Automated Three Dimensional Planning and Visualization Tool for Urban Environments

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Background: The Centre City Development Corporation (CCDC) is a public agency that oversees development within the community planning area for downtown San Diego. In 2001 CCDC began the process of updating their downtown community plan. For the first phase of the project, KTUA was contracted to:

1. Provide services to guide data collection/development and;
2. Develop a planning tool incorporating a three dimensional modeling environment. The tool required the ability to create, summarize, and visualize potential development in downtown San Diego.

The second phase of the project was performed by an additional firm to update the community plan for the downtown area. The firm was to use a custom tool developed by KTUA to generate planning scenarios. These scenarios would then be the basis of recommendations for changes to the current community plan. After generating scenarios resulting in preliminary building models and planning data, the firm was to visually enhance the basic volumetric models of potential projects by using additional software packages for presentation within the community plan update. Final presentations were to utilize technology that was unavailable to ArcGIS 8.x software such as advanced texture mapping and shadow casting. Advanced articulations to potential building models was out of scope with the goals of the software customizations, so any additional advanced articulations were to also be performed with alternative software packages.

Tasks:
1. Develop data that would be used as a baseline for visual models. The baseline data would consist of a terrain model. Terrain model would include surface breaklines and 1 foot contours. Building features were digitized separately. These features, both the digital terrain model and the buildings were created from true color orthophotography flown at an altitude of 2400 feet. The images were scanned in at a resolution of 1 pixel = 6 inches. Control Photo was contracted to perform image capture and photogrammetric processing of the imagery and feature creation.

2. Develop a tool to allow planners to generate hypothetical development scenarios for the downtown area. The tool will generate planning related data, and have the ability to visualize projects in a three dimensional environment. Basic development regulations were to be incorporated into the tool so that potential projects would conform with the major development restrictions pertaining to height, bulk(setbacks/vertical stepbacks), and floor area ratios. The three dimensional environment was to contain the models of proposed projects with current existing buildings so that the potential projects could be compared with existing environment in size and location.

Data Creation Summary (task1)
1. Fly CCDC Area at 2400 feet. Scan to create true color orthophoto imagery at _ foot = 1 pixel. (Control Photo)
2. Digitize terrain model and buildings in microstation. (Control Photo)
3. Convert microstation files into gis data. (KTUA)
   - create digital terrain model – TIN
   - create existing buildings – 3D shapefile (roofs)
4. Obtain select CAD drawings of existing buildings, planned construction and buildings currently under construction from La Jolla Group. (La Jolla Group, KTUA)
5. Interpret current zoning code to create gis files of setbacks, stepbacks. (KTUA)
6. Consult CCDC staff to develop attribute data regarding redevelopment feasibility.
7. Create macros to automate geoprocessing tasks for buildings and data
collection/compilation tasks. (KTUA)
8. Use scenario builder macros activated from project toolbar to create development
scenarios. Run reports to generate scenario data summaries for planning purposes. (Dyett
and Bhatia)
9. Use scenario analysis as a basis for alternatives in Community Plan Update. Modify
scenario building data by conversion into software format for enhancement and final
presentation. (Dyett and Bhatia)

Application Customization (task 2)
Two ESRI applications and one application extension were utilized in the customization of
two ArcGIS documents for the purposes of the project. ArcMap 8.x was customized for
planning and project scenario development while ArcScene 8.x/3D analyst extension was
used to model the scenario in a three dimensional environment. Macros were inserted into
the application documents and activated thorough a menu based toolbar(ArcMap) and
document startup events(ArcScene). These macros automated standard geoprocessing
techniques(ArcMap) to create the building models/project data and standard rendering
environments(ArcScene) to visualize the 3D scene. The only customization within the 3D
visualization environment consisted of startup scripts to render the scene in a standard
fashion. Custom VBA forms let the user of the application interact with the virtual projects
and alter the project's attributes(spatial and non-spatial).

All of the data created for scenario builder was specific to downtown San Diego. Many
uncertainties associated with data presence did not have to be addressed. Customization
was fairly straightforward as data and schemas were known. This same logic that scenario
builder utilizes to construct virtual projects could be expanded upon so that different
entities could use the tool with their own data. The software would need to be re-
engineered and packaged as a third party extension or loadable Dynamic Link Library(.dll)
to accommodate varied data sources, possible incorporation of different types of
analysis/development constraints, and different formats of reporting and calculating
statistics. A possible object model framework would have to be created and standard
planning methods agreed upon for universal use.

Example creation of Virtual Project
Scenario builder's methodology is based on taking multiple parcels and combining them to
create a virtual development project. The macros dissolve the feature(s) into a single
shape. That base is then combined with constraints that were taken from portions of the
city development code. Not all development constraints could be incorporated into the
projects logic. Most important were those affecting height and bulk. These constraints
were built into various GIS layers where they are geoprocessed as inputs with the project
data. The physical constraints to project development consisted of ground-level setbacks,
vertical stepbacks at various elevations, view corridors and height restrictions. These
variables ultimately influence the bulk of the virtual projects and thus the total amount of
space that a virtual project may occupy. The program was designed to do large scale
scenarios of multiple projects within an area. Default volumetric development restrictions
constantly operate. Attributes from the project user form affects the result of planning
reports and also help determine 3D rendering characteristics of the projects so that they
may be seen in relation to other buildings. Among the project attributes, some may be
edited by the program, others may not. Modifiable project attributes are Floor Area Ratio
(FAR), number of units(residential development), building shape and land use. Building
height is a byproduct of a project's shape and density. As FAR or total number of units is
modified by the user in the project user form, changes to unit size will be updated to reflect
the modification. As the user is constructing a virtual project, the form will flag instances
where the project exceeds height or density limits based on existing code. The user may
construct the project if it does not conform to development code, but it will be flagged as
illegal.
The purpose of creating the software customizations is such that given current development restrictions, planners can see what is possible in terms of what can realistically be developed. If a study is performed and if it discovered that certain goals are not met, then development codes may be changed so that targets can be met. Market conditions are not taken into account and the planner must use their intuition when manipulating the variables of the virtual project. Scenario Builder is an example of a lightweight application made in-house by employing VBA macros. The same application could be developed using Python in an ArcToolbox context.
Scenario Builder Toolbar that activates VBA macros after virtual project parcels have been selected

User created Scenarios rendered in 3D through ArcScene (red and yellow projects are proposed and under construction CAD models, green and blue are virtual projects)
CCDC Totals

Totals in square feet
Potential Gross Developable Area 2,624,246
Current Gross Developed Area 2,517,180
Current Projects Gross Development Potential 107,066
Remaining Developable Area 63,329,832

Non Transient Residence Totals
Permanent Residential Units Created 1,529
Average Residential Unit Size (square feet) 1,115
Residential Density (units per acre for residential projects within the CCDC Area) 291

Land Use Detail

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2,487,344 29,836 2,517,180 1,529

Sample output of report generated through Scenario Builder