An Environment for Real-time Urban Simulation

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ABSTRACT

Drawing from technologies developed for military flight simulation and virtual reality, a system for efficiently modeling and simulating urban environments has been implemented at UCLA. This system combines relatively simple 3-dimensional models (from a traditional CAD standpoint) with aerial photographs and street level video to create a realistic (down to plants, street signs and the graffiti on the walls) model of an urban neighborhood which can then be used for interactive fly and walk-through demonstrations.

The Urban Simulator project is more than just the simulation software. It is a methodology which integrates existing systems such as CAD and GIS with visual simulation to facilitate the modeling, display, and evaluation of alternative proposed environments. It can be used to visualize neighborhoods as they currently exist and how they might appear after built intervention occurs. Or, the system can be used to simulate entirely new development.

SIMULATION INTERFACE

Work at UCLA has focused on creating a user interface for viewing and interacting with a 3-dimensional environment which has been designed specifically to meet the needs of the planning and design professions. This interface and simulation software runs on a Silicon Graphics Onyx workstation with Reality Engine graphics hardware allowing extensive use of real-time texture mapping. The simulation software was developed using Silicon Graphic's IRIS Performer application development environment. Using a Motif/X-Windows standard, the UCLA interface to the simulation includes a well-defined set of functions that most users will find sufficient for loading and viewing models without additional programming effort. However, the interface has been designed in such a way that it is easy to custom tailor the simulation to a particular application.

The simulation interface includes fly/drive controls so that the user can travel anywhere and view any part of the model from a digitally accurate perspective. Dynamic objects (such as moving vehicles or pedestrians) can be included in the scene. The user has the option of attaching to any of these objects as they are moving through the model allowing specific paths to be followed and evaluated.

A separate mode of interaction allows three-dimensional selection ("picking") of objects in the scene. Once selected, an object can be removed from the scene (simulating, for example, the removal of a building from a lot), or highlighted in the scene (as if a colored spot light were focused on it). More importantly from a design perspective, alternative models can be substituted for the object. This latter function is useful for displaying design options for a particular site, or showing a sequential set of options (for example, models that show the development of a site over time or the growth over time of newly planted foliage).

Another key option in "pick" mode allows an associated data base to be queried for object attributes. This option provides the capability for dynamic query and display of information from an existing data base (for example, a Geographic Information System (GIS)) in a real time 3-dimensional format.

THE MODELING PROCESS

The simulation component of the system does not include capabilities for building the basic model geometry, rather it is used only for interactive viewing, manipulation and querying of the 3-dimensional model and associated databases. Software System's MultiGen is the primary 3-dimensional modeler used in the modeling process. MultiGen, traditionally used for military applications, has the ability to quickly model an urban scene by the application of photographic images ("textures") to highly simplified geometric models of objects such as buildings, trees, streets, etc.

The model creation process begins with plan view aerial photographs which are a quick, easy and accurate way to obtain up-to-date information on street widths, building foot prints, foliage, etc. These photos are scanned into the computer and appropriately scaled and rotated to fit into the California State Plane grid coordinate system that is used for all Los Angeles projects. Using these photos as a base, streets and blocks are quickly identified, outlined and inserted into the database using MultiGen. In many cases detailed street, parcel and building plan data already exists in DXF format (for many areas of the City of Los Angeles, for example), which can significantly shorten this phase of the modeling. If a DXF file is available, the aerial photograph can be calibrated to the DXF plan.

Generally modeling the 3-dimensional geometry of the existing buildings requires only simple rectilinear extrusions to the building

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heights, although more detailed model construction is possible. The photorealism of the model comes from the application of photographic textures to the simple 3-D forms. Textures are captured by video taping each building facade in the study area. This video information is fed directly into the computer, perspective and color corrected, and saved in a texture database.

The physical data base is organized spatially by partitioning the region into tiles. We find it is most efficient to use street intersections as the basic organizing units. Intersections give a convenient way to reference the locations in the database (for example, the intersection of Wilshire and Vermont). Thus one spatial tile includes an intersection and about a quarter of each of the four adjacent blocks. The blocks can be divided along parcel lines so that some data integrity is maintained, however, there is no direct link in the data structure between the separate block segments. While this partitioning scheme facilitates the modeling process (it is more convenient to split the blocks into parts than to divide the streets down the center lines), it causes additional complexity when linking the physical model to a GIS database where normally a block would be stored as a coherent entity.

APPLICATIONS

Currently there are several real-world projects underway that make use of this simulation technology and help focus the development effort. These projects, which range from architectural context studies to medium and large scale urban design and planning, emphasize different aspects of the system for design/decision making.

One project is using this visual simulation technology to provide a local, neighborhood level community-based planning and communications tool to aid in redevelopment of the Pico Union area of Los Angeles. This area was badly damaged by the 1992 riots and the 1994 Northridge earthquake. For the initial project a base area of about eighteen square blocks of the community has been modeled. Using only simple interactive features of the user interface, planners have been able to experiment with demolishing a number of existing buildings and reclaiming street areas to bring park and green space to the neighborhood. Planners in the community are particularly interested in linking the virtual reality model to a GIS data base for displaying information on parcel level characteristics such as building ownership, type and the willingness of the owner to work with the community in the redevelopment process. Accessing such data in real-time as part of the visual simulation will allow immediate identification of parcels which would be most suitable for change.

In another project, which was carried out for the Los Angeles Metropolitan Transportation Authority, an area around the Wilshire & Vermont subway transit station was modeled. This model of the existing neighborhood was then used to provide the context for evaluating development alternatives for the site above the station. One feature of the Urban Simulator interface which was particularly useful for this project is the ability to display development of a site over time. The proposed MTA development is intended to be built in five stages. By simply moving a slider on the user interface, the phases of development are added to the model. While the model has proved valuable to the MTA staff for generating conceptual plans, ultimately it is expected to be used to provide a context for interested community groups to experience alternative proposals for development around the station site.

While these projects look at redevelopment occurring in existing areas, another project focuses on conceptual modeling of a new

Pico Union Neighborhood Model

mixed-use, master planned community located near the Pacific coast approximately two miles north of the Los Angeles International Airport. To date the proposed Master Plan site layout with the surrounding natural bluff features and major existing buildings in the area have been modeled. This site model currently consists of the system of streets, lot boundaries and open spaces and will ultimately include the proposed landscaping. Once the infrastructure model is complete, articulated models of typical buildings will be placed on the lots based on a detailed set of zoning criteria from the Master Plan. Alternative forms which meet the criteria can be explored and textured with images taken from existing developments which have a similar feeling to those proposed. Rendered images of actual designs can also be tested when the project moves into this phase.

CONCLUSION

An earlier "proof of concept" prototype model focusing on a riot-torn portion of South Central Los Angeles recently won the top award in the education and academia category of the 1994 Computerworld Smithsonian Award Program. Actual experience using the system on real projects continues to validate this development effort. The system has proven to be an extremely useful tool for exploring potential design solutions. It is possible to evaluate alternatives rapidly and in more detail than through more traditional analysis. Results of the planning/design process are illustrated visually, allowing the client or community to view a proposed environment in a realistic fashion and become informed participants in the decision process.

To facilitate community participation in the simulation process, the UCLA Urban Simulation Team recently received a CalREN (California Research and Education Network) grant for a 155 megabit/second ATM connection to a wide area GTE and Pac Bell ATM net. Additional commitments from Bay Networks for ATM equipment and AT&T for their enhanced Multimedia Interface (EMMI) will enable the real-time transmission of the keyboard and mouse information in one direction and the video generated by the simulation in the other. This will allow the display of the simulation (in real-time) at any other CalREN or similarly connected site (high school, library, community center, etc.). It is not difficult to envision a time when the much prophesied 500 station interactive cable networks will support community member's connection to local city halls (at night when the machines are normally idle) where they will use this technology to interactively evaluate and comment on plans for the community.

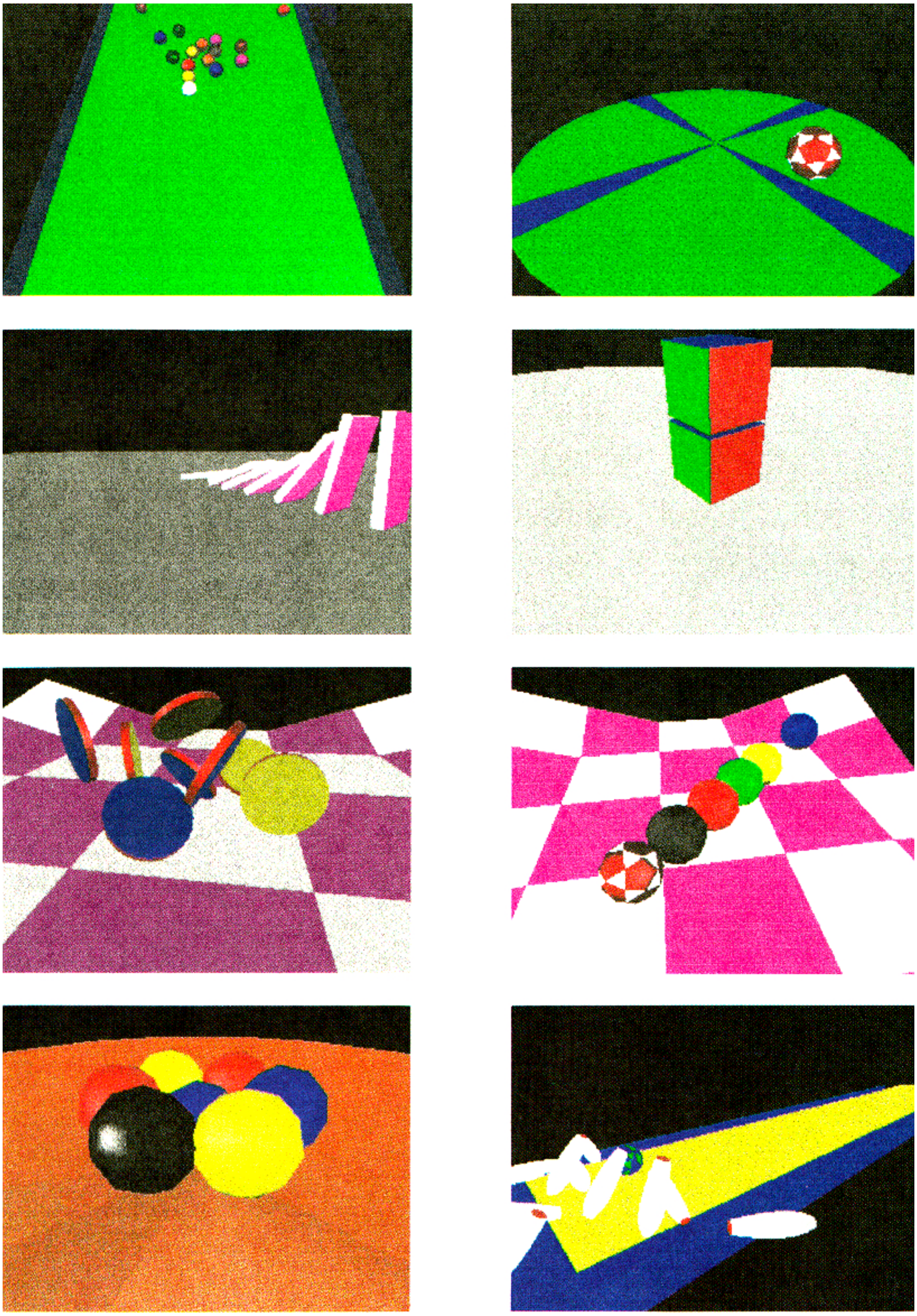

Figure 12: *Simulation snapshots.*

Mirtich and Canny, "Impulse-based Simulation of Rigid Bodies"