Annual Report for the Sea Grant project

Development of Virtual Coastal Cities for Indiana

For the period of February 2008 – February 2009

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Abstract

This report summarizes the activities and achievements accomplished in the calendar year 2008. The Purdue group (4 people) has met its collaborators and advisors twice in East Chicago and Gary. Through this meetings, we identified their needs, priority areas of interests, and required data formats and representation. Under the mutually agreed aspects, we have carried 3 major tasks. First of all, land cover maps are produced over areas in Northern Indiana based on 2005 aerial images, digital surface model, and digital terrain model. Potential and performance of automated land cover mapping were investigated. Second, 3D building models are generated over the interest areas or spots. This constitutes a great addition to the existing local geospatial data. Finally, all results are integrated into Google Earth plug in environment, such that the general public can visit the 3D virtual cities through a regular web browser.

1. Introduction

Virtual reality can enormously benefit sustainable urban planning over a long period of time. Effective visualization considerably relies on relevant and contemporary data, capabilities of interaction and analysis, and involvement of participants in the planning process. The goal of this work is to develop such visualization application for coastal cities by Lake Michigan in northern Indiana. To achieve this primary goal, a number of supporting objectives must be accomplished in this study. First of all, we will develop an effective 3-D data (in particular buildings) collection technique. Such data is essential for urban planning in terms of visibility analysis, cultural and natural heritage reservation, noise and pollution modeling, and tourism industry.

With the proposed development, we will be able to provide 3-D building models over selected interest areas at the proper levels of details. As for the second objective, we will develop highly automated method to derive land cover maps for coastal zones (the area from shoreline, marsh, sand to the city land boundary and near shore areas). This effort will provide the most recent and accurate coastal zone information for Indiana, which can then be used along with historical coastal information for coastal change modeling and prediction. The third objective is to provide interest users with the capabilities to interact, modify, manipulate, and demonstrate the views such that different design scenarios and modeling results can be evaluated. In summary, the outcome of the proposed study will be virtual cities over the selected areas that will meet a variety of needs in urbanization modeling, water resource planning, fishery industry, and ecosystem protection, and ultimately benefit long term sustainable economic and environmental development in the coastal areas in northern Indiana.

2. Narrative Report

Once the project was funded, we formed a team with Jie Shan as the PI, plus three graduate students: Jacob Dunham, Ejaz Hussain, KyoHyouk Kim. One of the is fully support by this grant, while the other two were funded elsewhere.

In the first calendar year, we have had the following activities and accomplishments

- Meeting with twice our advisors from East Chicago, Gary, and NIRPC
- Collection of local geospatial data, in particular building models
- Developing a webpage based on Google Earth Plug-in technique for coastal visualization

Such activities will be reported below.

2.1 Meeting with the collaborators

Two meetings have been held with our collaborators and advisors. A group of four of the Purdue team took field trips visiting NIRPC and Gary, one in the summer and the other in the Fall. We have met Christopher Meyers, Director, Department of Planning & Division of Zoning, City of Gary; Dwayne Williams, Director, East Chicago; John Swanson, Director of NIRPC, and many of their staffs and/or representatives. During the first meeting, we got a better understanding on the users' needs from city's point of view, identified the geographic

areas with higher priority for the cities, agreed on the data layers to be visualized, and made a plan for the technical implementation. Our second meeting was a demonstration for the progress since the first meeting. The participants were shown with the capabilities and features of the visualization tool that we developed. Comments and suggestions were taken by the Purdue group for further refinement and enhancement. The third meeting has been proposed for the summer 2009.

2.2 Land cover classification

Most Indiana coastal regions are subject to intensive resource management, environmental protection, land development and reclamation. The success of all such activities relies on good planning, for which it is essential to gather all relevant geospatial data to extract land use land cover information. Acquisition of land use and land cover information through conventional field visits and surveying is very tedious, time-consuming and costly. As an increasingly promising alternative, land use and land cover maps derived from high resolution satellite and airborne remote sensing imagery provides a rapid and cost-effective means for the planning and management of coastal zones.

To produce a land use land cover map, a part of the Gary, IN coastal areas (6 km x 1.5 km) has been selected. The left extent is about 0.8 km from the S. Lake Street and towards the right it extends up to the West Beach, shown in Figure 1. It covers part of the Lake Michigan water, coastline and in the depth slightly ahead of Dunes Highway. High resolution Indiana 2005 orthophoto image has been used for the classification. Eleven classes were included for classification to extract land use land cover map. These classes includes, Lake Michigan, lakes and ponds, dry lake and ponds, coast sand, sand dunes, buildings, roads and parking lots, Trees, grassy areas, deciduous tree areas and open areas. Because of the high resolution, some of the classes have spectral similarity with the others thus result in misclassification. To offset this problem and to achieve better results, Digital Elevation and Surface models have been added to the processing. The use of this additional data helps improve the classification and reduce the confusion among spectrally similar classes. The final land use land cover classification map is shown in Figure 2.

Figure 1. Gary, Lake County, Indiana coastal areas

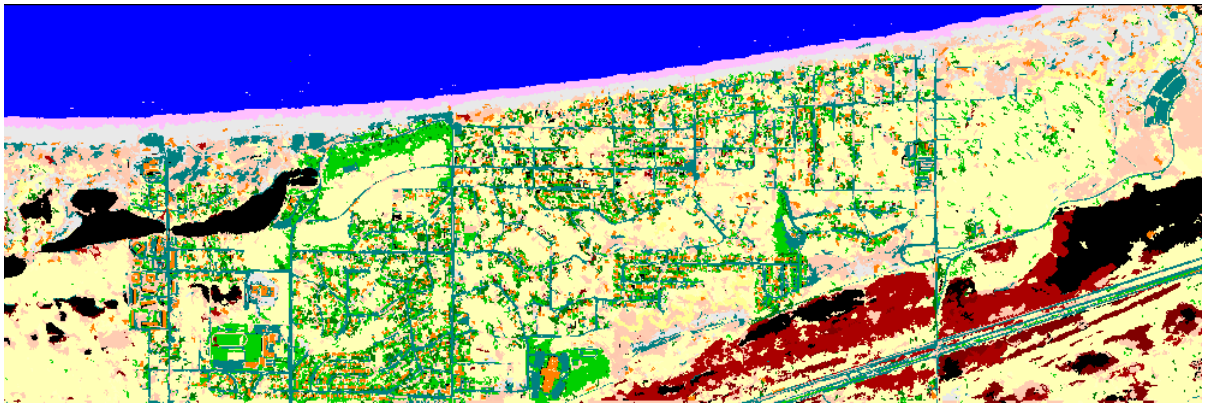

Figure 2. Land cover map produced

Lake Michigan	Coast sand	Sand dune	Lakes & ponds
Dry Lakes &Ponds	Trees	Grass	Deciduous tree areas
Buildings	Roads and parking lots		Open areas

The produced maps clearly demarcate the coastline and the adjacent sand beach and dunes area. The other small lakes and ponds (lagoons) have been effectively mapped along with their surrounding areas. As the image was acquired during the leaf off season, the trees class shows the presence of evergreen trees. The classification results show that bulk of this area is under the deciduous trees/ shrubs. This leaf off condition helps to better visualize these areas which is otherwise not possible due to the tree canopy cover. Roads and parking lots and buildings classes show some degree of misclassification.

2.3 3D building collection

One of the most popular and demanded features in visualization is 3D buildings. Unfortunately, we do not have 3D buildings for Northwestern Indiana, despite the fact that they are available for some big cities. This required the modeling of the buildings in the study areas of East Chicago and Gary. In order to collect the buildings the data from the 2005 Indiana Orthophotography Project was used to obtain building outlines and height. In order to obtain the height of the buildings a normalized Digital Surface Model was computed from the Digital Surface Model and the Digital Elevation Model. The approximate building outlines were obtained using tools that are available in ESRI ArcGIS. Then using the approximate building outline and the height information the buildings were modeled in Google SketchUp. The buildings are represented as wireframes, because Gary and East Chicago officials stated that is what they desired. There have been 152 building models collected to date. The building models have focused on East Chicago, Gary, and the casinos. The following significant buildings have been modeled: Gary City Hall, Gary Court House, Gary Public Library, Genesis Convention Center, Sheraton Hotel, U.S. Steel Yard, U.S. Post Office, Knights of Columbus Building, Genesis Tower, Standard Liquors Building, Palace Theater, Majestic Star Casino, and Ameristar Casino. Some of the example are shown below.

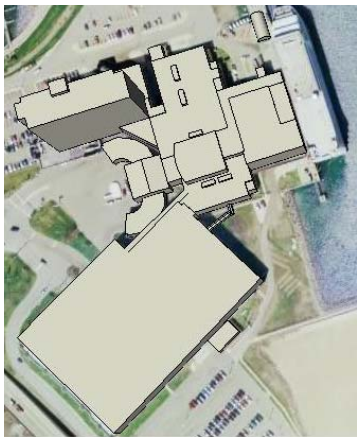

Figure 3. Ameristar Casino

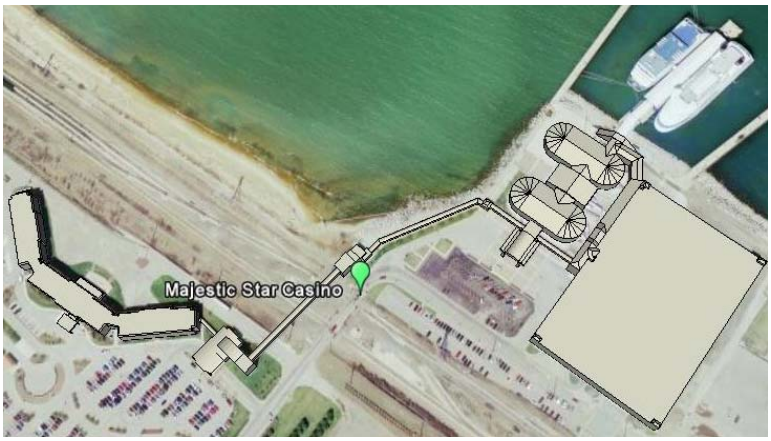

Figure 4. Majestic Star Casino

Figure 5. Downtown Gary (Genesis Convention Center, Sheraton Hotel, Gary City Hall, and Gary Court House)

2.4 Webpage development

Google Earth plug-in is used to visualized 3D building models. It is widely used to share and publish geospatial information because of its powerful visualization functionalities and abundant available data. Based on Google Earth plug-in functionalities, we designed and implemented our webpage to provide 3D building models and additional user requested functions. Javascript language is used to customize Google Earth plug-in API. The developed web-page is at https://engineering.purdue.edu/CE/indianacoast/main.htm.

Currently, the following OS and browser can access our webpage.
- Microsoft Windows 2000, XP and Vista (IE6.0+, FireFox 2.0+, Flock 1.0+)
- Apple Mac OS X 10.4+ (Safari 3.1+, FireForx 3.0+)

The webpage is composed of 3 parts, 1) Menu, 2) Map viewer and 3) Layer viewer.

- Menu
  From the Menu item, user can select different cities and use additional functions implemented.
  - Cities : Each button provide a shortcut to move to the different cities.
  - Geo-Location : Provide geocoding address service.
  - Load File: Support kml file overlay from local computer. To use this function, the following requirement should be satisfied.
- Map viewer
  User can handle map using mouse and keyboard, such as zoom-in/out, panning and rotation. The basic operation is the same as that of Google Earth desktop. User can check the attribute information of each object.

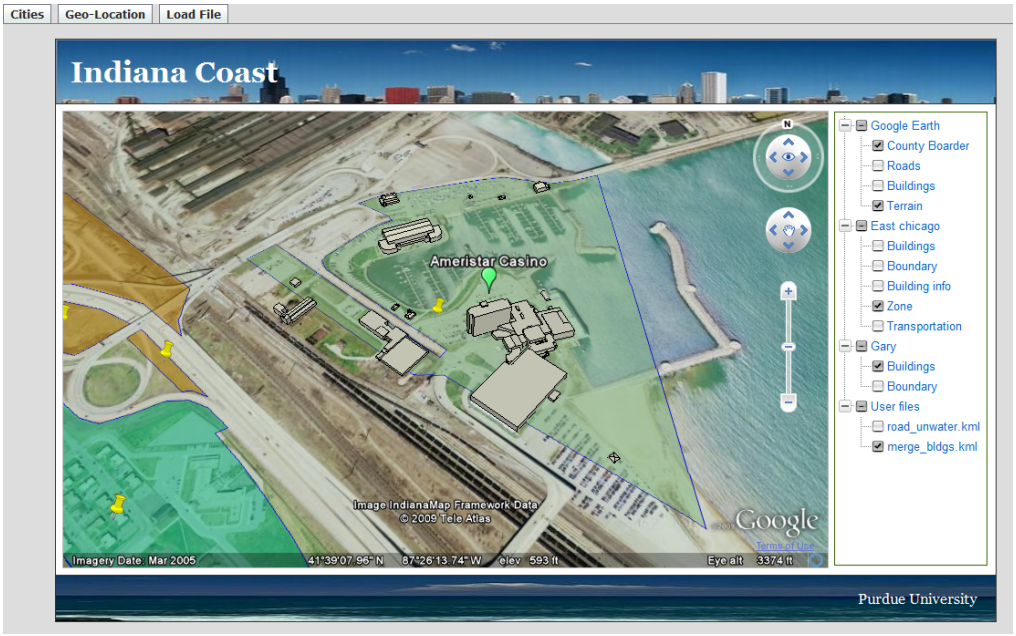

Figure 6. 3D Building models (Ameristar Casino) overlaid with zone data

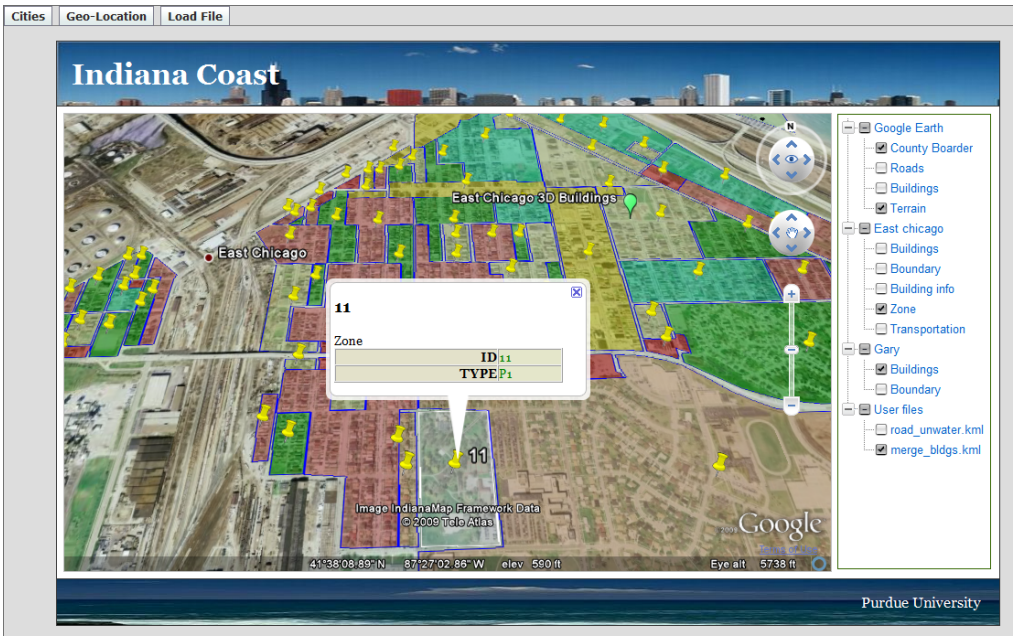

Figure 7. Identification of attribute information

- Layer viewer
  Using layer viewer, user can turn on/off the visibility of each layer. There are four predefined layers such as Borders, Roads, 3D buildings and Terrain provided by Google Earth. The others are organized and grouped for the current project step, and can be adjusted further for user request.

3. Potential Applications or Benefits

Since our collaborators and advisors are heavily involved in city planning much of the work has been slanted towards applications that are useful to city planners. Some of the applications that we have demonstrated are the ability to overlay existing data such as zoning data or street data over a web interface. This is useful in industry because it not only allows the user to use the layers provided by popular web services, such as GoogleEarth, but also layers that are of importance to them. This allows for the expansion of the applications that GoogleEarth can be used to visualize and it allows for data to be shared easily amongst city departments and the general public. Besides, another potential application is the ability to overlay current or future building models of projects that are under construction or proposed so that the general public can visualize how they will affect the city.

4. Keywords

Land cover, mapping, coast, 3D, visualization, urban modeling, remote sensing

5. Lay Summary

To plan and monitor the developments in coastal areas, up-to-date land use/land cover information is vital. The availability of high resolution remote sensing data provides an opportunity to correctly extract the land use /land cover information. This information can be as a base map for planning and development projects with in these areas. The land use and land cover information can help to identify measure and demarcate the areas which are available and potentially be used for future development.

This study will help identify locations which can be effectively developed to improve the coastal environment, create recreational facilities and made easy accessible and attractive to the public. This land use land cover information can be regularly updated by extracting the latest ground information from new imagery. The analysis of the change pattern with the areas of interests can be used as a tool for modeling the changes and predictions about the future expansion trends. All such information, both in 2D and 3D, will be integrated into a Web-based visualization environment for public access.

6. Others

- International Implications, If applicable to your report **- None**
- Media Coverage - **None**
- The current achievements are integrated into the webpage at **https://engineering.purdue.edu/CE/indianacoast/main.htm**
- Partnerships with other institutions/individuals initiated or continued by your project.
- Publications (if applicable) – **None at this time.**
- Undergraduate/Graduate Names and degree

    1) KyoHyouk Kim, supported by the project; Ph.D
    2) Ejaz Hussain, involved in the project, funded elsewhere; Ph.D
    3) Jacob Dunham, involved in the project, funded elsewhere; Ph.D

- Related Projects – **none at this time**
- Awards and Honors **- none at this time for this project**
- Patents/Licenses **- none**
- Graphs, figures and/or photos **–shown in the report**