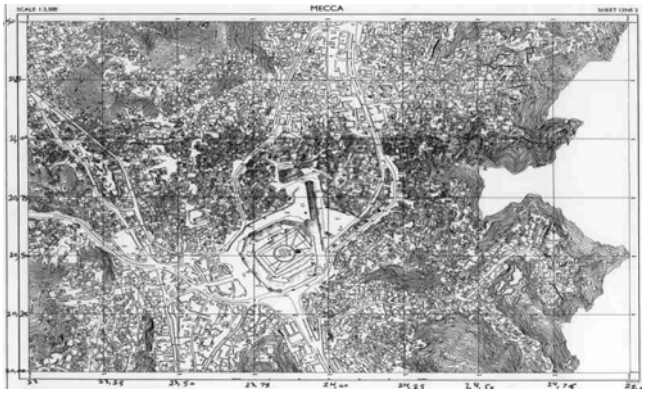

Figure 1: Topographic map showing the center of Makkah in 1967

3.1.2 Photographs of Center of Makkah

Several photographs had to be used because their dates did not exactly match that of the topographic map. This inaccuracy could be accepted as it is well known that the major change of the center of Makkah occurred after 1970. The photographs served as a source for estimating building heights based on the amount of floors and for modeling facades.

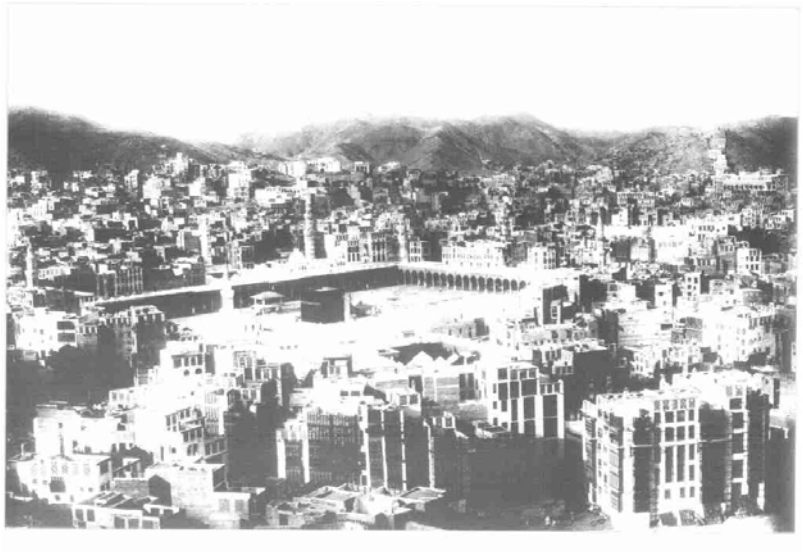

Figure 2: Photograph showing Makkah with the Holy Mosque before the King Fahd extension taken place in 1988.

3.1.3 Fly-Through of Makkah in 2007

Pictometry is a leading provider of geo-referenced, aerial, oblique image libraries and related software. Oblique refers to the angle at which an image is captured (Pictometry images are typically captured at a 40 degree angle). By capturing images at this angle, as opposed to a straight down or overhead shot, Pictometry's images reveal greater detail, enabling users to see different views of an image and notice relevant details such as street lights, fire hydrants etc.

The fly-through was produced by Pictometry using its Real3D Silver option that incorporates Pictometry's digital, oblique aerial data of the area's surroundings to create visually rich, detailed building facades and other side structural details from all the way around an area or feature. The resolution of the image shown in the figure below is 10 cm on the ground These data describe the current status of Makkah in a very realistic way.

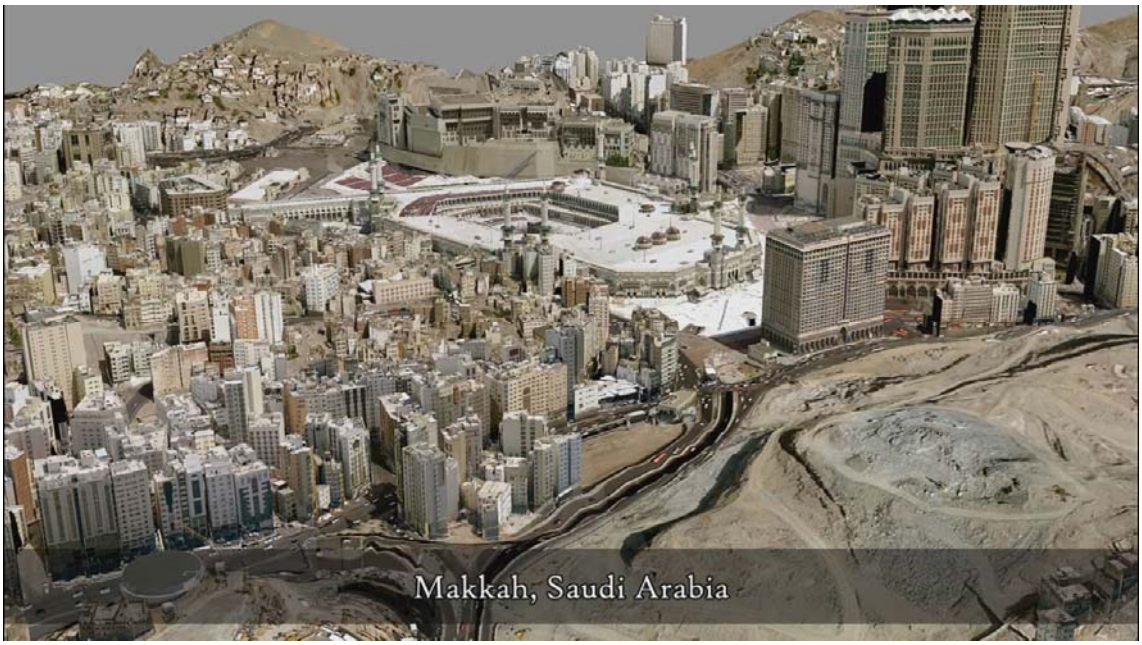

Figure 3: Screen shot of a fly-through simulation showing the center of Makkah with the Holy Mosque in the centre, the Vakf building to its right and the construction site of the "Jabal Omar" project in the foreground as of September 2007. Image viewed from the West.

3.1.4 DEM and Orthophoto of Makkah in 2007

Pictometry used the same data to produce a Digital Elevation Model (DEM) and orthophoto with a resolution of 10 cm. These data were used for all 3D modeling workds. Only the data for the central part of Makkah have been processed.

3.1.5 Master Plans of Important Development Projects in Makkah

Virtually, the whole center of Makkah will undergo major changes during the next years. More than 20 big development projects have been proposed. For them, master plans have been submitted by private companies but not yet finally approved. The original files in dwg format have been converted to shape files. Text from the dwg files have been converted into attribute data including amount of floors and heights. Main problem was the huge amount of dwg drawings, some of them contradicting each other, and its missing documentation. To overcome this situation additional information from other sources had to be included. In this research, only the master plans for the "Jabal Omar" project in the West and the "Shamia" Project in the North of the Holy Mosque have been included.

3.2 3D Modeling

3.1.6 Modeling of Historical Makkah

For the modeling of historical Makkah, the topographic map of 1967, panoramic photographs of this period and DEM from recent topographic data were used as an input. Building heights were available from the attribute data. The facades of typical Makkah buildings had been used in Sketchup to produce 3 D symbology that were imported into ArcGIS symbol libraries. Then, the topographic map was draped over the DEM and each building was displayed according to its attribute data with a special symbol from the library.

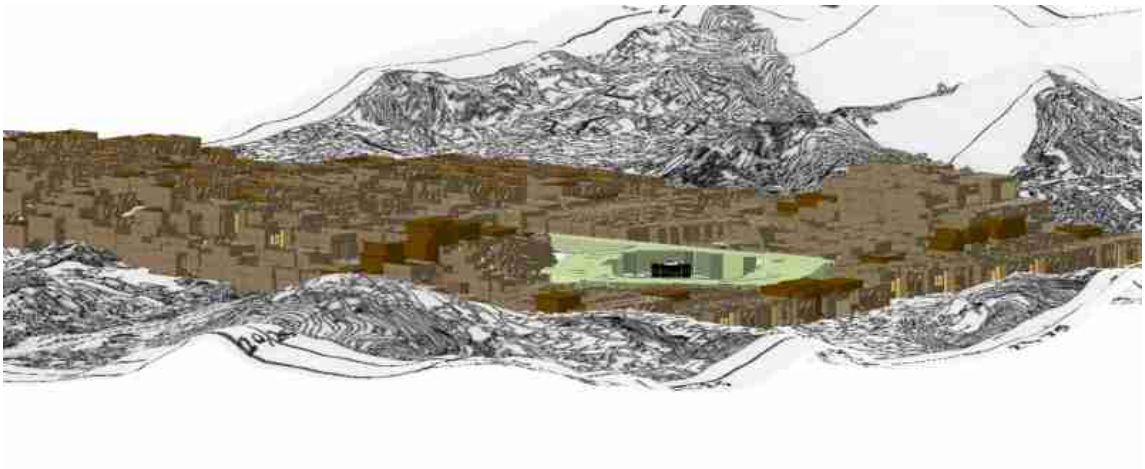

Figure 4: 3D model of center of Makkah showing the status before 1967. Only buildings in the center have been included. The Holy Mosque is shown in green colors. Model viewed from Southwest.

3.1.7 Modeling of the Future Makkah

For the modeling of the future Makkah, land use data, dwg drawings of development projects, and the DEM were used as an input. Because building heights were not available, the height was computed by using the amount of floors that were extracted from land use data. A certain amount of inaccuracy had to be accepted because an average height for all house were applied. The "Vakf" building that is dominating the South of the center of Makkah with its Empire State Building like shape has been digitized separately in order to gain more reality. These data show the current status of the center of Makkah.

On top of these data, the development projects are shown with darker colors. The single objects of the development projects have been grouped into separate layers (e.g. towers sharing the same height) and imported from dwg to shape files. Then, they were displayed in ArcScene according to their heights. For visualization purposes a Z factor of 10 has been applied to all data layers.

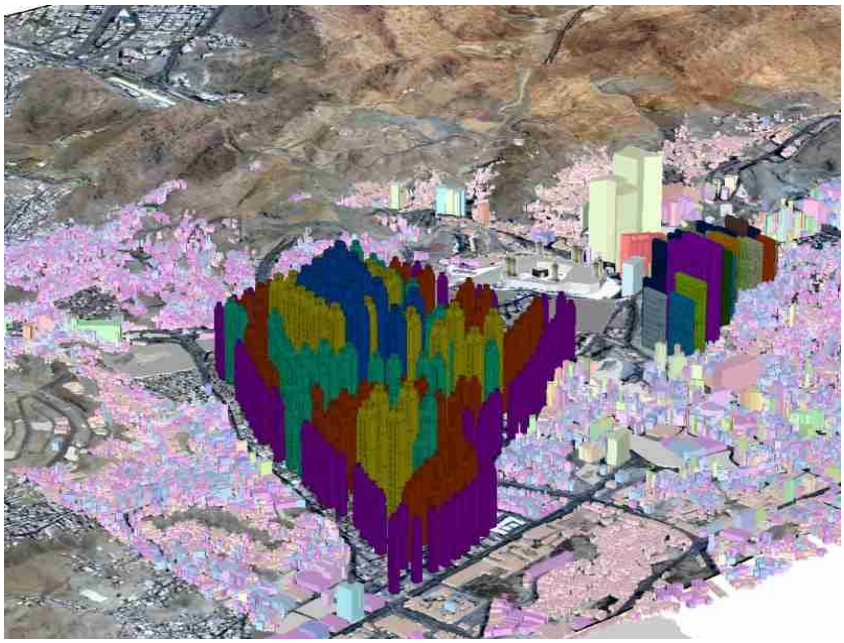

Figure 5: 3D model of future Makkah viewed from Northwest. Behind the Holy Mosque in the center the “Vakf” building, to its right and the "Jabal Omar" project, and to its left the “Shamia” project can been seen. Existing buildings are shown in bright colors.

4- DISCUSSION AND CONCLUSION

In the past, no comprehensive planning for Makkah in which new big development projects were included existed. Similar, GIS data of the different governmental organizations in charge were only organized at project level. DCOMMM has put big efforts in integrating these scattered and unrelated data into one comprehensive database that can serve the comprehensive planning process.

The development projects have been designed in high detail by means of thousands of CAD drawings. What was missing was their integration with the existing urban environment and its future enhancement. This integration was a major political and technological challenge for DCOMMM. On the technology side, in the beginning CAD and GIS components were developed without taking integration into consideration. Eventually, this integration had to be done by consuming much more efforts than if it had been done right from the beginning.

During this research, the integration of different data sources including CAD, GIS and photography for 3D modeling has been successfully conducted for the central part of Makkah. Future works will concentrate on the extension of the area and enhancement of 3D models.

During the past years and especially recently, much discussion took place about the necessity of new development projects in the center of Makkah and how Makkah would look like in the near and far future. During these discussion focus were on the single projects separated from each other.

However, DCOMMM has tried to promote the concept of a comprehensive planning for entire Makkah. Using its own GIS facilities DCOMMM has tried to combine data originating from different sources all around the Kingdom and to show the whole picture. Especially, by creating time series as explained above - the past, the present and the future - people can better understand how the future will look like and by this, they can judge whether this future would be in harmony with their cultural, social and religious values.

In the case of Makkah, CAD technology is still focusing on projects only whereas, GIS uses a holistic approach trying to show the whole picture. Without such a holistic approach the opportunity to develop Makkah according to Islamic and traditional cultural values might be lost for ever.

5- References

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